Humanities Distinction Track Project:

Approaches to Clinical Uncertainty Among Physicians in Surgical versus Non-surgical Medical Specialties

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Graduation Year: 2026

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Project Summary

Title: Approaches to clinical uncertainty among physicians in surgical versus non-surgical medical specialties

Purpose

This work will assess physician approaches to uncertainty in clinical judgment and medical decision-making among physicians in surgical versus non-surgical medical specialties. There appears to be relatively little published literature in this area.

Objectives

1. Review published literature addressing physicians' approaches to uncertainty in clinical judgment and medical decision-making.
2. Juxtapose approaches to uncertainty among physicians in surgical versus non-surgical medical specialties.
3. Suggest explanations for the differences in approaches to uncertainty (or lack thereof) among physicians in surgical versus non-surgical medical specialties.

Approach

- Perform a PubMed literature search using Boolean operators including:
  - "uncertainty" [ti] and "surg*" [ti]
  - "uncertainty" [ti] and "decision making" [ti] and "physician"

Preliminary Results

- The first PubMed search noted above with collection of articles with "uncertainty" and any variant of "surgery, surgical, surgeon, etc." in the title yielded 125 results.
- The second PubMed search noted above with collection of articles with "uncertainty" and "decision making" in the title with "physician" anywhere in the body of the article yielded 61 results.
- In total, this search strategy collected 186 candidate articles for review.

Next Steps

- The 186 PubMed articles identified by the search strategies indicated above will undergo abstract review for content pertaining to our purpose/objectives.
- Relevant articles will be reviewed and annotated in their entirety.
- These annotations will inform the drafting of a summative, 3000-word written work with at least 1 figure and 1 table.
- The figure will portray example mental workflows of clinical judgment and medical decision-making, comparing surgical and non-surgical approaches, including approaches to uncertainty.
- The table will summarize themes which characterize how physicians in surgical versus non-surgical specialties approach uncertainty in clinical judgment and medical decision-making, highlighting similarities and differences.
- More figures and tables may be included as additional findings become apparent.

Overarching Goal

- Construct a narrative review article for submission to a professional journal for publication (approximately 3000 words). If time is more limited than anticipated, a shorter, ‘perspectives’ piece may be written instead.

Annotated Bibliography

Out of the 186 PubMed articles that were found with the search strategies indicated above, 128 had titles and abstracts that were deemed consistent with the purpose and goal of this project. The entirety of these relevant articles are annotated – involving extraction of quotes that may be useful for a narrative review of the topic at hand – in chronological order within the bibliography below. Particularly useful tidbits are highlighted in yellow to indicate their significance, imperative findings are highlighted in red to indicate their necessity, and specific factoids relating to the points in red are highlighted in green. Each entry is followed by a summary written entirely by me.

1. Schoonhoven CB, Scott WR, Flood AB, Forrest WH, Jr. Measuring the complexity and uncertainty of surgery and postsurgical care. *Med Care*. Sep 1980;18(9):893-915. doi:10.1097/00005650-198009000-00003

Background

- Nationwide sample of more than 900 surgeons and post-surgical nurses, who were asked to rate the relative complexity and uncertainty of 71 surgical procedures frequently performed in hospitals.
- Examination of the relative difficulty of treating patients who have undergone different surgical procedures, as reported by surgeons and postsurgical ward nurses, is of interest not only as a means to describe this fascinating arena of work, but also to permit comparisons between these two groups that provide care for these patients.
- A tool that provides a comparative basis for describing surgical patients can be used by health care researchers wishing to understand or change the organizational arrangements within which such work is carried out. Such a tool can be used to promote efficiency of treatment by providing a rational basis for reimbursement of professional work which incorporates the inherent complexity and uncertainty of the work rather than relying primarily on actual costs incurred for treatment.

Methods

- Four sets of questions were developed to measure surgical technology: two to assess the complexity and uncertainty of the operative procedures performed by surgeons and two to assess the complexity and uncertainty of the postoperative procedures performed by nurses on the postsurgical wards. The questions used were based on observations by our research team and informal interviews with personnel in the operating rooms and postsurgical wards of two pilot hospitals. Early versions of questions were reviewed by surgeon and nursing consultants from a range of specialties and the final instruments were pretested using appropriate types of respondents.
- To evaluate the complexity of surgical work, surgeons were asked about the relative number of *steps* in performing a given operation, the complexity of *relationships* among the steps performed, and the extent to which *technical equipment* was employed. Surgical nurses were asked a parallel set of questions about the postsurgical care associated with each operation, except they were asked about the *frequency* of performing care tasks instead of the relationships among them.
- To evaluate the uncertainty of surgical work, surgeons were asked about the frequency with which *contingencies* arise requiring judgment, the number of *alternatives* confronted

requiring choice, and the extent to which the surgeon's work could be *standardized* (reverse scoring). Again, parallel questions were developed for nursing respondents.

- Note that each rater was asked to respond to only one indicator question: that is, he or she was given only one specific criteria of uncertainty or complexity as the basis for sorting among the 71 surgical procedures. For example, one set of surgeon and nurse raters was asked to distinguish among the procedures according to which required the most technical equipment: those requiring the most were to be placed in the envelope labeled 9; those requiring the least in the envelope labeled 1; and those requiring intermediate amounts in the envelopes labeled from 2 to 8.

Results and Discussion

- Examination of Table 3 reveals very high intercorrelations among the indicators of surgical complexity (columns 1-3); correlations range from a low of .68 to a high of .98, suggesting that the three indicator questions were tapping the same underlying dimension. Similarly columns 4-6, lower quadrant, report very high intercorrelations among the three indicators of surgical uncertainty: from a low of .86 to a high of .92. These results reveal a remarkably high amount of convergence in the independent judgments of surgical raters responding to different questions designed to tap the same underlying dimensions.
- It is of interest to note in Table 3 that the indicator question exhibiting the lowest degree of association with the other items was that relating to use of technical equipment. On reflection, this item does appear to be an ambiguous indicator: in some situations the introduction of technical equipment would signify that a set of activities had been rationalized and made routine so that it could be performed with less attention from the surgeons; in other situations, the technical equipment would constitute a more complex tool whose use required heightened attention and skill on the part of the surgeons. Perhaps because of such ambiguity, this item was a poor indicator of surgical uncertainty or complexity.
- Tables 3 and 4 support the conclusion that we can combine the ratings of surgical procedures which were based on different indicator questions into a dimension assessing uncertainty and a dimension assessing complexity without distortion. Indeed, with very little loss of information, we can further combine these two dimensions into a single overall rating of surgical complexity-uncertainty.
- Open heart surgery was judged to exhibit the highest level of complexity-uncertainty among the 71 surgical procedures rated by both surgeons and nurses. This procedure received an average uncertainty-complexity score of 8.11 from surgeons and 8.80 from nurses. At the opposite extreme, the procedure "proctoscopy and sigmoidoscopy without biopsy" was judged to exhibit the lowest level of complexity-uncertainty among those rated, with an average combined score of 1.72 from surgeons and of 1.24 from nurses.

TABLE 5. The Set of 71 Operative Categories and Their Complexity and Uncertainty Means for the Surgeon and Nurse Expert Ratings*

Operation Categories	Surgeons			Nurses			Number of Patients†	Deaths per 1,000†
	Rating of Complexity	Rating of Uncertainty	Complexity Uncertainty Combined	Rating of Complexity	Rating of Uncertainty	Complexity Uncertainty Combined		
1. Open heart surgery for valvular or vascular disease with cardiopulmonary bypass	8.75	7.47	8.11	8.85	8.74	8.80	129	69.8
2. Repair of abdominal aortic aneurysm involving renal vessels or involving reconstruction or revascularization	8.28	7.44	7.86	8.63	8.48	8.56	69	159.4
3. Operations for aneurysms and arteriovenous malformations of the brain (intracranial approach)	8.26	7.30	7.78	8.71	8.57	8.64	1	1,000
4. Operations for intracerebral tumors such as metastases and glioma	7.52	7.02	7.27	8.14	8.23	8.19	6	0
5. Operations for benign extra-axial tumors, e.g., acoustic neuroma, meningioma, pituitary adenoma (intracranial approach)	7.67	6.65	7.16	7.68	7.61	7.65	5	0
6. Repair of ruptured abdominal aortic aneurysm not involving renal vessels or reconstruction or revascularization	7.52	6.80	7.16	8.15	8.06	8.11	19	315.8
7. Total hip replacement	7.60	6.01	6.81	6.74	6.72	6.73	451	35.5
8. Radical hysterectomy (e.g., Wertheim's operation)	6.44	5.95	6.20	6.17	5.61	5.89	10	0
9. Radical dissection of neck	6.09	5.88	5.99	7.81	7.51	7.65	42	0
10. Laminectomy for disc protrusion, with spinal fusion	6.49	5.47	5.98	6.16	6.16	6.16	145	0
11. Operations on ossicles of ear	6.56	5.25	5.91	2.91	3.16	3.04	170	0
12. Pneumonectomy	6.61	5.19	5.90	7.78	7.28	7.53	15	133.3
13. Exploratory laparotomy for exploration and/or control of bleeding	4.94	6.83	5.89	5.90	5.92	5.91	647	94.3
14. Segmental resection of lung	6.29	5.36	5.83	7.56	7.25	7.41	86	11.6

15. Cholecystectomy with common duct exploration	5.95	5.46	5.71	6.11	5.55	5.83	199	35.2
16. Lobectomy of lung	6.26	5.08	5.67	7.78	7.29	7.54	28	35.7
17. Operations for incision and drainage of intracranial abscess, hematoma or hygroma	5.72	5.43	5.58	7.55	7.55	7.55	28	285.7
18. Gastric resection with or without vagotomy	5.46	5.44	5.45	6.52	6.20	6.36	252	15.9
19. Spinal fusion for instability or fracture without laminectomy	5.72	5.24	5.48	5.74	5.74	5.74	172	0
20. Partial or total nephrectomy	5.33	5.25	5.29	7.08	6.91	7.00	94	63.8
21. Repair or plastic operations on urethra	4.57	5.87	5.22	4.66	4.74	4.70	45	22.2
22. Triple arthrodesis and/or ankle fusion	5.45	4.83	5.14	4.16	4.20	4.18	105	0
23. Laminectomy for disc protrusion without spinal fusion	5.68	4.38	5.03	5.33	5.39	5.36	833	1.2
24. Open or closed reduction with internal fixation of fracture of neck of femur	5.24	4.80	5.02	4.93	4.65	4.79	559	75.1
25. Partial colectomy (segmental or hemi resection)	5.10	4.90	5.00	6.21	5.93	6.07	335	95.5
26. Excision of parotid or salivary gland (exclude radical neck)	5.09	4.89	4.99	4.12	4.03	4.08	59	0
27. Small bowel resection	4.80	4.85	4.83	6.39	6.15	6.27	66	136.4
28. Vaginal hysterectomy with or without anterior and/or posterior repair	4.79	4.59	4.69	4.75	4.51	4.63	1,227	0
29. Operations on mastoid antrum	4.86	4.40	4.63	3.12	3.58	3.35	142	0
30. Partial or subtotal thyroidectomy	4.65	4.58	4.62	5.30	5.20	5.25	293	0
31. Plastic repair of external ear	3.85	5.36	4.61	2.46	2.92	2.69	41	0
32. Radical mastectomy	4.89	4.23	4.56	5.73	5.38	5.56	179	11.2
33. Operations for strabismus	4.47	4.63	4.55	2.61	2.65	2.63	422	0
34. Abdominal hysterectomy with or without anterior and/or posterior repair	4.51	4.38	4.49	5.37	4.77	5.07	993	4.0

TABLE 5. Continued.

Operation Categories	Surgeons			Nurses			Number of Patients†	Deaths per 1,000†
	Rating of Complexity	Rating of Uncertainty	Complexity Uncertainty Combined	Rating of Complexity	Rating of Uncertainty	Complexity Uncertainty Combined		
35. Vagotomy and pyloroplasty	4.63	4.27	4.45	5.78	5.32	5.55	110	27.3
36. Splenectomy	4.61	4.18	4.40	6.28	6.23	6.26	105	66.7
37. Sympathectomy or ganglionectomy	4.45	4.33	4.39	3.63	3.48	3.56	175	28.6
38. Repair of recurrent inguinal hernia and incisional hernia	3.74	4.95	4.35	3.42	3.17	3.30	479	10.4
39. Open prostatectomy, suprapublic or perineal	4.45	4.21	4.33	5.68	5.34	5.51	102	58.8
40. Transurethral prostatectomy	4.83	3.78	4.31	5.27	4.72	5.00	640	3.1
41. Augmentation mammoplasty	3.97	4.54	4.26	3.50	3.58	3.54	66	0
42. Operations on nasal septum with or without rhinoplasty	3.96	4.32	4.14	2.76	2.76	2.76	1,034	0
43. Cholecystectomy wihtout common duct exploration	4.24	3.97	4.11	5.30	4.71	5.01	1,566	14.0
44. Cataract extraction	4.74	3.18	3.96	2.82	2.58	2.70	1,880	0.5
45. Operative procedures on fallopian tubes or ovaries (except tubal ligation for sterilization) (not in conjunction with hysterectomy)	3.37	4.50	3.94	3.51	3.41	3.46	218	0
46. Amputation of thigh (below hip) or disarticulation of knee	3.83	3.64	3.74	5.58	5.37	5..48	126	166.7
47. Simple mastectomy with or without axillary node dissection	3.63	3.76	3.70	3.95	3.56	3.76	223	9.0
48. Excision of semilunar cartilage of knee joint	3.82	3.44	3.63	3.33	3.23	3.28	713	0
49. Transurethral resection or fulguration of bladder lesion	3.93	3.25	3.59	4.49	4.36	4.43	216	18.5
50. Arteriography of head and neck	3.79	3.23	3.51	3.46	3.59	3.53	1,393	75.4
51. Orchiopexy	3.11	3.76	3.44	3.05	3.13	3.09	84	0
52. Repair of femoral, umbilical or inguinal hernia (exclude recurrent)	3.03	3.65	3.34	3.24	3.01	3.13	2,618	2.3

53.	Wide excision of lesion of skin, without graft or plastic cosure: local excision of lesion of skin and subcutaneous tissue, excluding external ear and external nose	2.46	4.03	3.25	3.10	3.35	3.23	2,893	6.2
54.	Excision and ligation of varicose veins	3.08	3.42	3.25	3.32	3.25	3.29	629	0
55.	Pyloramyotomy for pyloric stenosis	3.50	2.87	3.19	5.45	5.19	5.32	18	0
56.	Arthrotomy for removal of loose body, biopsy or synovectomy	3.08	2.96	3.02	2.91	2.84	2.88	362	0
57.	Appendectomy	2.83	3.14	2.99	3.19	2.90	3.05	1,704	1.2
58.	Biopsy or partial mastectomy	2.55	3.34	2.95	3.31	3.10	3.21	1,954	0.5
59.	Diagnostic bronchoscopy	2.87	2.44	2.66	1.54	1.79	1.67	1033	68.7
60.	Excision of hydrocele or hematocele	2.42	2.82	2.62	3.25	3.18	3.22	145	0
61.	Amputation or disarticulation of toe or toes	2.42	2.55	2.49	3.16	3.29	3.23	94	53.2
62.	Tonsillectomy with or without adenoidectomy	2.43	2.50	2.47	2.39	2.37	2.38	3,909	0.3
63.	Unilateral or bilateral orchiectomy	2.41	2.51	2.46	3.23	3.25	3.24	102	9.8
64.	Cystostomy	2.31	2.60	2.46	2.76	2.99	2.88	50	100
65.	Anal fistulotomy or fistulectomy	2.16	2.72	2.44	3.04	2.74	2.89	162	0
66.	tubal ligation for sterilization	2.40	2.46	2.43	2.20	2.35	2.28	1,505	0
67.	Hemorhoidectomy	2.01	2.82	2.42	2.82	2.53	2.68	613	0
68.	Biopsy of lymph nodes or excision of muscle, tendon, fascia	1.73	2.67	2.20	2.58	2.60	2.59	371	35
69.	Dilation and curretage of uterus	2.04	2.12	2.08	1.78	1.82	1.80	4,930	0.6
70.	Myringotomy	1.77	1.70	1.74	2.15	2.16	2.16	820	1.2
71.	Proctoscopy and sigmoidoscopy without biopsy	1.84	1.59	1.72	1.20	1.28	1.24	634	44.2
	Mean	4.53	4.37	4.43	4.70	4.59	4.62	716	38.
	Standard Deviation	1.75	1.40	1.54	2.01	1.91	1.95	1,021	61

* Each nurse and surgeon rated the set of operations using a scale of from 1 to 9. The ratings reported here are the mean scores for each procedure, displayed by type of rater (nurse and surgeon), type of question (complexity and uncertainty of procedure), and combined across each question type (complexity-uncertainty) for both surgeons and nurses.

† Based on 50,843 patients receiving one of the set of operative procedures during 1973 in all 17 study hospitals. See Discussion section for further explanation of these data.

- In some cases, operative procedures which are technically rather demanding for surgeons do not appear to pose as demanding a care task for nurses. This appears to be the case, for example, with Operation 31, plastic repair of the external ear. Surgeons gave this type of

a procedure an average combined score of 4.61, indicating a medium level of complexity-uncertainty, while nurses scored this procedure at 2.69, indicating a rather low degree of complexity-uncertainty was posed by the postsurgical care required by this procedure. Alternatively, some procedures, such as Operation 46, amputation of the thigh, appear to pose more severe problems for postsurgical nursing care than they present to the surgeons who perform the operation.

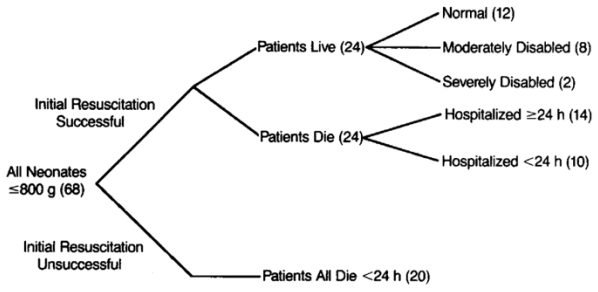
- Without specific knowledge of the factors producing consensus among surgeons, we speculate that 1) the common socialization experience of medical school and hospital internships and residencies and 2) the organizational standardization of work settings across hospitals may each contribute to the observed results. These same factors may also help to account for the equally high levels of consensus observed among nursing raters.
- Complexity and uncertainty are task properties that are expected to exhibit modest positive correlations. However, the extremely high level of association revealed for the ranking of procedures by the two dimensions suggests that we were not successful in operationalizing the analytical distinction between complexity and uncertainty. An inspection of the actual questions asked of raters convinces us that we did not succeed in formulating questions that would clearly emphasize either complexity or uncertainty. Indeed, we now believe that it is not possible to distinguish between these two dimensions of tasks except by explicitly asking the same respondent to rate a given task both in terms of its relative complexity and uncertainty. One needs to consider both dimensions simultaneously in order to separate them analytically.
- We do believe, however, that surgical procedures defined by surgeons as more complex and uncertain (relative to other surgical procedures) are more likely to be performed by board-certified specialists-a higher level of specialization among professionals.
- Nevertheless, inspection of surgical scores together with death rates suggests that the two measures are positively associated. The Pearson r between the surgeons' rating of surgical complexity and crude death rate for that category was .43. This seems to us appropriate: in attempting to assess complexity of work we did not want the surgical ratings simply to represent the surgeons' estimate of the probability of death associated with each surgical procedure; however, we would be surprised if there had been no association between the complexity of the work performed and the probability of a poor outcome.
- It would appear that the complexity scale might usefully be employed to both validate and help to refine pricing decisions in the surgical-care area.

Summary

- Surgeons and nurses exhibit a striking level of agreement regarding the complexity and uncertainty of a standard selection of procedures. There is a general trend towards more complex surgeries being those that are also more uncertain from the perspective of surgeons and nurses, and those that are more complex/uncertain have a higher rate of death as a surgical outcome. Probing this relationship may expose an advantageous avenue to bill patients and their insurance based on the complexity and uncertainty of the procedure they receive.

2. Fischer AF, Stevenson DK. The consequences of uncertainty. An empirical approach to medical decision making in neonatal intensive care. *Jama*. Oct 9 1987;258(14):1929-31. doi:10.1001/jama.258.14.1929

- The treatment of many different conditions affecting individual patients could not possibly be regulated by a few general directives based on the anticipated outcome for the entire group. The ability to predict outcomes for individual, severely disabled infants is limited, even with precise knowledge of the infant's condition at birth.
- As set forth in the Hippocratic tradition, the charge has two parts. The first is to save life; the second is to alleviate suffering. The challenge of this dual charge is to accomplish both goals simultaneously.
- The decision-making process that has been used in the Stanford (Calif) Intensive Care Nursery (ICN) is based on a nonprobabilistic paradigm with a goal of saving every infant's life. In other words, the probability of a "good outcome," or for that matter any particular outcome, has had little or no influence on the initiation of intensive care.
- The first step in this empirical paradigm is the decision to initiate intensive care support for extremely premature neonates at birth (Figure). If support is initiated successfully, there are two possibilities: the patient lives or the patient dies. If the patient lives, there are again two possibilities in this paradigm. Neonates may survive intact or with only moderate disability. Alternatively, the neonate may survive with severe disability. If the patient dies, it may occur shortly after birth or after prolonged hospitalization. This summarizes the consequences of this nonprobabilistic paradigm from the outcome viewpoint.
- However, just because suffering is difficult to conceptualize does not justify assigning it a weight of zero in a decision-making algorithm. To do so results in a dehumanization of those neonates who experience suffering.
- Overall, 24 infants (35%) survived; however, 24 (50%) of 48 infants admitted to the ICN survived. The decision not to initiate intensive care for 20 neonates was empirically based, not probabilistically determined. An attempt to initiate therapy was made in each case, but unresponsiveness of the neonate precluded transfer to the ICN. Thus, if intensive care support was successfully initiated, survival was 50%.



Outcome for 68 infants with birth weights of 800 g or less. Number of infants in each group is noted in parentheses. Two of the surviving infants were unavailable for follow-up.

Outcome Summary*

	Non-ICN Deaths	ICN Deaths	Survivors
No. of infants	20	24	24
Birth weight, g	572 (420-720)	695 (550-800)	688 (530-800)
Gestational age, wk	23 (21-27)	25 (20-29)	26 (23-29)
ICN cost, per $1000	. . .	52.7 (1.4-530.5)	163.2 (8.4-335.9)

*For birth weight, gestational age, and intensive care nursery (ICN) cost, the mean is presented, with the range for the group in parentheses.

- There are two consequences of the decision to initiate intensive care support in a nonprobabilistic paradigm. The first is that a certain amount of suffering among a majority of individuals cannot be avoided. While this is readily rationalized for those infants who survive intact, it is harder to dismiss for those who die after prolonged hospitalization or survive in a severely compromised condition. The second consequence is that there is a substantial economic cost for this loss of life and suffering. The reward for such an approach is that 55% of the survivors have no discernible disabilities, and up to 90% of them may be people who can live long, productive lives in society.
- As we have shown, an empirical blanket application of modern intensive care results in prolonged suffering for a significant number of neonates.
- There are a variety of possible alternative paradigms to the one presented. In a recent article, Rhoden examines a number of strategies for providing care in the face of uncertainty. She describes the paradigm presented above as the "wait until certainty" approach. Intensive care support is continued until death or devastating disability is as near to an absolute certainty as one can possibly determine. While such a strategy maximizes the number of intact survivors, it also promotes prolonged suffering for many who die and increases the survival of severely disabled infants. A second approach is the "statistical prognostic strategy." Here, intensive care is never initiated for neonates with a poor prognosis based on birth weight, gestational age, or some other factors predictive of outcome for the population. Such an approach sacrifices a number of infants who would have responded to treatment with favorable outcomes, despite their unfavorable prognosis.
- Alternatively, one might employ an "individualized prognostic strategy." Here, therapy is initiated for as many patients as possible; but, the appropriate level of support for a given neonate is reexamined at intervals. Both relevant statistical information and the neonate's response to therapy are integrated into the decision-making process. Intensive care is continued for those neonates who "beat the odds" and show improvement despite a grim prognosis.

Summary

- Medical prognostication is one of the most difficult and uncertain skills that physicians are often expected by patients to have. Some of this uncertainty may be thwarted by attempts at reasonably standardizing the care of applicable populations, such as neonates, where the perception of medical futility is less prevalent. Nonetheless, one must consider that neonates can indeed suffer as a result of our newfound medical ability to prolong life in arguably inappropriate manner, which largely nullifies any thwarted uncertainty and affirms the massive magnitude that clinical decision making can have on a family. An attempt to avoid uncertainty as clinicians seeking pure objectivity can lead us astray from our Hippocratic Oath that is potentially more strongly upheld when we embrace the uncertainty that comes with treating each patient as a collection of interrelated, imperfectly clear circumstances.

3. Boreham NC. Modelling medical decision-making under uncertainty. *Br J Educ Psychol*. Jun 1989;59 (Pt 2):187-99. doi:10.1111/j.2044-8279.1989.tb03090.x

Background

- Heuristics are inference procedures which, while not guaranteed to succeed, may nevertheless generate appropriate decisions most of the time. By eliciting them from

expert practitioners, it might be possible to identify a knowledge base which can be taught directly to students.

- The commonest way of representing heuristic knowledge is by productions, rules of the form IF(condition)THEN(action) (Anderson, 1976; Clancey, 1983). A large number of productions may be assembled into complex interlocking chains of inferences. Productions are simple, explicit and learnable, so it would be educationally advantageous if expertise in making drug dose decisions could be expressed in this way.
- Several studies of medical decision-making (e.g., Johnson et al., 1981) suggest that judgment depends on possessing a memory store of "schemata", stereotypical representations of situations experienced previously.

Results

- The results show that a significant part of the expertise of a leading practitioner is readily expressible as productions. While not guaranteed always to succeed, the production system was found to perform effectively, and at a higher level than that reached by most final year students, even after they had been given specific instruction in the use of this drug. Because the productions are simple, explicit and learnable, it follows that medical education could usefully represent decision-making in these terms.
- An alternative strategy would there-fore be to teach directly no more productions than are included in the existing system, but to encourage students through supervised clinical practice to use their knowledge of basic theory and their familiarity with the clinical context to override the production system where necessary. If the latter strategy were followed, then the production system would need to be presented to students not as a complete statement of expertise, but as the first stage of a two-stage model of what happens at each iteration in the dose decision-making procedure. In this model, the first stage uses the production system to reach a provisional decision about the required dose. In the second stage, which follows this immediately, the physician re-examines the patient data for contraindications of the provisional decision, based on an understanding of pharmacokinetic theory and mental models of the patient and clinical setting. In doing so, he or she is aware that the production system is not guaranteed to succeed, and so looks for data which would contra-indicate reliance on it - such as evidence of an unusually rapid increase in serum phenytoin. If such contra-indications are found, the physician modifies the provisional decision but otherwise lets it stand.

Summary

- Medical decision-making can be viewed as a cumulative byproduct of repetitious pattern-recognition where the certainty in an intervention is born out of prior encounters with a clinical problem that has been consistently solved with the same algorithmic actions. One unique avenue where expert clinicians exhibit this skill is during the delicate dosing of drugs such as phenytoin for seizure abortion/prophylaxis where loading and maintenance doses need to be selected so as to stop/prevent seizures without inducing drug toxicity. Physicians may strictly or loosely adhere to the heuristics they have developed when more novel clinical situations present themselves, perhaps partially based on their own comfort with uncertainty when a need may arise to veer away from the treatment algorithm their own repetitious pattern-recognition and problem-solving has devised.

4. Wolff N. Professional uncertainty and physician medical decision-making in a multiple treatment framework. Soc Sci Med. 1989;28(2):99-107. doi:10.1016/0277-9536(89)90136-6

- Physician medical decision-making is modelled as a two-stage sequential process. In Stage I. the patient's illness is diagnosed and the health outcomes for all illness-related restoration options are identified. In Stage 2, an "optimal" restoration option is selected.
- For example, 146 physicians responding to two hypothetical patients ordered over 80 different laboratory tests and procedures, where no single test was ordered by a majority of physicians and less than eight of the tests were ordered by one-third or more of the sample [I 1, p. 2661. In one state. the rate of use of a hemorrhoid treatment was 26 times the rate in another state. Surgical rates have been found to vary up to tenfold for different surgical procedures across market areas.
- The evidence of utilization differences is clear and consistent across studies. What is not so clear is why utilization levels differ across physicians and geographic areas. The easy. but perhaps misleading, explanation for the observed differences is that physicians in high use areas are exploiting their patients' lack of medical knowledge by prescribing unnecessary care which, correspondingly, increases the physician's income. The agency-based explanation suggests that some physicians are abusing their decision-making authority as the patient's agent by "inducing" or "creating" demand for their services beyond the patient's true demand for medical services. Proving demand inducement, however, is a formidable task.
- In recent years, a new, medically sophisticated, argument has surfaced to explain the well-documented variations in medical care utilization. The argument focuses on the lack of definitive scientific evidence and, hence, consensus within medical science [28,29]. Professional uncertainty, as it has been labeled, arises because medicine is often an inexact science.
- Well-defined scientific norms concerning the most appropriate or "optimum" illness diagnosis or treatment assignment do not currently exist because the necessary scientific studies have not been undertaken. Uncertainty in the current state of medical science results in clinical ambiguity; physicians are frequently compelled to make medically correct decisions in the absence of clear, objective standards delimiting their clinical choices regarding illness definition and treatment assignment. Clinical judgment. therefore. becomes the heart of medical decision-making.
- The now-famous 'Wennberg hypothesis' suggests that in response to such uncertainty, physicians develop physician-specific 'styles of practice,' which guide their use of medical resources [30]. Practice styles evolve over time and are influenced by prior medical training, clinical experience and expertise. local standards of acceptable practice, as well as by other more idiosyncratic factors, such as personality attributes, values, and professional convenience.
- Variations in medical care utilization may reflect professional uncertainty and consumer heterogeneity rather than demand inducement from physician income-maximizing behavior.

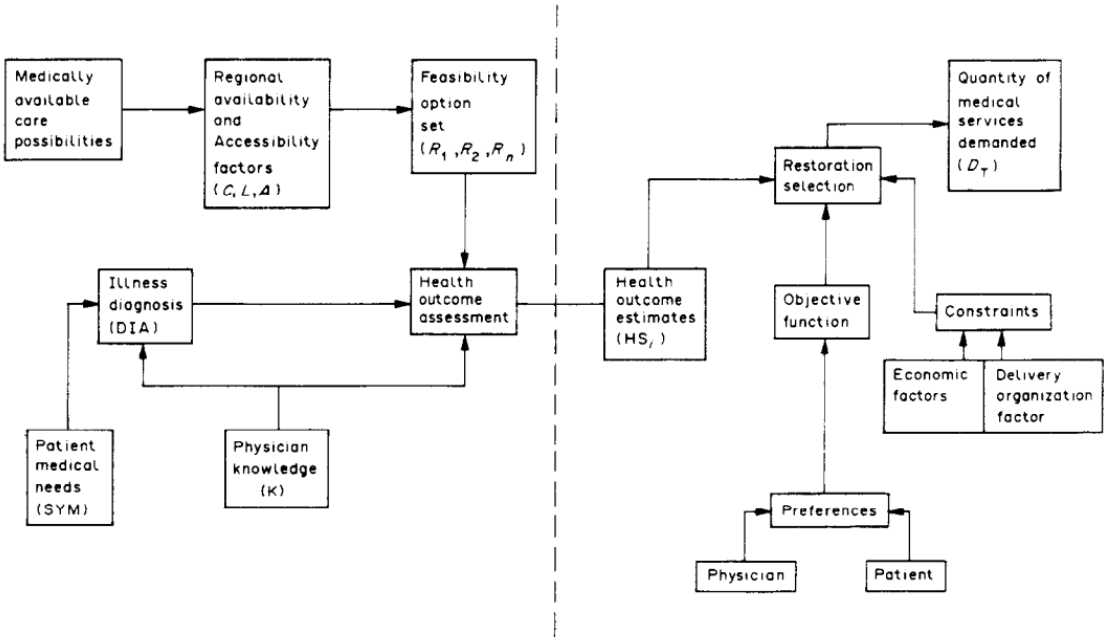


Fig. 1. The two-stage model of physician decision-making. Stage 1: medically technical decision-making. Stage 2: restoration selection decision-making.

- Two types of agency are considered: perfect and nonperfect altruism [33]. In the case of perfect altruism, the physician acts as a medically sophisticated consumer. The physician. in effect, subsumes all the consumer's preferences and constraints and suppresses all physician-specific preferences and constraints. The nonperfect altruist. on the other hand, acts at least partly on her own behalf: the physician may or may not include patient-specific preferences and constraints in her maximization problem.
- After controlling for patient-initiated care, the total quantity demanded (D_T) for a particular type of physician-initiated service has two components: medically necessary services (D*) and medically unnecessary services (D_{IND}) [34, 351. D* refers to services that the patient would have self-selected with the physician's medical judgment; i.e. the selections of a perfect altruist [36]. D_{IND} represents services induced or reduced by the physician-agent. That is. the D IND component captures the deviations from the perfect altruist levels and types of services prescribed by the physician.
- The specific arguments influencing D* depend on the underlying assumption regarding the nature of medicine and clinical practice in Stage 1. For instance, physician characteristics would enter the demand function if physicians were assumed to be heterogeneous producers of medical judgment in Stage 1; i.e. physicians would differ in what they see as the potential menu, as well as in the relative efficacy of various alternative restoration options.
- Given the H-G frontier, the preferred restoration option depends on the consumer-patient's subjective preferences for health relative to all other goods and services.
- Restoration options are indivisible services, ruling out an interior solution. The indivisibility of the restoration options constrains the patient to one of the three corner points on the H-G frontier.

- The H-G frontier in Fig. 3(a) has the same shape as Fig. 2 under the PAPC model. However, the H-G frontier in Fig. 3(b) is markedly different due to the HS! = HS_f finding of physician B in Stage 1. The horizontal segment of the H-G frontier in Fig. 3(b) (labeled 2. 3) indicates that patient X has the same expected health outcome under options 2 and 3, but option 3 costs less than option 2 and so the patient has more other goods and services (Z) with option 3 than with option 2. Again. the altruistic physician-agent selects the option yielding the highest possible utility for the patient that is consistent with a corner solution. For physician A, that implies option 2 [Fig. 3(a)], while for physician B it implies option 3 [Figure 3(b)]. The difference in choice is attributable only to variations in clinical judgment among physicians.
- Consumers may shift the responsibility of making an uncertain. and perhaps erroneous, medical decision to the physician [44]. How the physician responds to the responsibility shifting is captured in her practice signature. Therefore, the physician is a non-neutral perfectly altruistic agent.
- However, there is reason to believe that consumers know bits and pieces of the Stage 2 maximization problem. They know, for instance, that physicians have different practice preferences and, in addition, they know their own preferences and financial information, Patients lack the ability to produce the medical information in Stage 1. They may, however, acquire estimates of Stage 1 medical information by adopting a knowledge acquisition strategy to trace out a first-best approximation of their illness-related H-G frontier. Medical knowledge could be acquired by informal (experience sharing within a social network) or formal (seeking out additional medical opinions) channels. After the patient collects sufficient medical information, he determines his utility maximization restoration solution given his first-best approximation of the H-G frontier.
- The three physicians-one patient illustrations show that there are a host of contradictory subjective and objective patient and physician factors associated with each utility maximizing restoration decision And without perfect information on the medically correct diagnosis and health outcomes for each option and the patient's preferences and financial constraints, it is difficult to determine whether or not the nonperfect altruistic agent made a patient-correct medical decision. Decision inconsistency in Stage 2 is minimized, however, if patients align themselves with physicians who have similar restoration preferences.
- For instance, what factors influence the physician's clinical judgment production function? How stable is the function over time? How much variability is there in medical opinions across physicians (speciality-types) and what are the estimated costs associated with medical opinion heterogeneity? How passive is the "typical" patient? Is consumer passivity the result of asymmetric information (medical ignorance on behalf of the patient) or a consequence of the patient's riskpreferences?

Summary

- The enigmatic process of medical decision making can be deconstructed into the two stages of (1) technical theorizing and (2) restoration selection, but is simultaneously characterized by a seemingly irreducible complexity. This deceptively simple "two step" algorithm is influenced by almost limitless factors including what is medically available/feasible, patient preferences, and physician biases. The Wennberg Hypothesis argues that the uncertainty inherent to medicine – such that nothing can ever be trusted as completely reliable or completely unreliable – may be a major cause of physicians

adopting subjective "styles" of practice that function as reliable decision-making "safe zones."

5. Bodner EE, Browning GG, Chalmers FT, Chalmers TC. Can meta-analysis help uncertainty in surgery for otitis media in children. J Laryngol Otol. Oct 1991;105(10):812-9. doi:10.1017/s0022215100117426

- In addition, a more fundamental question that remains unanswered is whether OM is a condition that warrants intervention at all. Simply because a condition presents itself does not necessarily mean that it must be managed, particularly when natural resolution is common. Thus the clinical situation might be likened to cholecystectomy for silent gallstones. Surgery is clearly effective in eliminating the pathology, but doing so may create medical and surgical complications more common and more severe than those that would occur if the disease were left untreated.
- Scientifically Meta-Analysis (M-A) might be criticized because it can only combine studies that have been published, missing out on the often not inconsiderable number of studies that were not published for various reasons. This might introduce bias because one of the reasons for not publishing is that the results do not show what the authors would have liked to have proved, for example that surgery is of benefit.
- In designing a study there are two basic issues that could be addressed: (i) is intervention better than no intervention; and (ii) is intervention A better than intervention B. It is unfortunate that only two of the 12 studies addressed the first issue, that is whether surgery is of benefit at all. It is also disappointing that the strategies of how patients were managed after initial surgical intervention was clearly stated in only one third of the studies. Many studies were particularly poor both in listing reasons why patients withdrew from the trial and in thereafter performing a variety of comparative statistical analyses in this group of subjects.
- It should be possible to blind the recorders both to the outcome, whether this be the presence of the condition, the hearing thresholds, or the presence of complications, and to whether the child had surgical intervention, and if so, whether it included adenoidectomy or myringotomy. Similarly, observers must be blinded to the ongoing results of a trial to minimize bias in outcome assessment, particularly when blinding to therapy, as with tubes, is not possible. Only one (8 per cent) of the studies reported blinding throughout with this degree of rigour.
- The unresolved debate about the most efficacious management of OME is tragic given the magnitude of resources consumed and the number of children risking inappropriate or ineffective care with significant morbidity, including possible developmental consequences. An important role exists for general practitioners, community health officers and paediatricians collaborating in clinical trials with otolaryngologists to contribute to the all too limited pool of high quality studies. The natural history of OME, its sequelae when treated, and the efficacy of the controversial therapies for this disease need further attention.

Summary

- The study uses the surgical management of otitis media with effusion as an example of the hidden lack of clarity of both randomized controlled trials and meta-analyses given the multitude of considerations affecting their construction and performance. At a superficial level, the data presented by a randomized controlled trial or meta-analysis

may appear to be management-guiding; however, the design choices of the study can indubitably obscure the certainty of the results. Meta-analyses, considered the most authoritative research that can be realistically performed, is even subject to a hidden uncertainty given the potential for unpublished, null-hypothesis-accepting data to exist. The certainty of research results that are to guide clinical management are only as sound as the methods through which those results were obtained, and at the time of this reference being published it appears that human fallibility was the greatest contributor to uncertainty in how to clinically manage otitis media with effusion.

6. Holman WL, Kirklin JK, Pacifico AD. Quantitation of mapping uncertainty in Wolff-Parkinson-White syndrome. Implications for anatomic characterization and surgical division of accessory atrioventricular connections. J Thorac Cardiovasc Surg. Oct 1992;104(4):1045-52.

- The uncertainty of electrophysiologic mapping can be quantitated, and this error should be considered when making inferences regarding the anatomy of accessory pathways based on electrophysiologic data. A knowledge of the uncertainty inherent in the localization of accessory atrioventricular connections by electrophysiologic mapping can be used to plan borders of surgical dissection that will account for this uncertainty at a 95 % confidence level.
- Analysis of the electrophysiologic data led to the conclusion that accessory pathways in WPW syndrome may be either thin bridges of muscle, broad bands of muscle, or arborizing networks of muscle. It was further deduced from electrophysiologic data that aberrant AV pathways may traverse the AV groove anywhere from the endocardium to the epicardium and that they may pass obliquely across the AV groove.
- The uncertainty of localizing an accessory pathway at the time of pathway division led surgeons to empirically adopt wide margins of dissection. This policy has led to essentially 100% success in operations for WPW syndrome. It is possible, however, that a more quantitative knowledge of mapping error would allow surgeons to use somewhat narrower margins of dissection without sacrificing this rate of success.
- Empirically, surgeons have found that "wide" margins of dissection ensure a successful result. There are no data, however, to help surgeons quantitatively decide exactly how wide a particular dissection should be. The standard anatomically based dissections for WPW syndrome include the entire region (e.g., right free wall) that contains an accessory pathway. Disagreements, however, over regional boundaries describing the anatomy relevant to WPW syndrome and the fact that accessory pathways may be located eccentrically within any given anatomic region make the method somewhat imprecise. This imprecision is compensated for by the large region of dissection, so that the results of operations are excellent.

Summary

- Measurement error is an unavoidable source of uncertainty in research and, therefore, in evidence-based clinical practice. An example of this is in the surgical resection of Wolff-Parkinson-White Syndrome accessory atrioventricular connections where, at the time of reference publication, the *status quo* was to perform wide margins of accessory pathway dissection to ensure removal of this conductive atrioventricular tissue that occupies an interindividually variable and therefore uncertain distribution. This identifies an important surgical concept: when uncertain about the size, depth, and distribution of a pathological entity, it may be advantageous to simply resect more to “get all of it.” Or,

under circumstances where "resecting more" is judged as more dangerous than doing nothing, the patient is left to suffer with their pathological entity remaining *in situ* because of their surgeon's uncertainty. It goes without saying that developing predictive models and testing strategies to plan the span of a surgical dissection/resection will reduce operative uncertainty and put more patients on the operating table to receive the definitive management they desire and deserve.

7. Purtilo RB, O'Donohue WJ, Jr. Resources for medical decision-making in situations of high uncertainty. Nebr Med J. Oct 1992;77(10):277-80.

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- There is a perfectionistic pressure placed upon physicians by patients. A doctor who cannot solve a problem may be said to be a bad doctor, even if that problem is not solvable even by the best doctor. And, as has been described elsewhere herein, even if a confident physician makes an exceedingly *certain* diagnostic or therapeutic choice, she simply enters a game of probability. Will this patient be the "1" of the "1 in 10" number needed to treat? Or will this patient be the "1" of the "1 in 20" number needed to harm? Our sometimes seemingly dichotomous responsibility to uphold the principles of beneficence and nonmaleficence may arguably only be rectified by informed consent. This, alongside the ever-protective nature of compassion ("good bedside manner"), appears to be the highway toward patient satisfaction even if probabilistic and unintentional medical/surgical failure happens along the way.

8. Redeker NS. The relationship between uncertainty and coping after coronary bypass surgery. West J Nurs Res. Feb 1992;14(1):48-61; discussion 61-8. doi:10.1177/019394599201400104

- Uncertainty appears to be a stressor that may influence coping and adaptation throughout recovery from CABS. In the days following surgery, persons confront uncertainty about treatment and the potential for complications. Prior to their discharge from the hospital, persons experience uncertainty related to their ability to perform self-care while at home. Later, they experience uncertainty about the recurrence of signs and symptoms and their ability to return to former roles.

Summary

- The sphere of uncertainty's influence evidently extends beyond those making the medical decisions and shapes the experience of those being affected by the medical decision-making. This appears to carry a potentially greater weight during surgical interventions since to undergo surgery means to become completely vulnerable under the hands and minds of surgeons that one often does not know as well as, say, their primary care physician. We may appreciate the uncertainty within the technicalities of a particular surgery, or even a medical intervention, but imagine how that patient feels when agreeing to subject themselves to something that may be beneficial, may be equivocal, or may be harmful.

9. Wallis LA. Hormone replacement therapy: decision making in an age of uncertainty. J Am Med Womens Assoc (1972). Nov-Dec 1992;47(6):225-9.

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- This paper once again highlights the source of clinical uncertainty being the uncertainty of data. There may be associations within the literature of, say, breast cancer incidence and estrogen replacement therapy; however, what does a physician do when a real risk is paired with a real benefit? It almost seems like a physician is presented with two options in these scenarios: (1) recommend one choice or another in a dichotomous decision or (2) recommend neither choice and simply offer all of the options, risks, and benefits to the patient. However, clinical practice would suggest that patients can feel unsatisfied with option (2). If given option (2), patients may ask the classic and occasionally feared question, "what would you do if I was your mother/daughter?" I think we fear this question because we know that the decision is almost too uncertain to make. For some reason, however, it seems like we are simultaneously too afraid to articulate that point. Are we stuck between the rock of uncertainty and the hard point of wanting to uphold the idealistic societal view of medicine?

10. Anderson JD, Jay SJ, Weng HC, Anderson MM. Studying the effect of clinical uncertainty on physicians' decision-making using ILIAD. Medinfo. 1995;8 Pt 2:869-72.

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- From the age that we develop an ego, confidence wages an unending war against insecurity. While we engage in social interactions, take examinations, and make professional decisions, this war wages on. One might liken this war to the same one that occurs when physicians make uncertain clinical decisions. There may be a patient presenting with features consistent with many different diagnoses, or perhaps no known diagnoses whatsoever. Or, there may be a patient that could benefit from many different therapies with various potential adverse effects. How might a clinician rectify these competing options? Confidence evidently serves a role in making medical decisions that are beneficial to patients. This seems pretty logical, right? But how is confidence derived? Some may have the ability to conjure it out of thin air (we all know a guy), though not all of us have that ability. It seems reasonable to contend that confidence comes from leaning into what we know. Let's say a patient presents with "XYZ" that we are unsure of how to diagnose or manage. There may be a guideline recommending diagnosis/management of "Y," but not "XYZ" specifically. If we lean into what we confidently know, the paper presented here would suggest that we make objectively better clinical decisions by, say, treating "XYZ" with the "Y" guideline (perhaps with some reasonable adjustments) rather than making up our own "ABC" strategy.

11. White RE, Frasure-Smith N. Uncertainty and psychologic stress after coronary angioplasty and coronary bypass surgery. Heart Lung. Jan-Feb 1995;24(1):19-27. doi:10.1016/s0147-9563(05)80091-3

- Results showed that at both time periods angioplasty patients were more uncertain than bypass patients ($p < 0.05$), and that regardless of procedure, patients reported fewer symptoms of psychologic stress at 3 months than at 1 month ($p < 0.01$). Patients with

high social support had less uncertainty and psychologic stress than patients with low support ($p < 0.05$). Analysis of the social support and treatment group interaction showed that angioplasty patients with low perceived social support had significantly more psychologic stress than angioplasty patients with high support ($p < 0.01$). Analysis of the correlations between uncertainty and psychologic stress in the angioplasty and bypass grafting procedure groups after control for social support revealed that social support was a significant mediator of the relationship between uncertainty and stress only among patients undergoing percutaneous transluminal coronary angioplasty. There was little evidence of a mediating role for social support in the coronary artery bypass grafting group.

Summary

- Mishel's Model of Uncertainty in Illness asserts that stress arises when uncertainty persists. The authors of this paper go on to discuss that the reason for angioplasty patients having higher levels of uncertainty than bypass grafting patients is because of a reported 30% 6-month risk of coronary vessel restenosis in the former group. This is an interesting finding because one might presume bypass grafting patients would be more uncertain given that their procedure is a far more invasive surgery. However, the more definitive nature of bypass grafting must counterbalance the intensity of the surgery, perhaps making it less uncertain in the minds of patients. An interesting question poses itself: how often are we doing patients harm by engaging in routine informed consent, discussing all the important risks and benefits? For the sake of argument, let's say we are giving 100% of our angioplasty patients heightened uncertainty about the risk of restenosis even though 70% of them will be just fine. Is that 6-months of waking up every day not knowing if you are going to have another heart attack really worth it? Obviously, to not disclose a known risk of a procedure being performed for a given benefit is unbecoming of a virtuous physician. However, I feel that what I have questioned above is still an interesting thought experiment. I was also impressed by the self-evident nature of social support reducing uncertainty and psychological stress for patients. Would the same be true for the uncertainty and psychological stress encountered by physicians when they make uncertain decisions? Is the hospitalist who has a loving spouse at home a better, more confident, less uncertain doctor? Does the surgeon with supportive parents, in-laws, children operate more decisively and with better outcomes?

12. Mazur DJ, Merz JF. How older patients' treatment preferences are influenced by disclosures about therapeutic uncertainty: surgery versus expectant management for localized prostate cancer. J Am Geriatr Soc. Aug 1996;44(8):934-7. doi:10.1111/j.1532-5415.1996.tb01863.x

- Our results suggest that older patients are more likely to report a preference for expectant management (OR = 1.07). Our results show that preferences reflect patients' experiences with physical problems associated with disease and that these experiences need to be explored and considered by patients and their providers when making treatment decisions.
- Undoubtedly, there is comfort in aggressively treating a cancer, which may be seen as a physical intrusion in the body that needs to be excised. There may well be the psychological distress of living with a cancer, even if the best medical advice suggests it will not grow quickly and threaten the patient's life. […] Future research must focus on

patient perspectives on surgery and cancer and whether it is realistic for patients to want cancer removal so badly even in the face of no increased survival benefits. Qualitative study of patient decision-making is needed to shed light on the beliefs people bring to bear on their choices, on their understanding of the complex medical situations facing them, and on their values and the reasons for different choices. Patients in our study could have been realizing that expectant management as an approach only delays intervention until a later time, and patients may want to take a more proactive approach against the cancer for psychological benefits, even when there are no gains of average life expectancy and despite surgical sequelae such as urinary incontinence and impotence.

Summary

- An idea not specifically discussed in this article, but nevertheless impacted by its finding, is the supposition that we can thwart clinical uncertainty by bolstering the quality of our informed consent conversations with patients. We may be uncertain about whether to start a certain medication or perform a certain surgery, and, in those cases, we can clearly provide those options with their risks/benefits for a competent patient to decide their own course of action. However, the paper presented here may suggest that physicians do this for a selfish sense of security because they often cannot be sure that a patient deeply understands the medical information being communicated to them. Absolutely, one can use something like the "teach-back method," but the uncertainty is always inescapable. When it may be thought to be abolished, it appears elsewhere.

13. Mort EA. Clinical decision-making in the face of scientific uncertainty: hormone replacement therapy as an example. J Fam Pract. Feb 1996;42(2):147-51.

- There is widespread variation in the prescribing patterns of postmenopausal hormone replacement therapy. While some degree of variation is expected, the systematic variation according to geographic region, physician gender, and medical specialty raises questions about how clinical decisions are made. This paper explores the determinants of these practice patterns, specifically the contribution of patients' preferences, scientific uncertainty, and physicians' recommendations. A role for collaborative decision-making is described and the use of decision-support tools is discussed.
- Historically, physicians' recommendations have been important determinants of treatment decisions.[13] Obviously, physicians' recommendations should be based, to the extent possible, on scientific evidence. It is believed that physicians' recommendations are sensitive to the social and economic environment.[14] It is also believed that physicians' recommendations are sensitive to the level of certainty about the best course of action for a particular clinical situation. When the data are inconsistent and controversial, physicians' thresholds to recommend therapy vary.[15] Consider the quality of data on the efficacy of long-term HRT on reducing the risk of heart disease. Although the observational data point toward a benefit in reducing the risk of heart disease, professionals have mixed reactions.[16] The data about the relationship between long-term estrogen and breast cancer are even more controversial.[5] In the setting of scientific uncertainty about the risks and benefits of HRT, physicians' recommendations are likely to vary.[15] Physician uncertainty reaches beyond interpreting the data on the risks and benefits of therapy. Providers also express uncertainty about how to screen candidates for therapy and how to monitor patients once hormones have been prescribed.[17] Physicians also have differrent attitudes about prescribing a potentially harmful medication to

healthy women for prevention of feature disease. When asked, "Do you consider that even a small increase in the risk of cancer, either of the breast or uterus, would preclude the use of unopposed oestrogens, regardless of any benefit to cardiovascular disease?" British physicians were divided.[18] Uncertainty about whether the risks outweigh the benefits, from the physicians' perspective, also undoubtedly influences physicians' recommendations. Unless they inquire directly, physicians may also be uncertain about what matters to their patients. The attitudes and preferences of physicians and perimenopausal women regarding health outcomes associated with estrogen replacement are known to differ.[11] This certainly underscores the need to develop practical methods to help elicit patients' attitudes and preferences about their different health states.[19] The literature increasingly suggests that patients are better suited than physicians to judge the value of health states, particularly when quality-of-life issues are concerned.[20] Moreover, it has been suggested that outcomes would be improved if treatment decisions matched patients' values.[21]

- There is also much to be learned about decision-making styles of physicians and about how physicians and patients should be paired for the best results. From the physicians' perspective, there is also much to be learned about bow to collaborate. Merely giving information may not be enough. It may be inappropriate to put the decision entirely in the patient's hands without guidance. Interpreting information, supporting the patient, and even making the final decision when asked to do so are all consistent with the idea of collaborative decision-making. The physician-patient dialogue can be complex and variable.
- There is also much to be learned about the predictive value of patient preferences. When examined at 3 years after their surgery, breast cancer patients who were treated by surgeons who offered a choice between breast-conserving surgery and mastectomy showed less psychiatric morbidity than women whose surgeons favored mastectomy.
- While preliminary research looks promising and the face validity of patient empowerment and collaborative decision-making is high, there are potential risks to the patient, such as anxiety during the decision-making process or regret when an adverse outcome follows a decision that the patient heavily influenced.
- The shared decision-making program (SDP) uses interactive laser disk technology to combine didactic narrative, patient testimonials, and tailored estimates of risk and benefit. The didactic information provides patients with general facts about their condition, and patient testimonials allow viewers to hear from patients who have made different choices and experienced diferent outcomes. The tailored presentations of risk and benefit allow the viewer to receive personalized information.

Summary

- Several interesting ideas are proposed by this article. Firstly, the idea that physician uncertainty stems from data uncertainty is revisited with a persistent lack of solution. Secondly, the assertion is made that there is evidence that some patients prefer to be given all of the options available to them – especially when meeting with a surgeon and that surgeon gives them management options that are nonsurgical – but there are other patients that may carry greater guilt if making a medical decision when only given all of their options without a formal recommendation from their physician (who may be equivocal about the next steps). I find this fascinating because, as physicians, I think we find that aforementioned selfish security in offering all of the options but refusing to offer

our opinion when our clinical judgment tells us that all of the options "are as broad as they are wide." We hope that if our patient makes their decision for themselves, we will be "safe" because, in a clinically equivocal situation, we provided our patient with their options and *they* made their own decision. The burden of responsibility is relinquished from our minds but, unfortunately, it is then placed onto the spirit of our patient. By trying to avoid our own guilt – and lawsuits – we inadvertently open the windows of our glass house to throw stones at that of our patient. Finally, and as an ancillary point, there may be benefit to leaning back onto a concrete entity to provide some certainty within the uncertainty, such as the Shared Decision-Making Program that this paper discusses. The authors astutely recognize that greater certainty for many patients will not come from digestion of data, but from appreciation of the various stories from patients that have embarked on journeys similar to theirs.

14. Moore S, Katz B. Surgical residents' scores on measures of Machiavellianism and physicians' uncertainty. Psychol Rep. Apr 1997;80(2):456-8. doi:10.2466/pr0.1997.80.2.456

- Klein (3) found that residents in psychiatry scored significantly higher on the Mach V Scale than did residents in internal medicine. Although surgery is different from psychiatry, both provide face-to-face contact with patients, opportunities for manipulation, and professional uncertainties in decision-making within the clinical setting. Given these findings, one would expect that people employed in professions which sanction influence on others should have personalities consistent with that endeavor and be more tolerant of uncertainty. A group of this description is surgical residents who are professionally involved in the control of others and man-aging professional clinical uncertainties.
- The researchers expected those high Mach scorers would be more certain on clinical decision-making. The correlation between scores on the two measures was .21 ($p>.05$).
- The findings suggested that general uncertainly, uncertainty about sharing information with patients, fear of colleagues, and uncertainties in diagnosis is common among the residents in surgery regardless of age, area of specialty, or year of residency.

Summary

- Despite the authors seeming to be surprised by these findings, I am not. It appears assumptive to predict a negative correlation between manipulative personality traits and clinical uncertainties. The argument attempted to be made in this article, I think, is that having a more manipulative personality can maybe be explained by having lower levels of social uncertainty. One might call this having higher levels of confidence or bravery? Then, the authors contend that lower levels of social uncertainty must also mean lower levels of clinical uncertainty. The leap in this logic is reflected by the statistically insignificant data that was presented. Nonetheless, this article sparked a new idea: surely, there must be different kinds of uncertainty. A single physician can be affected by multiple uncertainties at any one time. Perhaps they are uncertain about whether their patient likes them, uncertain about whether their own articulations are making sense to the patient, uncertain about their lower level of experience compared to their colleagues, uncertain about whether they actually like practicing in the setting they are working in, uncertain about their clinical knowledge surrounding the patient's presentation, uncertain about which management option might be best for their patient. Any one of these uncertainties, or all of them, can be sensed by the patient at any time and will likely be

heuristically assessed as a lack of confidence held by the physician. Even if the physician is uncertain about something as noncontributory as their home-life, you can imagine how some less-than-stoic individuals may allow their less-than-confident attitude to creep into their working persona. As a result, the physician-patient relationship, founded upon trust and confidence, crumbles.

15. Staples P, Jeffrey J. Quality of life, hope, and uncertainty of cardiac patients and their spouses before coronary artery bypass surgery. Can J Cardiovasc Nurs. 1997;8(1):7-16.

- The relationships among quality of life, uncertainty, and hope for 21 patients and their spouses before bypass surgery were examined in this study. The instruments used included: Ferrans' and Powers' Quality of Life Index, Mishel's Uncertainty in Illness Scale, and the Herth Hope Index. Greater uncertainty was associated with lower quality of life and hope scores for patients and spouses. Spouses were more uncertain about the patients' cardiac disease and had higher quality of life scores than the patients. Female patients had more uncertainty about their disease. Patients with poor left ventricle function had lower quality of life. Implications for practice include the need to incorporate the spouse into the plan of care. Also, the presence of uncertainty in the waiting period for surgery for both patients and their spouses, and its negative association with quality of life, reinforces the importance of pre-admission intervention with this population.

Summary

- While focusing on the uncertainty that leads up to a medical decision being finalized in the minds of a physician and patient is important, the uncertainty that primarily plagues patients following that decision also deserves emphasis. The power of patients having storing social networks when encountering medical uncertainty has already been underscored, but presents an interesting problem here. We have already discussed that one more reliable than not method of ameliorating clinical uncertainty is educating the patient and, utilizing a robust informed consent procedure potentially even including thorough teach-back, getting them as involved in their own medical care as they want to be. How does that strategy change when a patient has their spouse there with them? What about when their spouse wants to be more involved in the medical decision making than the patient does? What if the patient and spouse disagree about the best course of action for the patient? Even if we perfectly execute our robust informed consent procedure with perfect understanding and buy-in from our patient for a certain surgical or medical intervention, the disagreement of their spouse may theoretically induce so much disagreement that any quality-of-life improvement we could offer our patient is obfuscated.

16. Pierce SF. Neonatal intensive care: decision making in the face of prognostic uncertainty. Nurs Clin North Am. Jun 1998;33(2):287-97.

- Addressing the infant's well-being is much more than a mere technical assessment of the likelihood of benefit or improvement through the application of anyone specific intervention or treatment. It is a total assessment of the nature of the infant's human experience. Is it, in balance, an experience of well-being? This assessment of well-being occurs with infants who can be grouped into three separate categories: (1) infants in whom aggressive care would probably be futile; (2) infants in whom aggressive care

would probably result in clear benefit to their overall well-being, and (3) infants in whom the effect of aggressive care is mostly uncertain. Clearly, the assessment of well-being is most difficult in the last category, in instances of uncertainty and novelty, such as the opening situation with the conjoined twins.

- This use of scientific data, the facts, although integral to decision making, is not singularly adequate to make individual decisions about infants. Decision making, particularly ethical decision making, is a holistic process that involves not only reasoning based on scientific facts and norms but also consideration of the particularistic, contextual, and individual case affected by one's ideals, values, virtues, self-view, and world view." Nonetheless, as a first step, individual infants can be placed in one of the three categories based primarily on the accumulated scientific evidence for physiologically beneficient outcomes.
- In these cases of probable futility, in which the "prognosis for meaningful life is extremely poor or hopeless," as early as 1973, Duff and Campbell- endorsed the legitimacy of concluding to withhold aggressive treatment. In these cases of probable futility, which is recognized early in the infant's course of treatment (within the first 24 hours), it seems most helpful if the health team renders that as the consensus opinion. That is, rather than engage the parents in "what do you want us to do," it is more appropriate to recommend that aggressive interventions not be pursued and that care focus on providing comfort and dignity for the infant in the time the child does have.
- Hess' ethic of engagement stands in contrast both to the ethic of compliance (parents doing what health professionals recommend and prescribe) and to its opposite, an ethic of abdication (health professionals standing aside and abiding by whatever decision parents make). Basically, engagement is a thorough, philosophical description of true joint decision making. It differs from a "good discussion" in that all parties in the engagement are granted equal status and assumed to have equal decision-making capacity, although using differing data sets: health professionals principally use science, clients principally use knowledge of the self. Thus, the ethic of engagement recognizes the moral agency of all involved parties and builds on the inherent superior medical knowledge of the health professional while it defers to competent parents' autonomy, insight, and ultimate moral agency.
- The idea of an ethic of engagement was first put forth by Gaddow and represents a turn away from universalism. Universalism is a philosophical approach that takes the stance of detached objectivity – a right and wrong that applies to everyone, regardless of age, gender, ethnicity, or other personal characteristics or circumstances. Rather than the universal, one right answer, engagement suggests that the knowledge of the right thing to do is created in the narrative that evolves from engaging in an open dialogue. Decision options are cocreated by client or parent and the nurse. These decisions are particular and contextual to the individual case and nongeneralizable to even similar other cases. However, this cocreation of decision options is not a turn to relativism (in which no ethical theories or principles bear any weight and each moral judge renders a best decision), rather, it is the effort to work jointly to evolve how this unique case relates to what ethical theories and principles have long defined as "good" and "right" actions.
- Thus stands the model of engagement. The health professional does not simply "recommend" what to do next, because the health professional knows only the scientific, objective data and not the unique, particular views and capabilities of this infant and his

or her family. Nor is the family left to choose from myriad options that they may comprehend minimally and that may or may not take into consideration their own unique view of the world and their own sense of their infant, themselves, and their material, emotional, and spiritual resources. Rather, engagement is a holistic process of assessment and decision making. Proceeding within an ethic of engagement involves bringing all data, views, and resources of all moral agents to bear on the ongoing decisions that must be made.

- In order to make treatment decisions, the assessment of actual and potential pain and suffering versus actual and potential pleasure and satisfaction for the infant must be faced by both parents and health professionals.
- The nurse must report the data and perceptions clearly to the parents and listen carefully to the parents' data and perceptions. Together, they can come to a consensus about what the experience appears to be like for the infant and a guarded judgment of what the future may hold for the child. In this exchange, the reasons behind recommendations must be rendered transparent to parents so that they have the opportunity to question the validity of assumptions and conclusions. This [is the] idea of transparency in care decisions (i.e., "sharing decision processes out loud in a language understandable to the parents."

Summary

- It is easy to agree with the contention that under circumstances where a clear path for potential therapeutic benefit or therapeutic futility lies, a physician should firmly recommend action or inaction as being in the best interest of the patient. Of course, this may be at-odds with the desires of legal decision-makers, but such is how a physician upholds their moral and ethical obligation. However, circumstances change when the therapeutic outcome (benefit or futility) is uncertain. Hess' Ethic of Engagement argues that these scenarios are adept for utilization of deep engagement between the physician (whose thinking in this scenario is likely, but arguably, driven primarily by science) and the patient/family (whose thinking in this scenario is driven primarily by their knowledge of self). Ideally, this strategy appears to promote the development of a solution to the problematic uncertainty by having a joint resolution (action or inaction) fall out of the "engagement" conversation. However, I assert that it is quite rare for interactions such as these to have such a solution magically fall out of conversation. These conversations cannot reasonably and appropriately be had without the physician (1) describing the perceived state of health of the patient and (2) providing options about what can be done for the patient including risks/benefits/possible results of action/possible results of inaction. At this point, the possible things that will likely happen are (a) the physician will recommend the option thought to be best by the healthcare team, (b) the physician will recommend no option and ask the patient/family what they think, or (c) the patient/family will interject with an option that they are adamant they want or do not want. Inevitably, a decision is rather binary. You can either choose something or not. Unfortunately, a therapeutic choice or lack thereof is not a Schrodinger's Cat that can exist as two different realities simultaneously for the patient. This article highlights that one of the most difficult and uncertain things for physicians to do, and something that often receives no attention in medical training because of the impossibility of the task (other than in very select circumstances where the natural history of a disease is very well studied and, frankly, often ends in either complete recovery or fatality), is to confidently prognosticate.

17. Calvin RL, Lane PL. Perioperative uncertainty and state anxiety of orthopaedic surgical patients. Orthop Nurs. Nov-Dec 1999;18(6):61-6.

Summary

- Nothing from this article stands out as being particularly useful for the goals of this Humanities Distinction Track project outside of what has already been mentioned elsewhere.

18. Fernandes HM, Gregson B, Siddique S, Mendelow AD. Surgery in intracerebral hemorrhage. The uncertainty continues. Stroke. Oct 2000;31(10):2511-6. doi:10.1161/01.str.31.10.2511

- BACKGROUND AND PURPOSE: Primary intracerebral hemorrhage (ICH) accounts for 10% to 20% of stroke but carries the highest rates of mortality and morbidity of all stroke subtypes. Current treatment, however, is varied and haphazard. The most recent Cochrane systematic review refers to 4 prospective, randomized controlled trials. We present a further meta-analysis to include 3 new trials. In addition, we review the trials of Chen et al and McKissock et al and discuss aspects of their quality that, we believe, prevent their inclusion in modern day meta-analysis. METHODS: Literature databases and articles were searched from 1966 to October 1999. Using the end points of death and dependency, the results of the 7 identified randomized trials were expressed as odds ratios. All available data were then analyzed with meta-analysis techniques. Analysis of relevant subsets of trials was also carried out. RESULTS: Meta-analysis of all 7 trials shows a trend toward a higher chance of death and dependency after surgery (OR 1.20; 95% CI 0.83 to 1.74). Meta-analysis was also carried out after exclusion of the Chen and McKissock trials for reasons discussed in the text. This meta-analysis suggests a benefit from surgery, with a reduction in the chances of death and dependency after surgical treatment by a factor of 0.63 (OR 0.63; 95% CI 0.35 to 1.14). CONCLUSIONS: When meta-analysis is restricted to modern-day, post-CT, well-constructed, balanced trials, a trend for surgery to reduce the chances of death and dependency is found. Perhaps, then, in the modern era of CT, good neuroanesthesia, intensive care, and the operating microscope, surgery has a role in the treatment of supratentorial intracerebral hemorrhage. The results of a large, multicenter, randomized controlled trial are urgently needed, and the ongoing International Surgical Trial of Intracerebral Hemorrhage should fulfill this objective.

Summary

- As a meta-analysis, this paper points out that even when we utilize some of the most advanced, robust, and reliable methodological and statistical research tools we have available, relatively decisive results still produce a lack of complete certainty. The paper appropriately identifies the only way to acquire a modicum of greater certainty is through a cohesive, large, multicenter, randomized controlled trial. Emphases should be placed on the word “large,” since the best way to technically increase the power of any study and decrease the uncertainty maximally is to have the largest number of patients possible. While uncertainty approaches zero, number of study participants approaches infinity.

19. Robinson A, Thomson RG. The potential use of decision analysis to support shared decision making in the face of uncertainty: the example of atrial fibrillation and warfarin anticoagulation. Qual Health Care. Dec 2000;9(4):238-44. doi:10.1136/qhc.9.4.238

- The quality of patient care is dependent upon the quality of the multitude of decisions that are made daily in clinical practice. Increasingly, modern health care is seeking to pursue better decisions (including an emphasis on evidence-based practice) and to engage patients more in decisions on their care. However, many treatment decisions are made in the face of clinical uncertainty and may be critically dependent upon patient preferences. This has led to attempts to develop decision support tools that enable patients and clinicians to make better decisions. One approach that may be of value is decision analysis, which seeks to create a rational framework for evaluating complex medical decisions and to provide a systematic way of integrating potential outcomes with probabilistic information such as that generated by randomised controlled trials of interventions. This paper describes decision analysis and discusses the potential of this approach with reference to the clinical decision as to whether to treat patients in atrial fibrillation with warfarin to reduce their risk of stroke.
- It has been shown that better informed patients are more likely to comply with treatment, to be more satisfied and less anxious, and to have improved outcomes.
- Nonetheless, patients may be ill equipped to integrate their values with complex medical information in order to make an appropriate and informed decision for themselves.11 Thus, the quality of care provided to patients is inevitably influenced by the quality of clinical decision making and the degree of engagement of the patient with this process
- Decision models attempt to achieve this in a particular way, by choosing the course of action which maximises the decision maker's expected utility—that is, that gives the best chance of achieving an outcome that is valued by the patient. The use of decision analytical techniques is appropriate whenever there is uncertainty about the appropriate clinical decision for a given group of patients or an individual patient and there is a meaningful trade-off in terms of advantages and disadvantages between at least two competing strategies. The use of anticoagulants in patients with atrial fibrillation is a clinical decision to which the application of decision analysis is particularly appropriate
- Thus, rationality is simply a means of making good decisions—ones which make effective use of the information available at the time of the decision. Of course, in a world of uncertainty, good decisions will not necessarily lead to good outcomes as the best available option will generally include some chance of a bad outcome. For example, patients with atrial fibrillation who are treated with warfarin still have a measurable risk of suffering a thromboembolic stroke. Rather, good decisions may be thought of as those which maximise the likelihood of achieving a good outcome. This is the basis of expected utility theory
- The decisions facing patients and clinicians may be thought of as gambles since the outcome of any particular course of action is rarely certain, but rather there will exist some probability distribution over a range of possible outcomes. While the probabilities in the examples given above were determined by a simple chance mechanism—that is, the toss of a fair coin—the probabilities attached to all possible outcomes of a medical decision will be determined by the clinical evidence on risks and benefits.
- That is, that by taking warfarin they gain more quality adjusted survival than by not taking the treatment.

- "Suppose a physician elicits a utility for severe and mild stroke, a major bleed and being on warfarin. Based on this, the decision analysis suggests she take warfarin to prevent stroke. Unfortunately, she suffers a major bleed and her reaction to this is flavoured by regret: 'if only I hadn't taken warfarin'. Having not factored this into the utility assessment, her reaction exceeds the disutility for a major bleed that was predicted by her answers to the standard gamble questions."
- These problems encountered in attempting to apply population based approaches to individual patients, or in attempting to advise patients on treatment choice without fully understanding their values or preferences, highlight the need for research into how decision analysis may be used at the level of the individual patient consultation
- For example, the work of Wennberg has led to the development of interactive computer programmes and video disks for patients which enable them to make better informed decisions based upon a presentation of the clinical evidence and likely effects of alternative approaches. This has been most extensively developed and evaluated in the case of men with prostate symptoms who seek to choose between prostatectomy and "watchful waiting".37 Other examples include decision boards developed to help women make decisions surrounding breast cancer treatments38 and audiotapes and booklets which address a range of clinical decisions including warfarin for atrial fibrillation.2
- The DARTS project has been developing a tool to do this by means of a three stage process. The prototype consists of three components: the derivation of patients' values for the relevant health states (for example, major/ minor stroke, warfarin treatment, major bleed) using a standard gamble method; presentation of risk information for an individual patient using the Framingham stroke risk equation in conjunction with estimates of the effectiveness of warfarin at reducing this risk and the associated risk of a major bleed; and generating an "optimal" decision for the individual patient by combining these data in a Markov decision

Summary

- The authors of this paper present a decision analysis model that attempts to condense population health statistics and patient's values of the expected utility for various treatment options regarding their health into a computer program that could make the "best" treatment choice for physician-patient pairs. However, I contend that population health statistics still lie at the core of making recommendations for individual patients since the data shows that if we perform a certain intervention on enough patients, we will reduce poor outcomes. This brings us back to the concept of number needed to treat. Furthermore, I think that patients use "expected utility theory" without even realizing it. As long as the physician consulting them about whether or not to start warfarin for their atrial fibrillation (being the example used in this paper) adequately discusses every detail about the pros and cons of this decision. They must articulate the small but real risk of having a stroke should patients not start warfarin. They should state the increased risk of other kinds of bleeding when taking warfarin and how those different types of bleeding may both present themselves and create difficulties in patient's lives that did not previously exist. They must disclose the cumbersome nature of patients returning frequently to the laboratory for INR checks while taking warfarin. However, they must also disclose positive things about these seemingly negative considerations: most warfarin-induced bleeds are likely reversible while a lot of strokes are not, INR checks become less frequent as you become more stable on a given warfarin dose without other

medication changes. The authors cite a fantastic definition of this informed consent and shared decision-making process: "An informed decision is one where a reasoned choice is made by a reasonable individual, using relevant information about the advantages and disadvantages of all possible courses of action, in accord with the individual's beliefs." Of course, there will always be patients that may become overwhelmed and confused at how much information a physician may have to provide about starting a medication like warfarin. However, there are multiple strategies prudent physicians may use when broaching the subject. They can draw things out on a piece of paper to provide more clarity and a long-lasting reminder of the discussion had during the visit. They could offer for patients to record the informed consent/shared decision-making conversation so that they could revisit the information later, in the comfort of their own home, and as frequently as they desire. And, of course, we should never pressure patients to make effectively non-urgent decisions during a single appointment.

20. Norheim OF, Hunskår S. [Knowledge must be combined with values for decision making in uncertainty]. Tidsskr Nor Laegeforen. Apr 30 2001;121(11):1387-90. Kunnskaper må kombineres med verdier ved beslutninger under usikkerhet.

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- Nothing from this article stands out as being particularly useful for the goals of this Humanities Distinction Track project outside of what has already been mentioned elsewhere.

21. Thunnissen FB, Ambergen AW, Koss M, Travis WD, O'Leary TJ, Ellis IO. Mitotic counting in surgical pathology: sampling bias, heterogeneity and statistical uncertainty. Histopathology. Jul 2001;39(1):1-8. doi:10.1046/j.1365-2559.2001.01187.x

- Mitotic counting in surgical pathology: sampling bias, heterogeneity and statistical uncertainty Although several articles on the methodological aspects of mitotic counting have been published, the effects of macroscopic sampling and tumour heterogeneity have not been discussed in any detail. In this review the essential elements for a standardized mitotic counting protocol are described, including microscopic calibration, specific morphological criteria, macroscopic selection, counting procedure, effect of biological variation, threshold, and the setting of an area of uncertainty ('grey area'). We propose that the use of a standard area for mitotic quantification and of a grey area in mitotic counting protocols will facilitate the application of mitotic counting in diagnostic and prognostic pathology.

Summary

- It would be very interesting if we could have some way to quantify and disclose to patients the amount of uncertainty physicians have when undergoing clinical decision-making conversations with patients. This would likely be an impressively hard parameter to derive and quantify for the effectively infinite clinical circumstances and choices a physician encounters, but an ideal exemplification of this concept would be a numerical scale (e.g. 1-10) where increasing levels of uncertainty are reflected by higher numbers to facilitate ease of the patient's understanding. The problem being, of course, that the uncertainty of physicians is impacted by a similarly infinite number of factors, including

a physician's medical knowledge, comfort with uncertainty in general, patient-specific variables.

22. Hall KH. Reviewing intuitive decision-making and uncertainty: the implications for medical education. Med Educ. Mar 2002;36(3):216-24. doi:10.1046/j.1365-2923.2002.01140.x

- It is argued that although uncertainty can be reduced, it can never be completely eliminated from decision-making. Therefore most decision-making performed in medicine contains an irreducible intuitive element and is thus vulnerable to these biases and heuristics. Given that few medical curricula overtly address the process of medical decision-making, both medical students and physicians remain vulnerable to these effects on their own (and their patients') decision-making. Insight via education appears the major means in which to avoid distorting decision-making processes.
- Although intuition is a recognised component of expertise, the exact nature of this relationship is not well understood and has been termed '…the supreme mystery of clinical reasoning…'. It is known that intuitive expertise requires a well organised store of networks and rules which allow efficient access and retrieval of information. These 'personal decision rules' are used by clinicians, particularly in conditions of uncertainty, even though these may not necessarily result in the best performance 5 and are prone to a number of well-recognised biases.
- Although this remains a widely-quoted work, a better conceptualisation (in terms of both breadth and depth) of the sourcesof uncertainty for physicians is Beresford's 8 who categorises sources of uncertainty into three types: technical, personal and conceptual.
- What makes Beresford's analysis particularly useful is that it shows that the management of uncertainty is more complicated than the simple provision of more information (a solution which has been suggested by some authors). 13 Further information would merely address the technical or first order sources of uncertainty, and leave untouched sources of meta-uncertainty. Acknowledgement of the broader sources of uncertainty results in acknowledging that a degree of uncertainty is an irreducible element of decision-making.
- It could be argued that it is in a health institution's interest to maintain the denial of uncertainty, as otherwise this challenges the prevailing power structure of that institution. It is in the individual doctor's self-interest to uphold orthodoxy, as this allows a (mostly unconscious) escape from having to face up to uncertainty, as well as engendering a (conscious or unconscious) feeling of security. What this 'mutual benefit society' does not do, is address the needs of the patient for information and participation in decision-making. On the whole, physicians are reluctant to disclose the inescapable uncertainty of decision-making to patients. 14 This reluctance is often linked to claims that it will cause unnecessary suffering and anxiety inpatients and not improve the patients' ability to make decisions. […] "All that the doctor can do is to quote objective probabilities modified by his own subjective probabilities which express to some extent the dynamics of his belief systems, and to leave the patient with a final uncertainty about the outcome of treatment. …[it]often leaves the patient asking why is there no precision when there is so much science."
- Katz believes more problems are caused by physicians' defences against uncertainty, than by patients' 'supposed intolerance of medical uncertainties'. He argues that the open recognition and inclusion of uncertainty may well facilitate trust between doctor and

patient, more honestly uphold the informed consent procedure, diminish unrealistic expectations on the part of the patient, and reduce the likelihood of litigation. Studies are not available to establish whether Katz or the physicians are correct

- Uncertainty also propels activity – doctors have a '…propensity to resolve uncertainty and ambiguity by action rather than inaction'. 22 Such activity may lead to increased hospital admissions 8 and may be a cause of excessive ordering of tests, 23 although this result has not always been found.
- In many situations using heuristics may result inaccurate predictions and reflect a highly adaptive and efficient response to decision-making in the real world. 35,36 However, the more commonly held view of heuristics is one of more negativity, with heuristics being regarded as sources of biases and errors. Many of these biases have been found to occur in medical decision-making.
- Physicians may hold incorrect intuitions about regression towards the mean: for example, improvement during a trial of therapy may be a regression towards the mean (chance variation) and not necessarily imply an increased likelihood that a diagnosis or choice of treatment was correct.

Summary

- This paper thoroughly outlines how there are three types of uncertainty from Beresford: technical, personal, and conceptual. "Technical sources of uncertainty are those where there is insufficient information to adequately predict prognosis or the effect of interventions [which includes effects of factors such as the speed of growth of medical knowledge, leaving one not knowing whether or not they are up-to-date]. […] Personal sources of uncertainty have their origins in the doctor–patient relationship, for example when the patient's wishes are unknown and not able to be solicited [which includes effects of factors such as the emotional attachment of the doctor for the patient that may impair the former's decision-making]. […] Conceptual sources of uncertainty arise from an inability to assess differing patient needs competing for the same resources (incommensurability), and the application of general criteria (for example, guidelines) to individual patients [which includes effects of factors such as applying past experiences to current patients as well as the general, existential uncertainty of the future]." Common ways that uncertain physicians attempt to come to terms with their uncertainty is through the use of heuristics, or generalizations. The authors here question whether heuristics are simply manifestations of the way that "expert" clinicians process medical information or whether such mental processes are just more-faulty-than-not mental shortcuts. Heuristics can lead to well-known cognitive errors such as recency bias, anchoring bias, patterning behaviors based on prior outcomes that would have potentially occurred regardless of the intervention that was made, the tendency for emotionally weighty medical factoids/clinical memories to be recalled easier, and the tendency for feared negative outcomes – despite being rare in reality – to be discussed and avoided as if they were more common. The combination of these factors and the use of subsequent "medical intuition" by physicians may be what results in the development of so-called "practice styles" that have been mentioned elsewhere. Doctors do have the tendency of performing more tests when feeling more uncertain about their patient's diagnosis and therapeutic plan, as they attempt to collect more data and catch their fish with a large net as it were. As such, there is also a seeming tendency for medical students who are more intolerant of uncertainty to choose specialties with more utilization of technology and a narrowing of

the general medical knowledge required of them. The dichotomy between the "public" and "private" experiences of uncertainty by clinicians is interesting, as there appears to be a general aversion amongst physicians for disclosing their uncertainty when it arises. Perhaps it is in the personal interests of health institutions and their doctors to not "break the fourth wall," so to speak, and uphold patient trust. However, reasonably so, there are many who argue that disclosing clinical uncertainty when it arises is actually the recipe for creating more physician-patient trust. This could be an increasingly true idea, especially in American culture, with increasing numbers of patients anecdotally just wanting doctors to tell them "I don't know" when they truly do not know something. Clearly, there is a gap in formal medical education where medical students are not directly taught how to engage with clinical uncertainty beyond generalities like "go search the literature!"

23. Bliton MJ. Parental hope confronting scientific uncertainty: a test of ethics in maternal-fetal surgery for spina bifida. Clin Obstet Gynecol. Sep 2005;48(3):595-607. doi:10.1097/01.grf.0000169660.80698.a8

- Independent of whether the evaluation of the scientific data is likely to answer these arguments conclusively, careful attention will need to be given to the ethical issues that remain unresolved, including the need for identifying and establishing legitimate ways to handle the issues surrounding maternal and fetal vulnerability at previable gestational stages, which is when the defect is often diagnosed and likewise when fetal repair is likely to be performed.

Summary

- Very interestingly, this article questions the patient's ability to reason through uncertainty even if the scientific data available to them is certain. More specifically, the patient they question the ability of is not just any patient, but a pregnant mother attempting to decide whether to receive maternal-fetal surgery to repair spina bifida. The paper was written before the conclusive evidence of the Management of Myelomeningocele Study (MOMS) trial, but argues that uncertainty surrounding this decision will remain pervasive as parents attempt to decide whether to move forward with a surgery that, despite (potentially) evidence shows is effective and safer-than-not, there are still risks. The parents may make a decision that is predicated on hope, and the question to wrestle with is whether such a decision-making state of mind is one that can participate in informed consent competently.

24. Childs JD, Flynn TW, Fritz JM, et al. Screening for vertebrobasilar insufficiency in patients with neck pain: manual therapy decision-making in the presence of uncertainty. J Orthop Sports Phys Ther. May 2005;35(5):300-6. doi:10.2519/jospt.2005.35.5.300

- **IT WAS FELT THAT THIS ARTICLE WAS INAPPROPRIATE FOR THE REVIEW ARTICLE GIVEN THE AUTHOR'S DISCUSSION OF PHYSICAL THERAPY INTERVENTIONS NOT PERFORMED BY PHYSICIANS (manual neck manipulation/mobilization).**

25. McCormick KM, McClement S, Naimark BJ. A qualitative analysis of the experience of uncertainty while awaiting coronary artery bypass surgery. Can J Cardiovasc Nurs. 2005;15(1):10-22.

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- Nothing from this article stands out as being particularly useful for the goals of this Humanities Distinction Track project outside of what has already been mentioned elsewhere.

26. McCulloch P, Kaul A, Wagstaff GF, Wheatcroft J. Tolerance of uncertainty, extroversion, neuroticism and attitudes to randomized controlled trials among surgeons and physicians. Br J Surg. Oct 2005;92(10):1293-7. doi:10.1002/bjs.4930

- Surgeons have a reputation for decisiveness and self-confidence, which suggests that they may tolerate uncertainty poorly and therefore be less capable than other doctors of experiencing clinical equipoise. Their 'typical' behaviour is characteristic of the stable extrovert personality and so they may prefer spontaneous clinical judgement over randomized trials. The aim of this study was to compare personality dimensions and tolerance of uncertainty among surgeons and hospital physicians, to determine whether differences in either property might help to explain the apparently poor performance of surgeons in conducting randomized controlled trials
- The response rate was 36·5 per cent. Physicians were more likely to be women ($P < 0·001$) and had spent 1 more year in academic posts than surgeons ($P < 0·030$). Surgeons were significantly more extrovert ($P < 0·001$) and less neurotic ($P < 0·001$) than physicians. Surgeons were significantly more intolerant of uncertainty than physicians ($P = 0·007$). Multivariate analysis identified age ($P < 0·030$) and sex ($P = 0·015$) as independent predictors of intolerance of uncertainty. The attitudes of surgeons and physicians to randomized trials were no different.
- Surgeons are not prejudiced against randomized trials, but their intolerance of uncertainty may inhibit them from deciding that an individual patient is suitable for trial entry. If more surgeons were female, this difference between surgeons and physicians might disappear.
- The stereotype of surgeons as outspoken, forceful, spontaneous and not afraid of risk or decisive action suggests that they possess the typical characteristics of stable extroverts7,8; such characteristics might lead them to prefer spontaneous clinical judgement over randomized trials. On the other hand, surgeons might find it difficult to achieve a state of 'clinical equipoise' because of a limited ability to tolerate uncertainty
- Lower intolerance of uncertainty was associated with longer time in an academic post, more academic publications and more recent degrees
- Surgery is characterized by the need to make critical and irreversible decisions during an operation without the benefit of long reflection or discussion. In this situation a low tolerance of uncertainty may be psychologically advantageous in allowing the individual to make a decision quickly without undue anxiety at the time or later. People who find this experience uncomfortable, on the other hand, may not wish to enter surgical training and be less likely to complete it. Surgeons proved significantly more intolerant of uncertainty than physicians, providing support for the pre-existing hypothesis

Summary

- I was hopeful prior to reading this paper that its contents would be profoundly valuable to our project. However, there was an ultimately unclear pontification of various thoughts here. The authors report that based on a survey they did of surgeons and physicians, surgeons are more extroverted, less neurotic, and more intolerant of uncertainty than their physician counterparts (which was true in their study even when controlling for sex). The authors beautifully articulate that surgeons must be tolerant of uncertainty to "make critical and irreversible decisions during an operation," but then say that "surgeons proved significantly more intolerant of uncertainty than physicians, providing support for the pre-existing hypothesis." It appears that the double negatives were confused by the authors here, since their data actually disproves their pre-existing hypothesis the way that they are describing it. Furthermore, there is an argument presented here that surgeons prefer to use their "spontaneous clinical judgment" over RCTs which is corroborated by the fact that "treatments in general surgery are half as likely to be based on RCT evidence as treatments in internal medicine." Nonetheless, the presented data shows that the attitude towards RCTs between surgeons and physicians was equivalent. If we take for face-value what the authors say about surgeons being more intolerant of uncertainty, could there be an argument to be made that being more intolerant of uncertainty actually means venturing deeper to try and find more certainty within available evidence/data rather than being comfortable shooting from the hip, so to speak? Another question of mine is whether or not surgeons are actually intolerant of uncertainty though or simply whether they refuse to believe that it exists? An intolerance of uncertainty suggests a mental anguish when presented with its existence. As the authors explicate, surgeons operate every day having to make uncertain and irreversible decisions. Sometimes they succeed greatly and sometimes they fail horribly; but after every case, there is a next one.

27. Tarantino DP. Decision making in uncertainty (Part 1). Physician Exec. Jan-Feb 2005;31(1):68-9.

- **ARTICLE UNABLE TO BE OBTAINED.**

28. Tarantino DP. Decision making under uncertainty: Part 2. Physician Exec. Mar-Apr 2005;31(2):64-5.

- **ARTICLE UNABLE TO BE OBTAINED.**

29. McCormick KM, Naimark BJ, Tate RB. Uncertainty, symptom distress, anxiety, and functional status in patients awaiting coronary artery bypass surgery. Heart Lung. Jan-Feb 2006;35(1):34-45. doi:10.1016/j.hrtlng.2005.08.002

Summary from Abstract

- Nothing from this article stands out as being particularly useful for the goals of this Humanities Distinction Track project outside of what has already been mentioned elsewhere.

30. Simpson AL, Ma B, Chen EC, Ellis RE, Stewart AJ. Using registration uncertainty visualization in a user study of a simple surgical task. Med Image Comput Comput Assist Interv. 2006;9(Pt 2):397-404. doi:10.1007/11866763_49

- Most notably, our work addresses the existence of uncertainty in guidance and offers a first step towards helping surgeons make informed decisions in the presence of imperfect data.

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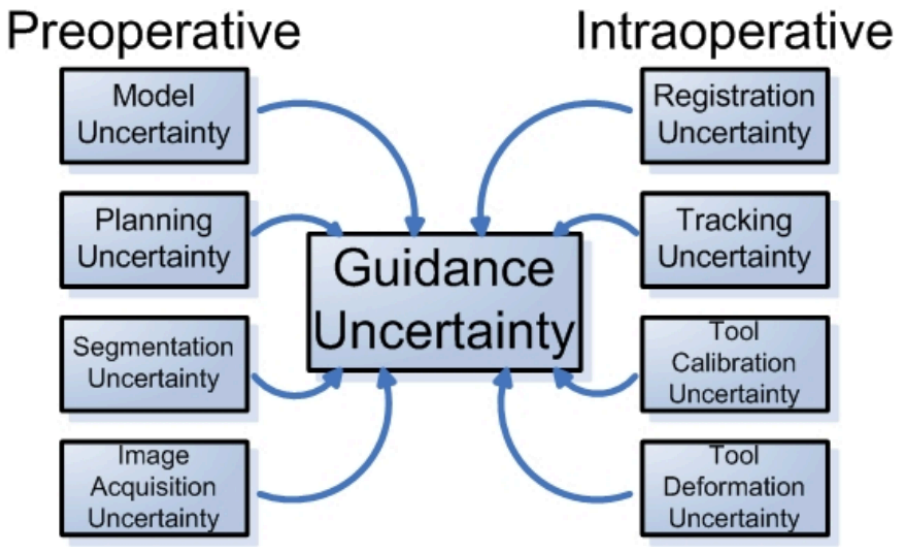


Fig. 1. Illustration of sources of uncertainty in computer–assisted surgery systems. Errors are introduced preoperatively in image acquisition, segmentation, 3D model generation and planning. Intraoperatively, errors occur in registration, tool calibration, tool deformation (deflection) and tracking. Uncertainty from all sources propagates through the entire surgical procedure.

- We demonstrated a simple method to determine the variation caused by registration uncertainty in a planned linear path. We visualized the uncertainty with a path uncertainty volume. Our visualization method resulted in a statistically significant reduction in the number of attempts required to localize a target, and a statistically significant reduction in the number of targets that the pool of subjects failed to localize.

Summary

- By repetitiously modeling the path that is frequented by surgeons performing a particular task, the uncertainty within the task can be modeled and used by future individuals performing that same task to minimize making the same mistakes others have committed. This is the value of introducing computerized capabilities of visualizing technical uncertainty in the middle of surgery. One could imagine that for a surgery such as a laparoscopic appendectomy, there might be a repository of laparoscopic video recorded for all of the laparoscopic surgeries that have been performed. One could then cross-match the different strategies/approaches utilized by the various surgeons with an assessment of whether complications of that surgery arose, allowing one to begin constructing a way to computationally visualize safe and unsafe technical decisions in the operating room.

31. Tubbs EP, Elrod JA, Flum DR. Risk taking and tolerance of uncertainty: implications for surgeons. J Surg Res. Mar 2006;131(1):1-6. doi:10.1016/j.jss.2005.06.010

- Among surgeons, failure to use "double-gloving" for protection against exposure to biological fluids [2, 4], the limited use of beta blockers among high-risk patients [8], antibiotic delivery within a short period of time of operative incision [9], intraoperative cholangiography during cholecystectomy [10–13] and venous thromboprophylaxis [14] are all examples of a gap between evidence-based "best practices" and what providers actually deliver. While the rationale behind the low rate of use of evidence-based prevention techniques is not completely understood, several possibilities have been offered. Surgeons may disagree with the published data relying instead on their personal experience or training, information about the utility of these practices may not have been adequately disseminated, or surgeons may simply be relying on heuristics [15, 16] ("rules of thumb") to guide practice
- Nightingale suggests that a willingness to gamble in the face of loss but not in the face of gain relates to the "Chagrin Factor" proposed by Feinstein [29]. This theory suggests that, "Since the relative magnitudes of chagrin will differ for different types of wrong results, a customary clinical strategy is to choose the option whose wrong result will cause the least chagrin." In the case of the gamble in the face of loss, from the physician's perspective it is better to gamble trying to minimize loss and fail in 50% of attempts than to accept a guaranteed loss.
- However, they did find that increased "anxiety due to uncertainty" was associated with increased patient charges and that an increased propensity toward risk taking (as measured by Pearson's adapted version of the JPI) was associated with decreased patient charges.
- Other examples of surgical areas that could benefit from exploration along these lines include the use of diagnostic technology for atypical abdominal pain, the willingness to offer patients exploratory surgery in the face of chronic pain, the use of computed tomography scanning in appendicitis, the willingness to incorporate new technology or procedures in operating room practice, and the threshold for operative intervention in patients with slow-to-resolve bowel obstruction

Summary

- There is substantial evidence to suggest that surgeons frequently do not follow gold-standard and evidence-based procedures such as double-gloving, intraoperative cholangiography during cholecystectomy, and venous thromboprophylaxis. One explanation for this is that the location of that surgeon's training did not emphasize such procedures as imperative, leading to a "practice style" that excludes these protocols from the surgeon's routine heuristics. This paper discusses several valuable tools for assessing clinician's tolerability of uncertainty that may be insightful for future studies. The authors go on to elucidate a fascinating point about how physicians may distill clinical risk-taking: they choose the option through an uncertain lens that they feel like they will regret the least (from Nightingale and Feinstein). It makes sense that clinical uncertainty, especially among risk-averse physicians, increases medical costs for patients since an intuitive method of attempting to reduce uncertainty is to order more tests to gain more information that may provide a greater sense of certainty or simply to reassure oneself that "I did everything I could in my role as this patient's physician." Indeed, it may be accurate that for surgery more than for other specialties, there is a tendency for surgeons

to adhere strictly to a "tried and true" method of performing their clinical duties with an aversion to change… even if that change may improve the outcomes of their patients. The finality of their role as surgeons with the irreversibility of their actions may dictate that they find comfort in their pattern of prior actions that did not result in poor patient outcomes. Even if there are ways to improve the perioperative process for these surgeons via better techniques/technology, those new things are untrustworthy and need to prove themselves within surgeons' minds. The conundrum being, of course, that the new, potentially beneficial, but untrustworthy surgical strategy or tool may never receive the opportunity to prove itself. The authors of this paper blame heuristics as a cause of surgeons not adhering to the aforementioned gold-standard procedures, but one should also realize that heuristics save time. The countless research papers milled out about how to increase operating room turnover for the economic benefit of the hospital speak for themselves about why surgeons may feel pressured to just cut the cystic duct with heuristically "good enough" data within their frontal lobes that they are cutting in the correct location without performing a cholangiogram.

32. Upile T, Fisher C, Jerjes W, et al. The uncertainty of the surgical margin in the treatment of head and neck cancer. Oral Oncol. Apr 2007;43(4):321-6. doi:10.1016/j.oraloncology.2006.08.002

- The extent of tissue resection is determined by the ''trade off'' between cancer control and the perioperative, functional and aesthetic morbidity and mortality of the surgery.
- The fundamental surgical goal is that of complete tumour resection. How does the surgeon ensure this? It is a common and convenient assumption that tumours are homogeneous and have a rectilinear edge. It was supposed that malignancy stopped at a visibly defined border and the surgeon simply had to cut along the 'dots', whilst leaving an adequate margin for error. This philosophy belies several flaws including two-dimensional thinking but contains an underlying empirical truism that tumours should be removed as completely as possible. With empiricism in mind, we shall discuss the 'all important' issue of the uncertainty of the 'surgical margin'.
- The enigma of this surgical margin applies to nearly all solid tumours and their management. How generous this margin should be has not been defined for all forms of cancer or selected classes of malignancy. Tumour site, anatomical restrictions, presumed biological characteristics of the cancer, the respective advantages of conservation and extended surgery affect the adequacy of surgical resection
- The minimalist approach using very narrow surgical margins which are at least histologically clear has resulted in equal if not better oncological control rates as compared with more radical resections.9–11 It has been postulated this effect is the result of both minimizing the impairment of endogenous tumour inhibitors (such as the immune response) and reducing the effect of surgically induced release of tumour facilitators (such as wound healing growth factors e.g. EGF, tissue plane breaches)
- There may be several foci of cancer giving some mucosal cancers multi-centricity i.e. multiple primaries. However, one cell line or clone will become dominant through natural clonal selection and have a suppressive effect on other clones, which may then not develop full malignant potential. Hence, a malignancy may be surrounded by a corona of potentially malignant heterogeneous sub-clones that during suppressive entrainment by the main mass do not exhibit all the phenotypic characteristics or histological

appearances of malignancy. There may even be a gradient of malignancy.14–17 This is borne out by the fact that immunohistochemical studies have revealed positive staining for markers of genomic alteration associated with malignancy (P53, eIF4.etc) in histologically negative surgical margins which are later correlated with a high recurrence rate.

- Due to the pathological and surgical difficulties inherent in the evaluation of pre-operatively irradiated tissues and the phenomena of sub-mucosal extension or skip lesions, the histological accuracy of assigning adequate surgical margin is at least 50% (judged by local recurrence)
- Perhaps margins should be binomially defined as involved along the progression of malignancy or normal and results given as confidence of clearance
- Furthermore primary radiotherapy and chemo-radiation is known to make the tumour margins more fibrotic and scarred hence any later salvage surgical margins are more difficult to access and hence tend to be wider and of more uncertain nature. Simple pre-operative chemotherapy may reduce obvious tumour bulk and display negative margins. However, margins should be marked pre-therapy since chemotherapy acts by probabilistic 'cell-kill' without reduction in the extent of disease because tissue is not ablated.
- The surgeon conceptualizes the malignancy as occupying a relatively homogenous volume of tissue and resects the tumour with a ''surgical margin'' based on measurement. Typically, this is at least 1 cm beyond the visible and palpable margin of the tumour.
- In reality most head and neck resections are a hybrid of both the ''metric'' and the ''barrier'' approach because there is so little non-functional tissue available in head and neck. An example of this is with a laryngopharyngectomy being performed for a piriform fossa apex lesion involving the deep surface of the inferior constrictor. The surgeon applies a ''metric'' approach to the mucosal extension and a ''barrier'' approach with respect to the adjacent carotid sheath. A typical histological report will often report greater than 1cm of mucosal clearance but only 1–2 mm clearance in the region of the inferior constrictor.

Summary

- It seems reasonable to argue that perioperative functional morbidity and mortality is an important consideration for all patients. However, could the argument be made that the aesthetic morbidity and mortality following a surgery such as oncological resection matters more for some patients? Obviously, surgeons should be expected to produce as good of aesthetic outcomes as they can – just as is true of their functional outcomes. But do the aesthetic outcomes in a 75-year-old military veteran matter the same amount as a 25-year-old model? Interestingly, there are no evidence-based guidelines regarding surgical margins, which is inherently a surgical variable affected by many considerations including "tumor site, anatomical restrictions, presumed biological characteristics of the cancer, the respective advantages of conservation and extended surgery affect the adequacy of surgical resection," and the biological/psychological/social impact of having positive margins. I was impressed at the proposition that there are oncological downsides to performing a more radical resection given the release of tissue healing factors that are actually tumor facilitators, making minimalistic resections potentially better (as long as the margins are negative). Even when having negative margins, though, there can be a

high chance of recurrence when dealing with a cancer that has one or more subfoci that were locally out-competed by the cancer that became the primary being surgically resected. The authors say it best: "At its simplest a tumour can be regarded as being surrounded by a three dimensional 'atmosphere' of malignancy. The more standard deviations of distance the surgical margin is from the tumour bulk the lower the probability of remaining viable tumour cells. This margin is further blurred by three dimensional stereometric sampling errors in observations and the presence of favored and unfavoured anatomicophysiological sites allowing rapid or slow tumour progression or sequestration." Indeed, the process is laden the uncertainty that cannot be controlled. Further complicating the matter is that even when we have negative margins, and if we assume for argument's sake that only positive margins have cancer recurrences, histological identification of negative margins is only correct 50% of the time. Pathologists are therefore plagued by the same uncertainty as surgeons in a different way. To try and correct this, the authors propose an idea I have mentioned before: disclosing results with an estimation of confidence even though that estimate will be inherently uncertain as well. Similar to obtaining blood cultures prior to beginning antibiotic therapy, cancer margins should be marked by methods such as subtle tattoos prior to beginning therapy to ensure a greater adherence to definitive surgical margin resection after neoadjuvant therapies.

33. Zapka JG, Moran WP, Goodlin SJ, Knott K. Advanced heart failure: prognosis, uncertainty, and decision making. Congest Heart Fail. Sep-Oct 2007;13(5):268-74. doi:10.1111/j.1527-5299.2007.07184.x

- However, significant uncertainty remains around estimating prognosis in the presence of significant comorbidity and functional impairment, which require tailored appreciation of multiple guidelines.

Summary

- As I have mentioned elsewhere, prognostication poses a significant challenge for all physicians. This paper interestingly explores the lacking ability of Internal Medicine physicians to prognosticate for two different heart failure patients, with lifespan estimates being well-off from a recently published computer model. Notably, this model (Seattle Heart Failure Model) is based on literature- and guideline-based criteria. The question arises then whether much of current physician prognostication is predicated simply on a sort of gestalt instinct of how sick or frail a patient is.

34. Farnan JM, Johnson JK, Meltzer DO, Humphrey HJ, Arora VM. Resident uncertainty in clinical decision making and impact on patient care: a qualitative study. Qual Saf Health Care. Apr 2008;17(2):122-6. doi:10.1136/qshc.2007.023184

- Residents report a ''hierarchy of assistance'', using colleagues and literature for initial management, followed by senior residents, specialty fellows and, finally, the attending physician. Barriers to seeking the attending physician's input included the existence of a defined hierarchy for assistance and fears of losing autonomy, revealing knowledge gaps, and ''being a bother''. For 12 of the 18 cases reported, patient care was compromised: delay in procedure or escalation of care (n = 8); procedural complications (n = 2); and cardiac arrest (n = 2).

- The most commonly reported type of uncertainty, conceptual uncertainty, demonstrates a resident's inability to apply abstract criteria to a clinical scenario, in particular in the setting of the need for escalation of care

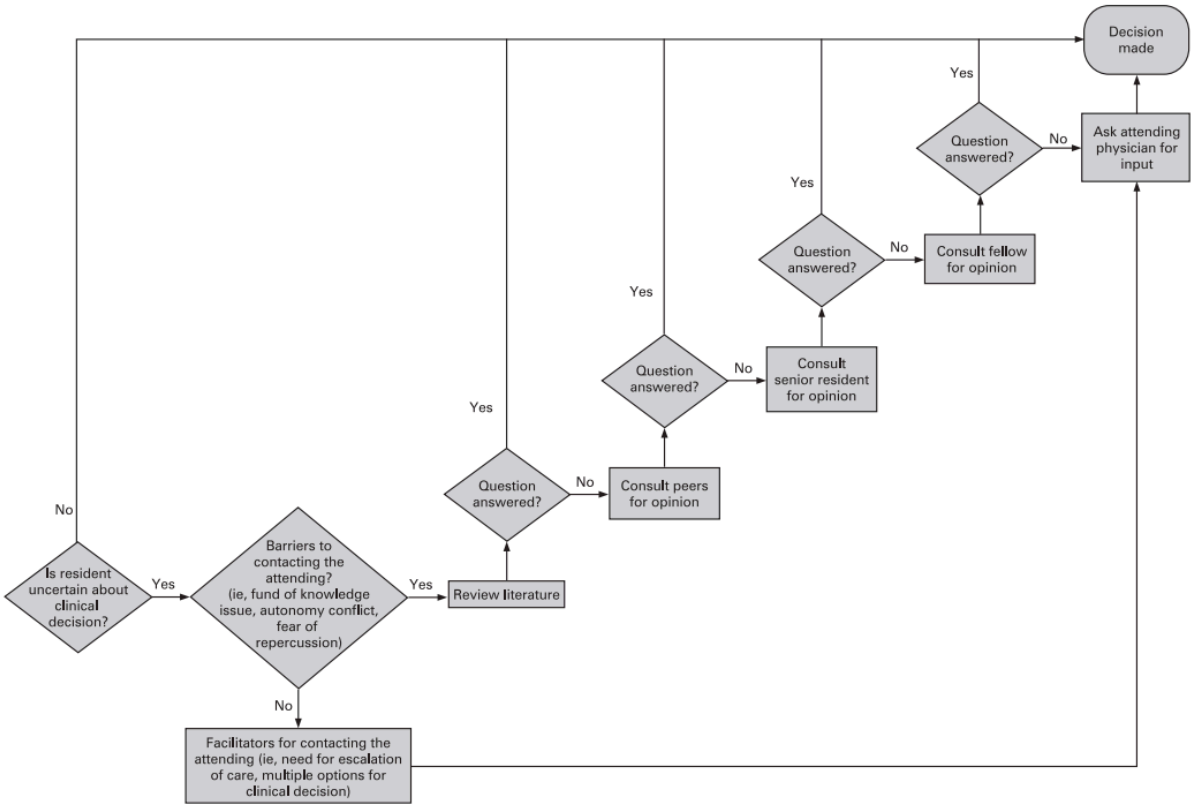


Figure 1 Clinical decision making as described by residents.

Summary

- The implicit contract of healthcare received at teaching hospitals dictate that, whether they know it or not, patients are receiving care from resident physicians – arguably more often than they are an attending physician despite the latter's general oversight. One can therefore anticipate that higher levels of uncertainty will characterize the medical decisions being made by residents, and there is a cultural tendency amongst resident physicians to save consultation of their attending physician as a "last resort" option. Undeniably, this is one of the many influences of the so-called "hidden curriculum" in medical education that stokes a fear of being perceived as "weak" or "overzealous." However, this paper identifies that moving through the hierarchy of advice (same-year resident colleagues, then senior residents, then specialty fellows, and then attendings) can frequently cause patient care compromises that would have been avoided if the attending physician had been contacted sooner. One unique way that the authors discussed uncertainty affecting the clinical practice of residents is through withholding information from patients. It can be easy to understand why this might happen, especially if critical laboratory values or changes in patient status that can "wait until the day" occur, and improper communication (or simply lack of disclosure from the overnight team) leads to the day-time residents blindsiding patients with novel updates. The most uncertainty-inducing clinical scenario for residents involved encountering a patient that potentially

needed an escalation of care. Additionally, the ability to perform certain procedures needed by different patients was a source of uncertainty in the residents that were surveyed, and their apprehension led to clinical decisions excluding performance of those procedures (e.g. covering for meningitis in a patient with a consistent clinical picture, without performing a lumbar puncture).

35. Johnson NP, Selman T, Zamora J, Khan KS. Gynaecologic surgery from uncertainty to science: evidence-based surgery is no passing fad. Hum Reprod. Apr 2008;23(4):832-9. doi:10.1093/humrep/dem423

- In general, gynaecology has been a specialty where surgical interventions have been well exposed to the scrutiny of RCTs compared with other surgical specialties
- The surprisingly small number of surgical RCTs was most striking in gynaecologic cancer treatment, in which a strong evidence base for techniques of surgical removal of cancer might be expected. This may be due in part to a reluctance of patients with cancer to submit to randomization, difficulties with obtaining ethical approval where a patient with cancer could be randomized to not having the cancer surgically removed, and a discomfort among gynaecologic oncology surgeons to admit to being in equipoise. We have disproved the widely held belief that a clear answer to a clinical dilemma is seldom the case from RCTs or meta-analysis of RCT results, in our finding that a reasonable proportion (60%) of all Cochrane reviews of gynaecologic surgical interventions were able to find evidence of effectiveness or superior relative effectiveness of these interventions for at least some primary outcomes
- Pitfalls with systematic reviews have been highlighted (Farquar and Vail, 2006). In common with trials and systematic reviews of medical interventions, clinical trials and systematic reviews of RCTs in gynaecologic surgery are prone to difficulties with study quality, funding bias, publication bias, reliance on outcomes of little help in clinical decision-making, analysis errors and incorrect use of evidence statements in conclusions. However, surgical trials and systematic reviews have their own unique pitfalls, including a lower threshold for limitations to completion of trials, more limitations to broad applicability of trial results, surgical reputation conflict of interest, in addition to design problems, such as the performance bias resulting from inability to employ blinding (especially concerning subjective outcomes). There are undoubtedly more confounding variables in surgical RCTs than in the more straightforward A versus B comparison that RCTs address in assessing the effectiveness of medical interventions, including variation in expertise of surgeons with different operations leading to an almost unavoidable confounding surgeon effect.
- A number of prerequisites for surgical RCTs will vastly improve the evidence base in the future. First, pragmatic trials with non-restrictive entry criteria will improve recruitment and generalizability of trial results. Second, only when we collaborate in large multi-centre RCTs of gynaecologic surgical interventions will we have sufficient power to find modest improvements that may add up to clinically meaningful improved quality of life, more babies born to infertile couples or even lives saved. Such an approach enhances generalizability and speeds recruitment, thus avoiding the problem seen with laparoscopic colposuspension, an operative intervention that became almost obsolete before the evidence base was established, owing to the rapid progress that is typical of

most surgical fields. A third key is the pursuit of important long-term outcomes, which are rarely reported in surgical RCTs.

Summary

- Contrary to what is said in the literature, gynecological surgery appears to have a predilection for having more RCT-derived evidence guiding its operations. It is generally difficult to perform RCTs for surgical specialties given the complexity with randomizing patients who *need* surgery to either getting the surgery or not. And, in cases when blinding might be recommended or required, it is next to impossible to ethically blind a patient to whether or not they received surgery. As such, surgeons seem to depend largely on outcome-based cohort studies to guide their practice. The authors here explicate that a "reasonable proportion (60%) of all Cochrane reviews of gynaecologic surgical interventions were able to find evidence of effectiveness or superior relative effectiveness of these interventions for at least some primary outcomes." This retains 40% absolute uncertainty on a population-based scale and relinquishes none of the uncertainty that arises when applying the results of well-powered and, arguably, more epidemiologically-based RCT evidence to singular patients. Dare I say that the complexity and uncertainty that bubbles to the surface when applying a "generally good" medical/surgical recommendation derived from RCT evidence *is* complex and uncertain because the singular patient is more irreducibly complex, in and of themselves, compared to the flock of humans studied as a herd with a NNT of 10. Nonetheless, the authors do a good job otherwise detailing more of the difficulties with performing RCTs from a surgical standpoint. They boldly articulate without further consideration that "RCT is the most reliable indicator of the effectiveness of an intervention, whether medical or surgical" and offer ideas for how to make surgical RCTs more mainstream.

36. Selman TJ, Johnson NP, Zamora J, Khan KS. Gynaecologic surgery from uncertainty to science: evolution of randomized control trials. Hum Reprod. Apr 2008;23(4):827-31. doi:10.1093/humrep/dem422

- Our study shows an improvement in quality of surgical trials in gynaecology over time as the CONSORT guidelines boosted allocation concealment. The trials got larger in size (more reliable or more precise) over time. There was also a general trend towards a reduction in effect size as a topic matured over time
- It is evident from our review that gynaecologic surgical practice is benefiting from improvement in its research base, a trend which has been highlight by the Cochrane Fertility Regulation Group, who also showed an improvement in RCT quality with the introduction of QUDAS, a checklist for quality items that should be included in studies of diagnostic test accuracy

Summary

- These authors, the same as in the previous paper, identify that guidelines governing the performance of RCTs such as CONSORT or QUDAS improved the quality of their RCTs in gynecological surgery. It makes sense that a universal rule for performing RCTs, if well developed, would bolster their quality – not dissimilar to development of the scientific method. Interestingly, the final line of this article says "It is also sobering to note that the improvements in research methodology are associated with less optimism about effects of gynaecologic surgery," which for professional and financial reasons could be an unfortunate and arguably unethical roadblock to the active engagement in

RCTs by surgeons. What if the very surgery that has given you a career is "disproven" by your RCT? Awkward indeed.

37. Cranley L, Doran DM, Tourangeau AE, Kushniruk A, Nagle L. Nurses' uncertainty in decision-making: a literature review. Worldviews Evid Based Nurs. 2009;6(1):3-15. doi:10.1111/j.1741-6787.2008.00138.x

- Little exploration has been done of nurses' experience of uncertainty in practice. Many investigators have not theorized about the uncertainty in their studies, but have described nurses' uncertainty in the context of clinical decision-making. The findings from these studies indicated that unfamiliarity with the aspects of patient care is a source of uncertainty, and nurses tended to rely on heuristics or on the expertise of colleagues as sources of information for practice decisions. Expressing uncertainties as information needs might help guide information seeking and reduce uncertainty. However, studies indicated that nurses have difficulty recognizing or expressing uncertainties, and as a result, information needs are not recognized and information seeking is not initiated.

Summary

- Almost identically to similar studies performed on physicians, nurses report the most uncertainty when encountering unfamiliar situations surrounding patient care. These situations are unfamiliar because they do not align with the heuristics they have encoded from their training and, also similar to physicians (especially residents), approaching colleagues for help is a mainstay of clinical problem-solving. The most important common theme here is the tendency for nurses – and doctors – to be hesitant about recognizing and expressing uncertainties. Perhaps an argument can be made about how human nature operates within the professional setting, with professionals being fearful of being wrong, being ridiculed by their peers, being seen as weak, being seen as lacking some supposedly necessary sense of stoicism. What can we boil these fears down into? Social anxiety might be a good explanation that makes sense in light of its commonality between both doctors and nurses – and potentially all/most humans alike. The picture presented here may dissuade a dissenter from using the extensive training doctors receive prior to independent practice as an argument for why doctors have a "foot-in-the-door" of neglecting to notice or confess their uncertainty. The point being that nurses are not required to complete as much training as physicians prior to beginning their own version of an independent professional career.

38. Genders TS, Meijboom WB, Meijs MF, et al. CT coronary angiography in patients suspected of having coronary artery disease: decision making from various perspectives in the face of uncertainty. Radiology. Dec 2009;253(3):734-44. doi:10.1148/radiol.2533090507

- For a prior probability of CAD of less than 40%, the probability of CAD after CT coronary angiography with negative results was less than 1%. The Markov model calculations from the patient/physician perspective suggest that CT coronary angiography maximizes life-years respectively in 60-year-old men and women at a prior probability of less than 38% and 24% and maximizes QALYs at a prior probability of less than 17% and 11%. From the hospital/health care perspective, CT coronary angiography helps reduce health care and direct nonhealth care-related costs (according to UK/U.S. recommendations), regardless of prior probability, and lowers all costs, including

production losses (Netherlands recommendations) at a prior probability of less than 87%-92%.

Summary

- Diagnostic uncertainty can be rephrased into consideration of pre-test probability and post-test probability. When a patient presents with a certain complaint, the physician develops their own pre-test probability estimates as to what the diagnosis of the condition might be. For some conditions, let's say a stye here for the sake of argument, the pre-test probability by a reasonable physician's history-taking and physical examination will be so high that no further diagnostic investigation (e.g. laboratory testing or radiological imaging) is necessary. Of course, however, there is still some uncertainty tied into a pre-test probability of nearly 1.0. Put philosophically, we can never really be *entirely* sure of anything. And put mathematically, even a number that is infinitely large is only ever *approaching* infinity. There are other conditions like headache that require more of a diagnostic work-up including laboratory testing and radiologic imaging because the "differential diagnosis," or pre-test probabilities of multiple different conditions, are often not possible to parse out. That is where post-test probabilities come in. Often, physicians will order multiple different tests to investigate the multiple different conditions on their differential diagnosis, such as CMP, CBC, arterial blood gas with carboxyhemoglobin levels, head CT/MRI, MR venography, and lumbar puncture for the given example of headache. Based on the results of those tests and how sensitive/specific their results are for the diagnosis of the given condition they are connected with, post-test probability estimates will develop in the mind of the physician that, when done correctly, will lead to the "correct" diagnosis of the patient's condition. "Correct" here meaning that multiple other reasonable physicians would come to the same conclusion.

39. Habal FM, Kapila V. Inflammatory bowel disease and pregnancy: evidence, uncertainty and patient decision-making. Can J Gastroenterol. Jan 2009;23(1):49-53. doi:10.1155/2009/531638

- Women with IBD who are in remission at the time of conception appear to have a good chance of having a successful pregnancy with a normal fetal outcome (38,39). With the exception of methotrexate, the majority of drugs appear to be effective and safe during pregnancy, including 5-ASA, antibiotics and corticosteroids. The safety of the newer biological agents on pregnancy has not been fully established. Infliximab is effective in certain patients with refractory disease, and pregnancy outcomes in more than 100 women taking infliximab did not differ from outcomes in the general population. The risks of increased CD activity during pregnancy appear to outweigh the risks of continued infliximab treatment in patients with severe disease. Anti-TNF therapy during pregnancy can be a safe adjunct to current medical management of these patients. One of the most important advances in the management of IBD over the past decade has been recognizing that normal pregnancy outcomes can be achieved when a woman enters the pregnancy in remission. Maternal fears of taking medication that could potentially harm the fetus are understandable, but the potential harm should be weighed against the risks associated with discontinuing treatment (4,23,24). Women with IBD should be informed of the increased risk of adverse pregnancy outcomes (13). Because the available evidence indicates that the best pregnancy outcomes are achieved during remission, women should be counselled to continue taking their medication to maintain remission. Additional

studies are required to clarify IBD-realated issues and pregnancy to assist patient and clinician decision-making. However, the review of the literature to date suggests that a shift in thinking may be required – that current medical therapy, including anti-TNF agents, may indeed be a safe rescue treatment in pregnant patients.

Summary

- In concluding that drugs for IBD treatment are "effective and safe during pregnancy," the authors indirectly call attention to an interesting anecdotal point. When I was working in the OB/GYN department on my core year rotation, faculty and residents consistently emphasized use of the phrase "low risk" rather than "safe." They felt that by telling pregnant patients that their medical decisions during pregnancy were colloquially "safe" was a simplification of the truth as one can anticipate that even though 5-ASA may be "safe" in pregnancy, it would be even safer if the pregnancy were entirely normal without IBD or the need to take 5-ASA at all. Therefore, being prudent with our words can help convey our own inherent clinical uncertainty to patients that may be making medical decisions that have potentially lifelong effects on themselves or their fetuses. The decision of taking a medication regardless of how "safe" or "low risk" it is, however, nevertheless requires risk-benefit analysis which is evidently an underpinning theme of how physicians and patients alike approach medical uncertainty.

40. Lien CY, Lin HR, Kuo IT, Chen ML. Perceived uncertainty, social support and psychological adjustment in older patients with cancer being treated with surgery. J Clin Nurs. Aug 2009;18(16):2311-9. doi:10.1111/j.1365-2702.2008.02549.x

- Uncertainty varied with cancer stage. At the time of surgery, the patients had moderate levels of uncertainty. There was a significant decrease in uncertainty at the second data collection period before hospital discharge. In these participants, anxiety was significantly associated with past medical history. The participants obtained social support from family members, physicians, nurses, relatives and other patients. Married patients had higher levels of social support than those without a spouse. Significant relationships were found among uncertainty and anxiety and depression. Interestingly, a positive relationship between anxiety and social support after surgery was also identified.

Summary

- Logically, patients experience increasing levels of uncertainty as invasive medical interventions such as surgery draw near. This uncertainty tapers, however, as patients recover postoperatively and are healed by the passage of time, so-to-speak. I would imagine these decreasing levels of uncertainty are manifold in origin, being derived from a combination of feeling better in the long-run and escaping surgical complications that patients reason will likely crop up sooner than later following surgery. Given that "significant relationships were found among uncertainty and anxiety and depression" amongst patients, it would be fascinating to examine if the same were true amongst physicians. Do surgeons or non-surgeons have a higher prevalence of anxiety and depression? Does such prevalence exacerbate the objective quantity or subjective quality of clinical uncertainty?

41. Mishel MH, Germino BB, Lin L, et al. Managing uncertainty about treatment decision making in early stage prostate cancer: a randomized clinical trial. Patient Educ Couns. Dec 2009;77(3):349-59. doi:10.1016/j.pec.2009.09.009

- Significant main effects for the treatment groups were found for uncertainty management (cancer knowledge, problem-solving, and patient-provider communication), medical communication competence, number and helpfulness of resources for information, and decisional regret. The intervention was effective in uncertainty management for Caucasian and African-American men, specifically in preparing competent patients with improved knowledge, problem-solving skills, information resources, and communication skills. Using the Uncertainty in Illness Theory, specific skills were selected with a focus on the antecedents of uncertainty. In the treatment decision-making context, patients and supportive others need information about disease, treatment options and side effects but they also need communication skills training prior to the treatment decision consultation.

Summary

- Even when a theoretically perfect shared-decision making process is utilized for presenting patients with their medical and surgical options, there is nagging persistence of uncertainty maintaining its ubiquitous existence as physicians can never be sure if a patient truly understood the shared-decision making process. Interestingly, this paper found that patient uncertainty and decisional regret can be reduced if we employ a strategy to teach patients the biomedical and logical basics driving what information the physician is sharing and how they are going about sharing it. In the setting of cancer management, this could be established as the authors describe by having an individualized training session (being individualized by having the patients complete a standardized pre-test assessing existing and gaps in knowledge/expectations) for patients and family member(s) prior to their appointment with their medical/surgical oncologist to prime their understanding of what may be discussed. Of course, this is a very resource-intensive endeavor with much standardization of the training session's skeleton required for various sites of clinical implementation (e.g. throughout the hospital when difficult or uncertain clinical decisions are anticipated). The authors had nurses be the main point of patient contact for the study, who were trained in coaching patients on the aforementioned items. Anecdotally, this reminds me quite a bit of the integrated, attentive, and personal role that nurses play in the coordination of evaluating patients for organ transplantation.

42. Moores LK. Medical uncertainty: informing decision making for patients with acute pulmonary embolism. Chest. Oct 2009;136(4):952-953. doi:10.1378/chest.09-1092

- LRs are not dependent on the prevalence of the disease in question. Predictive values relate to populations, whereas LRs can be applied to a specific patient. Most importantly, LRs help clinicians in areas of clinical uncertainty.8 Application of the LR of a diagnostic test after determination of the pretest probability of disease (obtained either empirically, through prediction scores, or from other diagnostic tests) changes the posttest probability of disease, sometimes dramatically. Tests should be done only when they will affect the management of the patient. In order to affect clinical practice, the negative LR should be low enough to preclude further testing (generally < 0.2) or the positive LR should be high enough to begin treatment (generally > 10).
- However, they noted that neither the positive nor the negative LR of an elevated or normal troponin level in patients with acute PE is extreme enough to either (1) warrant more aggressive therapy, such as thrombolysis, or (2) send a patient home to receive outpatient therapy. Perhaps, rather than looking at the serum troponin level as a

dichotomous test (as was done in the metaanalysis by Jimenez et al6), the determination of categorical levels of troponin might identify serum levels that are more useful in guiding management decisions.9 If so, troponin levels and other cardiac biomarkers (eg, the levels of Nterminal pro-brain natriuretic peptide), when used in conjunction with echocardiographic or CT angiography evidence of right ventricular strain, or with clinical prediction scores, such as the Pulmonary Embolism Severity Index (or PESI), might identify a group of patients with acute PE who will benefit from more aggressive monitoring or treatment. This, in turn, could lead to more costeffective and safe care of these patients

Summary

- This brief commentary supplements what I discussed previously regarding physicians making clinical decisions in a way that utilizes pre-test and post-test probabilities with further details explicated herein about the role of likelihood ratios. Albeit, physicians do not pull a chart out of their pocket every time a patient tells them a symptom or they receive a new test result to see what their pre-test probability is and how their post-test probability is affected by the positive or negative likelihood ratios… Despite not directly saying this point, the author suggests that with enough research-based validation, there could be clinical prediction scores and risk models that could harness in tandem the entire clinical picture of a patient (including laboratory tests, radiologic imaging, etc.) to give uncertain physicians a better idea of which patients are at a higher risk of worse outcomes following pulmonary embolism (according to the given example) and are therefore deserving of more cautious care.

43. Alam M. Uncertainty and variance in the management of high-risk cutaneous squamous cell carcinoma: comment on "Uncertainty in the perioperative management of high-risk cutaneous squamous cell carcinoma among Mohs surgeons". Arch Dermatol. Nov 2010;146(11):1231-2. doi:10.1001/archdermatol.2010.1231

Summary

- **THIS REFERENCE IS A COMMENT ON THE ARTICLE ANNOTATED BELOW. THE COMMENT DOES NOT CONTRIBUTE TO THIS HUMANITIES DISTINCTION TRACK PROJECT.**

44. Jambusaria-Pahlajani A, Hess SD, Katz KA, Berg D, Schmults CD. Uncertainty in the perioperative management of high-risk cutaneous squamous cell carcinoma among Mohs surgeons. Arch Dermatol. Nov 2010;146(11):1225-31. doi:10.1001/archdermatol.2010.323

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- This study highlights the subjectivity that can plague specialties without RCT- or guideline-based evidence supporting clinical decisions. Such clinical practices likely provide a false sense of certainty to clinical decisions that, given the lack of evidence, is actually uncertain in reality. In a counterintuitive result that is frankly a bit of an oxymoron and would likely be disconcerting to patients, “expert” Mohs surgeons had inconsistent and disagreeing practice styles regarding when they perform radiologic nodal staging, adjuvant radiation therapy, and sentinel lymph node biopsy. Relating this to one of the prior articles I read that discussed “practice styles” in more detail, the inconsistency amongst Mohs surgeons cited here likely stems from the practice styles

conferred onto them by their superiors wherever they did their dermatology and Mohs surgery training. These instances make affected aspects of medicine far more of an art than a science which I do not think all patients would be particularly fond of.

45. Politi MC, Légaré F. Physicians' reactions to uncertainty in the context of shared decision making. Patient Educ Couns. Aug 2010;80(2):155-7. doi:10.1016/j.pec.2009.10.030

- Holding one or more graduate degrees in addition to an MD (i.e., more years of formal education) was significantly associated with willingness to disclose uncertainty to patients, a key variable influencing intention to adopt SDM. Formal education in a specific field may allow physicians to explore ways to communicate uncertainty. Education could also help individuals feel more comfortable with concepts needed to communicate uncertainty (e.g. risks, probabilities). Further studies are warranted to explore this relationship and determine whether SDM interventions should incorporate aspects of education related to disclosure of uncertainty. Female physicians reported more anxiety from uncertainty than male physicians. Although eligible non-participants were more likely to be male, possibly introducing a selection bias, these findings are consistent with previous studies [11,13–16]. Residents were also found to experience more anxiety about uncertainty than established physicians, consistent with past findings [17]. Medical experience may have an impact on physicians' reaction to uncertainty. In contrast, working more hours per week was significantly associated with less anxiety from uncertainty. It is possible that working more hours with more patients allows physicians to accept uncertainty inherent in most medical situations. It is also possible that physicians who experience more anxiety from uncertainty choose to work fewer hours.
- The physicians enrolled in the study were all naı¨ve to SDM at the baseline, thus none were likely to engage in the practice. After the intervention, physicians who were more reluctant to disclose uncertainty reported less intention to engage in SDM. Given that SDM requires clinicians to acknowledge and discuss uncertainty, reluctance to disclose uncertainty might lead clinicians to dismiss messages in SDM trainings.

Summary

- There is a positive association between anxiety levels from clinical uncertainty and being female or working fewer hours per week. However, the willingness of providers to disclose that uncertainty to patients has a negative association with possession of a graduate degree in addition to an MD. The authors further contribute to what has been said previously about the various kinds of uncertainty: "Experts conceptualize scientific uncertainty in many ways, including but not limited to: stochastic uncertainty (risk or probability of a future event); ambiguity (uncertainty about the strength or quality of risk estimates, resulting from conflicting study results or differences in study design used to calculate risk); uncertainty from unknown data; and uncertainty resulting from translating population level findings to individuals." Study participants who were more anxious about their clinical uncertainty were also more fearful of sharing those feelings with patients. The authors report that their study participants were actually naïve to the concept of shared-decision making (in 2010?) and, even more concerningly, there was a trend for folks more reluctant of engaging in shared-decision making at baseline to perform it even less after learning about it. It goes without saying that an ideal state of medical education would inculcate students with the understanding that no amount of

uncertainty or lack thereof should prevent disclosure of those feelings to patients or the performance of shared-decision making.

46. Schroen AT, Brenin DR. Breast cancer treatment beliefs and influences among surgeons in areas of scientific uncertainty. Am J Surg. Apr 2010;199(4):491-9. doi:10.1016/j.amjsurg.2009.04.005

- Nine hundred twenty-three responses were received, with 459 eligible for analysis. Responses diverged most regarding significance of positive sentinel lymph node biopsy (SNLB) and role of post-lumpectomy radiation for low-risk ductal carcinoma-in-situ (DCIS). Overall, expert opinion ranked as the most influential information source.
- In each case, the "expert opinion of someone you regard as a leader in the field" ranked as the most influential source of information. In each case, published guidelines or consensus statements were ranked as the second most influential source of information. Academic surgeons, however, consistently ranked published data as more influential than expert opinion.

Summary

- Differing surgical practices "regarding significance of positive sentinel lymph node biopsy (SNLB) and role of post-lumpectomy radiation for low-risk ductal carcinoma-in-situ (DCIS)" may have drastic effects on patient outcomes. Even more concerningly, any astute reader may pose the question, "what does expert opinion mean? Who grants these individuals the title of expert? And what are *they* basing their 'opinion' on?" Academic surgeons were found to consider published data superior to expert opinion. Pontification might yield the concern that academic physicians believe such answers are "expected" of them. Also, unless there are rigorous RCTs and/or society-based guidelines derived from such research evidence, there are times when published data may be subjected to the opinions of the reader when determining whether to apply the results to their clinical practice. Further intriguing findings of the cited paper include regional patterns of immunohistochemistry utilization (potentially indicating so-called aforementioned "practice styles"?), fewer specialty society surgeon members than non-members recommend complete axillary dissection after positive sentinel lymph node biopsy (but members offer sentinel lymph node biopsy in DCIS much more than non-members), academic surgeons were more willing to participate in clinical trials, "83% of surgeons in practice <20 years offered sentinel lymph node biopsy in DCIS as compared to 69% of surgeons in practice >20 years ($P = .002$)" while "surgeons in practice longer than 20 years were more likely to recommend adding post-mastectomy radiation [with one positive lymph node] than surgeons in practice a shorter duration (24% vs 10%, respectively; $P < .001$)," and surgeons with a larger breast cancer patient caseload offer sentinel lymph node biopsy in DCIS more often than those with smaller caseloads. There is much to unpack and speculate about here. Regardless, these areas of uncertainty amongst breast surgeons begs for gold-standards to be developed.

47. Fraenkel L. Uncertainty and patients' preferred role in decision making. Patient Educ Couns. Jan 2011;82(1):130-2. doi:10.1016/j.pec.2010.02.026

- Patients' perceived seriousness of the decision was associated with an increased desire to participate. Several studies have found that sicker patients prefer more passive roles (2,9,10). While older age is associated with preference for a more passive role, other

demographic factors, including gender, education and race do not consistently predict patients' role preferences

Summary

- There is an argument to be made regarding the value of physicians first assessing which decision style their patient prefers (whether they would like to take a strong leading role, be an active co-participant, follow whatever their doctor advises, or anywhere else along this spectrum) prior to approaching with a style of sharing information that is individualized for their patient. Being older or sicker may predispose patients to take on a more passive decision-making role, but medical decisions whose outcomes carry heavy consequences tend to motivate patients to be more of an active participant or leader. This may prove to be an important difference in the way that surgeons versus non-surgeons encounter patients where one may be able to posit that patients view surgery as carrying heavier consequences than starting most medications than can simply be stopped alongside their side effects. Importantly, though, it is easy to perceive that the role patients want to take in the shared-decision making process has multifactorial influences such as previous experiences with healthcare, health literacy, values, personality, perspective(s) of trusted loved ones, and so forth. It would be interesting to see if the certainty of a physician affects the role that *they* prefer to play in medical decision-making. I anticipate that it would, with certain doctors preferring to lead the patient encounter and uncertain doctors tending to give all of the options to patients for the patients to then decide. There is an obvious disconnect here as patients tend to prefer a greater amount of physician input when clinical circumstances are uncertain.

48. Melhado L, Bushy A. Exploring uncertainty in advance care planning in African Americans: does low health literacy influence decision making preference at end of life. Am J Hosp Palliat Care. Nov 2011;28(7):495-500. doi:10.1177/1049909110398005

- Advance care planning focuses on the set of uncertainties that are most challenging and discussions are centered on obtaining directives for end-of-life preferences, but if the clinician is uncertain about the prognosis or uncomfortable with end-of-life discussions, the clinician's uncertainties may add to the burden of the advance care planning leading to indecision and continuing life-sustaining treatments
- For example, if the clinician assumes that the uncertainty is rooted in lack of information, he or she is inclined to provide even more information. If the patient's uncertainty stems from information that is too complex to understand or mistrust in the clinician, information may fail to facilitate efforts that lead to advance care planning.

Summary

- Clinician uncertainty is found very strikingly in the difficulty of prognostication, and this uncertainty with concomitant prognostic difficulty can be problematic for patients and their family members wanting to establish advance care planning or determine whether to continue life-sustaining treatment. Once again, when physicians would prefer to not take-a-stand in uncertain clinical situations, the patients that were presented all of the options without a recommendation would like their doctor *to* take-a-stand and offer their advice with all of their expected medical expertise. As aforementioned, the certainty of patients is strongly dependent on their health or medical literacy – understandably given how much training doctors receive to reach the position they occupy – and it may be wise to perform interventions to *prepare* patients via a standardized approach to receive the

clinical information they need to make a decision on. When constructing end-of-life plans, the arguably worst possible outcome is patients or families making legal decisions predicated on uncertainties and misunderstandings that go unreported on their part and uninvestigated by the physician, leading to end-of-life care enactments that may not truly be what the patient and family wants. The likelihood of this is increased due to the observation we have seen elsewhere that people are generally afraid of being vulnerably outspoken about their uncertainty.

49. Politi MC, Clark MA, Ombao H, Dizon D, Elwyn G. Communicating uncertainty can lead to less decision satisfaction: a necessary cost of involving patients in shared decision making? Health Expect. Mar 2011;14(1):84-91. doi:10.1111/j.1369-7625.2010.00626.x

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- Unfortunately for the movement of motivating physicians to exemplify honesty with their patients about their uncertainty regarding certain healthcare decisions, this study showed that patients experience higher rates of dissatisfaction with their decision when physicians voiced their clinical uncertainty. Fortunately for this movement, however, this effect was tempered by involving patients in their medical decisions. This should be expected given the preponderance of evidence and logic supporting utilization of shared-decision making whenever it is possible. It is also expected that patients receiving cancer care (the population surveyed in this study) would be especially disappointed when they go to a cancer doctor hoping for hope and receiving honest yet equivocal physician uncertainty.

50. Politi MC, Street RL, Jr. The importance of communication in collaborative decision making: facilitating shared mind and the management of uncertainty. J Eval Clin Pract. Aug 2011;17(4):579-84. doi:10.1111/j.1365-2753.2010.01549.x

- Thus a number of scholars [1–3] have defined quality medical decisions as those that (1) are based on the best clinical evidence; (2) incorporate the patient's values and preferences; (3) involve the patient in the decision-making processes to the extent that the patient wants or needs to be; (4) are endorsed by patient/ family and clinicians; and (5) are feasible to implement

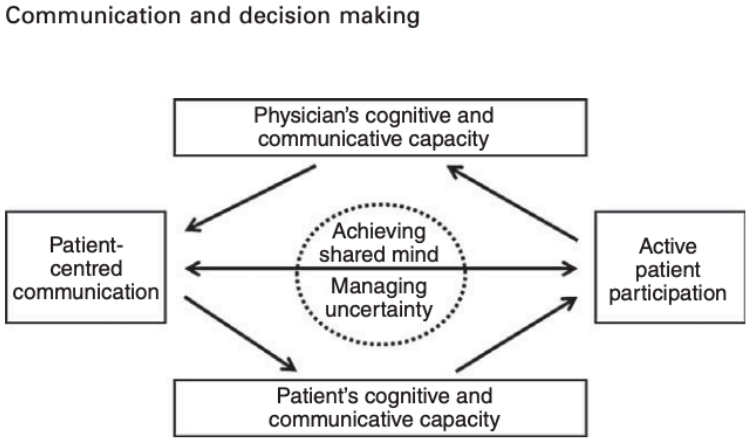


Figure 1 Model of collaborative decision making.

- In order to successfully engage in collaborative decision making, clinicians and patient must have both cognitive and communicative capacity to do so. For clinicians, cognitive capacity represents knowledge of the clinical evidence, clinical experience, knowledge of the patients' context, and perceptions of the patient. For the patient, cognitive capacity represents understanding of the clinical evidence, relevant personal experiences and perception of the clinician.
- Doctors may be hesitant to communicate uncertainty for several reasons. They may have been trained to display confidence to patients and emphasize an illusion of certainty to increase patients' trust in the information presented [21,22]. Doctors also fear that the complexity of uncertainty might lead to confusion and anxiety [23,24] and could lead patients to delay or reject decision making as a result. Doctors' own discomfort with uncertainty might also lead them to engage in a more paternalistic style of decision communication
- Finally, individual treating professionals involved in a patient's care might differ in their interpretation of uncertain or insufficient clinical evidence. For example, guidelines for the treatment of early stage prostate cancer include active surveillance (also called 'watchful waiting'), radiation therapy, or surgery depending on patients' individual circumstances and preferences. However, a radiation oncologist might recommend radiation as a first line treatment for prostate cancer, a surgeon might recommend surgery, and a gerontologist might recommend active surveillance, even while acknowledging the other valid treatment options. These practitioners need to be proactive in managing the uncertainty that often is created by multiple conversations with multiple treating professionals

Summary

- In a way that could not be said better myself, the authors argue herein that "Strategies such as providing clear explanations, checking for understanding, eliciting the patient's values, concerns, needs, finding common ground, reaching consensus on a treatment plan, and establishing a mutually acceptable follow-up plan can facilitate collaborative decision making." It should be the goal of the reasonable physician to make the best clinical decisions possible for their patients which may be accomplished by employing evidence-based diagnosis/treatment, being mindful of the patients' values/goals/expectations, utilizing those patient values/goals/expectations to help them occupy the role in clinical decision-making that is most agreeable to them, and can be reasonably enacted. The requirement of clinicians to have "cognitive and communicative capacity" to "engage in collaborative decision making," which includes "knowledge of the patients' context and perceptions of the patient" makes this endeavor arguably more difficult for surgeons. Some may content that surgery is the specialty with the littlest continuity of care; patients present with a problem needing fixing, surgeons fix that problem, and the patients *maybe* have one surgical follow-up appointment. Surgeons therefore have to know their patients as well as their respective context and perceptions very quickly (e.g. within perhaps one appointment) and probably incompletely relative to non-surgeons where managing medical problems are usually more chronic in nature. Unlike medical management, ongoing conversation about the uncertainty of surgical management cannot occur after the surgery has been performed and the "damage has been done," so to speak – although hopefully the damage was helpful. The likely truths presented here to explain why doctors may be hesitant to communicate their uncertainty

with patients (i.e. displaying confidence to gain trust, fearing the complexity is too much for the patient to understand and that they might just give up, resorting to a paternalistic defense mechanism) can be added to with conceptualization of the state of modern medicine. Seemingly at a higher and higher frequency, patients might prefer alternative or homeopathic therapies if they are available in addition to patients exhibiting growing vaccine hesitancy. Physicians who prefer a more strictly allopathic practice style may be worried that admitting any uncertainty in their "evidence-based" Western medicine will exacerbate the homeopathic tendencies in their patients and worsen their health outcomes. Another intriguing point was addressed in this paper which is the capacity for different physician specialties to address clinical uncertainty in different ways according to how their specialty might prefer to approach a problem, simply on the basis of familiarity. The engagement of patients with academic medicine may further their uncertainty if "a radiation oncologist might recommend radiation as a first line treatment for prostate cancer, a surgeon might recommend surgery, and a gerontologist might recommend active surveillance."

51. Fisher M, Ridley S. Uncertainty in end-of-life care and shared decision making. Crit Care Resusc. Mar 2012;14(1):81-7.

- Assessing the appropriateness of continuing life support is a difficult task for intensive care unit staff. Part of this difficulty relates to prognostic uncertainty and the varying reliability of clinical decisions. Uncertainty about prognosis is quickly recognised by patients and families, and can be a source of mistrust and potential conflict.
- The collective wisdom of experienced health care workers with good communication skills and informed patient advocates increases the likelihood of achieving practical certainty and the best decisions
- Dunstan proposed that intensive care should be judged by the quality of life of those who survive rather than the number of lives saved, and by the quality of death of those in whose best interest it is to die.1
- A hallmark of clinicians is the ability to tolerate uncertainty. In clinical practice, this is often managed by deindividualising the patients, denying uncertainty, redefining the problem to eliminate uncertainty, shrinking the problem to smaller dimensions, and recognising that present uncertainty will resolve in time.
- Different religious and ethnic beliefs between countries are known to affect how end-of-life decisions are made.39 However, as society becomes more pluralist, differences between the patient and the clinical staff may cause problems when treating minority groups. There may be apprehension about being culturally inappropriate, inadvertently causing offence or appearing discriminatory or racist. If this is not recognised and managed, it may lead to uncertainty, disempowerment and inertia in practice.4
- If this process is adhered to, it may be reasonable to say to patients and families that "we are as certain as we can possibly be". Practical certainty can also be applied to determining patient's wishes, where, in contrast to prognosis, the major source of information will be the family

Summary

- Prognostic uncertainty is certainly one of the most difficult and complicated challenges faced by doctors staffing the intensive care unit with contemplation of allowing the patient an honorable, peaceful, and pain-free death versus attempting all the life-saving

efforts modern medicine allows despite an appreciable likelihood for the patient to enter a life state that would be unacceptable to them. The prospect of reaching "practical certainty" despite a palpably real clinical uncertainty is fascinating nonetheless. In a way not quite encountered in other papers, the one here says that clinicians manage their uncertainty by "deindividualising the patients, denying uncertainty, redefining the problem to eliminate uncertainty, shrinking the problem to smaller dimensions, and recognising that present uncertainty will resolve in time." The way that this so-called "practical certainty" might be achieved is through a combinatorial use of severity-of-illness scoring systems, agreement amongst fellow physicians (which is few and far between with much disagreement about the prognosis of hypothetical patients, although ICU doctors are more likely to anticipate a much worse prognosis than reality for the "sickest" patients), and facilitating family conferences. Yet another source of uncertainty in both prognosticating and advising patients on the continuation or withdrawal of care is the lack of formal cultural education that takes place in medical school. One might consider this as part of the "hidden curriculum," but a medical student, resident physician, or faculty physician may nevertheless encounter a patient who is part of a culture different than their own which the clinician is unfamiliar with. This may lead to culturally inappropriate recommendations being made at the end of life (for some cultures, withdrawing/continuing care may not even be an option). A question that I have for the advocation of this "practical certainty," however, is whether promoting such a concept is falling into the same aforementioned trap of physicians simply being in denial of uncertainty. Separately from anything this article reports, but where my mind wandered while reading this paper, I wonder how often life-saving/sustaining care is withdrawn from exceptionally sick patients due to a sort of ICU culture where patients that do not "look as good" as the others are written off as likely to die and given up on. This, of course, then frees up an ICU bed to be filled with another patient that non-ICU doctors have been repeatedly calling for the admission of.

52. Kirkegaard P, Risør MB, Edwards A, Junge AG, Thomsen JL. Speaking of risk, managing uncertainty: decision-making about cholesterol-reducing treatment in general practice. Qual Prim Care. 2012;20(4):245-52.

- The study identified two modalities of medical uncertainty: epistemological uncertainty about scientific knowledge and evidence-based medicine; and situational uncertainty produced in the one-to-one relationship between the GP and the patient during the consultation. The study also stressed that the decision making about cholesterol-reducing treatment is interpreted by the GPs as reversible and provisional.
- The GPs in the study disagreed strongly on whether to recommend cholesterol-reducing medication to patients with high cholesterol but without manifest morbidity. Some relied on the 'newest evidence' produced by scientific trials and stressed the importance of commanding knowledge and skills of continually advancing modern medicine in order to optimise and standardise patient care. Others, however, argued that too little is known about the effect of cholesterol reduction in otherwise healthy patients. When they discussed the role of scientific knowledge and evidence-based medicine, they agreed that science and evidence should form the basis of medical practice, but also felt that it is impossible 'to know all'

- Fox distinguishes between epistemological 'collective-oriented' uncertainty, derived from the limitation in current medical knowledge; epistemological 'individual-oriented' uncertainty, derived from the individual doctor's inability to know all; and epistemological uncertainty, derived from the individual doctor's inability to distinguish between the two.37 Beresford distinguishes between 'technical' uncertainty, derived from limitations in current medical knowledge, 'personal' uncertainty derived from the doctor's inability to know the patient's wishes, and 'conceptual' uncertainty, which derives from the application of abstract knowledge to concrete situations.39 Edwards et al distinguish between 'collective professional uncertainty' (similar to Fox's collective-oriented uncertainty and Beresford's technical uncertainty), 'individual professional uncertainty' (similar to Fox's individual-oriented uncertainty) and stochastic uncertainty.40

Summary

- The primary findings of this paper reiterate those that we have discussed elsewhere such that uncertainty exists within both the scientific evidence itself and in the complexity of interpersonal interaction. The advantage, or "saving grace" if you will, for non-surgeons managing medical uncertainty is that the majority of their interventions are pharmacological and can be stopped at any time with likely reversal of undesirable side effects. It may be that, as seen in this study, there are some providers that when faced with medical uncertainty, they trailblaze into the cutting edge of research and provide guidance based on whatever the newest/most reliable evidence recommends… even if this means making a different recommendation every week for each new trial that becomes published! Other providers, however, have a more cautious approach and want to wait until both short-term trials and longitudinal studies are published to better inform the recommendations they make to patients. In the meantime, then, those more cautious providers may be either (1) presenting all the options to their patients and letting them decide or (2) occupying a position of complete inaction which may result in harm for their patients. A problem identified by the general practitioners interviewed for this study is the difficulty of applying study data – which is inherently epidemiological, or population-based – to their singular patients. Furthermore, it is impossible to ever be sure of a patient's complete context, values, expectations, worries, and lifestyle to help eliminate the aforementioned "situational uncertainty." The authors nicely review the various other kinds of uncertainty that have been explored in the literature. They strongly argue that different medical situations may place a greater stress on certain forms of uncertainty, like situational uncertainty being the focus of conversations surrounding primary prophylaxis of ASCVD with statins – which in 2012 was evidently more uncertain than it is today. The fact that many of these articles use examples of clinical uncertainty that have since become more certain is a sincere source of hope. Importantly, and interestingly, doctors appear to "recommend treatment in cases of medical uncertainty," but "patients have been shown to prefer watchful waiting over treatment when faced with medical uncertainty." More thought should be devoted to why this is. Are doctors more death averse than patients? This might make sense given all of the medical training that goes into holding off this "enemy" for as long as possible. Are patients blissfully ignorant of their likelihood of poor health outcomes if treatment is not pursued (even if uncertain); for example, even if a myocardial infarction does not result in death, it might cause debilitating heart failure or arrhythmia.

53. Marshall MJ, Bethune R, Daniels IR. Response to Rosenberg et al.: Current controversies in colorectal surgery: the way to resolve uncertainty and move forward. Colorectal Dis. Aug 2012;14(8):1028-9. doi:10.1111/j.1463-1318.2012.03083.x

- **THIS REFERENCE IS A COMMENT ON THE ARTICLE ANNOTATED BELOW.**

Summary

- The authors make interesting comments contrary to the article annotated below related to the performance of RCTs in surgery. Specifically, they argue that surgical RCTs are arguably unethical given that the "testing" arm is likely to be adopted in surgery anyways; so, to compare this new surgical technique that would – based on the historical precedent of surgery – be implemented regardless of an RCT, comparing it against a control arm of patients receiving the older surgery opens the door for those control arm patients to have worse outcomes. Those worse outcomes would have been avoided had the surgeons simply stuck with the *status quo* of their predecessors by adopting newer and therefore supposedly better surgical strategies as they crop up in the literature. They also comment on a topic that has been addressed elsewhere: much research can be done into the use of new technologies, types of incisions, etc. in surgery, but the bottom-line is that such details "are dependent upon the surgeon and his or her decision-making; the instruments do not perform the surgery."

54. Rosenberg J, Fischer A, Haglind E. Current controversies in colorectal surgery: the way to resolve uncertainty and move forward. Colorectal Dis. Mar 2012;14(3):266-9. doi:10.1111/j.1463-1318.2011.02896.x

- A way forward could therefore be to form multicenter and even multinational research groups in order to ensure accrual of sufficient sample sizes.
- In surgery there is a tendency to disregard the normal scientific methods of evaluation [19], whereas in medicine it is fully established that a new drug cannot be used without formal assessment according to strict scientific principles. The risk in surgery is that new and unproven techniques will spread rapidly. If the hypothesis behind a new technique cannot be realized, this will be very difficult to find out and report because it has become 'standard care'.
- If we want to retain the respect of colleagues from other areas of medicine, and if we want to improve outcome and not harm the patients, we have to behave as responsible academics.

Summary

- These authors suggest that the reason for lacking surgical RCT data is because of a lack of statistical power that may be ameliorated by forming "multicenter and even multinational research groups in order to ensure accrual of sufficient sample sizes." I question where the tendency for surgical approaches to be implemented without academically sufficient research supporting such implementation came from. Could this relate to the proposition that a certain surgical technique is only as good as the surgeon utilizing it? In other words, one surgeon might pick up the technique and note that their patients are doing suddenly much better. One can understand how incentivizing this would be for the surgeon to continue using this surgical approach despite not having rigorous scientific backing. Relative to the comment annotated above, it is reassuring, concerning, and fascinating nonetheless that surgeons are so divided over this point of

establishing RCTs to guide their surgical management. It is definitely clear from other articles that the apparent lack of evidence-based medicine practiced by surgeons is a chronic tongue-in-cheek joke so widely found amusing that it has been immortalized in the medical literature.

55. Simmonds MJ, Derghazarian T, Vlaeyen JW. Physiotherapists' knowledge, attitudes, and intolerance of uncertainty influence decision making in low back pain. Clin J Pain. Jul 2012;28(6):467-74. doi:10.1097/AJP.0b013e31825bfe65

- **IT WAS FELT THAT THIS ARTICLE WAS INAPPROPRIATE FOR THE REVIEW ARTICLE GIVEN THE AUTHOR'S DISCUSSION OF PHYSICAL THERAPISTS MAKING DECISIONS OUTSIDE THE CONTEXT OF PHYSICIANS.**

56. Stone AM, Lammers JC. The uncertainty room: strategies for managing uncertainty in a surgical waiting room. Perm J. Fall 2012;16(4):27-30. doi:10.7812/tpp/12-028

- The surgical waiting room represents the intersection of several sources of uncertainty that families experience. Findings also illustrate the ways in which staff manage the uncertainty of families in the waiting room by communicating support. Staff in surgical waiting rooms are responsible for managing family members' uncertainty related to insufficient information. Practically, this study provided some evidence that staff are expected to help manage the uncertainty that is typical in a surgical waiting room, further highlighting the important role of communication in improving family members' experiences.
- Family members are likely to feel uncertain as they wait for their loved one to come out of surgery, despite attempts to create comfortable waiting spaces.1,2 Much research on waiting rooms has focused on physical changes (eg, lowering the volume of the television, having a pot of coffee available, and providing more comfortable chairs).1,3 Some studies have highlighted the important role that staff play in supporting family members through a difficult time

Summary

- I am admittedly flabbergasted that much research has gone into something as unexpected as how to minimize the amount of uncertainty one experiences inside of a waiting room based on how it is organized. Justifiably, a strong source of uncertainty amongst the family members of patients receiving surgery was due to miscommunication or inadequate communication from surgeons. For example, the authors here nicely highlight the fact that patients/family members will commonly ask how long the surgery will take. Surgeons will likely respond with the intraoperative time, not noting that it will be *longer* until the family and the patient can be reunited – which is often what the patients/family members are asking. This may cause much undue familial anxiety as they question "why it is 'taking so long.'" There is a point in this article where "distraction" is described as a strategy to "manipulate the uncertainty of others." I wonder how that plays into our research here?

57. Suzuki M. Quality of life, uncertainty, and perceived involvement in decision making in patients with head and neck cancer. Oncol Nurs Forum. Nov 2012;39(6):541-8. doi:10.1188/12.Onf.541-548

Summary

- Nothing from this article stands out as being particularly useful for the goals of this Humanities Distinction Track project outside of what has already been mentioned elsewhere.

58. Cristancho SM, Apramian T, Vanstone M, Lingard L, Ott M, Novick RJ. Understanding clinical uncertainty: what is going on when experienced surgeons are not sure what to do? Acad Med. Oct 2013;88(10):1516-21. doi:10.1097/ACM.0b013e3182a3116f

- Factors such as the novelty of the situation, difficulty in predicting the outcome, and difficulty deciding the course of action mainly characterize an uncertain situation in surgery according to the participants.
- The naturalistic decision making (NDM) framework10 was one theory that began to inform research into the role of uncertainty in decision making, particularly in Lipshitz and Strauss's11 work in the late 1990s, which conceptualized uncertainty as characterized by inadequate understanding (i.e., a sense of not having sufficiently coherent situation awareness), incomplete information (i.e., a sense of having incomplete, ambiguous, or unreliable information), and conflicting alternatives (i.e., a sense that available alternatives are insufficiently differentiated).

Summary

- It makes sense that the clinical uncertainty encountered by faculty surgeons likely decreases over time as they become more comfortable in their practice and exposed to the broad extent of surgical decisions they need to make on a regular basis. The same is true of non-surgeons. Therefore, the more novel situations with accompanying difficulty predicting the proper course of action and predicting the likely outcome are most likely to cause the greatest uncertainty for all surgeons, but especially the experienced surgeons that may otherwise be less uncertain than others by virtue of simply "being around" longer and "seeing more." Prior to entering the operating room, there may be anticipated complications that do not occur, and entirely unanticipated complications that completely derail the case – such as peculiar anatomies. As in other papers, the authors here outline various other explorations of the types of clinical uncertainty in the literature such as "inadequate understanding, incomplete information, and conflicting alternatives." There is a digression of addressing the argument from other authors that clinical uncertainty is a cause for physicians to veer into unsafe decision-making practices. Put colloquially, clinical uncertainty can purportedly make doctors act 'more cowboy.' The authors here aptly articulate that this behavior may conversely "be conceptualized as necessary deviations employed as individuals attempt to cope with conflicting demands in complex and uncertain situations," which may also lead to "long-term innovation" in the field rather than causing healthcare providers to be more accepting of rash decision-making. The operating room can be subjected to uncertainty-inducing influences that are not as expected as patient-related characteristics, such as the external factors of being on-call and having to staff new consults while operating and 'keep everything straight,' as it were. The main way that the authors noticed surgeons to respond to uncertainty is via "prioritizing alternatives, reevaluating and adapting the plan, creating innovative solutions, and seeking advice." I would argue that non-surgeons wrestle with clinical uncertainty in the same way, but the need to create innovative solutions is more uniquely surgical. Each moment that a surgeon encounters an issue that raises the requirement to

respond to uncertainty, they perform "risk management, [analyze] potential outcomes, and [anticipate] technical issues" prior to performing the next intraoperative technical motion. Non-surgeons, on the other hand, often do not try to become creative with their prescription of drugs for indications they are not FDA approved for – as an example. It may be reasonable to argue here as well that creative medical actions need to be performed by surgeons much quicker on average than non-surgeons. Perhaps the largest source of intra-operative uncertainty is incomplete visualization, where no amount of overhead or headlamp light can allow a surgeon to see exactly what they want. This requires surgeons to "operate by feel" where they use their sense of touch and knowledge of anatomy to assess the practicality of their next surgical maneuver – if it is even possible to do at all. Dealing with intra-operative uncertainty may include utilizing surgical instruments for intentions they are not routinely employed for to solve problems with unique and innovative solutions. Once again, this is often not something explored by non-surgeons outside of taking advantage of medication side effects to treat multiple conditions at once (e.g. bupropion for depression and smoking cessation or propranolol for migraine prophylaxis and social anxiety). Uncertainty in the surgical setting, when encountered by 'good' surgeons, breeds adaptation and creativity. This requires great prudence so that a moment intended to be innovative does not lead to a mistake and poor surgical outcome that would have been avoided had more standard protocols been followed – although, perhaps then the surgical outcome would have been poor anyway since the surgeon would not have had to innovate if standard protocols were working. Surgeons must be cautious to distinguish the "fine line [between] 'being innovative' from 'being lucky'."

59. McCullough LB. The professional medical ethics model of decision making under conditions of clinical uncertainty. Med Care Res Rev. Feb 2013;70(1 Suppl):141s-158s. doi:10.1177/1077558712461952

- The professional medical ethics model of decision making may be applied to decisions clinicians and patients make under the conditions of clinical uncertainty that exist when evidence is low or very low. This model uses the ethical concepts of medicine as a profession, the professional virtues of integrity and candor and the patient's virtue of prudence, the moral management of medical uncertainty, and trial of intervention. These features combine to justifiably constrain clinicians' and patients' autonomy with the goal of preventing nondeliberative decisions of patients and clinicians. To prevent biased recommendations by the clinician that promote such nondeliberative decisions, medically reasonable alternatives supported by low or very low evidence should be offered but not recommended.
- The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system is widely used in the development and continuous improvement of clinical practice guidelines (Guyatt et al., 2011). GRADE defines low and very low evidence succinctly: Low: "Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect." Very low: "We have little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of the effect" (Balshem et al., 2011, p. 404).

- Low and very low levels of evidence should be responsibly managed by clinicians by only offering medically reasonable alternatives and not making recommendations among them.
- To the extent that current models of decision making, under whatever rubric, eliminate the constraint of professional integrity on the exercise of patient autonomy, such models deprofessionalize medical ethics (McCullough, 2011). In deprofessionalized medical practice, patient autonomy becomes the overriding ethical consideration. As a consequence, the clinician is at high risk of becoming a mere technical purveyor of clinical information and a reluctant, cautious, self-protective advisor. The expertise of the clinician in making expert clinical judgments about what is in the patient's health-related interests, and therefore what would be prudent for the patient to do in order to protect his or her health-related interests, is subtly but powerfully discounted in deprofessionalized medical ethics. Accounts like Kon's (2010) are at risk for freeing the exercise of patient autonomy from professional integrity and prudence.
- The nature of low levels of evidence does not support recommending a medically reasonable alternative with a low level of evidence over alternative(s) with very low levels of evidence. Not making recommendations in this circumstance protects the patient from the clinician's bias—whether it is based in experience, familiarity, and comfort—toward one alternative. Medically reasonable alternatives with moderate or high levels of evidence should be recommended over alternative(s) with low or very low levels of evidence.

Summary

- By creating an ethical model of decision making that relies on "the professional virtues of integrity and candor and the patient's virtue of prudence, the moral management of medical uncertainty, and trial of intervention," the author of this paper assumes much health literacy within the patient. Although this may sometimes be true, practicality would likely conclude that though the patient may be generally prudent, they are not always so in making medical decisions that they incompletely understand. Indeed, however, the physician should take their best understanding of the patient's "basic values and interests" to play a large role in approaching their medically uncertain clinical decision-making. Interestingly nonetheless, the author believes that by promoting deliberation of medical decisions that would otherwise be "nondeliberative," the differences between diagnostic/therapeutic pathways taken by physician-patient pairs will be minimized and potentially less influenced by the 'practice styles' of different physicians. To analyze the underbelly of this same point, the author clearly articulates that if we place the patient in charge of deliberation and effectively delimit the physician's impact (e.g. "deprofessionalize"), then we would be nullifying the role of the position that a physician has earned which is to make "expert clinical judgments about what is in the patient's health-related interests." Another literature-based tool to define uncertainty that I have not seen before is introduced in this article: The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE). The authors advocates for a bottom-line that is not unique within this field of literature, which is for physicians to simply lay-out all of the "medically reasonable alternatives" *without* recommending any particular option when working with a patient to make a medically uncertain clinical decision. The primary issue with this, as we have addressed elsewhere, is that it is under these circumstances that patients want their doctor to take the lead

despite it being 'easiest' and more 'risk-free' (especially from the legal perspective) for doctors in this position to *not* take the lead. The author basically says this same thing: "Expecting all patients to actively participate in all the components of decision making about plans of care violates the most fundamental form of respect for autonomy: respect for the patient's preference either to make decisions for himself or herself or to delegate this authority to others whom the patient trusts with such tasks (Brody, 1988). Patients who express the latter preference are probably not appropriate candidates for shared decision making or informed decision making, inasmuch as they likely will not welcome its burdens—burdens that increase when evidence is low or very low." Honesty should be used with the patient regardless with an openness of communication that makes it clear to them that the physician is not confident there even is a diagnostic/therapeutic option that would be better than the others. It is under these circumstances that refusing care altogether may be one of the more reasonable things to do from the patient's perspective. As an aside, I wonder to what extent does the Hippocratic Oath act at-odds with versus in-tune with the legalities of medicine? The author goes on to say that physician should not recommend a "low certainty" diagnostic/therapeutic plan over a "very low certainty" plan, since it is likely that the recommendation would be based more on doctoral bias ("whether it is based in experience, familiarity, and comfort") rather than evidence. I might contend in this situation that the patient would prefer choosing that recommendation even despite the "bias" because such bias is (1) apt to be considered a far more professional sort of bias and (2) the patient may continually see their doctor because they trust their expertise and may even have overlapping/complimentary values. This may negate the negative connotation of physician "bias" in recommending a "low certainty" initiative over a "very low certainty" one for their patient.

60. Borg MA. Prolonged perioperative surgical prophylaxis within European hospitals: an exercise in uncertainty avoidance? J Antimicrob Chemother. Apr 2014;69(4):1142-4. doi:10.1093/jac/dkt461

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- As we have discussed elsewhere, a common strategy that physicians use when encountering uncertainty is to "do more," even if accomplishing less, perhaps to make themselves feel better that they did "all they could" for their patients. This article suggests a similar conclusion amongst surgeons from cultures that score higher levels of preferring to avoid uncertainty. These uncertain surgeons were more likely to provide perioperative surgical prophylactic antibiotics for longer than 24 hours prior to surgery – an intervention that has otherwise shown little clinical benefit in the literature. There are many intricate reasons this might occur, however, as perhaps the surgical site infection rates in those 'uncertain culture's' hospitals are so high that the only way they can hope to try and bring them down is through their anecdotal/experiential evidence of providing long timescale perioperative antibiotics.

61. Cunningham BA, Bonham VL, Sellers SL, Yeh HC, Cooper LA. Physicians' anxiety due to uncertainty and use of race in medical decision making. Med Care. Aug 2014;52(8):728-33. doi:10.1097/mlr.0000000000000157

- *Anxiety Due to Uncertainty* (ADU) is a 5-item measure of emotional reactions to clinical uncertainty. *Bonham and Sellers Racial Attributes in Clinical Evaluation* (RACE) scale includes 7 items that measure **self-reported** use of race in medical decision-making. We used bivariate regression to test for associations between physician characteristics, ADU and RACE. Multivariate linear regression was performed to test for associations between ADU and RACE while adjusting for potential confounders.
- The mean score on ADU was 19.9 (SD=5.6). Mean score on RACE was 13.5 (SD=5.6). After adjusting for physician demographics, physicians with higher levels of ADU scored higher on RACE (+β=0.08 in RACE, p=0.04, for each 1-point increase in ADU), as did physicians who understand "race" to mean biological or genetic ancestral, rather than sociocultural, group. Physicians who graduated from a US medical school, completed fellowship, and had more white patients, scored lower on RACE.

Summary

- The "Anxiety Due to Uncertainty" scale is yet another research tool that can be used to measure the uncertainty of clinicians. The paper here suggests that more uncertain physicians tend to use "race" as a factor in their clinical decision-making more often. However, these physicians were also more likely to understand "race" as being equivalent to what is now understood to be "genetic ancestry"; a misconception that is beginning to be purged from US medical schools. Interestingly, I wonder if the more certain physicians who apparently used "race" less in their clinical decision-making and who also did not as highly correlate "race" with "genetic ancestry" did not consistently consider the "race" of the patient because, without any genetic correlates, it does not matter with it being a mere social construct? Is this good or bad? Nonetheless, it goes without saying that the "race" of a patient may influence the decision-making of a physician – especially an uncertain one – regardless because of "implicit bias." I appreciate that the authors state how "a certain amount of anxiety due to uncertainty may push physicians to explore a broad array of potential diagnostic and treatment options in order to make good clinical decisions."

62. Imanaka K, Kawata M, Matsuoka T, Yamabi H. Uncertainty of axillary artery perfusion during surgery for acute aortic dissection. Ann Thorac Surg. May 2014;97(5):1781-2. doi:10.1016/j.athoracsur.2013.08.046

- Nothing from this article stands out as being particularly useful for the goals of this Humanities Distinction Track project outside of what has already been mentioned elsewhere.

63. Lindley SW, Gillies EM, Hassell LA. Communicating diagnostic uncertainty in surgical pathology reports: disparities between sender and receiver. Pathol Res Pract. Oct 2014;210(10):628-33. doi:10.1016/j.prp.2014.04.006

- Surgical pathologists use a variety of phrases to communicate varying degrees of diagnostic certainty which have the potential to be interpreted differently than intended.
- We conclude that non-standardized language used in the communication of diagnostic uncertainty is a significant source of miscommunication, both amongst pathologists and between pathologists and clinicians.
- In our focused study of seven senior clinicians, we found marked variability in the way that the clinicians ranked the certainty associated with various phrases. We also found

varied opinions as to how we should resolve this communication problem from the different clinicians surveyed. Many of the free text comments we received were illuminating, reflecting their own preferred manner for resolving such issues. For example, one surgeon emphasized the need to review the slide directly with the pathologist, or at a minimum have a direct phone conversation. Another emphasized that the issue was not so much grading the degree of uncertainty as it was determining the threshold to treat or pursue further diagnostic evidence.

- An interesting trend appears to be emerging from both our discussion at our institution and those at the national meeting: more recently trained pathologists more fully support national guidelines on terminology while more senior pathologists tend to resist this loss of individuality in reporting. In this and so many other aspects, it will be fascinating to see where the new generations of pathologists take our field. Inasmuch as interpersonal communication is a core competency for physicians and training programs, the issue herein raised centers around a critical practice skill for pathologists, and one where the data might indicate we are not yet fully competent.

Summary

- A strategy not unfamiliar to most – if not all – physicians, "hedging" on one's wording when recording their medical decision-making is quite common. This can manifest in the reading of results with a common example being something like "moderate to severe"; well, which is it? Moderate or severe? This practice extends into pathology, perhaps most unfortunately because the results determined by pathologists is a stern, hard finality that often guides future management of the patient. Ironically, this probably incites pathologists to "hedge" even more, especially when they are uncertain. This uncertainty "may understandably be due to inadequate tissue, or extensive artifact that makes definite interpretation impossible. Other cited reasons for uncertainty include nonstandard histomorphology, ambiguous immunohistochemical stains, lack of clinical information, uncertain criteria in the literature, lack of experience with the diagnosis, and hope (however unsubstantiated) to avoid legal liability for misdiagnosis." The authors here acknowledge that the "hedging" wording used by pathologists is *not* universal and is therefore subject to misinterpretation by surgeons and non-surgeons alike. Some of these phrases are "suggestive of", "worrisome for", "cannot rule out", "highly suspicious for", "favor", and "indefinite for". The uncertainty of the pathologist creates uncertainty of the primary physician about whether the patient truly needs further diagnostic/therapeutic pursuits. Like I discussed elsewhere as a potential solution to this problem, the authors propose adding an area to pathology reports where pathologists can report a numerical value estimating their level of certainty… or lack thereof… in addition to ambitiously creating societal guidelines for wordage in pathology results nationwide. Of course, there is uncertainty within pathologists estimating their own uncertainty and this is likely highly dependent on the comfort that the reporting pathologist has with diagnostic uncertainty.

64. Masuda M, Oishi H, Yamamoto M. Uncertainty in patients with unruptured intracranial aneurysms undergoing endovascular surgery: a qualitative and inductive study. Nurs Res. Sep-Oct 2014;63(5):366-74. doi:10.1097/nnr.0000000000000050

- BACKGROUND: Advances in diagnostic imaging technology have increased opportunities to discover unruptured intracranial aneurysms (UIA), and prior research has

shown that UIA patients experience uncertainty both when making choices regarding treatment and after surgery. OBJECTIVES: The purpose of this study was to clarify the nature of the uncertainty experienced by UIA patients who elect to undergo endovascular surgery. METHODS: Data from interviews with 31 subjects were synthesized with findings from previous research and then analyzed qualitatively and inductively. RESULTS: Six categories were derived from the analysis to describe the uncertainty experienced by UIA patients who undergo intravascular surgery: Nature of the Disease, Treatment Characteristics, Information, Decision-making, Course of the Future, and Living with UIA. DISCUSSION: The Treatment Characteristics and Decision-making categories reflect new aspects of uncertainty arising from advances in diagnostic imaging and appeared specific to patients with UIA. This suggests a need to select appropriate nursing methods adapted to the situation of each patient that can both reduce and manage their uncertainty. Developing an uncertainty scale for UIA patients based on the structural concepts clarified in this study and investigating reliability and validity of scores are topics for future research.

Summary

- The continual progression in radiologic image resolution and diagnostic power will undoubtedly lead to more "incidentalomas," as it were, that are not currently causing patients problems now but may in the future. Patients, knowing they have one of these "incidentalomas," then has to live with the resultant uncertainty unless they approach a doctor – probably a surgeon – about what can be done for management. They parlay their uncertainty onto the supposedly all-knowing physician for a cure, but I imagine that the patients feel the weight of that uncertainty quickly returned to their shoulders as most "incidentalomas" probably do not have strong indications or contraindications for surgery versus medical management. I appreciate how the authors discuss that the categories of thought affecting the uncertainty that patients experience following the diagnosis of unruptured intracranial aneurysm are "Nature of the Disease, Treatment Characteristics, Information, Decision-making, Course of the Future, and Living with UIA." I would like to imagine that the same categories are considered by physicians when determining whether to treat or not to treat.

65. Simpson AL, Ma B, Vasarhelyi EM, Borschneck DP, Ellis RE, James Stewart A. Computation and visualization of uncertainty in surgical navigation. Int J Med Robot. Sep 2014;10(3):332-43. doi:10.1002/rcs.1541

- Recent research has provided methods to compute registration uncertainty (1,2). In other work, we described a method of visualizing registration uncertainty that rendered the 95% confidence interval around the path of a tracked surgical instrument (3). A user study of that method compared the success of locating a tumor with and without registration uncertainty visualization. In the presence of large registration uncertainty, subjects were better able to locate the tumor with uncertainty visualization: the large error caused subjects to fail on their first attempt to localize the tumor; the subjects then used the uncertainty visualization to guide their subsequent attempts, which were more often successful than when uncertainty was not visualized.

Summary

- As I believe I have mentioned elsewhere, harnessing the power of visualizing uncertainty when possible during robotic or laparoscopic surgery undoubtedly carries huge benefit to

surgeons as their perception of the uncertainty places limits on the outer bounds of what surgical maneuvers are possible. It may be advantageous for surgeons to have an understanding of what strategies have been tried before in prior surgeries, especially under uncertain circumstances, with ways to visualize safer and more dangerous technical options based on prior outcomes. One might colloquially describe this as being able to have hundreds of surgeons in their OR during every case (based on the computerized advice of their past successes and failures). In the paper presented here, the authors aptly point out that "Figure 1 shows a commercial surgical navigation system in use clinically for pedicle screw fixation. In the figure, the top right quadrant of the interface is the most interesting. The green (virtual) surgical tool is to be aligned with the yellow planned path. Given that uncertainty exists in the computed tool position, the green virtual tool may appear to be positioned properly when, in fact, the real tool is touching critical structures." Of course, the incidence of this magnitude of error is probably quite small or else the commercial surgical navigation system would not be used so widely. The authors report here that adding visual estimates of uncertainty do not negatively impact the ability of commercial surgical navigation system users to perform the surgery.

66. Berger Z. Navigating the unknown: shared decision-making in the face of uncertainty. J Gen Intern Med. May 2015;30(5):675-8. doi:10.1007/s11606-014-3074-8

- Han et al. define uncertainty as a "subjective perception of ignorance" 7 . Another definition might encompass multiple domains of uncertainty, such as epistemological uncertainty (arising out of the incompleteness or inapplicability of knowledge) and situational uncertainty (arising out of the physician–patient encounter).8 A more pragmatic approach might acknowledge that uncertainty comes in many different forms that may overlap—e.- g., a patient's feeling that the available evidence is not applicable to her might be exacerbated in the moment of decision.

Table 1. Uncertainty Toolbox: Principles in the Approach to Uncertainty in the Clinical Encounter

Principle	Definition or Clarification	Example	Reference
Honesty	Intersects with other concepts such as integrity, truth-telling; empowers patients to decide on the course of therapy	"Whether statins should be used to prevent heart disease is a matter of dispute."	10
Recognition of emotion	Explicit mention of the non-cognitive element of the decision that may be felt by patient or provider	"It seems like you are very nervous about the possibility of cancer. I understand that might play into your desire to have a mammogram at your age."	11
Hope	The ability to envisage a positive outlook	"There is every reason to believe that regular activity and a healthy diet can favorably affect the progression of knee osteoarthritis."	12
Support/coordination of care	Presenting possible options and following up on their execution	"While I do not think that the evidence for prostate biopsy is unequivocal, many people would see a urologist in this instance, and I could discuss with him the goals for a referral."	13
Willingness to readdress	Actively presenting the possibility of future discussions in which other options might be chosen	"We can come back to this decision later. If things get worse you might want to make another choice."	14
Respecting personal decisions	Explicitly stating that the decision can rely on the patient's personal preference and that the provider will respect that	"While we are sharing the process of making this decision, you should feel free to make a decision which is right for you."	3
A lack of decision is possible	Offering the status quo as an option	"You don't have to make a decision right now."	15,16

- In real-world settings, there are gaps remaining with regard to implementation of DAs. For example, the review by Stacey et al.25 showed a lack of evidence regarding the effectiveness of DAs in identifying situations in which a decision could be made, as well

as inconsistent evidence regarding the types of decisions for which DAs actually resulted in a change in patient choice: such change was found in 3 of 46 different decisions. For most types of decisions, the evidence regarding the effect of DAs is mixed, of low quality, or shows no effect at all. The effects of DAs were limited with respect to the ultimate choice that the patient made and on their satisfaction with the decision-making process.

Summary

- Useful definitions of uncertainty are provided in the beginning of this article. Intriguingly, this paper introduces the idea of encountering clinical uncertainty as harnessing a toolbox of multiple different possibly effective strategies that can be utilized and exchanged to find the best "tool," as it were, to fit the job. An excellent table of these strategies was screenshotted and included above. Despite other articles arguing for the utility of decision aids, especially under circumstances of clinical uncertainty, the data has suggested these interventions to lack consistent evidence-based utility for bolstering healthcare provision – despite it decreasing the *feeling* of uncertainty by the provider. This draws attention to the point that uncertain clinicians do not provide worse care. One might liken this to taking a doctoral board exam: you may frequently feel uncertain about your answer choices, but you will likely do well given that you choose the "best" answer.

67. Santos AA, Moura JA, de Araújo JM. A Conceptual Framework for Decision-making Support in Uncertainty- and Risk-based Diagnosis of Rare Clinical Cases by Specialist Physicians. Stud Health Technol Inform. 2015;216:857-61.

- **ARTICLE UNABLE TO BE OBTAINED.**

Summary from Abstract

- We have already discussed how clinical uncertainty often leads physicians to "to more" for patients, which can be viewed as a two-sided coin: on one side, the patient is getting thoroughly worked up so that a diagnostic/therapeutic plan can be made; on the other side, the patient is potentially paying higher healthcare costs and accumulating the risk of unnecessary procedures/tests. There may be opportunity for the IT and Clinical Decision Support Systems of hospitals to intervene when these "cures" for uncertainty (e.g. casting the widest diagnostic/therapeutic net they can) begin to be enacted by physicians.

68. Wasfy JH, Armstrong K, Milford CE, Sundt TM. Bicuspid aortic disease and decision making under uncertainty - The limitations of clinical guidelines. Int J Cardiol. Feb 15 2015;181:169-71. doi:10.1016/j.ijcard.2014.12.020

- Medical and surgical specialty societies issue guidelines intending to simplify clinical decision making. By creating objective standards, guidelines provide a mechanism to assess physician decision making and provide a straightforward reference for clinicians. Unfortunately, in some cases, guidelines developed by different organizations or even different workgroups within the same organization can differ [1,2] based at least in part on different interpretations of complex data, engendering confusion for patients and providers.
- In training, medical students and trainees learn to make decisions analytically, and physicians develop over time an intuitive sense of pattern recognition. Psychologists call these two methods of medical decision-making "type 1" and "type 2" processes [6,7]. Type 1 processes are intuitive, gestalt hunches rooted in experience. Type 2 processes, on

the other hand, originate from conscious, resource-intensive, analytic deliberations. When decisions that involve uncertainty with multiple parameters become too complex, physicians revert to type 1 processes — hunches rooted in experience. This can also occur when decisions become more challenging [8]. Unfortunately this type of "expert decision making" depends upon individual experience of the clinician, and is subject to heuristic bias.

- Decision-analytic models created with Monte Carlo techniques capture both stochastic and parameter uncertainty [9]. These models typically are used in the academic literature to establish confidence intervals for a dominant strategy. But the same techniques could be used to convey uncertainty to patients in individual clinical circumstances. The doctor then becomes a guide for the patient, interpreting the data produced by the models, but not the final arbiter. Such an approach would enable incorporation of individual patients' values – and likely would reflect known risks, benefits, and uncertainties more accurately.

Summary

- Providers may deem societal guidelines to be uncertainty-reducers in the sense that they give a widely agreed upon, potential "gold standard" of care to follow. The astute reader will predict the next point, however, that guidelines are frequently a moving target and may cause confusion for patients and providers. The authors here provide the example of guidelines for surgical correction of aortic root dilatation and an example I thought of was normal ranges for cholesterol alongside statin indications. I find that in this swath of literature it is clear that we are stuck between a rock and a hard place: if we are without guidelines, there is uncertainty; if we have guidelines, there is still uncertainty. Albeit, I feel like the former uncertainty is probably greater since the intention of guidelines are to create a reasonable, largely evidence-based rule of thumb that acting upon will be beneficial for patients on the population-wide scale. The authors continue to call attention to valuable ideas such as the fact that medicine's reliance on population-based medicine is made more inaccurate by the likely extensive amount of people with the disease in question who are asymptomatic or simply never interact with the healthcare system – as in aortic root dilatation (selection bias). Even with guidelines or RCTs guiding certain clinical decisions, a prudent physician must still battle with the uncertainty of determining whether the external validity of the underlying studies apply to their singular patient. And, even if the external validity *does* apply, they must then battle with however hedging the confidence intervals supporting that $p < 0.05$ value might be. I have always been fascinated by the discussion of Type 1 and Type 2 decision-making processes with the classic example being that of medical student decision-making (Type 2, "resource-intensive, analytic deliberations") and veteran faculty physician decision-making (Type 1, "intuitive, gestalt hunches rooted in experience"). However, perhaps a little concerningly, the authors herein postulate that "when decisions that involve uncertainty with multiple parameters become too complex, physicians revert to type 1 processes — hunches rooted in experience." This simply does not make sense. If decisions are quick, easy, and follow pattern-recognition, then Type 1 processes should be utilized, but wouldn't you want your physician to truly contemplate your clinical case if you did not fit their heuristic (i.e. using Type 2 processing)? To give patients more agency under circumstances of clinical uncertainty surrounding their own healthcare decisions, accurate risk-assessing decision aids could be transitioned into the hands of patients rather than

just researchers and physicians, the patients having the ability to directly input the influence of their values on the next best evidence-based diagnostic/therapeutic steps. This might solve the problem we have identified previously of patients wanting their physician to be certain when they are uncertain, despite the physician being potentially *just as uncertain* and consequently only providing options rather than recommendations. I do wholeheartedly agree with the necessity of incorporating high-power computing into medicine with a cumulative assessment of multiple risk models with many different patient-specific and evidence-based parameters to determine which interventions for singular patients will have the highest benefit:harm ratio.

69. Bracamonte E, Gibson BA, Klein R, Krupinski EA, Weinstein RS. Communicating Uncertainty in Surgical Pathology Reports: A Survey of Staff Physicians and Residents at an Academic Medical Center. Acad Pathol. Jan-Dec 2016;3:2374289516659079. doi:10.1177/2374289516659079

- With respect to modes of communication between the surgical pathology laboratory and its service users, clinicians indicated they preferred to use tumor boards/interdisciplinary conferences, face-to-face meetings, and phone calls to clarify their interpretations of a pathologist's diagnoses, as compared with simply reading free-text comments.

Summary

- Similar to the previous article discussing this same topic, the authors here describe the preference of non-pathologists to discuss pathology results with the pathologists rather than simply reading their sometimes hedging/waffling written results in the medical record because of how significantly pathology results can guide next steps in management. The ultimate conclusion, however, is that the field of pathology *needs* to develop a standardized way of communicating the uncertainty of their final reads rather than relying on a variety of subjectively dubious phrases. I think that it is inappropriate to even suggest that management-guiding decisions based on pathology results are uncertain because of fault within the non-pathologist. Just like it is the duty of every non-pathologist physician to communicate with their patients using clear and easy-to-understand language, pathologists should develop a way of doing so (and what better way than a standardized one that can begin to be learned in medical school) for the non-pathologists that depend on them. This paper reports that "few respondents felt that one could ever be 100 percent certain. Although this is an interesting philosophical point, there is a practical legal aspect to this belief. The fear of the legal ramifications of over or under communicating a diagnosis may affect a pathologist's interpretation and use of diagnostic phrasing." I also appreciate their statement that "Consensus often only approximates truth even in ideal clinical settings."

70. Chuang MF, Tung HH, Clinciu DL, et al. The effect of an integrated education model on anxiety and uncertainty in patients undergoing cervical disc herniation surgery. Comput Methods Programs Biomed. Sep 2016;133:17-23. doi:10.1016/j.cmpb.2016.05.003

- BACKGROUND: Educating patients about receiving surgical procedures is becoming an important issue, as it can reduce anxiety and uncertainty while helping to hasten decisions for undergoing time sensitive surgeries. We evaluated a new integrated education model for patients undergoing cervical disc herniation surgery using a quasi-experimental design. METHODS: The participants were grouped into either the new integrated

educational model (n = 32) or the standard group (n = 32) on the basis of their ward numbers assigned at admission. Anxiety, uncertainty, and patient satisfaction were measured before (pre-test) and after the educational intervention (post-test-1) and post-surgery (post-test-2) to assess the effectiveness of the model in this intervention. RESULTS: We found that the generalized estimating equation modeling demonstrated this new integrated education model was more effective than the conventional model in reducing patients' anxiety and uncertainty ($p < 0.05$). Patients were also more satisfied with our newly developed model as it takes a more holistic approach to individual health. CONCLUSION: This novel systemic educational model enhances patient's understanding of the medical condition and surgery while promoting patient-caregiver interaction for optimal patient health outcomes. We present a comprehensive and consistent platform for educational purposes in patients undergoing surgery as well as reducing the psychological burden from anxiety and uncertainty. Integrating medicine, nursing, and new technologies into an e-practice and e-learning platform offers the potential of easier understanding and usage. It could revolutionize patient education in the future.

Summary

- It goes without saying that efficacious patient education, especially prior to invasive surgical interventions that cannot simply be discontinued or reversed like most medical interventions, is exceptionally important for reducing patient uncertainty. This article is quite similar to others that I have annotated above, and it highlights the theme that preoperative appointments should be buttressed with e-learning (or other validated platforms) for patients that they can take home with them to study, re-study, and contemplate according to their own desire so that they may have an improved literacy of what they are subjecting their bodies to.

71. Cottin V. Lung biopsy in interstitial lung disease: balancing the risk of surgery and diagnostic uncertainty. Eur Respir J. Nov 2016;48(5):1274-1277. doi:10.1183/13993003.01633-2016

- One challenge with this diagnostic approach is that many patients with a CT pattern of possible UIP or inconsistent with UIP do not undergo a surgical lung biopsy. There are multiple reasons for that [9], including the legitimate perception by some physicians and patients that the risk of performing a lung biopsy may be excessive. Often, the biopsy is deemed impracticable due to age, disease severity or comorbidities [10]. Although every clinician and thoracic surgeon routinely needs to evaluate the benefit/risk balance of a lung biopsy in patients with ILD, and the benefit of a secure and tentatively early diagnosis is now well established, the literature to evaluate the risk associated with a surgical lung biopsy is surprisingly scarce.

Summary

- In words better than I could write myself, the author here explains step-by-step the multidisciplinary approach to the diagnosis of idiopathic pulmonary fibrosis in a way that minimizes uncertainty as much as possible: “As stated in international guidelines [5], in the appropriate clinical setting with all possible causes of ILD ruled out, the presence of a definite usual interstitial pneumonia (UIP) pattern on chest computed tomography (CT) is sufficient for the diagnosis of IPF. In the absence of a UIP pattern on CT, establishing a secure diagnosis of IPF requires a surgical lung biopsy [5]. This approach, therefore, relies heavily on the CT appearance of ILD that is stratified into three categories, namely

UIP, possible UIP and inconsistent with UIP. In theory, a lung biopsy should be contemplated in patients with a pattern of possible UIP or inconsistent with UIP. All possibly relevant information available is then synthesised during the multidisciplinary discussion among clinicians, radiologists and pathologists, all being experts in the field of ILD, a process that increases the accuracy of the diagnosis [6] and impacts management [7]. The multidisciplinary discussion also allows the diagnosis to be made with higher confidence than by clinicians or radiologists alone (although reproducibility between different teams needs to be optimised for diagnoses other than IPF [8]), and has become the gold standard for the diagnosis of ILD." The unfortunate reality of getting diagnostic lung biopsy is that they appear to be under-performed given the nature of the procedure combined with the age/comorbidities of patients that often need these diagnostic lung biopsies. Similar to the article above on risks of aortic root dilatation, data on the risk of lung biopsy to confirm IPF is uncertain because an unfortunately numerous amount of patients who qualify as low-risk candidates for lung biopsy never receive one.

72. Leopold SS. Editor's Spotlight/Take 5: Do Orthopaedic Surgeons Acknowledge Uncertainty? Clin Orthop Relat Res. Jun 2016;474(6):1356-9. doi:10.1007/s11999-016-4708-4

- **GIVEN THAT THE ARTICLE THIS "EDITOR'S SPOTLIGHT" REFERS TO WILL BE ANNOTATED BELOW, THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT.**

73. Libert Y, Canivet D, Ménard C, et al. Predictors of physicians' satisfaction with their management of uncertainty during a decision-making encounter with a simulated advanced stage cancer patient. Patient Educ Couns. Jul 2016;99(7):1121-1129. doi:10.1016/j.pec.2016.01.008

- Physicians' satisfaction (mean = 67 mm; standard deviation = 17 mm) was not predicted by their communication, but by their anxiety due to uncertainty (PRU) (b = -.42; p = < .001) and their perceived empathy (JSPE) (b = .26; p = .009). These variables accounted for 25% of variance in physicians' satisfaction. Conclusions: Physicians' satisfaction with their management of uncertainty was not affected by their communication performance, but by their psychological characteristics.

Summary

- In a rather unique style, this article assessed how physicians *felt* after managing uncertainty during a hypothetical simulated clinical decision-making scenario. The authors found that the two predictors of physicians being satisfied by their clinical performance was (1) "their anxiety due to uncertainty" and (2) "their perceived empathy." The first of these findings makes sense; if a physician has a lower tolerance of uncertainty, one can clearly see how those physicians will be less comfortable and satisfied following an uncertain clinical situation. Furthermore, I have heard in passing that tolerance of uncertainty has been factors that have influenced faculty physicians' initial choice of specialty. For example, a pediatric hematologist once told me that he wanted to be a surgeon until he realized how anxiety-inducing the finality of surgery is – once you cut something, you cannot always un-cut it. Perhaps a little ironically, the satisfaction of physicians in this study with the care that they provided to the simulated patient was not correlated with the satisfaction of the simulated patient. There is concern, however, that those physicians who have less anxiety due to uncertainty and are more

satisfied with the clinical performance could actually be inadequately managing uncertainty in a way that is, in a way, blissfully ignorant. Three strategies that could very well prove useful for the future training of physicians are (1) "assess[ing] the patient's preferred level of involvement in the treatment decision, (2) "assess[ing] the patient's desire for information and the method of delivery for that information", and (3) "us[ing] direct expressions of uncertainty about their patient's outcome." These are quite nuanced and nontrivial questions to ask patients, especially because such questions kind of break down the fourth wall, so to speak, of the social contract that the patient expects when seeing their physician.

74. Saposnik G, Sempere AP, Raptis R, Prefasi D, Selchen D, Maurino J. Decision making under uncertainty, therapeutic inertia, and physicians' risk preferences in the management of multiple sclerosis (DIScUTIR MS). BMC Neurol. May 4 2016;16:58. doi:10.1186/s12883-016-0577-4

- Despite the availability of different markers for risk stratification in patients with MS, it is difficult for expert clinicians to select the best strategy when the progression pattern of the disease is uncertain. MS experts and clinicians are trained to quickly recognize patterns or critical aspects of particular situations [28]. Some clinicians apply the knowledge they have acquired from previous experience, others use information available at the time of the assessment, others use risk score tools or a combination of the above. However, it is not known how MS experts behave in clinical scenarios with ambiguous outcomes (unknown probability or uncertain risk of an outcome) or when more therapeutic options become available. In addition, we have a limited understanding about physicians' beliefs and preferences on the widely available therapeutic options for the optimal management of MS.

Summary

- Multiple Sclerosis is an unfortunately fertile ground for clinical uncertainty as there are multiple treatment options that are largely selected based on side effect/comorbidity combinations with treatment intensification based on already manifested progression of disease. MS experts have no way of predicting which patients are adequately treated and will not progress (or take longer to progress) than others, and these "experts" differ widely in how they come to their clinical decisions – some relying on their prior experience, some using risk stratification tools, and others using both. One may be able to boil down these effectively black box decision-making circumstances into "expected utility theory," which is essentially cost-benefit analysis (what appears to be the most foundational/fundamental logical process used by physicians to determine the best course of action in uncertain clinical situations). This paper proposes interesting new terminology that I have not seen in other resources: Neuroeconomics ("the science that studies the principles of how we make decisions") and therapeutic inertia ("the lack of treatment initiation or intensification in patients not at goals of care"), both of which may involve "cognitive distortions (e.g., overconfidence, tolerance to risk and ambiguity, etc.) that may lead to suboptimal decisions (e.g., therapeutic inertia)." This problem of "therapeutic inertia" likely exists far more potently in the fields of those managing conditions like Multiple Sclerosis where there is no singular gold-standard treatment, and where new treatments are constantly being reported in the press. How can one reasonably expect to see patients all day utilizing a certain paradigm, spend all night reading the

literature reading about a new paradigm, and then institute that new paradigm the next day? Indeed, a difficult task is it not? Who wants to be the first "MS Expert" at an institution to adopt widespread use of a new disease-modifying therapy that may still have ambiguous datapoints?

75. Schapira MM, Aggarwal C, Akers S, et al. How Patients View Lung Cancer Screening. The Role of Uncertainty in Medical Decision Making. Ann Am Thorac Soc. Nov 2016;13(11):1969-1976. doi:10.1513/AnnalsATS.201604-290OC

- RATIONALE: Radiographic lung cancer screening guidelines and coverage requirements warrant a shared decision-making process. Guidance is needed regarding how to conduct shared decision making effectively. A useful organizing theme should include consideration of a patient's response to and tolerance of uncertainty associated with lung cancer screening. OBJECTIVES: The objectives of this study are to: (1) describe how patients respond to specific categories of uncertainty in the context of lung cancer screening, and (2) inform strategies for addressing concerns about uncertainty as part of the shared decision making. METHODS: We performed two series of structured interviews on participants in a convenience sample of current or former cigarette smokers recruited from primary care and pulmonary practices in Philadelphia. An interview guide included prompts related to benefits, harms, and responses to general and specific types of uncertainty (stochastic, statistical, and evidentiary) associated with lung cancer screening. Interviews were audio-recorded, transcribed, and independently coded by two investigators. An inductive analysis was conducted, and major themes were identified. MEASUREMENTS AND MAIN RESULTS: Twenty-two adults participated in the study. Sixty-eight percent were men, 72% were black or African American, and 50% met U.S. Preventive Services Task Force criteria for lung cancer screening. The primary themes to emerge from our study were: (1) the desire to decrease uncertainty may motivate lung cancer screening decisions; (2) uncertainty is an attribute of health states that impacts how patients weigh benefits and harms of lung cancer screening; (3) patient understanding and tolerance of uncertainty varies across stochastic, statistical, and evidentiary uncertainty; and (4) provider-patient communication may mitigate intolerance of uncertainty in the context of lung cancer screening. CONCLUSIONS: A systematic approach to understanding and addressing patients' concerns about uncertainty in the context of lung cancer screening can guide a patient-centered approach to shared decision making. The results of this study can inform provider-patient communication strategies regarding the decision to perform radiographic lung cancer screening.

Summary

- Lung cancer screening is a preventative intervention that many patients undergo, potentially without a complete understanding of what may lie ahead should the results of their screening procedure lead to the diagnosis of malignancy. A prudent physician should assess for how uncertain patients might be following the results of these screening procedures and, most importantly, if a patient would even want to know or intervene if they had lung cancer. Notably, it appears from this article that patients who tolerate uncertainty less were more likely to desire lung cancer screening – not dissimilar from our previous discussions of uncertain physicians wanting to order more tests for their patients in an effort to gain some semblance/modicum of certainty.

76. Schiavazzi DE, Arbia G, Baker C, et al. Uncertainty quantification in virtual surgery hemodynamics predictions for single ventricle palliation. Int J Numer Method Biomed Eng. Mar 2016;32(3):e02737. doi:10.1002/cnm.2737

- The adoption of simulation tools to predict surgical outcomes is increasingly leading to questions about the variability of these predictions in the presence of uncertainty associated with the input clinical data. In the present study, we propose a methodology for full propagation of uncertainty from clinical data to model results that, unlike deterministic simulation, enables estimation of the confidence associated with model predictions. We illustrate this problem in a virtual stage II single ventricle palliation surgery example. First, probability density functions (PDFs) of right pulmonary artery (PA) flow split ratio and average pulmonary pressure are determined from clinical measurements, complemented by literature data. Starting from a zero-dimensional semi-empirical approximation, Bayesian parameter estimation is used to find the distributions of boundary conditions that produce the expected PA flow split and average pressure PDFs as pre-operative model results. To reduce computational cost, this inverse problem is solved using a Kriging approximant. Second, uncertainties in the boundary conditions are propagated to simulation predictions. Sparse grid stochastic collocation is employed to statistically characterize model predictions of post-operative hemodynamics in models with and without PA stenosis. The results quantify the statistical variability in virtual surgery predictions, allowing for placement of confidence intervals on simulation outputs.

Summary

- It is undoubtedly valuable to have a sense of the uncertainty within the data that is going to guide clinical decision-making, as higher levels of research-based uncertainty should translate into higher levels of practical uncertainty in the real-world with everyday patients. A confidence interval for relative risk, for example, ranging from 1.5 to 90 says something much different than one ranging from 2 to 4.

77. Teunis T, Janssen S, Guitton TG, Ring D, Parisien R. Do Orthopaedic Surgeons Acknowledge Uncertainty? Clin Orthop Relat Res. Jun 2016;474(6):1360-9. doi:10.1007/s11999-015-4623-0

- Recognition of uncertainty in daily practice did not vary by years in practice (0–5 years, 3.2 ± 1.3; 6–10 years, 2.9 ± 1.3; 11–20 years, 3.2 ± 1.4; 21–30 years, 3.3 ± 1.6 years; p = 0.51), but overconfidence bias did correlate with years in practice (0–5 years, 6.2 ± 1.4; 6– 10 years, 7.1 ± 1.3; 11–20 years, 7.4 ± 1.4; 21–30 years, 7.1 ± 1.2 years; p \ 0.001).
- The degree to which surgeons regard uncertainty does not seem to change with greater experience. We found a pervasive overconfidence bias (confidence that one's skill is greater than it actually is) among orthopaedic surgeons, because 83% of the group considered themselves to be above average diagnosticians, and none regarded themselves as below average. Similarly, 74% of our group regarded themselves as above average surgeons and 25% regarded themselves as being in the top 5%. Although it is possible that this is accurate—maybe the surgeons in this study group are above average—this seems more likely attributable to overconfidence bias. There is evidence that confidence and accuracy are at odds in medicine. For example, radiologists who performed less well were highly confident that they were accurate [20]; a survey of 100 internal medicine physicians found only a very small difference in confidence in diagnostic accuracy

between very difficult and simple clinical cases, whereas there was a large difference in actual diagnostic accuracy [16], and surgical residents were confident they would recognize different distal radius fractures 68% of the time while actually identifying only 33% correctly [18]. Overconfidence bias can lead to other biases such as the availability heuristic (considering only the first thing that comes to mind) and confirmation bias, where a person notices only the things that agree with his or her point of view and is less attentive to support for alternative viewpoints [15]. Limiting confirmation bias in medical decision-making requires an effort to seek disconfirming evidence, a characteristic of type 2 (analytical, reflective, slow) rather than type 1 (fast, intuitive, heuristic) thinking disposition [7, 25, 26]. Uncertainty-intolerant physicians might be less likely to use analytical thinking, contributing to their sense of overconfidence.

Summary

- Overconfidence is evidently a potential byproduct of increasing years in practice, especially within a surgical subspecialty where there are often not universal, ubiquitous evidence-based gold standard protocols for treating different pathologies with various surgeries that may be quite similar or disparate. This leads surgeons to stick with what is personally familiar and with what has the best outcome "in their hands." Greater statistical prowess may be a protective factor against neglect of uncertainty. A prudent question that might be posed is whether research-derived evidence that contradicts surgeons practicing "familiar" strategies of managing conditions they treat will actually even cause those surgeons to alter their practices. Will they simply fall deeper into their overconfidence bias and reject the research as an erratum? I was shocked at these authors pointing out that "Clinical Evidence [3] currently classifies 50% of 3000 common medical treatments as of ''unknown effectiveness'' and only 11% as proven beneficial (of the remainder 24% are likely to be beneficial, 7% a tradeoff between benefits and harms, 5% unlikely to be beneficial, and 3% likely to be ineffective or harmful)." I have heard colloquially that the reason surgeons are so confident is that such confidence is the one of the few things that allow them to operate decisively and efficiently. If they were to pause and utilize Type 2 decision-making at every fork-in-the-road, intraoperative and anesthesia times would significantly increase, carrying increased healthcare costs and morbidity/mortality risks for patients. Nonetheless, I appreciate what the authors say about overconfidence maladaptively becoming an availability heuristic paired with a confirmation bias that leads to a lack of consideration of options outside of those that immediately come to mind. In a way that might be expected, and perhaps reassuring, academic center surgeons "had the greatest awareness of uncertainty, especially compared with those working in multispecialty groups." The same was interestingly true for atheists compared to theists; the authors argue that this may be due to the tendency of believers to seek certainty and be more intolerant of uncertainty. Indeed, there may be an overall benefit to further incorporating statistical education, journal clubs, and admissions of uncertainty during surgical residency training.

78. Bhattacharya B, Maung A, Schuster K, Davis KA. Uncertainty Among Acute Care Surgery Providers Does Not Change with Experience. Conn Med. Mar 2017;81(3):133-139.

- Acute care surgery (ACS) is a demanding profession that is by its na- ture unpredictable and requires practitioners to routinely deal with uncertainty and stress. We hy- pothesized that the field attracts people who are comfortable working in such an environment and

that their comfort with uncertainty increases with experience. A surgeon's stress with uncertainty can be assessed usingthe previouslyvalidated Physician Reaction to Uncertainty Scale (PRU scale). METHODS: After approval from our IRB and the Eastern Association for the Surgery of Trauma (EAST) Research and Scholarship Committee, an online-survey was sent to EAST members. The survey included demographic questions and the PRU scale. 'The PRU scale requires answering 15 questions on a scale of one to six (strongly disagree to strongly agree) with four subsections measuring anxiety to uncertainty, concern about outcomes, reluctance to disclose uncertainty to patients, and reluctance to disclose mistakes to physicians. A higher score represents greater discomfort. Survey requests were sent to 1707 members; 424 surveys were complete and used for analysis. RESULTS: Most respondents were surgeons (92.4%) and male (77.1%). Average total score was 40.4/90. Overall discomfort with uncertainty on the PRU scale did not vary with gender (p = .88), experience (P=.11), age (P=.21), or practice location (P=.26). With increased experience, there was decreased re- luctance to disclose uncertaintyto patients (P = .03) and a trend to decreased anxiety about outcomes (P=.09). CONCLUSION: Overall discomfort with uncertainty among ACS providers appears to be inherent in their personality and does not change over a career span.'Ihis factor may play a role in the development of occupational stress since discomfort with uncer- tainty appears to persist over time. Future studies looking at other surgical specialties for comparison and atlongitudinal studies may provide insight into the personality of the community.

Summary

- This study using the Physician Reaction to Uncertainty Scale (PRU Scale) suggests that acute care surgeons do not have any more or less uncertainty dependent on gender, experience, or age. However, more experienced acute care surgeons were more reluctant to disclose their uncertainty to patients and be less worried about outcomes for their patients. The question is therefore raised whether this trend is dependent on experience in and of itself, or whether it is a reflection of transitioning emphases on medical/residency training and the intrinsic personal qualities of newer acute care surgeons.

79. Dhawale T, Steuten LM, Deeg HJ. Uncertainty of Physicians and Patients in Medical Decision Making. Biol Blood Marrow Transplant. Jun 2017;23(6):865-869. doi:10.1016/j.bbmt.2017.03.013

- Nontheless, decisions regarding the optimum treatment strategy for any individual patient remain challenging, given that all prognostic projections are based on statistics. The challenge lies in identifying parameters that characterize individual patients as prospective responders or nonresponders and thus determine the prognosis. Both physicians and patients are confronted with the uncertainty of the success of treatment with any strategy in a particular disease condition and with the impact of treatment on overall prognosis
- In the clinical context, uncertainty may arise independently from patient and provider, as well as from the complex relationship between the two. Uncertainty may arise from patients' inability to provide a complete history, unpredictable response to treatment, varying preferences for information, and desire to participate, incompletely informed, in the clinical decision making process [15,16]. These patient-specific factors may lead to both diagnostic uncertainty on the part of the physician and ambiguity in treatment

recommendations as understood or experienced by the patient. Patients' personal experiences of uncertainty may be further affected by their ability to comprehend quoted risk estimates, particularly if their numeracy (ie, numeric literacy) is limited [17,18]. In some patients, the use of simple or conditional probabilities over frequencies may result in misunderstanding or information overload. The degree of uncertainty experienced by patients also may vary as a function of their age, educational status, illness coping mechanisms, and priorities for future care, making some patients more tolerant of uncertainty than others

- A second cognitive formulation of uncertainty, referred to as ambiguity, also has been used to characterize uncertainty as it pertains to future events. The concept of ambiguity captures the "uncertainty about uncertainty" [7]. Mathematically, ambiguity is represented as the confidence interval around individual probability estimates. Confidence intervals acknowledge that there are limitations to the methods used to generate risk assessments and probabilities. Of note, however, previous studies have shown that the presentation of confidence intervals in clinical studies results in an increased perception of risk, and that patients tend to avoid choices that are presented as unknown versus known probabilities ("ambiguity aversion") [17]. It is perhaps for this reason that clinicians often avoid the use of decision support models that include calculations of confidence intervals around probabilities or risk estimates.
- Despite all of the shortcomings, effective communication about uncertainty is essential, because it is likely to inform treatment decisions. Game theory suggests that optimal decision making requires probabilistic weighing of all possible future outcomes [26]. Accordingly, the strategy then depends on the degree of uncertainty about the factors that come into play (model uncertainty). The presence of uncertainty may impair an individual's ability to create a cognitive schema about a complex decision that is needed to clearly judge the situation and commit to a course of action. Indeed, the expression of uncertainty may have psychological and social impacts on patients and physicians, resulting in anxiety [15], greater perception of danger [20], and avoidance or deference of decision making [17]. In addition, some studies suggest that the disclosure of uncertainty can heighten cancerrelated worries [17], and decrease patient satisfaction with treatment decisions [7] and treatment outcomes [20]. Yet uncertainty is not universally experienced as a negative force. In fact, some patients, especially those with high-risk disease or a poor prognosis, may find hope in the ambiguity inherent in confidence intervals of survival probabilities or an unpredictable future. For these patients, the presence of uncertainty is a positive force that is self-protective and allows them to maintain a positive outlook. Naturally, such a patient perspective does not relieve physicians from the responsibility of conveying the most appropriate information regarding therapy.

Summary

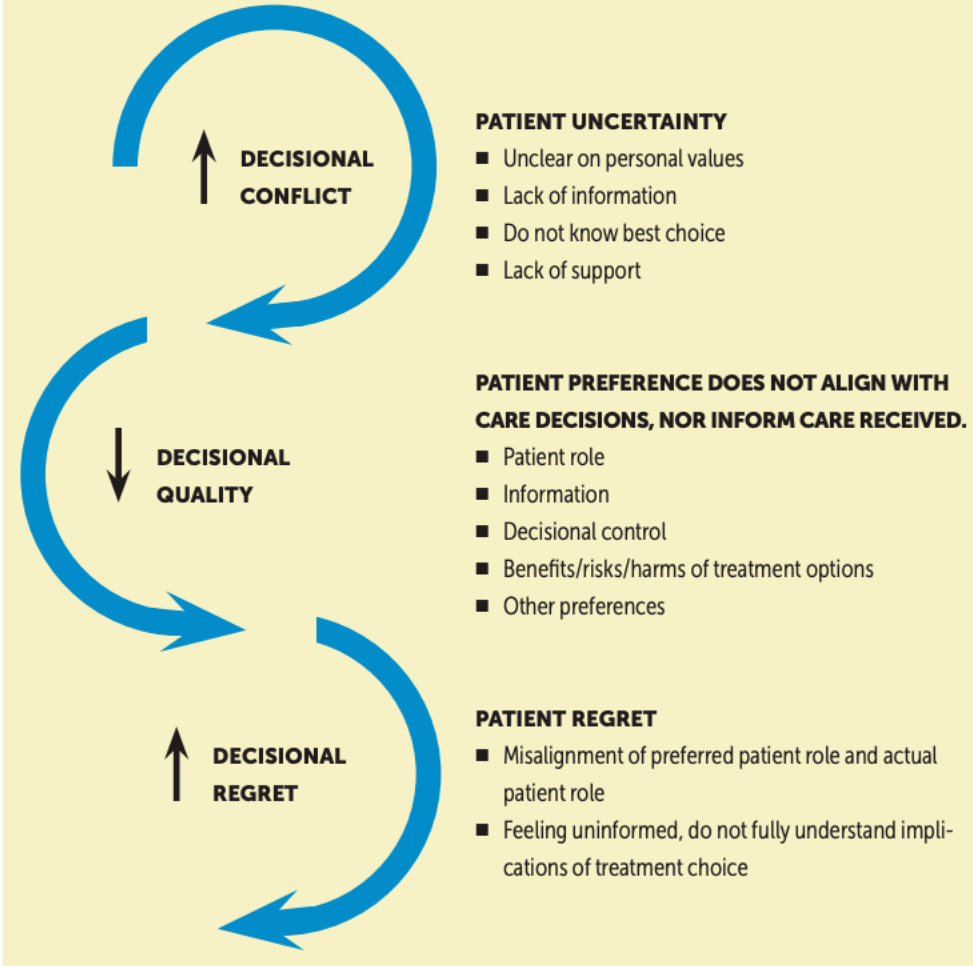
- Medical oncology carries the unique challenge of needing to combine population-based, statistical evidence with personalized medicine so that therapeutic strategies (chemoradiation, targeted agents, immunotherapy) can be effective for a singular patient after it has been proven to be safe and effective for a cohort of patients. This becomes even more difficult with the exceptional amount of information that patients have at their fingertips and can research prior to their oncology appointment to bring with them – physically or mentally – and achieve a sense of control over their new cancer diagnosis. However, this information is frequently so nuanced that only the oncologists themselves

have the insight to interpret it and apply it to individual patients. The authors aptly quote Sir William Osler: “Medicine is the science of uncertainty and the art of probability.” Another unique consideration within oncology is the high amount of toxicity and symptomatology of their therapies that may not carry an exceptional survival benefit. Therefore, the uncertainty of physicians in this situation is multiplied by the uncertainty of patients deciding if an extra year of life with an otherwise uncurable cancer is worth the side effects of their treatment – something that is difficult for a physician to advise a patient on. There is a new description of uncertainty provided in this article, with it being any combination of “lack of familiarity with the necessary information, unavailability of relevant information, inability to assess the impact of patient or disease characteristics on outcome with one versus another treatment strategy, and poor understanding of patient preferences or priorities.” Furthermore, “at its most basic level, uncertainty can be defined as a cognitive state characterized by an awareness of incomplete understanding of a situation or event [7,12]. To be uncertain implies a relative or absolute inability to accurately establish a diagnosis, predict response to treatment, or estimate future events.” Mishel’s Theory of Uncertainty in Illness, that has been briefly mentioned elsewhere, further “posits that uncertainty arises from complexity, unpredictability, ambiguity, and lack of information.” All of this uncertainty is exasperated independently by the patient, provider, or both. Patients contribute to clinical uncertainty by their “inability to provide a complete history, unpredictable response to treatment, varying preferences for information, and desire to participate […], ability to comprehend quoted risk estimates particularly if their numeracy (i.e., numeric literacy) is limited, […], their age, educational status, illness coping mechanisms, and priorities for future care, [ultimately] making some patients more tolerant of uncertainty than others.” Physicians contribute to clinical uncertainty by varying abilities to explain concept medical concepts to patients with varying levels of health literacy, inconsistent adherence to remaining abreast of cutting-edge research. The difficulty of all these intricacies is relentless such that uncertainty itself is even uncertain. Here lies the limit of what should probably be shared with patients since research has shown that when there is too much uncertainty surrounding a treatment, for example – even if that treatment has been shown in the literature to be superior to placebo or a previous gold standard – patients may exhibit “ambiguity aversion” and forego a treatment that may be beneficial for them out of fear of being unable to conceptualize the associated risk. This is an appropriate time to pose the question of the acceptability of “coercing” patients. A difficult conundrum exists for physicians where some patients may abhor healthcare uncertainty because it exposes their own overestimation of how many problems medicine truly has a “solution” for, disappoints them as they feel like they are “paying the big bucks” for nothing, and paralyzes them in the sense that there is no clear best therapeutic option for something like their cancer care. Conversely, other patients might be grateful for medical uncertainty because the glass appears half full to them – rather than half empty – and they interpret the lack of certainty as reassurance that they may indeed “make it” despite their terminal diagnosis. Either way, this chasm needs to be bridged through objective and validated, yet personalized patient education initiatives and improved uncertainty training for physicians.

80. Gustafson A. Reducing Patient Uncertainty: Implementation of a Shared Decision-Making Process Enhances Treatment Quality and Provider Communication. Clin J Oncol Nurs. Feb 1 2017;21(1):113-115. doi:10.1188/17.Cjon.113-115

- Cancer care's complexity can easily overwhelm patients faced with difficult decisions that may have serious consequences for their health and wellbeing. Caring for patients with cancer requires an acute awareness of patient status and role flexibility (Tariman et al., 2016).
- Nurses have a role in resolving decisional conflict by making sure that patients are assessed for decisional conflict and that patient concerns are uncovered through therapeutic communication. The Decisional Conflict Scale (DCS) is a valid and reliable tool for assessing decisional conflict (O'Connor, 1995).

FIGURE 1.
RELATIONSHIP BETWEEN DECISIONAL CONFLICT, DECISIONAL QUALITY, AND DECISIONAL REGRET



Summary

- There is an unfortunately irreducible nature to clinical uncertainty that carries varying weights depending on the specific circumstance that such uncertainty is impacting. Under dire circumstances, like a new cancer diagnosis with a guarded prognosis, the weight of uncertainty upon patients is undoubtedly immense. Providers must exhibit role flexibility

to easily transition between roles of objective information provision to subjective emotional support according to the needs of the patient. The assessment of patients' needs is accomplished by therapeutic communication and active listening. However, even when these strategies are perfectly executed, patients may still have decisional conflict that can negatively affect their quality of life and satisfaction with care; the Decisional Conflict Scale can be used to ascertain the turmoil of choice within the minds of patients. I appreciate how this author says "providers [must] equip patients with as much information as needed and tolerated…" which creates a great goal for physicians, but also further complicates their already difficult responsibility. I can imagine many less-interested physicians simply giving up, as it were, and encountering patients in ways that conserves the expenditures of their own mental economy so that their workdays may progress smoother and without as much emotional exhaustion. I say this because the astute reader will realize that to perfectly encounter each patient, a physician must become a clean slate and recursively restart, prior to each patient visit, the process of (1) knowing what background information to give a patient and how to deliver it, (2) assessing how that patient might most prefer to receive and interact with that information, (3) engage in therapeutic communication and active listening to shift their roles between objective information provision to subjective emotional support if needed, and (4) leading the discussion of while also letting the patient be in control of – to the extent that they wish to be –therapeutic decision-making. The author suggests that use of the Decisional Control Scale may be helpful in parsing through some of these patient preferences ahead of time.

81. Moore AJ, Blom AW, Whitehouse MR, Gooberman-Hill R. Managing uncertainty - a qualitative study of surgeons' decision-making for one-stage and two-stage revision surgery for prosthetic hip joint infection. BMC Musculoskelet Disord. Apr 12 2017;18(1):154. doi:10.1186/s12891-017-1499-z

- Surgeons balance multiple factors when choosing a surgical strategy which include multiple patient-related factors, their own knowledge and expertise, available infrastructure and the infecting organism. Surgeons questioned whether it was appropriate that the two-stage revision remained the best treatment, and some surgeons' willingness to consider more one-stage revisions had increased over recent years and were influenced by growing evidence showing equivalence between surgical techniques, and local observations of successful one-stage revisions. Custom-made articulating spacers was a practice that enabled uncertainty to be managed in the absence of definitive evidence about the superiority of one surgical technique over the other.

Summary

- Similar to what we have articulated before, there is good evidence to suggest what are and are not surgical problems, but there is insufficient evidence to guide the specific surgical strategy for treating these problems. Surgeons often utilize what works "in their hands," which is highly dependent on subjective factors such as where the surgeon trained, common practices of their institution, and the technical capabilities of their operating rooms. The orthopedic surgeons in this study describe the difference in their decision-making of utilizing a one-stage versus two-stage approach to the correction of prosthetic hip joint infections. Interestingly, there is new, equivocal data showing that infection recurrence is comparable between one-stage and two-stage approaches despite

the two-stage approach often being the *status quo*. However, there is much nuance as the two-stage approach requires 2-3 months of walking on a loosely fixed, articulating spacer that may not be suitable for very elderly or infirm patients that may simply want to go with less surgery and try the one-stage approach or even merely starting chronic suppression antibiotics. Sometimes patients are planned to undergo a two-stage approach but decide against it, especially if they too are elderly, and so they remain walking with the aforementioned spacer. This happens much less commonly in younger patients whose greater lifespan left to live and functional capacity make them great two-stage surgical candidates. Perhaps reassuringly, there appears to be a tendency amongst surgeons to attempt extensive personalization of their surgical plans for the patients that they are operating on, considering factors like the kind of organism causing the joint infection, patient age/comorbidities, goals of care for their patient, hospital infrastructure. One might argue that if there were a certain surgery (one-stage or two-stage, in this case) that showed statistically better outcomes on a population-based scale, then surgeons would feel pressured to use that singular approach for all their patients. The question subsequently arises whether or not what is good for the population is good for the individual? Another interesting point of this paper is the discussion of how the aforementioned articulating spacer (CUMARS) being versatile enough to allow it to remain in place as a pseudo-one-stage approach. In this case, the use of a new surgical technology helped surgeons overcome the uncertainty of utilizing the previously lesser-appreciate one-stage approach that has been gaining more traction amongst orthopedic surgeons. This identifies innovations in surgical technology as potential avenues of both providing patients better biomedical products and breaking surgeons out of their shells of using familiar, but outdated and less efficacious, surgical techniques.

82. Bories P, Lamy S, Simand C, et al. Physician uncertainty aversion impacts medical decision making for older patients with acute myeloid leukemia: results of a national survey. Haematologica. Dec 2018;103(12):2040-2048. doi:10.3324/haematol.2018.192468

- A multivariate model (n=210) revealed that physicians averse to uncertainty recommend significantly more intensive chemotherapy: Odds Ratio (OR) [95% Confidence Interval (CI)]: 1.15 [1.01;1.30]; P=0.039. Male physicians who do not conform to the expected utility model (assumed as economically irrational) recommend more intensive chemotherapy [OR (95% CI) = 3.45 (1.34; 8.85); P=0.01]. Patient volume per physician also correlated with therapy intensity [OR (95% CI)=0.98 (0.96; 0.99); P=0.032]. The physicians' medical decision-making was not affected by their age, years of experience, or hospital facility
- Even though the MDM process cannot be restricted to a computational process, novel methods such as decision-making tools supported by knowledge banks of matched genomic-clinical data47 are warranted. They will help physicians absorb large amounts of complex information and likely act as moderators of uncertainty

Summary

- This paper identifies positive associations between intense chemotherapy for treatment of elderly AML and uncertainty aversion, lack of adherence to the expected utility model of patient case, and patient volume. Putting the interesting nature and potential causes of these findings aside, I do not believe that patients with AML would be particularly pleased to know that such subjective and nonscientific considerations are made by their

physician to guide the management of their cancer that may be life or death. One might argue that the perspective of the patient should matter more than the perspective of the physician, as data has shown intensive chemotherapy to offer the "greatest chance of complete remission but is associated with a significant risk of early death, while hypomethylating agents yield a lower chance of complete remission but lower risk of early death." What may be a fascinating, yet extremely resource-intensive endeavor (but maybe not with the rapid advancement of AI), is to culminate an inventory of every kind of patient encountered by a particular specialty, the clinical decisions made for those patients, and the outcomes such patients experience. By doing so, the best clinical decisions for those patients will become evident over time and "fall out" of the massive amount of available data.

83. Kidane B. Stereotactic body radiation therapy versus video-assisted thoracoscopic surgery in stage I lung cancer: Honesty in the face of uncertainty. J Thorac Cardiovasc Surg. Jan 2018;155(1):365-366. doi:10.1016/j.jtcvs.2017.08.059

Summary

- I found one quote from this short piece to be significant: "We must be cautious not to use evidence such as this article (although it may align with our biases) to make inappropriate claims with overzealous finality about the definitive superiority of surgery." Indeed, it is quite easy, as many of us are aware at this point, to agree with mediocre research that resounds what we already experientially believe to be true. This experiential basis of truth is apparently quite prevalent in surgery, and I would contend that a good surgeon may rely on this experiential truth (since it is so commonplace and, on average, patients do fine) but a great surgeon believes in good research when it tells them to put their knife down.

84. LaMartina J, 2nd, Christmas KN, Simon P, et al. Difficulty in decision making in the treatment of displaced proximal humerus fractures: the effect of uncertainty on surgical outcomes. J Shoulder Elbow Surg. Mar 2018;27(3):470-477. doi:10.1016/j.jse.2017.09.033

- Successful management of displaced proximal humerus fractures requires both technical and decision-making abilities. The difficulty in making these decisions is reflected by the agreement of experienced shoulder surgeons only 63.5% of the time regarding the treatment performed. When uncertainty occurs, patients may have reduced outcomes as seen in the ORIF treatment group.
- Frankle et al5 showed that nonanatomic reduction of tuberosities in 4-part proximal humerus fractures treated with reverse arthroplasty can lead to impairment of external rotation. This evidence would suggest that not only does the evolution of technology bring increased difficulty in deciding what operation to perform but also the treating surgeon must possess the technical skills to carry out the appropriate treatment if needed.

Summary

- To my knowledge, this is the first paper that analyzes the outcomes of actual patient cases relative to the degree of agreement amongst multiple different surgeons. I am fascinated to see that there is a real difference in surgical outcomes under situations of surgical uncertainty where greater agreement amongst multiple shoulder surgeons about the best course of action leads to better outcomes and vice versa. I imagine that this reflects the degree of complexity of the surgical situation at hand – it makes sense that the most

uncertain of surgical circumstances would be a matter of hot debate for shoulder specialists whereas less notably uncertain surgical circumstances still have a surgical option that edges out the others. Of course, surgery is unique in the sense that it requires a unique combination of theoretical knowledge and technical skill, and even when new surgical technology comes out with improved patient outcomes (analogous to FDA approval of a new, effective drug), there is a novel hurdle for surgeons to then learn how to use that new surgical technology. Some surgeons will pick it up, but others may not because of a lack of remaining up-to-date on the literature, because of being late in their career and consequently reluctant to put in the effort to try anything new, or because of simple stubbornness.

85. Mangado N, Pons-Prats J, Coma M, et al. Computational Evaluation of Cochlear Implant Surgery Outcomes Accounting for Uncertainty and Parameter Variability. Front Physiol. 2018;9:498. doi:10.3389/fphys.2018.00498

- Cochlear implantation (CI) is a complex surgical procedure that restores hearing in patients with severe deafness. The successful outcome of the implanted device relies on a group of factors, some of them unpredictable or difficult to control. Uncertainties on the electrode array position and the electrical properties of the bone make it difficult to accurately compute the current propagation delivered by the implant and the resulting neural activation. In this context, we use uncertainty quantification methods to explore how these uncertainties propagate through all the stages of CI computational simulations. To this end, we employ an automatic framework, encompassing from the finite element generation of CI models to the assessment of the neural response induced by the implant stimulation. To estimate the confidence intervals of the simulated neural response, we propose two approaches. First, we encode the variability of the cochlear morphology among the population through a statistical shape model. This allows us to generate a population of virtual patients using Monte Carlo sampling and to assign to each of them a set of parameter values according to a statistical distribution. The framework is implemented and parallelized in a High Throughput Computing environment that enables to maximize the available computing resources. Secondly, we perform a patient-specific study to evaluate the computed neural response to seek the optimal post-implantation stimulus levels. Considering a single cochlear morphology, the uncertainty in tissue electrical resistivity and surgical insertion parameters is propagated using the Probabilistic Collocation method, which reduces the number of samples to evaluate. Results show that bone resistivity has the highest influence on CI outcomes. In conjunction with the variability of the cochlear length, worst outcomes are obtained for small cochleae with high resistivity values. However, the effect of the surgical insertion length on the CI outcomes could not be clearly observed, since its impact may be concealed by the other considered parameters. Whereas the Monte Carlo approach implies a high computational cost, Probabilistic Collocation presents a suitable trade-off between precision and computational time. Results suggest that the proposed framework has a great potential to help in both surgical planning decisions and in the audiological setting process.

Summary

- A unique source of uncertainty within surgical fields is the extent of anatomical variability among multiple different patients with the same underlying pathology.

Encountering these anatomical anomalies intraoperatively may result in complications due to a lacking knowledge of how to deal with them or due to neglecting unique considerations that they require. The example of this presented in the given article is cochlear implantation.

86. Salhiyyah K, Barlow C. Antiplatelet therapy after coronary bypass surgery: "Broken portions" and "uncertainty" in the search for "absolute truth". J Thorac Cardiovasc Surg. Jan 2018;155(1):223-224. doi:10.1016/j.jtcvs.2017.08.049

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

87. Timmermans S, Yang A, Gardner M, et al. Does Patient-centered Care Change Genital Surgery Decisions? The Strategic Use of Clinical Uncertainty in Disorders of Sex Development Clinics. J Health Soc Behav. Dec 2018;59(4):520-535. doi:10.1177/0022146518802460

- Genital surgery in children with ambiguous or atypical genitalia has been marred by controversies about the appropriateness and timing of surgery, generating clinical uncertainty about decision making. Since 2006, medical experts and patient advocates have argued for putting the child's needs central as patientcentered care. Based on audio recordings of 31 parent–clinician interactions in three clinics of disorders of sex development, we analyze how parents and clinicians decide on genital surgery. We find that clinicians and parents aim for parent-centered rather than infant-centered care. Parents receive ambivalent messages about surgery: while clinicians express caution, they also present the surgery as beneficial. We examine how parents and clinicians reach agreement about surgery—differentiating parents who push strongly for surgery from parents who do not express any preconceived preferences about surgery and parents who resist surgery. We conclude that clinicians use clinical uncertainty about surgery strategically to direct parents toward perceived clinically appropriate decisions.
- We find that clinicians exhibit sensitivity to external criticism of DSD surgeries and caution parents against rushing an irreversible decision. However, this sensitivity is undermined by positive and optimistic portrayals of surgery. The resulting mixed messaging produces ambivalence and clinical uncertainty, which both parties may leverage for a desired decision. Since parents tend to be neutral or in favor of surgery and clinicians present the benefits of surgery, the consultation often ends in favor of surgery
- Does patient-centeredness mean following parents' wishes, or does it require clinicians and parents to advocate for the child's future interests? And if the latter, does patient-centeredness mean adhering to Money et al.'s (1955) theories of aligning sex and gender early after birth, or does it mean being sensitive to advocates' concerns and postponing surgery until the child can make a decision? If it means following parents' wishes, most will request surgery (Dayner, Lee, and Houk 2004; Sanders, Carter, and Goodacre 2012), considering it "obvious and necessary" (Crissman et al. 2011:4). If it means prioritizing children's future interests, clinicians may have to subvert parents' wishes and postpone or avoid surgeries.

Summary

- This article provides a very interesting portrayal about how clinical uncertainty can be leveraged as a means of coercing parents of children with disorders of sex development (DSD) to choose the course of action for their children that the physician most agrees with. Indeed, it is easy to imagine how a room full of mirrors can become even more disorienting when smoke is introduced. Then, of course, the guiding light of surgery's potentially more optimistic outcome will be acted upon. A unique challenge is undoubtedly created when the "patient" being implicated in an uncertainty-laden shared-decision making process cannot make medical decisions for themselves. The fact of surgery's irreversibility is also strongly embedded in this discussion since, with the surgical correction of DSD, patients cannot necessarily "go back." The authors here seem to be suggesting that patients who receive a surgical correction of DSD tend to do just fine, and the vast majority of DSD patients do receive surgery since parents are often specifically requesting it. However, there is a subset of DSD advocates that call for there to be greater clinical uncertainty surrounding surgical correction of DSD since they see a real benefit of either not having their DSD corrected or being able to participate in such aspects of their healthcare at a later date outside of infancy – which is very understandable. However, one might aptly question whether it is appropriate to judge this weighty decision as one that a child can/should make. One inherent issue is the apparent lack of evidence as to the superiority of surgical versus nonsurgical management of DSD, especially since such surgical techniques change so frequently that any long-term follow-up studies would be relatively meaningless to the present-day DSD surgeon. A potentially useful strategy to effectively approach this conversation with parents is to emphasize that there is often no necessity to make any surgical decisions urgently or rashly, making it helpful to schedule consultation visits over many weeks-months to build in time for families to ponder their decision.

88. Shelton RC, Brotzman LE, Crookes DM, Robles P, Neugut AI. Decision-making under clinical uncertainty: An in-depth examination of provider perspectives on adjuvant chemotherapy for stage II colon cancer. Patient Educ Couns. Feb 2019;102(2):284-290. doi:10.1016/j.pec.2018.09.015

- Though most providers were aware of stage II colon cancer treatment guidelines, their use and communication of recommended guidelines was limited. Most reported tailoring delivery and content of their communication, often based on perceived patient education level, but patient involvement in decision-making varied. Findings highlight the complexity of, ACT decision-making, including the central role of providers and family members. Conclusions: Providers are not consistently following recommended guidelines for communicating about ACT among stage II colon cancer patients or eliciting patient preferences for involvement in treatment decisions.
- Very few providers felt numbers were the best way to communicate risk and benefits of treatment.
- Most providers reported putting substantial effort into ensuring that patients understand they are making a decision based on imperfect data.
- Emphasis on patient education level as a barrier in patient involvement is consistent with other studies, which find less educated populations report less involvement in treatment decision-making [53,54], due to limited understanding of clinical information, or lack of

lower literacy or numeracy decision-making resources [55,56]. Of some concern, providers seemed to be making assumptions regarding patient education or literacy level, without objective information or assessment, limiting deliberate efforts to involve and communicate with patients.

Summary

- I wonder if there is a combinatorial effect occurring as a cause of this article's findings: first, medical and surgical oncologists do an insufficient job of remaining fully abreast of all the newest research and clinical guidelines in the same way as they did when they were trainees. Second, there is a certain predisposition burned into the minds of faculty medical and surgical oncologists to perpetuate the teachings they learned wherever they trained, even if that contradicts the newest guidelines (especially if they perceive their patients as doing fine overall). Nonetheless, this paper reiterates themes that have "fallen out" elsewhere: it is unwise to assume numerical competency amongst patients and it is probably the most prudent idea to make patients aware of when recommendations are being made on the basis of certain versus uncertain data. Providers should continue eliciting from patients their baseline healthcare literacy and their desire to be involved in the decision-making process through both direct and indirect means prior to engaging in the most substantial aspects of the question being plagued by clinical uncertainty. This way, that question can be discussed in a way that is tailored to the patient and their clinical situation. Indeed, these authors state that "it may be important for providers and practitioners to revisit assumptions about the use and dynamics of SDM models in the context of heightened clinical uncertainty, when decisions are preference-sensitive rather than evidence-driven, as in the case of stage II colon cancer. In particular, it is not only the provider that shapes this decision, but the team of providers or multiple providers when patients receive 2nd opinions, as well as family members and caregivers. As such, it is critical to understand their influence and perspectives, and recognize that decision-making is rarely dyadic."

89. Spratt B, Kozan E, Sinnott M. Analysis of uncertainty in the surgical department: durations, requests and cancellations. Aust Health Rev. Jan 2019;43(6):706-711. doi:10.1071/ah18082

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

90. Helou MA, DiazGranados D, Ryan MS, Cyrus JW. Uncertainty in Decision Making in Medicine: A Scoping Review and Thematic Analysis of Conceptual Models. Acad Med. Jan 2020;95(1):157-165. doi:10.1097/acm.0000000000002902

- The practice of medicine is rarely straightforward. Medical decision-making is fraught with the potential for bias, and the optimal evaluation and management plan for a patient may vary by individual or system factors, such as the patient's degree of pain and suffering as well as the cost of the care.2 Data used to facilitate decision-making may be conflicting, ambiguous, or scarce, and providing optimal care requires balancing clinicians' expertise and the available evidence with patients' preferences. Collectively, researchers attribute these challenges to the uncertainty inherent in medicine.3

Uncertainty affects the clinical decision-making process, which has been described as a complex processing of knowledge and experience, using both critical thinking skills and intuition, while recognizing the inherent bias that can exist in medical decisions.2,4,5 Sources of uncertainty include the complexity of clinical information, the probability of particular outcomes, and individual clinician characteristics, such as tolerance for ambiguity6 or an individual's ability to cope with complexity, risk, and uncertainty.7 A low tolerance for ambiguity has been associated with increased resource utilization and higher rates of burnout in practicing physicians. Furthermore, it has been linked to poorer attitudes toward the underserved, decreased leadership capacity, psychological distress, and subspecialty choice in medical students.

- Boschetti proposed a spectrum of awareness based on 4 quadrants created by 2 axes: uncertain to certain and unaware to aware. For the decision maker, understanding whether you fall into the certain and aware quadrant of "known knowns" or the uncertain and unaware quadrant of "unknown unknowns" can have drastic implications for your ability to make a sound decision.2
- Han synthesized the literature to describe uncertainty in medicine in terms of source, issue (i.e., practical, scientific, and personal), and locus (i.e., patient versus clinician). He further distinguished between probability, complexity, and ambiguity as the sources of uncertainty surrounding the potential outcomes of a treatment decision
- McKenzie and colleagues described this process as the ability to "acknowledge and hold contradictions until one finds a position that transcends the tensions. Transcendence produces a solution that resonates across the meaning systems of a broad constituency of stakeholders."36 The steps to consider the viewpoints of key stakeholders included recognizing the various possible viewpoints, gathering such viewpoints, and negotiating between them to determine the appropriate course of action.
- We further identified 4 subthemes that characterized clinicians' overall approach to decision-making in terms of the strategies they use: intuitive, protocol-driven, team-based, or shared.

Summary

- This article is arguably the most imperative one for this Humanities Distinction Track project that I have read so far, as its review-style makes it similar to the one I am completing but on a smaller scale (with fewer articles) and broader concept (uncertainty overall). Aligning perfectly with the things we have already written about above, the authors say: The practice of medicine is rarely straightforward. Medical decision-making is fraught with the potential for bias, and the optimal evaluation and management plan for a patient may vary by individual or system factors, such as the patient's degree of pain and suffering as well as the cost of the care. Data used to facilitate decision-making may be conflicting, ambiguous, or scarce, and providing optimal care requires balancing clinicians' expertise and the available evidence with patients' preferences. Collectively, researchers attribute these challenges to the uncertainty inherent in medicine. Uncertainty affects the clinical decision-making process, which has been described as a complex processing of knowledge and experience, using both critical thinking skills and intuition, while recognizing the inherent bias that can exist in medical decisions. Sources of uncertainty include the complexity of clinical information, the probability of particular outcomes, and individual clinician characteristics, such as tolerance for ambiguity or an individual's ability to cope with complexity, risk, and uncertainty." As might be

expected, despite being mildly disappointing, is that there are plenty of physicians who cannot recognize their own uncertainty – this provides great value in the Boschetti model that classifies uncertainty as a four-quadrant spectrum on an X and Y axis of uncertain to certain and unaware to aware, respectively. The Han model then simplifies uncertainty into three descriptors: source (probability, complexity, ambiguity), issue (practical, scientific, personal), and locus (patient versus family member versus physician). The tension created by these factors existing in competition as different "stakeholders" may also create uncertainty which can only be managed by cost-benefit analyzing each stakeholder perspective to determine the solution that "transcends the tensions." Even if these processes are perfected, the algorithm itself may be afflicted by knowledge gaps within the patient/family or the physician that can be known or unknown. Another independent affliction is the constraint of time and how decisions can be rendered more certain within the mind if allowed more time for their consideration. Approaches that can be taken to counteract these counterweights (uncertainties) unbalancing the delicate scale of reasonable clinical decision-making are intuitive (e.g. heuristics), protocol-driven (e.g. guidelines), team-based (e.g. in a multidisciplinary healthcare team), and shared (e.g. between patient and physician) strategies. The most prudent physicians then reflect on the decisions they are currently making and have made *for* and *with* patients – even including the effects of their decisional outcome if such information is available upon later assessment – to improve their uncertain clinical choices in the future.

91. Hinton L, Armstrong N. 'They don't know themselves, so how can they tell us?': parents navigating uncertainty at the frontiers of neonatal surgery. Sociol Health Illn. Aug 2020;42 Suppl 1:51-68. doi:10.1111/1467-9566.13073

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92. Huang L, Chua MLK. Surgery as an alternative to radiotherapy in early-stage nasopharyngeal carcinoma: innovation at the expense of uncertainty. Cancer Commun (Lond). Mar 2020;40(2-3):119-121. doi:10.1002/cac2.12015

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND (despite the enticing title).**

93. Lampalzer U, Briken P, Schweizer K. Dealing With Uncertainty and Lack of Knowledge in Diverse Sex Development: Controversies on Early Surgery and Questions of Consent. Sex Med. Sep 2020;8(3):472-489. doi:10.1016/j.esxm.2020.03.002

- INTRODUCTION: Diverse sex development (dsd) is an umbrella term for different congenital conditions with incongruence of chromosomal, gonadal, and phenotypic sex characteristics. These are accompanied by various uncertainties concerning health-related, medical, psychosocial, and legal issues that raise controversial discussion. AIM: The aim of this exploratory study was to investigate 3 questions: What are the most controversial and disputed issues in the context of intersex/dsd? Which issues are

associated with the biggest knowledge gaps? Which issues involve the greatest difficulty or uncertainty in decision-making? A further aim was to investigate whether the group of persons concerned, the parents of intersex children, and the group of experts in the field had differing views regarding these questions. METHODS: A self-developed questionnaire was distributed among persons concerned, parents of children with intersex/dsd, and experts in the field. It contained open and multiple-choice questions. The answers from 29 participants were entered into data analysis. A mixed-method approach was applied. Quantitative data were analysed descriptively. Qualitative data were analysed according to the principles of qualitative content analysis. MAIN OUTCOME MEASURE: Participants answered questions on the most controversial and disputed issues, issues associated with the biggest knowledge gaps, and issues associated with the most difficulty or uncertainty in decision-making. RESULTS: The findings indicate that controversial issues and uncertainties mainly revolve around surgical interventions but also around the question of how to adequately consider the consent of minors and how to deal with intersex in the family. Significant differences were found between persons concerned and parents vs academic experts in the field regarding the perceptions of procedure of diagnostic investigation and/or treatment in adulthood, on legal questions concerning marriage/registered civil partnerships, and on lack of psychosocial counseling close to place of residence. CONCLUSION: The necessity of irreversible gonadal and genital surgery in early childhood is still a matter of strong controversy. To ensure the improvement in well-being of intersex persons, including a sexual health perspective, the positive acceptance of bodily variance is an important prerequisite. Psychosocial support regarding one-time decisions as well as ongoing and changing issues of everyday life appears to be an important means in reaching overall quality of life.

Summary

- The finality of surgical intervention is a consistent source of its uncertainty amongst multiple different subspecialty-focused articles; surgical correction for diverse sex development is no different. As I mentioned elsewhere, one significant source of such uncertainty is that children cannot “go back” once they are old enough to participate in their own sexual-medical decision-making. This creates an ethical conundrum of parents making decisions for their children regarding pursuing or foregoing the correction of DSD for the sake of typical sexual function, alignment of birth sex and genital construct, and fear of social ridicule. While it is definitely true that “positive acceptance of bodily variance is an important prerequisite” to these conversations, there is yet to be data that definitively shows surgical or nonsurgical correction to be superior overall for children with DSD. I would be curious to know whether this “widely accepted” notion is more due to the sociopolitical controversy of such medical data than due to its lack of presence… Medicine should not be subject to the frivolities of sociopolitical controversy, but physicians, patients, and researchers are all simply flawed humans at the end of every day.

94. Lee JY, Jang Y, Kim S, Hyung WJ. Uncertainty and unmet care needs before and after surgery in patients with gastric cancer: A survey study. Nurs Health Sci. Jun 2020;22(2):427-435. doi:10.1111/nhs.12677

- Uncertainty and unmet care needs constantly change in patients with cancer. However, there is a lack of information regarding the changing pattern of these variables. This study aimed to examine the changes in uncertainty and unmet care needs at diagnosis and after surgery among patients with gastric cancer. In total, 86 individuals completed a self-reported questionnaire. Data were collected twice - to measure uncertainty and unmet care needs at cancer diagnosis (T1), and after surgery (T2) - and analyzed using descriptive analysis and a dependent t-test. Uncertainty was moderate at both periods but significantly higher at T1. Unmet care needs were highest in the information domain and lowest in the sexuality domain at both T1 and T2. Only the physical/daily living domain were significantly higher at T2, whereas the information, psychological, and patient care/support domains were significantly higher at T1. Different levels of uncertainty and unmet needs were identified at T1 and T2. Healthcare providers should assess changing unmet care needs at each stage of the cancer trajectory and provide related nursing care and information to this population, even immediately after diagnosis.

Summary

- Surgeons can contribute to reducing uncertainty within their patients – which, as we have described elsewhere, is one of many potent sources of uncertainty within any clinical encounter – by providing them expectations of when they will have uncertainty and what kinds of uncertainty they will experience when they have it. Notably, this paper showed that patients with gastric cancer had (albeit predictively) higher physical/daily living domain uncertainty after surgery versus higher information, psychological, and support uncertainty prior to surgery.

95. Pergolotti M, Bailliard A, McCarthy L, Farley E, Covington KR, Doll KM. Women's Experiences After Ovarian Cancer Surgery: Distress, Uncertainty, and the Need for Occupational Therapy. Am J Occup Ther. May/Jun 2020;74(3):7403205140p1-7403205140p9. doi:10.5014/ajot.2020.036897

- IMPORTANCE: Despite the growing literature on the association of functional, physical, and quality-of-life (QOL) deficits with poor postoperative outcomes, there is a gap in the literature identifying women's occupational performance needs after ovarian cancer surgery. OBJECTIVE: To describe the experiences of women hospitalized after ovarian cancer surgery to identify potential areas for intervention. Goals were to (1) identify functional needs and limitations at time of discharge as measured by the typical acute care occupational therapy evaluation and semistructured interview and (2) understand the women's perspectives of their needs for occupational therapy and a safe return to home. DESIGN: Single-arm, cross-sectional descriptive study. Mixed-methods data collection and analysis. SETTING: Academic cancer center. PARTICIPANTS: Women with ovarian cancer (N = 11) who had completed surgery. INTERVENTION: Semistructured interviews and patient-reported outcome measures (PROMs) completed postsurgery. OUTCOMES AND MEASURES: PROMs included the National Comprehensive Cancer Network (NCCN) Distress Thermometer and Problem List, the PROMIS(®) Global Physical Health (GPH) and Global Mental Health (GMH) scales, and the Possibilities for Activity Scale-Women (PActS-W). RESULTS: The mean NCCN Distress score was 6.0 (standard deviation [SD] = 3.1, with the top three concerns being pain (80%), worry (80%), and fatigue (78%). Mean GPH and GMH T scores were 38.0 (SD = 8.8) and 48.2 (SD = 8.4), respectively. Women scored a mean of 39.2 (SD = 11.2, range = 26-58) on

the PActS-W. Thematic analyses found that the women were uncertain about potential functional limitations and significantly distressed. CONCLUSION AND RELEVANCE: Women with ovarian cancer experienced high levels of uncertainty and distress after surgery. Integrating in-home or community-based occupational therapy into routine care could decrease functional distress and uncertainty and help women manage concerns related to pain, worry, and fatigue. WHAT THIS ARTICLE ADDS: This study suggests that occupational therapy evaluation and intervention are needed to decrease distress and improve QOL of women upon discharge after ovarian cancer surgery.

Summary

- It is unfortunate that women experience continuing uncertainty after receiving surgery for ovarian cancer. I would be unsurprised to learn that this is due to the unsure nature of surgery for ovarian cancer regarding its curative property. However, in addition to "integrating in-home or community-based occupational therapy into routine care" for women receiving surgery for ovarian cancer, surgeons should ask themselves whether something about the operation that they gave these women can provide them improved post-operative quality of life without sacrificing, in this instance, success of cancer resection.

96. Ying LD, Harrington A, Assi R, et al. Measuring Uncertainty Intolerance in Surgical Residents Using Standardized Assessments. J Surg Res. Jan 2020;245:145-152. doi:10.1016/j.jss.2019.07.035

- PRU and PRA scores were analyzed with respect to personality factors to determine if certain dichotomies are associated with increased UI. There was a trend toward higher UI in individuals identifying with Judging.
- We aim to prepare our residents for the uncertainties of surgical practice by implementing a new education initiative which will highlight the gray-shades of surgical practice. In our program, we plan to specifically address the topic of uncertainty in surgical practice by developing a UI Curriculum. This initiative will include invited speakers who are experts in the topic, didactic sessions where attendings discuss their personal strategies for managing uncertainty in the operating room or in perioperative care, and peer-to-peer sessions where junior residents can discuss their concerns candidly with their senior colleagues. It is our hope that increasing the awareness of this subject and proactively addressing it will help our residents become better prepared for independent practice.

Summary

- I am very fascinated by general surgery residents having a greater intolerance of uncertainty (measured by Physician Reaction to Uncertainty and Physician Risk Attitude scales) when having a Myers-Briggs Type Indicator personality factor assessment including "Judging." It should be noted that later in the text, the authors begin to describe how "Judging" is associated with more uncertainty *tolerance*, potentially because of their pre-programmed algorithms for dealing with novel circumstances that their "Perceiving" counterparts handle too freely and not decisively enough… Despite its arguably irreducible nature, it sounds like a wise idea to integrate uncertainty intolerance into the training of medical students and physicians. I am intrigued by the application of this strategy in the Yale general surgery program that "will include invited speakers who are experts in the topic, didactic sessions where attendings discuss their personal strategies

for managing uncertainty in the operating room or in perioperative care, and peer-to-peer sessions where junior residents can discuss their concerns candidly with their senior colleagues." This is especially important, as the authors identify here, because their senior residents had equivalent levels of uncertainty intolerance to their junior resident counterparts. You might hope that senior residents would become more tolerant of uncertainty as they achieve more experience and responsibilities; however, perhaps their acquisition of more responsibilities as they overcome their deficits they had as junior residents simply causes new uncertainty to take the place of old uncertainty.

97. Brotzman LE, Crookes DM, Austin JD, Neugut AI, Shelton RC. Patient perspectives on treatment decision-making under clinical uncertainty: chemotherapy treatment decisions among stage II colon cancer patients. Transl Behav Med. Oct 23 2021;11(10):1905-1914. doi:10.1093/tbm/ibab040

- The decision to use adjuvant chemotherapy (ACT) after surgical resection for stage II colon cancer remains an area of clinical uncertainty. Many patients diagnosed with stage II colon cancer receive ACT, despite inconclusive evidence of long-term clinical benefit. This study investigates patient experiences and perceptions of treatment decision-making and shared decision making (SDM) for ACT among patients diagnosed with stage II colon cancer. Stage II colon cancer patients engaged in treatment or follow-up care aged >18 years were recruited from two large NYC health systems. Patients participated in 30-60-min semi-structured interviews. All interviews were transcribed, translated, coded, and analyzed using a thematic analysis approach. We interviewed 31 patients, of which 42% received ACT. Overall, patient perspectives indicate provider inconsistency in communicating ACT harms, benefits, and uncertainties, and poor elicitation of patient preferences and values. Patients reported varying perceptions and understanding of personal risk and clinical benefits of ACT. For many patients, receiving a clear treatment recommendation from the provider limited their participation in the decision-making process, whether it aligned with their decisional support preferences or not. Findings advance understanding of perceived roles and preferences of patients in SDM processes for cancer treatment under heightened clinical uncertainty, and indicate a notable gap in understanding for decisions made using SDM models in the context of clinical uncertainty. Educational and communication strategies and training are needed to support providers in communicating uncertainty, risk, treatment options, and implementing clinical guidelines to support patient awareness and informed decisions.
- These patient perspectives indicate that recommended clinical guidelines for stage II colon cancer patients (e.g., to have an in-depth discussion of harms, benefits, treatment options, and assumed clinical benefit) are not being consistently followed in practice. Participants reported variable perceptions and valuing of the same risk information; a 5% probability of improvement in risk of reoccurrence was reported as a reason to receive ACT for some patients, and a reason not to receive ACT for others.

Summary

- Contrary to what other articles have argued, these authors find that even when clinical uncertainty is high, patients do not necessarily seek clear treatment recommendations from their providers since it limits "their participation in the decision-making process." However, this result may have been due to the providers in their study making recommendations without a clear explanation of risks and benefits within situations that

were palpably uncertain for patients, making the doctoral certainty a bit suspicious from the patient perspective. Implicated in this discussion may be the widespread impact of and familiarity with cancer and chemotherapy such that patients enter these clinical discussions with an *a priori* understanding of their uncertainty.

98. Cleveland C, Patel VA, Steinman SA, Razdan R, Carr MM. Relationship Between Parental Intolerance of Uncertainty and Decisional Conflict in Pediatric Otolaryngologic Surgery. Otolaryngol Head Neck Surg. Aug 2021;165(2):354-359. doi:10.1177/0194599820973644

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

99. Harish V, Morgado F, Stern AD, Das S. Artificial Intelligence and Clinical Decision Making: The New Nature of Medical Uncertainty. Acad Med. Jan 1 2021;96(1):31-36. doi:10.1097/acm.0000000000003707

- Estimates in a 1989 study indicated that physicians in the United States were unable to reach a diagnosis that accounted for their patient's symptoms in up to 90% of outpatient patient encounters. Many proponents of artificial intelligence (AI) see the current process of moving from clinical data gathering to medical diagnosis as being limited by human analytic capability and expect AI to be a valuable tool to refine this process. The use of AI fundamentally calls into question the extent to which uncertainty in medical decision making is tolerated. Uncertainty is perceived by some as fundamentally undesirable and thus, for them, optimal decision making should be based on minimizing uncertainty. However, uncertainty cannot be reduced to zero; thus, relative uncertainty can be used as a metric to weigh the likelihood of various diagnoses being correct and the appropriateness of treatments. Here, the authors make the argument, using as examples the experiences of 2 AI systems, IBM Watson on Jeopardy and Watson for Oncology, that medical decision making based on relative uncertainty provides a better lens for understanding the application of AI to medicine than one that minimizes uncertainty. This approach to uncertainty has significant implications for how health care leaders consider the benefits and trade-offs of AI-assisted and AI-driven decision tools and ultimately integrate AI into medical practice.
- Notably, Watson's "thinking" process did not mirror how a human Jeopardy contestant processes questions. While both humans and Watson take confidence-driven approaches, only Watson explicitly incorporated confidence as a quantifiable and objective metric. Watson had to proceed in this manner because, unlike humans, it associates all potentially related concepts from raw data with each question. Humans, on the other hand, have an immediate instinct for whether they know the correct answer. This intuitive confidence is a subjective experience for a human contestant. AI approaches such as DeepQA therefore function in a way that is fundamentally different from human intelligence.

Summary

- AI is still in the phase of being trained on data that already exists so that it may, in small leaps, extrapolate what it knows to novel situations in ways that are as cumulatively

intelligent as the data that was fed into its creation. With that being said, it seems unreasonable to expect AI – at this point in time – to make better decisions while weighing "relative uncertainty" than humans since I do not believe us humans even have such uncertainty data available. Nonetheless, there are examples of emergent AI properties such as their ability to predict protein structure and perform tasks such as radiologic interpretation and dermatopathology diagnosis better than humans. However, the blunders made by AI are often so self-evidently silly that even patients would be able to identify their reasoning errors in clinical practice. As we have discussed before, the authors here delineate the diagnostic pathway: "First, the clinician enumerates the diagnostic possibilities and estimates their relative likelihood. Second, the clinician incorporates new information to update the relative probabilities, rules out certain possibilities, and, ultimately, chooses the most likely diagnosis. Thus, with each new finding, the clinician moves from one probability (the pretest probability) to another probability (the posttest probability) to arrive at a diagnosis." Then, to assess the prognosis of the patient if a particular intervention is chosen (or not chosen), physicians generalize "risk from a study population to the target-patient population of interest, followed by a patient-specific estimation of the probability that a given individual falls within the target population." Interestingly, AI has the ability to quantify its confidence – whether or not this quantification is true can be debated – whereas humans have a simple, nonnumerical "feel" of how confident they are in their diagnosis, treatment, and prognosis.

100. Seemann RJ, Melcher P, Eder C, et al. [Informed consent for surgery: clearly regulated by the patient rights law-significant uncertainty among medical students : Legal analysis and inventory of over 2500 medical students in Berlin as part of the Progress Test Medicine]. Orthopade. Nov 2021;50(11):937-945. Chirurgische Aufklärung: Klar geregelt durch das Patientenrechtegesetz – deutliche Unsicherheit bei Medizinstudierenden : Rechtsanalyse und Bestandsaufnahme bei über 2500 Berliner Medizinstudierenden im Rahmen des Progress Test Medizin. doi:10.1007/s00132-021-04080-1

- BACKGROUND: Obtaining informed consent is a challenging task and is part of the educational objectives in the German NKLM. Teaching formats are inconsistent and time-consuming, with little emphasis on legal aspects, although they have moved into the focus of attention since the implementation of patient rights laws and play an important role in legal proceedings. OBJECTIVES: The aim of this study was the evaluation of medical students' knowledge about the legal aspects of obtaining informed consent. A legal analysis was performed, and the patient rights laws were reviewed with reference to implications for undergraduate medical education. MATERIALS AND METHODS: After the analysis of laws and jurisdiction, multiple-choice questions regarding the legal aspects of obtaining informed consent were created and placed in the Progress Test Medicine (PTM). A statistical analysis of the results of Berlin medical students was performed descriptively. RESULTS: The answers of 2625 (winter semester 2018/19) and 2409 (summer semester 2019) medical students in Berlin were analyzed. The rate of students who answered the questions about the procedures requiring informed consent and adequate time for consideration increased over time but did not reach comparable values to all PTM questions. Questions about required content were answered correctly by 30 to 60% of the students, regardless of their level of training; we did not see an

increase along with the time of study. CONCLUSION: In our study, we were able to show that medical students of all educational levels show tentativeness when it comes to the legal aspects of obtaining informed consent. Yet, the legal framework offers room for new teaching formats like "Co-Action", introduced in this paper for the first time, where students acquire informed consent while being supervised by the medical doctor in charge.

Summary

- Medical students generally have an admittedly poor understanding of the legal underpinnings governing their field. However, in their defense with perhaps a wee bit of bias, their training emphasis the core competencies required to be a physician: diagnosis, treatment, and prognosis. I would far rather more time be dedicated to enhancing this knowledge in my medical students than distracting their focus onto legal concepts that they will likely learn passively at a later date. Additionally, if a medical student is interested in legalities, they will likely take the initiative to seek out their own learning material on that topic.

101. Serra-Aracil X, Montes N, Mora-Lopez L, et al. Preoperative Diagnostic Uncertainty in T2-T3 Rectal Adenomas and T1-T2 Adenocarcinomas and a Therapeutic Dilemma: Transanal Endoscopic Surgery, or Total Mesorectal Excision? Cancers (Basel). Jul 22 2021;13(15)doi:10.3390/cancers13153685

- Deciding on the best treatment in these situations is a difficult task. There is a risk of overtreatment—that is, the performance of unnecessary major surgery, which entails greater surgical morbidity and mortality, alterations in quality of life, and higher economic costs. On the other hand, TES may prove to be insufficient for these lesions and the surgical treatment may need to be completed with TME
- With respect to the objective of the study, i.e., to establish whether these patients should undergo TES or TME, we contend that in group I patients with uncertain diagnosis, TES is the surgical technique of choice. The risk of requiring TME completion surgery is 15% (OR 2.3; 95% CI 1.1–4.7), but this means that TES is the correct approach in 85% of patients.

Summary

- The concern for overtreatment may be more prevalent in surgical fields than medical fields given the irreversibility of surgical actions. If “overtreatment” occurs in the non-surgical setting to the detriment of a patient, the treatment intensity can be lessened. However, a total mesorectal excision (TME) cannot be downgraded to a transanal endoscopic surgery (TES) once completed. This highlights the difficulty of new and potentially advantageous surgical techniques becoming in vogue: uncertainty can be created when applying these new techniques to patients whose indication is equivocal and may lead to overtreatment or undertreatment based on the previous “gold standard.” Cohort studies such as these – if not actual randomized controlled trials – are excellent means to decrease surgical uncertainty one study at a time by comparing the outcomes of competing techniques. This is especially true given that the present study found that for uncertainty surrounding the use of TES or TME for adenoma versus adenocarcinoma resection, patients did better overall when receiving the less invasive technique first even if that meant a smaller proportion of patients had to receive the more invasive technique subsequently (contrary to what may be more typical physician instinct: just do the more

invasive technique from the start if you are uncertain so that you can be sure to "get it all," which would be overtreatment in this study).

102. Sokas C, Minami C, Trinh QD. ASO Author Reflections: How We Convey Empathy, Address Uncertainty, and Share Serious News: Challenges to Remote Surgical Care. Ann Surg Oncol. Dec 2021;28(13):8697-8698. doi:10.1245/s10434-021-10326-1

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

103. Stowers C, Lee T, Bilionis I, Gosain AK, Tepole AB. Improving reconstructive surgery design using Gaussian process surrogates to capture material behavior uncertainty. J Mech Behav Biomed Mater. Jun 2021;118:104340. doi:10.1016/j.jmbbm.2021.104340

- To produce functional, aesthetically natural results, reconstructive surgeries must be planned to minimize stress as excessive loads near wounds have been shown to produce pathological scarring and other complications (Gurtner et al., 2011). Presently, stress cannot easily be measured in the operating room. Consequently, surgeons rely on intuition and experience (Paul et al., 2016; Buchanan et al., 2016). Predictive computational tools are ideal candidates for surgery planning. Finite element (FE) simulations have shown promise in predicting stress fields on large skin patches and in complex cases, helping to identify potential regions of complication. Unfortunately, these simulations are computationally expensive and deterministic (Lee et al., 2018a). However, running a few, well selected FE simulations allows us to create Gaussian process (GP) surrogate models of local cutaneous flaps that are computationally efficient and able to predict stress and strain for arbitrary material parameters. Here, we create GP surrogates for the advancement, rotation, and transposition flaps. We then use the predictive capability of these surrogates to perform a global sensitivity analysis, ultimately showing that fiber direction has the most significant impact on strain field variations. We then perform an optimization to determine the optimal fiber direction for each flap for three different objectives driven by clinical guidelines (Leedy et al., 2005; Rohrer and Bhatia, 2005). While material properties are not controlled by the surgeon and are actually a source of uncertainty, the surgeon can in fact control the orientation of the flap with respect to the skin's relaxed tension lines, which are associated with the underlying fiber orientation (Borges, 1984). Therefore, fiber direction is the only material parameter that can be optimized clinically. The optimization task relies on the efficiency of the GP surrogates to calculate the expected cost of different strategies when the uncertainty of other material parameters is included. We propose optimal flap orientations for the three cost functions and that can help in reducing stress resulting from the surgery and ultimately reduce complications associated with excessive mechanical loading near wounds.

Summary

- This article highlights the fascinating fact that uncertainty within the medical field in general changes, through either decreasing or increasing, as innovation either abolishes or creates sources of uncertainty. In this instance, computer models were used to predict how surgeons could best reduce undue stress being placed on skin flaps to reduce

pathological scarring. Prior to the power of computation, surgeons had to rely entirely on their "feel" (likely being composed of heuristics, primacy/recency biases, the effects of the status quo within their institution of training, etc.) rather than present day surgeons that can – in theory based on this paper – utilize computers to reduce via calculation some "solved" uncertainties.

104. Velayudhan BV. Embracing uncertainty: an empathy and resilience-based approach to cardiothoracic surgery in a post-pandemic era. Indian J Thorac Cardiovasc Surg. May 2021;37(3):247-254. doi:10.1007/s12055-021-01193-2

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

105. Vivian LMH, Hunter C, Tan L, Comitis G, Neveling G, Lawrenson J. Found in translation: navigating uncertainty to save a child's heart. Paediatric cardiac surgery in Cape Town, South Africa. Med Humanit. Mar 2021;47(1):112-122. doi:10.1136/medhum-2019-011650

- **ARTICLE UNABLE TO BE OBTAINED.**

106. Waller DA, Opitz I, Bueno R, et al. Divided by an Ocean of Water but United in an Ocean of Uncertainty: A Transatlantic Review of Mesothelioma Surgery Guidelines. Ann Thorac Surg. Feb 2021;111(2):386-389. doi:10.1016/j.athoracsur.2020.10.009

- There is a tendency towards more complete staging for all patients in North America with the routine use of positron emission tomography–computed tomography (PET-CT) as well as specific recommendations for magnetic resonance imaging (MRI) with intravenous contrast (to assess the subclavian vessels, chest wall, diaphragmatic, and mediastinal invasion), whereas the European approach appears to be more selective in recommending PET scan and MRI dependent on the eventual treatment destination.
- As expected, there is most divergence of opinion when the role of radical or 'cytoreductive' surgery is considered. Radical surgery in MPM is defined as macroscopic complete resection (MCR), which can be achieved by extrapleural pneumonectomy (EPP) consisting of en bloc resection of the pleura, lung, pericardium and diaphragm, or (extended) pleurectomy/decortication (P/D), which includes resection of the total parietal and visceral pleura with or without part of the pericardium and diaphragm. Both procedures are combined with systematic mediastinal lymph nodes sampling or dissection for optimal staging. The North American attitude is far more supportive of these procedures than that of the Europeans.

Summary

- A quite fair frustration when encountering clinical uncertainty is the differences found within guidelines created by different societies that, in theory, are supposed to exemplify the authoritative recommendation. It is interesting to note that, in the example given from the current article, North American and European guidelines differ on their preferred aggression of working up and managing mesothelioma, with North Americans appearing more comfortable with a more aggressive approach. Why might this be? Is this a byproduct of cultural differences between the members of the two societies? Differences

in the patient population – perhaps the decreasing incidence and prevalence in the United States despite persisting in Europe?

107. Clair CA, Abshire Saylor M, Nolan MT, Gallo JJ. "You think you got it down and then the moment comes": The certainty of uncertainty in end-of-life decision making. Palliat Support Care. Aug 2 2022:1-6. doi:10.1017/s1478951522001031

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

108. Ford CM, Regan H, Dwyer M, Patel G. Adenomyoepithelioma of the breast: a rare diagnosis complicated by surgical emergency and diagnostic uncertainty. BMJ Case Rep. Feb 8 2022;15(2)doi:10.1136/bcr-2021-246390

- A woman in her 80s was referred as an emergency case with a large oedematous and ulcerating lesion of the right breast. There was a 5-month history of increasing breast volume with new onset skin breakdown and discharge. Imaging revealed an extensive heterogeneous mass requiring drainage. No diagnosis was received from multiple biopsies and immediate surgical resection of the breast and axillary sampling was prioritised given the deteriorating patient condition. Postoperative histology identified a biphasic Adenomyoepithelioma of low malignant potential, a rare presentation compounding the complexity of management. The diagnostic uncertainty of this case highlighted the importance of MDT collaboration and the flexibility of current management pathways when dealing with cases requiring urgent surgical intervention. Axillary sampling in the context of unsuccessful preoperative biopsy represented a comprehensive means for assessing the need for further surgical or systemic management in the context of unconfirmed malignancy in a deteriorating patient.
- Given the late presentation and diagnostic uncertainty in this case, a complete mastectomy with wide margins encompassing all affected skin and axillary node sampling was clinically indicated

Summary

- Under clinical instances of higher than usual uncertainty, multidisciplinary collaboration often leads to diagnostic and therapeutic conclusions given the value of having multiple brilliant minds from various specialty disciplines (each having their own biases) weigh-in. And as we have explored previously, there is often a necessity of veering away from typical guidelines/management pathways when atypical cases present themselves. There seems to be a trend within doctoring as a whole to be much more general in the diagnostic and therapeutic approach when uncertainty is prevalent. In surgery, this may involve “cutting out more,” and, in medicine, this may involve empirically covering for a broader array of pathogens with antibiotic treatment prior to receiving culture results.

109. Haier J, Mayer M, Schaefers J, Geyer S, Feldner D. A pyramid model to describe changing decision making under high uncertainty during the COVID-19 pandemic. BMJ Glob Health. Aug 2022;7(8)doi:10.1136/bmjgh-2022-008854

- In a crisis situation, however, the uncertainty regarding decision making in clinical processes massively increases both in individual areas and in the overall system.

Physicians are confronted with a 'postnormal' situation determined by a lack of evidence or even empirical values to such an extent that previous decision-making patterns and paradigms cannot be continued without scrutiny. […] In many of these situations, healthcare professionals, but also patients, were extensively confronted with moral distress, as decisions in either direction can lead to highly uncertain outcomes

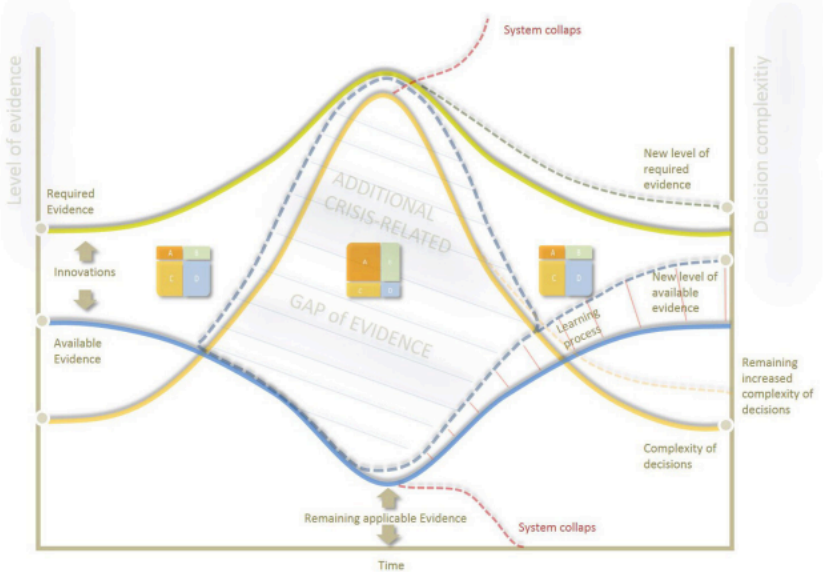

Figure 2 Relationship between complexity of decision-making (yellow line): available evidence (blue line), evidence gap (grey area) and the learning process during a healthcare crisis (dotted lines). Levels of uncertainty can rise within a short time frame (adapted miniature uncertainty diagrams). If the adaptation process is inadequate, a system collapse can occur, in which a sufficient knowledge basis for decision-making is absent due to excessive complexity (dotted red lines).

- Evidence, scientific certainty and experience, often described as known knowns and known unknowns, have created a generally accepted decision-making framework with a corresponding framework of values. The available evidence enables a risk management system that offers a manageable balance of new information required for justified action. During this state, the difference between existing and required evidence covers the area of process innovation, that is, the known way of generating new evidence (areas C and D of the uncertainty diagram). People usually approach unknown situations by first applying tested strategies, trying out whether they work, subsequently modifying them
- During a crisis, the required evidence increases suddenly in correlation with the growing uncertainty, interdependencies and complexity of decisions (figure 2). At the same time, the applicability of existing evidence decreases to a large extent, opening up gaps in evidence that cannot be satisfactorily filled in a timely manner and might even lead to a system collapse. This phenomenon is associated with critical decision-making uncertainty
- This new information may consist of fast-track data, preliminary investigations, rapid reviews, modelling based on experience and theoretical concepts, among others, and over

time in more substantial data. For some systemic aspects, an organization may return to the decision-making pattern of the precrisis period
- At the same time, an infrastructure for permanent crisis monitoring needs to be created in order to enable the early detection of the above-described need for a changed applicability of value structures and normative frameworks. Since the decision-making complexity and its determinants cannot be measured directly, this monitoring must use suitable surrogate parameters

Summary

- The COVID-19 pandemic represented a state of such potent uncertainty that it serves as an excellent example of how physicians augment their problem-solving to maintain efficacy without sufficiently referenceable data. Such complexity within the pandemic was exacerbated by the public assignment of moral, ethical, and sociopolitical value to decisions about COVID-19, including its prevention and treatment. Within normal levels of uncertainty (outside of situations like the COVID-19 pandemic), the knowns are known and the unknowns are also known because of extensive research into the matter (usually), allowing physicians to sufficiently explore the unknowns that interact with their decision-making. So-called "critical decision-making uncertainty" occurs during healthcare crises such as the COVID-19 pandemic where the knowns and unknowns are largely unknown, making it so that there is no good place to start for solving novel, obscure medical problems. As we saw with the Pandemic, overcoming this uncertainty and avoiding a "system collapse" requires "fast-track data, preliminary investigations, rapid reviews, modelling based on experience and theoretical concepts" that – despite being helpful for the internal workings of the healthcare system – became popularized within the general society and caused a new kind of cultural uncertainty as healthcare was attempting to solve their own uncertainty. Another exacerbating factor of sources of uncertainty such as a pandemic is the impact that compensatory mechanisms have on non-pandemic related healthcare system activities; for example, "elective" procedures may matter quite a bit to the patients unable to receive them. Contrary to other clinical scenarios where there may be exorbitant amounts of data suggesting what interventions are best for patients on the population-based scale, highly uncertain decision-making environments with unknown knowns and unknown unknowns may call for greater use of basing subsequent decisions on the outcome of the most recent similar decision (availability heuristic).

110. Ivany E, Lotto RR, Lip GYH, Lane DA. Managing Uncertainty: Physicians' Decision Making for Stroke Prevention for Patients with Atrial Fibrillation and Intracerebral Hemorrhage. Thromb Haemost. Sep 2022;122(9):1603-1611. doi:10.1055/a-1789-4824

- Twenty physicians from five European countries (Austria, France, Germany, Spain, United Kingdom) participated. The overarching theme "Managing uncertainty," addressed the process of making high-risk clinical decisions in the context of little available robust clinical evidence for best practice. Three subthemes were identified under the umbrella theme: (1) "Computing the risks," captured the challenge of balancing the risks of ischemic stroke with the risk of recurrent ICH in a complex patient population; (2) "Patient factors" highlighted the influence that physician-perceived patients' beliefs and previous experience of stroke had on physicians' decisions; and (3)

"Making a decision" explored the process of reaching a final decision regarding initiation of OAC therapy or not

Summary

- Anticoagulating patients for the preventive treatment of stroke in the setting of atrial fibrillation is undoubtedly complicated in the patient subpopulation who have experienced bleeding diathesis pathologies such as intracerebral hemorrhage. The main themes that their decision-making utilizes to overcome this uncertainty are "computing the risks," "patient factors," and "making a decision" that may be aided by shared decision making but – from the perspective of the European physicians in this study – choosing to proceed with stroke prevention is an act that can only be finalized by the physician. Regarding risk computation, physicians reported using "reliance on existing knowledge, personal clinical experience, and awareness of patients' comorbidities and clinical risks of stroke." Regarding consideration of patient factors, physicians ranged from contemplating the cause of intracerebral hemorrhage, level of disability after intracerebral hemorrhage, age, and number of comorbidities. The process of "making a decision" with patients is complicated by their misconceptions about therapies such as warfarin simply being "rat poison," experiences their family members have had with a certain drug, or even lifestyle details such as outdoor escapades that may make death more likely with a bleeding diathesis. As we have seen articulated in other articles, the physicians surveyed here felt more comfortable advising their patients whether or not to be anticoagulated for stroke prevention in the setting of atrial fibrillation if the decision was made with multidisciplinary physician colleagues – a strategy that increases the amount of contemplation of a medical problem through parallelization and diffuses the responsibility of the patient's clinical outcome. Furthermore, the present article also references the belief that explaining the uncertainty inherent within a medical decision can cause patients to become deferential to the expertise of the physician.

111. Javanmard-Emamghissi H, Moug SJ. The virtual uncertainty of futility in emergency surgery. Br J Surg. Nov 22 2022;109(12):1184-1185. doi:10.1093/bjs/znac313

- Futility is underpinned by risk, where the danger or hazard to a patient is extreme. Although risk assessment is relevant in the elective setting, the emergency setting provides increased complexity due to time-pressured decisions that commonly happen in the middle of the night with limited multidisciplinary team support and reduced family presence to guide decisions. In 1995, medical ethicist Bernard Lo divided medical futility into seven principles, including quantitative and qualitative futility, which we apply in this high-risk emergency surgical setting2 . Quantitative futility is the statistical probability of surviving a procedure or the success of a treatment, for example application of the NELA score (https://data.nela.org.uk/riskcalculator/) or Clinical Frailty Score to predict 30-day mortality after emergency laparotomy3 . Qualitative futility is where the quality of benefit that surgical intervention will result in is poor, for example the formation of a permanent high-output stoma in a palliative oncological setting

Summary

- The applicability of uncertainty to futility is simultaneously fascinating and terrifying. These authors identify that the concept of medical/surgical futility dates back to Hippocrates and has since permeated the minds of physicians that appear to, at the slightest notion of futility, avoid further invasive or intensive intervention. However, is

futility ever certain? The authors reference Bernard Lo and his creation of the seven principles of futility that includes quantitative futility ("the statistical probability of surviving a procedure or the success of a treatment, for example application of the NELA score (https://data.nela.org.uk/riskcalculator/) or Clinical Frailty Score to predict 30-day mortality after emergency laparotomy") and qualitative futility ("the quality of benefit that surgical intervention will result in is poor"). Interestingly, there had been a push from the American College of Chest Physicians, American Thoracic Society, and European Society for Intensive Care Medicine to replace "futility" with "potentially inappropriate." This transition is likely appropriate as the constant progression of our understanding of science, medicine, and surgery optimistically turns what used to be futile into what can be possible.

112. Parisi G, Kurotschka PK. [From evidence-based medicine to shared decision making: how to manage uncertainty in clinical practice.]. Recenti Prog Med. May 2022;113(5):305-316. Dalla medicina basata sulle evidenze alla decisione condivisa con il paziente: come gestire l'incertezza nella pratica clinica. doi:10.1701/3803.37892

- **ARTICLE UNABLE TO BE OBTAINED IN ENGLISH.**

113. Saposnik G, Ismail Z, Rivard AM, et al. Decision making under uncertainty in the diagnosis and management of Alzheimer's Disease in primary care: A study protocol applying concepts from neuroeconomics. Front Med (Lausanne). 2022;9:997277. doi:10.3389/fmed.2022.997277

- In behavioral economics, uncertainty is a general term that comprises two concepts: risk and ambiguity. Risk applies to events with known probability, whereas ambiguity is a term reserved for events for which probabilities are unknown. Uncertainty is one of the most important contributing factors affecting decisions in medical care
- We hypothesized that participants will make automatic decisions (involving system 1) for straightforward simulated scenarios where there is limited degree of uncertainty, compared to deliberate choices when face more complex scenarios (system 2).
- For example, patients with mild or no symptoms having a low risk of developing a disease progression or a serious medical conditions may elect to avoid "risky" treatments (given the low gains while having a significant risk of developing side effects), whereas patients with symptoms interfering with their quality of living or being at high risk of developing a disease or a medical complication would be willing to accept more risky treatments (given the higher gains even if the likelihood of side effects is increased).

Summary

- The dichotomy between risk ("events with known probability") and ambiguity ("events for which probabilities are unknown") is an interesting comparison I do not recall seeing before. These authors also helpfully provide a name for Type 1 and Type 2 reasoning: "The Dual Process Theory." One might expect that more uncertain clinical scenarios would initiate a Type 2 reasoning that is slower and more methodical; however, I think that the occasional over-reliance on cognitive biases we have discussed elsewhere does not always lend truth to this expectation. "The Prospect Theory," on the other hand, is more of a cost-benefit analysis where, put simply, less severe situations require less severe interventions and more severe situations may require more severe interventions.

114. Charrois TL, Sewell HD. Clinical decision-making by fourth-year pharmacy students: Towards an understanding of their uncertainty. Curr Pharm Teach Learn. Sep 2023;15(9):779-786. doi:10.1016/j.cptl.2023.07.020

- **IT WAS FELT THAT THIS ARTICLE WAS INAPPROPRIATE FOR THE REVIEW ARTICLE GIVEN THE AUTHOR'S DISCUSSION OF PHARMACY STUDENTS MAKING DECISIONS OUTSIDE THE CONTEXT OF PHYSICIANS/MEDICAL STUDENTS.**

115. Duval M, Zewdie M, Kapadia MR, et al. How to say "I don't know": development and evaluation of workshops for medical students and surgical residents on communicating uncertainty using the ADAPT framework. Global Surg Educ. 2023;2(1):1. doi:10.1007/s44186-022-00075-4

- The authors developed ADAPT, a mnemonic framework to improve student comprehension and recall of the important steps in uncertainty disclosure: assess the patient's knowledge, disclose uncertainty directly, acknowledge patient emotions, plan next steps, and temper expectations.
- Importantly, our results suggest a significant link between learner confidence prior to skills practice and observer/SP assessment of their skills demonstration, validating the importance of assessing and addressing skills confidence.

Summary

- The ADAPT framework developed by the authors stands for "assess the patient's knowledge, disclose uncertainty directly, acknowledge patient emotions, plan next steps, and temper expectations" so that uncertainty can be disclosed safely to patients without running as high of a risk of harming the therapeutic relationship. The authors then cite that "in one analysis of over 1000 encounters, PCPs and surgeons discussed the uncertainty surrounding their treatment plan in 1% of encounters for basic decisions, 6% for intermediate decisions, and 17% for complex decisions" which significantly limits the ability for patients to actively and appropriately engage in their own decision making when they might not even be aware of the looming uncertainty. Interestingly, and perhaps expectedly, there may be a positive association between the confidence a provider has in addressing uncertainty with patients and the subjective interpretation of that expression of uncertainty. I am curious whether this is due to an objective increase in the ability to convey uncertainty (making the confidence a byproduct of known skill) or whether simply imbuing the act with confidence makes patients take it better.

116. Friedlaender GE. CORR Insights®: Imposter Syndrome Among Surgeons is Associated With Intolerance of Uncertainty and Lower Confidence in Problem Solving. Clin Orthop Relat Res. Apr 1 2023;481(4):672-674. doi:10.1097/corr.0000000000002427

- **GIVEN THAT THE ARTICLE THIS COMMENTARY REFERS TO WILL BE ANNOTATED BELOW, THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT.**

117. Jeon JY, Kim DH, Kang K. Effect of audiovisual media-based nursing information on environmental stress, anxiety, and uncertainty in patients undergoing open-heart surgery. Medicine (Baltimore). Feb 22 2023;102(8):e33001. doi:10.1097/md.0000000000033001

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118. Lee CW, Evans E, Vitous CA, Suwanabol PA. Living with uncertainty in surgery: integrating palliative care principles into conversations as a solution to patient and family, provider, and health system disquietude. Ann Palliat Med. Jan 2023;12(1):16-20. doi:10.21037/apm-22-1332

- Clinician-led serious illness conversations (i.e., primary palliative care skills) have been shown to improve the quality of conversations for both patient and clinician, while simultaneously achieving uniformity in conversational elements between different providers to ensure the critical issues are addressed. […] For patients being considered for surgery or having undergone surgery, surgical specialists carry unique responsibilities owing to the nature of high-stakes surgical procedures and the challenge of appropriate patient selection. Surgeons are therefore in an advantageous, and arguably the best, position to have these conversations in surgical contexts given their expertise in surgical diseases and expected outcomes.
- Surgeons encounter uncertainty routinely, yet it is unclear whether increasing experiences with uncertainty generates greater willingness, aptitude, or comfort in managing cases. Rather, the inability to offer tangible solutions or cure may deter surgeons to further engage with patients, to ensure candor about unclear prognoses, and to discuss alternative treatment option
- Similarly, the Best Case/Worst Case Communication Framework developed for discussion about treatment options in the context of serious illness combines the clinician's knowledge of the presenting illness and the patient's overall health to give patients and families the best estimate of what may happen (21). This allows patients and families to prepare for the uncertain. The key elements in utilizing Best Case/Worst Case Communication Framework are to utilize a graphic aid to illustrate a conversion of statistical probabilities into stories of what the patient's life may look like if these probabilities occur

Summary

- "Serious illness conversations" advance the patient's understanding of their complex and inherently uncertain medical/surgical situation in addition to providing physicians an opportunity to exercise their skill of placing diagnoses and treatments into the perspective of uncertainty. The authors use surgeons as an example of a specialty that should more often initiate these serious illness conversations, even if such serious illness has not occurred yet, to prepare patients for what could happen during a surgical intervention. Conversely, previous papers have articulated the tricky position of surgeons to remain inwardly and outwardly confident in the face of uncertainty because patients will not be pleased seeing a physician who wants to non-confidently cut them open. Interestingly, surgeons are often hesitant to intervene on patients that have uncertain diagnoses and prognoses, suggesting that certainty about the likely outcome of surgery is an important consideration that surgeons make prior to consenting patients for surgery. Similar to but more extreme than medical specialists, surgeons place the "burden of proof" on patients and their pathologies to prove that they need surgery rather than performing "not

unreasonable" empiric interventions that can be halted if needed. On the other hand, these authors also argue that surgeons often operate binarily with patients; that is, the surgeon does much internal processing to decide whether they want to offer this patient surgery (sometimes even deciding before beginning their interview of the patient), spending their visit either explaining why or why not surgery is the best option for them. This is done instead of ascertaining the patient's goals, values, and nonoperative options even if a patient is a surgical candidate (this is called the "fix-it model" in the paper). The authors also describe the "Best Case/Worst Case Communication" model where physicians can employ the simple strategy of discussing the best and worst case scenario outcomes for each therapeutic option (including doing nothing at all).

119. Lin E, Crijns TJ, Ring D, Jayakumar P. Imposter Syndrome Among Surgeons Is Associated With Intolerance of Uncertainty and Lower Confidence in Problem Solving. Clin Orthop Relat Res. Apr 1 2023;481(4):664-671. doi:10.1097/corr.0000000000002390

- The finding that feelings of imposter syndrome may be modestly to notably associated with modifiable factors, such as difficulty managing uncertainty and lack of confidence in problem-solving, spark coaching opportunities to support and sustain a surgeon's mindset, which may lead to increased comfort and joy at work.
- A systematic review identified clinician attitudes toward risk and uncertainty as a source of between-clinician variability and suggested interventions to improve comfort with uncertainty as targets for reducing unwarranted variations in care
-

Summary

- The primary finding of this paper was that "imposter syndrome may be modestly to notably associated with modifiable factors, such as difficulty managing uncertainty and lack of confidence in problem-solving," and the authors identify that finding ways to "sustain a surgeon's mindset" may be the preventive and corrective response to surgeons experiencing imposter syndrome and its sequelae. Importantly, clinical uncertainty can result in variations of care provided to the same patient by different providers simply based on the subjective experience of that uncertainty by the providers. While this may be understandable in the surgical setting since different surgeons may have different technical strengths/weakness affecting their surgical recommendations, this should not be occurring in the world of general practitioners (unless due to a simple lack of knowledge) and especially not medical specialists. These authors conclude by mentioning "surgical coaching programs such as the Wisconsin Surgical Coaching Program and the Harvard Surgical Coaching for Operative Performance Enhancement might also help ameliorate feelings of imposter syndrome in part by increasing comfort with uncertainty and confidence in problem solving." This made me realize a source of uncertainty that is more esoteric than the others we have previously discussed: uncertainty caused by one being relatively confident that a medical or surgical decision is likely appropriate, but being unsure of whether one's medical or surgical superior will approve of that decision. There are many times in medicine, especially as a trainee, where there are multiple objectively correct ways to diagnose or treat a pathology; however, there is often one singular preference of the senior resident, fellow, or attending.

120. Lumsden L, Cannon P, Wass V. Challenge GP: using gamification to bring the reality and uncertainty of a duty doctor's surgery to early year medical students. Educ Prim Care. Mar 2023;34(2):103-108. doi:10.1080/14739879.2023.2190936

- They appreciated the opportunity to apply and consolidate some of their learning 'things that we learn in our clinical handbook that we don't really get . . . it's nice to start thinking about it in a more clinical sense'. They believed that it was 'good clinical reasoning. Just in general. . . it's like a muscle. You kinda practice, going through the thought process'.

Summary

- Similar to previous articles that have been annotated, the authors here emphasize the importance of practicing the experience of and approach to clinical uncertainty "like a muscle." Rather than avoiding uncertainty as something undesirable, there is likely benefit in embracing it as a necessity that is ubiquitous in varying magnitudes and – like anything else – can be better managed by encountering it more often.

121. Puriani D, Allenidekania A, Afiyanti Y. The Experience of Uncertainty in Mothers Caring for Children at Home after Palliative Heart Surgery. Indian J Palliat Care. Jan-Mar 2023;29(1):46-50. doi:10.25259/ijpc_453_20

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

122. Wu M, Dai S, Wang R, Yang S. The relationship between uncertainty and acute procedure anxiety among surgical patients in Chinese mainland: the mediating role of resilience. BMC Psychiatry. Nov 1 2023;23(1):796. doi:10.1186/s12888-023-05315-5

- **THIS CITATION WAS NOT DEEMED NECESSARY OR SUITABLE FOR THIS HUMANITIES DISTINCTION TRACK PROJECT GIVEN ITS LACK OF DISCUSSING ANYTHING INTERESTING OR NOVEL PERTAINING TO THE TOPIC AT HAND.**

123. Appel H, Sanatkar S. Systematic Search and Scoping Review of Physicians' Intolerance of Uncertainty and Medical Decision-Making Uncertainties During the COVID-19 Pandemic: A Summary of the Literature and Directions for Future Research. J Clin Psychol Med Settings. Jun 2024;31(2):338-358. doi:10.1007/s10880-023-09974-0

- Qualitative studies emphasized decisional uncertainty as a stressor for physicians, and quantitative studies suggest it may have fostered more unproven treatment choices. While the prevalence and impact of physician uncertainty under COVID-19 conditions requires further investigation, sighting available literature indicates that IU coincided with experiences of poor mental health and, at least towards the beginning of the pandemic, with willingness to endorse unproven treatments
- Recent theorizing has highlighted fear of the unknown as a central aspect of IU (Carleton, 2016b). The unknown is widely regarded as one of the most fundamental sources of human fear, if not the most fundamental one (Carleton, 2016a).
- Rosen et al. (2014) theorized "cognitive closure" as a possible reaction, which means resorting to any answer to avoid uncertainty (Kruglanski & Fishman, 2009). Individuals

with need for cognitive closure are thereby prone to blinding out conficting, albeit potentially important information (Dolinski et al., 2016). Focusing more specifically on medical implications, previous research found associations between traits related to difficulties tolerating uncertainty and rejection of new treatments and technologies (Hamann et al., 2013; Turner et al., 2014), which may reflect reluctance to innovate.

- However, such treatment choices may be explained by reasons other than only uncertainty (e.g., time pressure, condition severity, etc.). Situational factors can indeed interact with uncertainty, for example, by making uncertainty less tolerable, and thus moderating the response

Summary

- The COVID-19 pandemic was fraught with such extensive uncertainty that doctors and patients were effectively equalized as the basis of their usual social contract (knowledge) was unfounded. Nonetheless, doctors felt obligated to "do something" for the scared patients they cared about, leading to the choice of unproven treatments for patients. This echoes the tendency for people in general to make rash decisions when stressed (e.g. test taking when anxious or under a time-crunch) and the tendency for physicians to order more tests when uncertain. Even worse, there is another tendency for the combination of uncertainty and pressured situations to cause people – even doctors – to "freeze." The authors cite the uncertainty taxonomy of Hal: "probabilities (i.e., probabilities being inherently indetermined, e.g., a 50:50 chance of a treatment being effective vs. ineffective), ambiguity (i.e., due to imprecise, insufficient, or conflicting information, e.g., a 30–70% chance of a treatment being effective), and complexity (i.e., overly intricate information, e.g., a wide array of interacting moderators influencing treatment effectiveness)." One of the potentially most fundamental reasons for uncertainty intolerance to be analyzed in medicine is due to the human fear of the unknown. In addition to what we have already described, this uncertainty weighs on physicians at every step of their way, including the process of triaging and even when they consider how they are going to speak with their patients in a professional way about their uncertainty. Furthermore, I contend that this uncertainty is summative such that it is often not one moment of uncertainty that makes a physician crumble; it is the additive effect of every small moment of uncertainty that meets the physician around every corner and in every patient room. Put succinctly, "high pressure decision making under conditions of sometimes extreme uncertainty is thus seen as a major challenge in medical practice." The cognitive bias of "cognitive closure" is a subtle defense mechanism used by physicians to neglect too much information that leaves too much doubt in their mind created by uncertainty. The tendency towards cognitive closure was associated with a tendency towards being more comfortable with off-label and ill-proven therapeutic use. The authors also discuss how intolerance of uncertainty unfortunately leads physicians to reject novel and – to my supposition – not practically tried-and-true innovations (despite them being theoretically validated). One of the articles meeting the inclusion criteria of this paper describes telemedicine during the Pandemic having a negative effect on decisional confidence. There was a tendency for men, non-Infectious Disease internist specialists, and less published physicians to choose more off-label and ill-proven therapeutics to treat patients with COVID-19 in addition to "more severe" cases of COVID-19 often leading uncertain physicians to be more uncertainly aggressive in their treatment approach. Perhaps ironically, physicians who felt they had more "COVID-19

expertise" and higher "perceived quality of COVID-19 publications" also made more inappropriately aggressive and unfounded COVID-19 treatment choices. Complicating things further is the apt description of uncertainty as modifiable by variables like "time pressure, condition severity". Uncertainty may manifest from unpredicted locations, as there were undeniably instances during the Pandemic when physicians were made more uncertain by impositions from their employing institution.

124. Datta R, Kiwak E, Fried TR, et al. Diagnostic uncertainty and decision-making in home-based primary care: A qualitative study of antibiotic prescribing. J Am Geriatr Soc. May 2024;72(5):1468-1475. doi:10.1111/jgs.18778

- Participants reported uncertainty about the diagnosis of infection due to the characteristics of homebound patients (atypical presentations of disease, presence of multiple chronic conditions, presence of cognitive impairment) and the challenges of delivering medical care in the home (limited access to diagnostic testing, suboptimal quality of microbiological specimens, barriers to establishing remote access to the electronic health record). When faced with diagnostic uncertainty about infection, participants described many factors that influenced the decision to prescribe antibiotics, including those that promoted pre-scribing (desire to avoid hospitalization, pressure from caregivers, unreliable plans for follow-up) and those that inhibited prescribing (perceptions of antibiotic-associated harms, willingness to trial non-pharmacological interventions first, presence of caregivers who were trusted by clinicians to monitor symptoms).

Summary

- A unique source of clinical uncertainty is found outside of the confines of the hospital when medicine is performed during home-based primary care. There is no laboratory at home, patients are often cognitively impaired, and there no electronic medical record. Home-based primary care physicians find novel factors to consider under these atypical circumstances to guide their choice of prescribing antibiotics "including those that promoted pre-scribing (desire to avoid hospitalization, pressure from caregivers, unreliable plans for follow-up) and those that inhibited prescribing (perceptions of antibiotic-associated harms, willingness to trial non-pharmacological interventions first, presence of caregivers who were trusted by clinicians to monitor symptoms)."

125. Gwilym BL, Twine CP, Bosanquet DC. Information Provision to Facilitate Vascular Surgery Shared Decision Making in the Face of Uncertainty. Eur J Vasc Endovasc Surg. May 27 2024;doi:10.1016/j.ejvs.2024.05.032

- Information would ideally comprise accurate individualised outcome predictions. Examples include predicting the risk of amputation after revascularisation, death after abdominal aortic aneurysm (AAA) repair, or stroke after carotid endarterectomy. In its crudest form, predicting outcomes relies on clinicians combining their experiential knowledge with data from relevant evidence to the patient in front of them. Clinicians' accuracy in predicting outcomes after surgical intervention using their gestalt (intuition) alone depends on the outcome being predicted and the intervention considered, but is often imprecise and sometimes woefully poor.3 This imprecision can be due to availability heuristic (events that provoke negative emotion in our memories are more readily recalled), self serving bias, and confirmation bias

- Patient satisfaction is inversely correlated with clinician expression of uncertainty, especially so when clinical reasoning is not explained alongside this disclosure. Communicating uncertainty can challenge the doctor– patient relationship where, doctor knows best, that some patients hold true, which can negatively affect patient perceived competence, confidence, and trust. A natural response to a patient experiencing emotional distress before an important decision is to reassure with statements of certainty. Shared decision making, however, demands transparency and disclosure of uncertainty.
- The OVIDIUS study is a good example of how decision aids could affect shared decision making in vascular surgery. Decision aids that could be accessed before consultations improved shared decision making for patients with AAAs, intermittent claudication, or varicose veins, and increased patients choosing non-surgical options.7 The study showed that focused training improved shared decision making, but this resulted in longer consultation times. This study suggests that pre-consultation education and exploration of patients' goals by using a decision aid, longer consultation times, and shared decision making training for surgeons could improve our ability to navigate uncertainty with patients and provide better shared decision making. Clinician time is one of the most important resources needed to deliver some of these interventions.

Summary

- A properly performed shared-decision making event regarding surgery should include surgeons providing a prognostication of the likelihood of common adverse events as well as the life-threatening adverse events. Like we have previously discussed, the ability for physicians to prognosticate is quite underwhelming and is affected by "availability heuristic (events that provoke negative emotion in our memories are more readily recalled), self-serving bias, and confirmation bias." Even if a statistical model was derived to predict a more objective adverse event rate for a particular patient, that prediction is uncertain within the field of surgery given that the statistical model does not know the strengths/weaknesses of the surgeon, who else will be in the OR and what their strengths/weaknesses are, and other small butterfly effects influencing the patient's outcome. It goes without saying that even the most advanced prediction model will still be too simplistic for the multitudinous factors affecting clinical decisions. The single most important question this paper should aim to comment on is whether or not surgeons and/or non-surgeons should openly disclose their uncertainty to patients pending the conclusion that some patients prefer physicians to disclose their uncertainty while other patients hate it and view it as a marker of incompetence. My initial instinct is to suggest that non-surgeons should be more open about their uncertainty given the possibility for them to stop medications that do not work; however, surgeons would scare away all of their patients if they freely expressed their uncertainty to the same extent that they likely feel it. Patients must have more confidence in the person who is going to irreversibly cut them open while they lay asleep and completely vulnerable than they do the person who is going to prescribe them a reversible medication. Surgeons may be better able to express their uncertainty through strategies like the framing effect which involves "framing risk information in a positive manner, e.g., a one in six chance of preventing a stroke with carotid endarterectomy, rather than a five in six chance of carotid endarterectomy being unnecessary". These authors underscore another point that has been made elsewhere: pre-visit decision aids can help walk patients through the decision-tree that physicians will be making with them during their upcoming consultation

appointment. Priming patients with this information can allow them to better "speak the language" of their specialist in addition to allowing them time to think of the right questions to ask and consider beforehand so that they do not rashly and regretfully consent themselves to surgery.

126. Incze T, Pinkney SJ, Li C, et al. Using the Operating Room Black Box to Assess Surgical Team Member Adaptation Under Uncertainty: An Observational Study. Ann Surg. Jul 1 2024;280(1):75-81. doi:10.1097/sla.0000000000006191

- Numerous studies link teamwork deficiencies (eg, communication failures and lack of situation awareness) to technical errors and poor surgical outcomes, with the odds of surgical complications being nearly 5 times higher when fewer positive teamwork skills are observed.1–3 Improving surgical teamwork has proven deceptively difficult to achieve, partly because research often fails to capture the unique contributions of each interdisciplinary team member's role and the adaptive skills required under uncertainty, particularly when responding to disruptions such as intraoperative adverse events
- Even team members themselves report having a limited understanding of how they personally contribute to operating room (OR) teams.10 This is concerning as role clarity is an essential element of high-performing teams and successful surgery
- Seeing as coordination was the most frequently expressed teamwork skill across all roles, engraining standard coordination strategies, such as check-backs (ie, closed-loop communication to verify and validate information) and precise communication (ie, high-quality and accurate messages to avoid confusion) should be prioritized to build a common fundamental communication protocol across all roles

Summary

- Intraoperative adverse events (IAEs) are transient moments of intensely heightened intraoperative uncertainty that these authors fascinatingly analyze to determine how the surgical team responds. Notably, "nurses adapted to IAEs by expressing more backup behavior skills (5.3× increase; 13.9 instances/hour during an IAE vs 2.2 instances/hour when no IAE) while surgeons and medical trainees expressed more psychological safety* skills (surgeons: 3.6× increase; 30.0 instances/hour vs 6.6 instances/hour and trainees: 6.6× increase; 31.2 instances/hour vs 4.1 instances/hour). All roles expressed fewer situation assessment skills during an IAE versus no IAE." Surgery is undeniably a team sport, and poor teamwork leads to a 5x higher rate of IAEs. Inexplicably, however, there does not seem to be a common thread underpinning what exactly "good teamwork" in surgery consists of which is likely due to the singular uniqueness of each intraoperative personality. This is yet another likely unique source of uncertainty for surgeons compared to non-surgeons. The differing personalities in the operating room can lead to support staff and even medical trainees to be unfortunately unsure of their intraoperative role and how those roles change when met with intraoperative uncertainty – which is a predictor of IAEs. A familiar tendency for those with OR experience was also observed in this study: a significant decrease in leadership activity by non-surgeons during IAEs, probably to allow the evident leader of the room (surgeon) to coordinate correction of the IAE. Notably, the tendency for psychological safety expression during IAEs was not observed for nurses and anesthesiologists like it was for medical trainees. The interpretation of this is tricky, but it may reflect their lack of feeling the need to apologize to the surgeon? Because of the irreducible complexity and consequent uncertainty of

medicine in general, abolishing easy-to-solve sources of uncertainty should be priority number one. When confronted with overwhelming uncertainty, the least a good physician can do is take control of the uncertainty that is controllable despite still being at the mercy of the remaining, omnipresent uncertainty. The uncertainty I am referring to here consists of things like clear and closed-loop communication, setting clear expectations, clarifying team roles.
*Psychological safety refers to “admits mistakes and shortcomings”

127. Murphy E, Finucane FM. Addressing uncertainty about the role of structured lifestyle modification for metabolic surgery patients. Metabolism. Feb 2024;151:155739. doi:10.1016/j.metabol.2023.155739

- There is good evidence that structured lifestyle modification programmes improve health in patients with metabolic and cardiovascular disorders, but there is no specific evidence that they improve outcomes in patients undergoing metabolic or obesity surgery. Despite expert consensus guidelines stating this fact, some healthcare systems still compel patients to participate in a structured lifestyle modification programme prior to metabolic or obesity surgery. There is a well-established need for individualised multidisciplinary dietetic and physical activity care for metabolic and obesity surgery patients, and the benefits of intentional weight loss prior to surgery are well proven, but these are distinct from potentially harmful requirements for patients to undertake compulsory structured lifestyle programmes of fixed duration, frequency and intensity, which may delay surgery and reinforce obesity stigma. A critical step in rejuvenating metabolic surgery is to reframe patient participation in structured lifestyle modification programmes as an opportunity for education and empowerment, not as an indicator of motivation or suitability for metabolic surgery. Large, well-designed and adequately powered clinical trials are needed to address uncertainties in the evidence base for these programmes. Given genuine equipoise, they will need to determine whether "surgery plus lifestyle" is superior to "surgery plus placebo". Moreover, they will need to determine the cost-effectiveness of these programmes and identify some of the factors giving rise to the substantial heterogeneity in responses to structured lifestyle modification.

Summary

- Surgical fields appear to be plagued more often than non-surgical fields by the continuation of practices that are not evidence-based but have persisted in the culture for long enough that they have become dogma. This article highlights a good example being strict “structure lifestyle modification programme[s] prior to metabolic or obesity surgery” even though there are no clinical trials proving such practices to be causally beneficial. We have already discussed the difficulty that surgery has with performing RCTs, but until it becomes the mainstay of proving the efficacy of surgical practices, I fear that many practices will remain in use simply because “it has always been that way.”

128. Valentine KD, Leavitt L, Sepucha KR, et al. Uncertainty tolerance among primary care physicians: Relationship to shared decision making-related perceptions, practices, and physician characteristics. Patient Educ Couns. Jun 2024;123:108232. doi:10.1016/j.pec.2024.108232

- Higher UT was associated with greater physician age ($p = .01$) and years in practice ($p = 0.015$), but not sex or race. Higher UT was associated with greater SDM self-efficacy ($p < 0.001$), but not patient-reported SDM.

Summary

- For high-driven individuals such as those that pursue medicine, uncertainty is an undesirable variable in a system that many of us would probably want to make perfect if we could. The ability to tolerate this uncertainty has long been thought to be secondary to one's personality, and this article suggests that uncertainty is easier to tolerate as physicians grow older and gain more experience… or is this tolerance simply because they care less? Hopefully not. Interestingly, physicians being confident in their shared decision-making skills does not correlate with patients being satisfied with those share decision-making skills. The authors provide examples of where intolerance of uncertainty has had a direct impact on the recommended course of action for patients: "an early study using hypothetical scenarios showed that physicians with lower UT were more likely to withhold negative diagnostic test results with a high false-negative rate from patients, and to recommend pregnancy termination following abnormal results from prenatal genetic testing."

Organizing My Thoughts for Manuscript Construction

In this section, I will take all of the "Summary" statements that I wrote above for each entry of my Annotated Bibliography and organize them into thematic subcategories that will guide the placement of each article into the appropriate section of the review article. The review article sections are: Introduction, Surgical Uncertainty, Non-surgical Uncertainty, Comparing and Contrasting Surgical and Non-surgical Uncertainty, The Patient Perspective, and Conclusions.

Introduction

Thunnissen FB, Ambergen AW, Koss M, Travis WD, O'Leary TJ, Ellis IO. Mitotic counting in surgical pathology: sampling bias, heterogeneity and statistical uncertainty. Histopathology. Jul 2001;39(1):1-8. doi:10.1046/j.1365-2559.2001.01187.x

- It would be very interesting if we could have some way to quantify and disclose to patients the amount of uncertainty physicians have when undergoing clinical decision-making conversations with patients. This would likely be an impressively hard parameter to derive and quantify for the effectively infinite clinical circumstances and choices a physician encounters, but an ideal exemplification of this concept would be a numerical scale (e.g. 1-10) where increasing levels of uncertainty are reflected by higher numbers to facilitate ease of the patient's understanding. The problem being, of course, that the uncertainty of physicians is impacted by a similarly infinite number of factors, including a physician's medical knowledge, comfort with uncertainty in general, patient-specific variables.

Hall KH. Reviewing intuitive decision-making and uncertainty: the implications for medical education. Med Educ. Mar 2002;36(3):216-24. doi:10.1046/j.1365-2923.2002.01140.x

- This paper thoroughly outlines how there are three types of uncertainty from Beresford: technical, personal, and conceptual. "Technical sources of uncertainty are those where there is insufficient information to adequately predict prognosis or the effect of interventions [which includes effects of factors such as the speed of growth of medical knowledge, leaving one not knowing whether or not they are up-to-date]. […] Personal sources of uncertainty have their origins in the doctor–patient relationship, for example when the patient's wishes are unknown and not able to be solicited [which includes effects of factors such as the emotional attachment of the doctor for the patient that may impair the former's decision-making]. […] Conceptual sources of uncertainty arise from an inability to assess differing patient needs competing for the same resources (incommensurability), and the application of general criteria (for example, guidelines) to individual patients [which includes effects of factors such as applying past experiences to current patients as well as the general, existential uncertainty of the future]." Common ways that uncertain physicians attempt to come to terms with their uncertainty is through the use of heuristics, or generalizations. The authors here question whether heuristics are simply manifestations of the way that "expert" clinicians process medical information or whether such mental processes are just more-faulty-than-not mental shortcuts. Heuristics can lead to well-known cognitive errors such as recency bias, anchoring bias, patterning behaviors based on prior outcomes that would have potentially occurred regardless of the intervention that was made, the tendency for emotionally weighty medical

factoids/clinical memories to be recalled easier, and the tendency for feared negative outcomes – despite being rare in reality – to be discussed and avoided as if they were more common. The combination of these factors and the use of subsequent "medical intuition" by physicians may be what results in the development of so-called "practice styles" that have been mentioned elsewhere. Doctors do have the tendency of performing more tests when feeling more uncertain about their patient's diagnosis and therapeutic plan, as they attempt to collect more data and catch their fish with a large net as it were. As such, there is also a seeming tendency for medical students who are more intolerant of uncertainty to choose specialties with more utilization of technology and a narrowing of the general medical knowledge required of them. The dichotomy between the "public" and "private" experiences of uncertainty by clinicians is interesting, as there appears to be a general aversion amongst physicians for disclosing their uncertainty when it arises. Perhaps it is in the personal interests of health institutions and their doctors to not "break the fourth wall," so to speak, and uphold patient trust. However, reasonably so, there are many who argue that disclosing clinical uncertainty when it arises is actually the recipe for creating more physician-patient trust. This could be an increasingly true idea, especially in American culture, with increasing numbers of patients anecdotally just wanting doctors to tell them "I don't know" when they truly do not know something. Clearly, there is a gap in formal medical education where medical students are not directly taught how to engage with clinical uncertainty beyond generalities like "go search the literature!"

Farnan JM, Johnson JK, Meltzer DO, Humphrey HJ, Arora VM. Resident uncertainty in clinical decision making and impact on patient care: a qualitative study. Qual Saf Health Care. Apr 2008;17(2):122-6. doi:10.1136/qshc.2007.023184

- The implicit contract of healthcare received at teaching hospitals dictate that, whether they know it or not, patients are receiving care from resident physicians – arguably more often than they are an attending physician despite the latter's general oversight. One can therefore anticipate that higher levels of uncertainty will characterize the medical decisions being made by residents, and there is a cultural tendency amongst resident physicians to save consultation of their attending physician as a "last resort" option. Undeniably, this is one of the many influences of the so-called "hidden curriculum" in medical education that stokes a fear of being perceived as "weak" or "overzealous." However, this paper identifies that moving through the hierarchy of advice (same-year resident colleagues, then senior residents, then specialty fellows, and then attendings) can frequently cause patient care compromises that would have been avoided if the attending physician had been contacted sooner. One unique way that the authors discussed uncertainty affecting the clinical practice of residents is through withholding information from patients. It can be easy to understand why this might happen, especially if critical laboratory values or changes in patient status that can "wait until the day" occur, and improper communication (or simply lack of disclosure from the overnight team) leads to the day-time residents blindsiding patients with novel updates. The most uncertainty-inducing clinical scenario for residents involved encountering a patient that potentially needed an escalation of care. Additionally, the ability to perform certain procedures needed by different patients was a source of uncertainty in the residents that were surveyed, and their apprehension led to clinical decisions excluding performance of those

procedures (e.g. covering for meningitis in a patient with a consistent clinical picture, without performing a lumbar puncture).

Cranley L, Doran DM, Tourangeau AE, Kushniruk A, Nagle L. Nurses' uncertainty in decision-making: a literature review. Worldviews Evid Based Nurs. 2009;6(1):3-15. doi:10.1111/j.1741-6787.2008.00138.x

- Almost identically to similar studies performed on physicians, nurses report the most uncertainty when encountering unfamiliar situations surrounding patient care. These situations are unfamiliar because they do not align with the heuristics they have encoded from their training and, also similar to physicians (especially residents), approaching colleagues for help is a mainstay of clinical problem-solving. The most important common theme here is the tendency for nurses – and doctors – to be hesitant about recognizing and expressing uncertainties. Perhaps an argument can be made about how human nature operates within the professional setting, with professionals being fearful of being wrong, being ridiculed by their peers, being seen as weak, being seen as lacking some supposedly necessary sense of stoicism. What can we boil these fears down into? Social anxiety might be a good explanation that makes sense in light of its commonality between both doctors and nurses – and potentially all/most humans alike. The picture presented here may dissuade a dissenter from using the extensive training doctors receive prior to independent practice as an argument for why doctors have a "foot-in-the-door" of neglecting to notice or confess their uncertainty. The point being that nurses are not required to complete as much training as physicians prior to beginning their own version of an independent professional career.

Genders TS, Meijboom WB, Meijs MF, et al. CT coronary angiography in patients suspected of having coronary artery disease: decision making from various perspectives in the face of uncertainty. Radiology. Dec 2009;253(3):734-44. doi:10.1148/radiol.2533090507

- Diagnostic uncertainty can be rephrased into consideration of pre-test probability and post-test probability. When a patient presents with a certain complaint, the physician develops their own pre-test probability estimates as to what the diagnosis of the condition might be. For some conditions, let's say a stye here for the sake of argument, the pre-test probability by a reasonable physician's history-taking and physical examination will be so high that no further diagnostic investigation (e.g. laboratory testing or radiological imaging) is necessary. Of course, however, there is still some uncertainty tied into a pre-test probability of nearly 1.0. Put philosophically, we can never really be *entirely* sure of anything. And put mathematically, even a number that is infinitely large is only ever *approaching* infinity. There are other conditions like headache that require more of a diagnostic work-up including laboratory testing and radiologic imaging because the "differential diagnosis," or pre-test probabilities of multiple different conditions, are often not possible to parse out. That is where post-test probabilities come in. Often, physicians will order multiple different tests to investigate the multiple different conditions on their differential diagnosis, such as CMP, CBC, arterial blood gas with carboxyhemoglobin levels, head CT/MRI, MR venography, and lumbar puncture for the given example of headache. Based on the results of those tests and how sensitive/specific their results are for the diagnosis of the given condition they are connected with, post-test probability estimates will develop in the mind of the physician that, when done correctly, will lead to

the "correct" diagnosis of the patient's condition. "Correct" here meaning that multiple other reasonable physicians would come to the same conclusion.

Moores LK. Medical uncertainty: informing decision making for patients with acute pulmonary embolism. Chest. Oct 2009;136(4):952-953. doi:10.1378/chest.09-1092

- This brief commentary supplements what I discussed previously regarding physicians making clinical decisions in a way that utilizes pre-test and post-test probabilities with further details explicated herein about the role of likelihood ratios. Albeit, physicians do not pull a chart out of their pocket every time a patient tells them a symptom or they receive a new test result to see what their pre-test probability is and how their post-test probability is affected by the positive or negative likelihood ratios… Despite not directly saying this point, the author suggests that with enough research-based validation, there could be clinical prediction scores and risk models that could harness in tandem the entire clinical picture of a patient (including laboratory tests, radiologic imaging, etc.) to give uncertain physicians a better idea of which patients are at a higher risk of worse outcomes following pulmonary embolism (according to the given example) and are therefore deserving of more cautious care.

Jambusaria-Pahlajani A, Hess SD, Katz KA, Berg D, Schmults CD. Uncertainty in the perioperative management of high-risk cutaneous squamous cell carcinoma among Mohs surgeons. Arch Dermatol. Nov 2010;146(11):1225-31. doi:10.1001/archdermatol.2010.323

- This study highlights the subjectivity that can plague specialties without RCT- or guideline-based evidence supporting clinical decisions. Such clinical practices likely provide a false sense of certainty to clinical decisions that, given the lack of evidence, is actually uncertain in reality. In a counterintuitive result that is frankly a bit of an oxymoron and would likely be disconcerting to patients, "expert" Mohs surgeons had inconsistent and disagreeing practice styles regarding when they perform radiologic nodal staging, adjuvant radiation therapy, and sentinel lymph node biopsy. Relating this to one of the prior articles I read that discussed "practice styles" in more detail, the inconsistency amongst Mohs surgeons cited here likely stems from the practice styles conferred onto them by their superiors wherever they did their dermatology and Mohs surgery training. These instances make affected aspects of medicine far more of an art than a science which I do not think all patients would be particularly fond of.

Melhado L, Bushy A. Exploring uncertainty in advance care planning in African Americans: does low health literacy influence decision making preference at end of life. Am J Hosp Palliat Care. Nov 2011;28(7):495-500. doi:10.1177/1049909110398005

- Clinician uncertainty is found very strikingly in the difficulty of prognostication, and this uncertainty with concomitant prognostic difficulty can be problematic for patients and their family members wanting to establish advance care planning or determine whether to continue life-sustaining treatment. Once again, when physicians would prefer to not take-a-stand in uncertain clinical situations, the patients that were presented all of the options without a recommendation would like their doctor *to* take-a-stand and offer their advice with all of their expected medical expertise. As aforementioned, the certainty of patients is strongly dependent on their health or medical literacy – understandably given how much training doctors receive to reach the position they occupy – and it may be wise to

perform interventions to *prepare* patients via a standardized approach to receive the clinical information they need to make a decision on. When constructing end-of-life plans, the arguably worst possible outcome is patients or families making legal decisions predicated on uncertainties and misunderstandings that go unreported on their part and uninvestigated by the physician, leading to end-of-life care enactments that may not truly be what the patient and family wants. The likelihood of this is increased due to the observation we have seen elsewhere that people are generally afraid of being vulnerably outspoken about their uncertainty.

McCullough LB. The professional medical ethics model of decision making under conditions of clinical uncertainty. Med Care Res Rev. Feb 2013;70(1 Suppl):141s-158s. doi:10.1177/1077558712461952

- By creating an ethical model of decision making that relies on "the professional virtues of integrity and candor and the patient's virtue of prudence, the moral management of medical uncertainty, and trial of intervention," the author of this paper assumes much health literacy within the patient. Although this may sometimes be true, practicality would likely conclude that though the patient may be generally prudent, they are not always so in making medical decisions that they incompletely understand. Indeed, however, the physician should take their best understanding of the patient's "basic values and interests" to play a large role in approaching their medically uncertain clinical decision-making. Interestingly nonetheless, the author believes that by promoting deliberation of medical decisions that would otherwise be "nondeliberative," the differences between diagnostic/therapeutic pathways taken by physician-patient pairs will be minimized and potentially less influenced by the 'practice styles' of different physicians. To analyze the underbelly of this same point, the author clearly articulates that if we place the patient in charge of deliberation and effectively delimit the physician's impact (e.g. "deprofessionalize"), then we would be nullifying the role of the position that a physician has earned which is to make "expert clinical judgments about what is in the patient's health-related interests." Another literature-based tool to define uncertainty that I have not seen before is introduced in this article: The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE). The authors advocates for a bottom-line that is not unique within this field of literature, which is for physicians to simply lay-out all of the "medically reasonable alternatives" *without* recommending any particular option when working with a patient to make a medically uncertain clinical decision. The primary issue with this, as we have addressed elsewhere, is that it is under these circumstances that patients want their doctor to take the lead despite it being 'easiest' and more 'risk-free' (especially from the legal perspective) for doctors in this position to *not* take the lead. The author basically says this same thing: "Expecting all patients to actively participate in all the components of decision making about plans of care violates the most fundamental form of respect for autonomy: respect for the patient's preference either to make decisions for himself or herself or to delegate this authority to others whom the patient trusts with such tasks (Brody, 1988). Patients who express the latter preference are probably not appropriate candidates for shared decision making or informed decision making, inasmuch as they likely will not welcome its burdens—burdens that increase when evidence is low or very low." Honesty should be used with the patient regardless with an openness of communication that makes it clear to

them that the physician is not confident there even is a diagnostic/therapeutic option that would be better than the others. It is under these circumstances that refusing care altogether may be one of the more reasonable things to do from the patient's perspective. As an aside, I wonder to what extent does the Hippocratic Oath act at-odds with versus in-tune with the legalities of medicine? The author goes on to say that physician should not recommend a "low certainty" diagnostic/therapeutic plan over a "very low certainty" plan, since it is likely that the recommendation would be based more on doctoral bias ("whether it is based in experience, familiarity, and comfort") rather than evidence. I might contend in this situation that the patient would prefer choosing that recommendation even despite the "bias" because such bias is (1) apt to be considered a far more professional sort of bias and (2) the patient may continually see their doctor because they trust their expertise and may even have overlapping/complimentary values. This may negate the negative connotation of physician "bias" in recommending a "low certainty" initiative over a "very low certainty" one for their patient.

Cunningham BA, Bonham VL, Sellers SL, Yeh HC, Cooper LA. Physicians' anxiety due to uncertainty and use of race in medical decision making. Med Care. Aug 2014;52(8):728-33. doi:10.1097/mlr.0000000000000157

- The "Anxiety Due to Uncertainty" scale is yet another research tool that can be used to measure the uncertainty of clinicians. The paper here suggests that more uncertain physicians tend to use "race" as a factor in their clinical decision-making more often. However, these physicians were also more likely to understand "race" as being equivalent to what is now understood to be "genetic ancestry"; a misconception that is beginning to be purged from US medical schools. Interestingly, I wonder if the more certain physicians who apparently used "race" less in their clinical decision-making and who also did not as highly correlate "race" with "genetic ancestry" did not consistently consider the "race" of the patient because, without any genetic correlates, it does not matter with it being a mere social construct? Is this good or bad? Nonetheless, it goes without saying that the "race" of a patient may influence the decision-making of a physician – especially an uncertain one – regardless because of "implicit bias." I appreciate that the authors state how "a certain amount of anxiety due to uncertainty may push physicians to explore a broad array of potential diagnostic and treatment options in order to make good clinical decisions."

Lindley SW, Gillies EM, Hassell LA. Communicating diagnostic uncertainty in surgical pathology reports: disparities between sender and receiver. Pathol Res Pract. Oct 2014;210(10):628-33. doi:10.1016/j.prp.2014.04.006

- A strategy not unfamiliar to most – if not all – physicians, "hedging" on one's wording when recording their medical decision-making is quite common. This can manifest in the reading of results with a common example being something like "moderate to severe"; well, which is it? Moderate or severe? This practice extends into pathology, perhaps most unfortunately because the results determined by pathologists is a stern, hard finality that often guides future management of the patient. Ironically, this probably incites pathologists to "hedge" even more, especially when they are uncertain. This uncertainty "may understandably be due to inadequate tissue, or extensive artifact that makes definite interpretation impossible. Other cited reasons for uncertainty include nonstandard

histomorphology, ambiguous immunohistochemical stains, lack of clinical information, uncertain criteria in the literature, lack of experience with the diagnosis, and hope (however unsubstantiated) to avoid legal liability for misdiagnosis." The authors here acknowledge that the "hedging" wording used by pathologists is *not* universal and is therefore subject to misinterpretation by surgeons and non-surgeons alike. Some of these phrases are "suggestive of", "worrisome for", "cannot rule out", "highly suspicious for", "favor", and "indefinite for". The uncertainty of the pathologist creates uncertainty of the primary physician about whether the patient truly needs further diagnostic/therapeutic pursuits. Like I discussed elsewhere as a potential solution to this problem, the authors propose adding an area to pathology reports where pathologists can report a numerical value estimating their level of certainty… or lack thereof… in addition to ambitiously creating societal guidelines for wordage in pathology results nationwide. Of course, there is uncertainty within pathologists estimating their own uncertainty and this is likely highly dependent on the comfort that the reporting pathologist has with diagnostic uncertainty.

Schiavazzi DE, Arbia G, Baker C, et al. Uncertainty quantification in virtual surgery hemodynamics predictions for single ventricle palliation. Int J Numer Method Biomed Eng. Mar 2016;32(3):e02737. doi:10.1002/cnm.2737

- It is undoubtedly valuable to have a sense of the uncertainty within the data that is going to guide clinical decision-making, as higher levels of research-based uncertainty should translate into higher levels of practical uncertainty in the real-world with everyday patients. A confidence interval for relative risk, for example, ranging from 1.5 to 90 says something much different than one ranging from 2 to 4.

Shelton RC, Brotzman LE, Crookes DM, Robles P, Neugut AI. Decision-making under clinical uncertainty: An in-depth examination of provider perspectives on adjuvant chemotherapy for stage II colon cancer. Patient Educ Couns. Feb 2019;102(2):284-290. doi:10.1016/j.pec.2018.09.015

- This article is arguably the most imperative one for this Humanities Distinction Track project that I have read so far, as its review-style makes it similar to the one I am completing but on a smaller scale (with fewer articles) and broader concept (uncertainty overall). Aligning perfectly with the things we have already written about above, the authors say: The practice of medicine is rarely straightforward. Medical decision-making is fraught with the potential for bias, and the optimal evaluation and management plan for a patient may vary by individual or system factors, such as the patient's degree of pain and suffering as well as the cost of the care. Data used to facilitate decision-making may be conflicting, ambiguous, or scarce, and providing optimal care requires balancing clinicians' expertise and the available evidence with patients' preferences. Collectively, researchers attribute these challenges to the uncertainty inherent in medicine. Uncertainty affects the clinical decision-making process, which has been described as a complex processing of knowledge and experience, using both critical thinking skills and intuition, while recognizing the inherent bias that can exist in medical decisions. Sources of uncertainty include the complexity of clinical information, the probability of particular outcomes, and individual clinician characteristics, such as tolerance for ambiguity or an individual's ability to cope with complexity, risk, and uncertainty." As might be

expected, despite being mildly disappointing, is that there are plenty of physicians who cannot recognize their own uncertainty – this provides great value in the Boschetti model that classifies uncertainty as a four-quadrant spectrum on an X and Y axis of uncertain to certain and unaware to aware, respectively. The Han model then simplifies uncertainty into three descriptors: source (probability, complexity, ambiguity), issue (practical, scientific, personal), and locus (patient versus family member versus physician). The tension created by these factors existing in competition as different "stakeholders" may also create uncertainty which can only be managed by cost-benefit analyzing each stakeholder perspective to determine the solution that "transcends the tensions." Even if these processes are perfected, the algorithm itself may be afflicted by knowledge gaps within the patient/family or the physician that can be known or unknown. Another independent affliction is the constraint of time and how decisions can be rendered more certain within the mind if allowed more time for their consideration. Approaches that can be taken to counteract these counterweights (uncertainties) unbalancing the delicate scale of reasonable clinical decision-making are intuitive (e.g. heuristics), protocol-driven (e.g. guidelines), team-based (e.g. in a multidisciplinary healthcare team), and shared (e.g. between patient and physician) strategies. The most prudent physicians then reflect on the decisions they are currently making and have made *for* and *with* patients – even including the effects of their decisional outcome if such information is available upon later assessment – to improve their uncertain clinical choices in the future.

Brotzman LE, Crookes DM, Austin JD, Neugut AI, Shelton RC. Patient perspectives on treatment decision-making under clinical uncertainty: chemotherapy treatment decisions among stage II colon cancer patients. Transl Behav Med. Oct 23 2021;11(10):1905-1914. doi:10.1093/tbm/ibab040

- Contrary to what other articles have argued, these authors find that even when clinical uncertainty is high, patients do not necessarily seek clear treatment recommendations from their providers since it limits "their participation in the decision-making process." However, this result may have been due to the providers in their study making recommendations without a clear explanation of risks and benefits within situations that were palpably uncertain for patients, making the doctoral certainty a bit suspicious from the patient perspective. Implicated in this discussion may be the widespread impact of and familiarity with cancer and chemotherapy such that patients enter these clinical discussions with an *a priori* understanding of their uncertainty.

Harish V, Morgado F, Stern AD, Das S. Artificial Intelligence and Clinical Decision Making: The New Nature of Medical Uncertainty. Acad Med. Jan 1 2021;96(1):31-36. doi:10.1097/acm.0000000000003707

- AI is still in the phase of being trained on data that already exists so that it may, in small leaps, extrapolate what it knows to novel situations in ways that are as cumulatively intelligent as the data that was fed into its creation. With that being said, it seems unreasonable to expect AI – at this point in time – to make better decisions while weighing "relative uncertainty" than humans since I do not believe us humans even have such uncertainty data available. Nonetheless, there are examples of emergent AI properties such as their ability to predict protein structure and perform tasks such as radiologic interpretation and dermatopathology diagnosis better than humans. However,

the blunders made by AI are often so self-evidently silly that even patients would be able to identify their reasoning errors in clinical practice. As we have discussed before, the authors here delineate the diagnostic pathway: “First, the clinician enumerates the diagnostic possibilities and estimates their relative likelihood. Second, the clinician incorporates new information to update the relative probabilities, rules out certain possibilities, and, ultimately, chooses the most likely diagnosis. Thus, with each new finding, the clinician moves from one probability (the pretest probability) to another probability (the posttest probability) to arrive at a diagnosis.” Then, to assess the prognosis of the patient if a particular intervention is chosen (or not chosen), physicians generalize “risk from a study population to the target-patient population of interest, followed by a patient-specific estimation of the probability that a given individual falls within the target population.” Interestingly, AI has the ability to quantify its confidence – whether or not this quantification is true can be debated – whereas humans have a simple, nonnumerical “feel” of how confident they are in their diagnosis, treatment, and prognosis.

Seemann RJ, Melcher P, Eder C, et al. [Informed consent for surgery: clearly regulated by the patient rights law-significant uncertainty among medical students : Legal analysis and inventory of over 2500 medical students in Berlin as part of the Progress Test Medicine]. Orthopade. Nov 2021;50(11):937-945. Chirurgische Aufklärung: Klar geregelt durch das Patientenrechtegesetz – deutliche Unsicherheit bei Medizinstudierenden : Rechtsanalyse und Bestandsaufnahme bei über 2500 Berliner Medizinstudierenden im Rahmen des Progress Test Medizin. doi:10.1007/s00132-021-04080-1

- Medical students generally have an admittedly poor understanding of the legal underpinnings governing their field. However, in their defense with perhaps a wee bit of bias, their training emphasis the core competencies required to be a physician: diagnosis, treatment, and prognosis. I would far rather more time be dedicated to enhancing this knowledge in my medical students than distracting their focus onto legal concepts that they will likely learn passively at a later date. Additionally, if a medical student is interested in legalities, they will likely take the initiative to seek out their own learning material on that topic.

Haier J, Mayer M, Schaefers J, Geyer S, Feldner D. A pyramid model to describe changing decision making under high uncertainty during the COVID-19 pandemic. BMJ Glob Health. Aug 2022;7(8)doi:10.1136/bmjgh-2022-008854

- The COVID-19 pandemic represented a state of such potent uncertainty that it serves as an excellent example of how physicians augment their problem-solving to maintain efficacy without sufficiently referenceable data. Such complexity within the pandemic was exacerbated by the public assignment of moral, ethical, and sociopolitical value to decisions about COVID-19, including its prevention and treatment. Within normal levels of uncertainty (outside of situations like the COVID-19 pandemic), the knowns are known and the unknowns are also known because of extensive research into the matter (usually), allowing physicians to sufficiently explore the unknowns that interact with their decision-making. So-called “critical decision-making uncertainty” occurs during healthcare crises such as the COVID-19 pandemic where the knowns and unknowns are largely unknown, making it so that there is no good place to start for solving novel,

obscure medical problems. As we saw with the Pandemic, overcoming this uncertainty and avoiding a "system collapse" requires "fast-track data, preliminary investigations, rapid reviews, modelling based on experience and theoretical concepts" that – despite being helpful for the internal workings of the healthcare system – became popularized within the general society and caused a new kind of cultural uncertainty as healthcare was attempting to solve their own uncertainty. Another exacerbating factor of sources of uncertainty such as a pandemic is the impact that compensatory mechanisms have on non-pandemic related healthcare system activities; for example, "elective" procedures may matter quite a bit to the patients unable to receive them. Contrary to other clinical scenarios where there may be exorbitant amounts of data suggesting what interventions are best for patients on the population-based scale, highly uncertain decision-making environments with unknown knowns and unknown unknowns may call for greater use of basing subsequent decisions on the outcome of the most recent similar decision (availability heuristic).

Saposnik G, Ismail Z, Rivard AM, et al. Decision making under uncertainty in the diagnosis and management of Alzheimer's Disease in primary care: A study protocol applying concepts from neuroeconomics. Front Med (Lausanne). 2022;9:997277.

- The dichotomy between risk ("events with known probability") and ambiguity ("events for which probabilities are unknown") is an interesting comparison I do not recall seeing before. These authors also helpfully provide a name for Type 1 and Type 2 reasoning: "The Dual Process Theory." One might expect that more uncertain clinical scenarios would initiate a Type 2 reasoning that is slower and more methodical; however, I think that the occasional over-reliance on cognitive biases we have discussed elsewhere does not always lend truth to this expectation. "The Prospect Theory," on the other hand, is more of a cost-benefit analysis where, put simply, less severe situations require less severe interventions and more severe situations may require more severe interventions.

Lumsden L, Cannon P, Wass V. Challenge GP: using gamification to bring the reality and uncertainty of a duty doctor's surgery to early year medical students. Educ Prim Care. Mar 2023;34(2):103-108. doi:10.1080/14739879.2023.2190936

- Similar to previous articles that have been annotated, the authors here emphasize the importance of practicing the experience of and approach to clinical uncertainty "like a muscle." Rather than avoiding uncertainty as something undesirable, there is likely benefit in embracing it as a necessity that is ubiquitous in varying magnitudes and – like anything else – can be better managed by encountering it more often.

Appel H, Sanatkar S. Systematic Search and Scoping Review of Physicians' Intolerance of Uncertainty and Medical Decision-Making Uncertainties During the COVID-19 Pandemic: A Summary of the Literature and Directions for Future Research. J Clin Psychol Med Settings. Jun 2024;31(2):338-358. doi:10.1007/s10880-023-09974-0

- The COVID-19 pandemic was fraught with such extensive uncertainty that doctors and patients were effectively equalized as the basis of their usual social contract (knowledge) was unfounded. Nonetheless, doctors felt obligated to "do something" for the scared patients they cared about, leading to the choice of unproven treatments for patients. This echoes the tendency for people in general to make rash decisions when stressed (e.g. test

taking when anxious or under a time-crunch) and the tendency for physicians to order more tests when uncertain. Even worse, there is another tendency for the combination of uncertainty and pressured situations to cause people – even doctors – to "freeze." The authors cite the uncertainty taxonomy of Hal: "probabilities (i.e., probabilities being inherently indetermined, e.g., a 50:50 chance of a treatment being effective vs. ineffective), ambiguity (i.e., due to imprecise, insufficient, or conflicting information, e.g., a 30–70% chance of a treatment being effective), and complexity (i.e., overly intricate information, e.g., a wide array of interacting moderators influencing treatment effectiveness)." One of the potentially most fundamental reasons for uncertainty intolerance to be analyzed in medicine is due to the human fear of the unknown. In addition to what we have already described, this uncertainty weighs on physicians at every step of their way, including the process of triaging and even when they consider how they are going to speak with their patients in a professional way about their uncertainty. Furthermore, I contend that this uncertainty is summative such that it is often not one moment of uncertainty that makes a physician crumble; it is the additive effect of every small moment of uncertainty that meets the physician around every corner and in every patient room. Put succinctly, "high pressure decision making under conditions of sometimes extreme uncertainty is thus seen as a major challenge in medical practice." The cognitive bias of "cognitive closure" is a subtle defense mechanism used by physicians to neglect too much information that leaves too much doubt in their mind created by uncertainty. The tendency towards cognitive closure was associated with a tendency towards being more comfortable with off-label and ill-proven therapeutic use. The authors also discuss how intolerance of uncertainty unfortunately leads physicians to reject novel and – to my supposition – not practically tried-and-true innovations (despite them being theoretically validated). One of the articles meeting the inclusion criteria of this paper describes telemedicine during the Pandemic having a negative effect on decisional confidence. There was a tendency for men, non-Infectious Disease internist specialists, and less published physicians to choose more off-label and ill-proven therapeutics to treat patients with COVID-19 in addition to "more severe" cases of COVID-19 often leading uncertain physicians to be more uncertainly aggressive in their treatment approach. Perhaps ironically, physicians who felt they had more "COVID-19 expertise" and higher "perceived quality of COVID-19 publications" also made more inappropriately aggressive and unfounded COVID-19 treatment choices. Complicating things further is the apt description of uncertainty as modifiable by variables like "time pressure, condition severity". Uncertainty may manifest from unpredicted locations, as there were undeniably instances during the Pandemic when physicians were made more uncertain by impositions from their employing institution.

Valentine KD, Leavitt L, Sepucha KR, et al. Uncertainty tolerance among primary care physicians: Relationship to shared decision making-related perceptions, practices, and physician characteristics. Patient Educ Couns. Jun 2024;123:108232. doi:10.1016/j.pec.2024.108232

- For high-driven individuals such as those that pursue medicine, uncertainty is an undesirable variable in a system that many of us would probably want to make perfect if we could. The ability to tolerate this uncertainty has long been thought to be secondary to one's personality, and this article suggests that uncertainty is easier to tolerate as physicians grow older and gain more experience… or is this tolerance simply because

they care less? Hopefully not. Interestingly, physicians being confident in their shared decision-making skills does not correlate with patients being satisfied with those share decision-making skills. The authors provide examples of where intolerance of uncertainty has had a direct impact on the recommended course of action for patients: "an early study using hypothetical scenarios showed that physicians with lower UT were more likely to withhold negative diagnostic test results with a high false-negative rate from patients, and to recommend pregnancy termination following abnormal results from prenatal genetic testing."

Surgical Uncertainty

Schoonhoven CB, Scott WR, Flood AB, Forrest WH, Jr. Measuring the complexity and uncertainty of surgery and postsurgical care. *Med Care*. Sep 1980;18(9):893-915. doi:10.1097/00005650-198009000-00003

- Surgeons and nurses exhibit a striking level of agreement regarding the complexity and uncertainty of a standard selection of procedures. There is a general trend towards more complex surgeries being those that are also more uncertain from the perspective of surgeons and nurses, and those that are more complex/uncertain have a higher rate of death as a surgical outcome. Probing this relationship may expose an advantageous avenue to bill patients and their insurance based on the complexity and uncertainty of the procedure they receive.

Bodner EE, Browning GG, Chalmers FT, Chalmers TC. Can meta-analysis help uncertainty in surgery for otitis media in children. J Laryngol Otol. Oct 1991;105(10):812-9. doi:10.1017/s0022215100117426

- The study uses the surgical management of otitis media with effusion as an example of the hidden lack of clarity of both randomized controlled trials and meta-analyses given the multitude of considerations affecting their construction and performance. At a superficial level, the data presented by a randomized controlled trial or meta-analysis may appear to be management-guiding; however, the design choices of the study can indubitably obscure the certainty of the results. Meta-analyses, considered the most authoritative research that can be realistically performed, is even subject to a hidden uncertainty given the potential for unpublished, null-hypothesis-accepting data to exist. The certainty of research results that are to guide clinical management are only as sound as the methods through which those results were obtained, and at the time of this reference being published it appears that human fallibility was the greatest contributor to uncertainty in how to clinically manage otitis media with effusion.

Holman WL, Kirklin JK, Pacifico AD. Quantitation of mapping uncertainty in Wolff-Parkinson-White syndrome. Implications for anatomic characterization and surgical division of accessory atrioventricular connections. J Thorac Cardiovasc Surg. Oct 1992;104(4):1045-52.

- Measurement error is an unavoidable source of uncertainty in research and, therefore, in evidence-based clinical practice. An example of this is in the surgical resection of Wolff-Parkinson-White Syndrome accessory atrioventricular connections where, at the time of reference publication, the *status quo* was to perform wide margins of accessory pathway

dissection to ensure removal of this conductive atrioventricular tissue that occupies an interindividually variable and therefore uncertain distribution. This identifies an important surgical concept: when uncertain about the size, depth, and distribution of a pathological entity, it may be advantageous to simply resect more to "get all of it." Or, under circumstances where "resecting more" is judged as more dangerous than doing nothing, the patient is left to suffer with their pathological entity remaining *in situ* because of their surgeon's uncertainty. It goes without saying that developing predictive models and testing strategies to plan the span of a surgical dissection/resection will reduce operative uncertainty and put more patients on the operating table to receive the definitive management they desire and deserve.

Fernandes HM, Gregson B, Siddique S, Mendelow AD. Surgery in intracerebral hemorrhage. The uncertainty continues. Stroke. Oct 2000;31(10):2511-6.

- As a meta-analysis, this paper points out that even when we utilize some of the most advanced, robust, and reliable methodological and statistical research tools we have available, relatively decisive results still produce a lack of complete certainty. The paper appropriately identifies the only way to acquire a modicum of greater certainty is through a cohesive, large, multicenter, randomized controlled trial. Emphases should be placed on the word "large," since the best way to technically increase the power of any study and decrease the uncertainty maximally is to have the largest number of patients possible. While uncertainty approaches zero, number of study participants approaches infinity.

Simpson AL, Ma B, Chen EC, Ellis RE, Stewart AJ. Using registration uncertainty visualization in a user study of a simple surgical task. Med Image Comput Comput Assist Interv. 2006;9(Pt 2):397-404. doi:10.1007/11866763_49

- By repetitiously modeling the path that is frequented by surgeons performing a particular task, the uncertainty within the task can be modeled and used by future individuals performing that same task to minimize making the same mistakes others have committed. This is the value of introducing computerized capabilities of visualizing technical uncertainty in the middle of surgery. One could imagine that for a surgery such as a laparoscopic appendectomy, there might be a repository of laparoscopic video recorded for all of the laparoscopic surgeries that have been performed. One could then cross-match the different strategies/approaches utilized by the various surgeons with an assessment of whether complications of that surgery arose, allowing one to begin constructing a way to computationally visualize safe and unsafe technical decisions in the operating room.

Tubbs EP, Elrod JA, Flum DR. Risk taking and tolerance of uncertainty: implications for surgeons. J Surg Res. Mar 2006;131(1):1-6. doi:10.1016/j.jss.2005.06.010

- There is substantial evidence to suggest that surgeons frequently do not follow gold-standard and evidence-based procedures such as double-gloving, intraoperative cholangiography during cholecystectomy, and venous thromboprophylaxis. One explanation for this is that the location of that surgeon's training did not emphasize such procedures as imperative, leading to a "practice style" that excludes these protocols from the surgeon's routine heuristics. This paper discusses several valuable tools for assessing clinician's tolerability of uncertainty that may be insightful for future studies. The

authors go on to elucidate a fascinating point about how physicians may distill clinical risk-taking: they choose the option through an uncertain lens that they feel like they will regret the least (from Nightingale and Feinstein). It makes sense that clinical uncertainty, especially among risk-averse physicians, increases medical costs for patients since an intuitive method of attempting to reduce uncertainty is to order more tests to gain more information that may provide a greater sense of certainty or simply to reassure oneself that "I did everything I could in my role as this patient's physician." Indeed, it may be accurate that for surgery more than for other specialties, there is a tendency for surgeons to adhere strictly to a "tried and true" method of performing their clinical duties with an aversion to change… even if that change may improve the outcomes of their patients. The finality of their role as surgeons with the irreversibility of their actions may dictate that they find comfort in their pattern of prior actions that did not result in poor patient outcomes. Even if there are ways to improve the perioperative process for these surgeons via better techniques/technology, those new things are untrustworthy and need to prove themselves within surgeons' minds. The conundrum being, of course, that the new, potentially beneficial, but untrustworthy surgical strategy or tool may never receive the opportunity to prove itself. The authors of this paper blame heuristics as a cause of surgeons not adhering to the aforementioned gold-standard procedures, but one should also realize that heuristics save time. The countless research papers milled out about how to increase operating room turnover for the economic benefit of the hospital speak for themselves about why surgeons may feel pressured to just cut the cystic duct with heuristically "good enough" data within their frontal lobes that they are cutting in the correct location without performing a cholangiogram.

Upile T, Fisher C, Jerjes W, et al. The uncertainty of the surgical margin in the treatment of head and neck cancer. Oral Oncol. Apr 2007;43(4):321-6. doi:10.1016/j.oraloncology.2006.08.002

- It seems reasonable to argue that perioperative functional morbidity and mortality is an important consideration for all patients. However, could the argument be made that the aesthetic morbidity and mortality following a surgery such as oncological resection matters more for some patients? Obviously, surgeons should be expected to produce as good of aesthetic outcomes as they can – just as is true of their functional outcomes. But do the aesthetic outcomes in a 75-year-old military veteran matter the same amount as a 25-year-old model? Interestingly, there are no evidence-based guidelines regarding surgical margins, which is inherently a surgical variable affected by many considerations including "tumor site, anatomical restrictions, presumed biological characteristics of the cancer, the respective advantages of conservation and extended surgery affect the adequacy of surgical resection," and the biological/psychological/social impact of having positive margins. I was impressed at the proposition that there are oncological downsides to performing a more radical resection given the release of tissue healing factors that are actually tumor facilitators, making minimalistic resections potentially better (as long as the margins are negative). Even when having negative margins, though, there can be a high chance of recurrence when dealing with a cancer that has one or more subfoci that were locally out-competed by the cancer that became the primary being surgically resected. The authors say it best: "At its simplest a tumour can be regarded as being surrounded by a three dimensional 'atmosphere' of malignancy. The more standard deviations of distance the surgical margin is from the tumour bulk the lower the

probability of remaining viable tumour cells. This margin is further blurred by three dimensional stereometric sampling errors in observations and the presence of favored and unfavoured anatomicophysiological sites allowing rapid or slow tumour progression or sequestration." Indeed, the process is laden the uncertainty that cannot be controlled. Further complicating the matter is that even when we have negative margins, and if we assume for argument's sake that only positive margins have cancer recurrences, histological identification of negative margins is only correct 50% of the time. Pathologists are therefore plagued by the same uncertainty as surgeons in a different way. To try and correct this, the authors propose an idea I have mentioned before: disclosing results with an estimation of confidence even though that estimate will be inherently uncertain as well. Similar to obtaining blood cultures prior to beginning antibiotic therapy, cancer margins should be marked by methods such as subtle tattoos prior to beginning therapy to ensure a greater adherence to definitive surgical margin resection after neoadjuvant therapies.

Johnson NP, Selman T, Zamora J, Khan KS. Gynaecologic surgery from uncertainty to science: evidence-based surgery is no passing fad. Hum Reprod. Apr 2008;23(4):832-9. doi:10.1093/humrep/dem423

- Contrary to what is said in the literature, gynecological surgery appears to have a predilection for having more RCT-derived evidence guiding its operations. It is generally difficult to perform RCTs for surgical specialties given the complexity with randomizing patients who *need* surgery to either getting the surgery or not. And, in cases when blinding might be recommended or required, it is next to impossible to ethically blind a patient to whether or not they received surgery. As such, surgeons seem to depend largely on outcome-based cohort studies to guide their practice. The authors here explicate that a "reasonable proportion (60%) of all Cochrane reviews of gynaecologic surgical interventions were able to find evidence of effectiveness or superior relative effectiveness of these interventions for at least some primary outcomes." This retains 40% absolute uncertainty on a population-based scale and relinquishes none of the uncertainty that arises when applying the results of well-powered and, arguably, more epidemiologically-based RCT evidence to singular patients. Dare I say that the complexity and uncertainty that bubbles to the surface when applying a "generally good" medical/surgical recommendation derived from RCT evidence *is* complex and uncertain because the singular patient is more irreducibly complex, in and of themselves, compared to the flock of humans studied as a herd with a NNT of 10. Nonetheless, the authors do a good job otherwise detailing more of the difficulties with performing RCTs from a surgical standpoint. They boldly articulate without further consideration that "RCT is the most reliable indicator of the effectiveness of an intervention, whether medical or surgical" and offer ideas for how to make surgical RCTs more mainstream.

Selman TJ, Johnson NP, Zamora J, Khan KS. Gynaecologic surgery from uncertainty to science: evolution of randomized control trials. Hum Reprod. Apr 2008;23(4):827-31. doi:10.1093/humrep/dem422

- These authors, the same as in the previous paper, identify that guidelines governing the performance of RCTs such as CONSORT or QUDAS improved the quality of their RCTs in gynecological surgery. It makes sense that a universal rule for performing RCTs, if

well developed, would bolster their quality – not dissimilar to development of the scientific method. Interestingly, the final line of this article says "It is also sobering to note that the improvements in research methodology are associated with less optimism about effects of gynaecologic surgery," which for professional and financial reasons could be an unfortunate and arguably unethical roadblock to the active engagement in RCTs by surgeons. What if the very surgery that has given you a career is "disproven" by your RCT? Awkward indeed.

Schroen AT, Brenin DR. Breast cancer treatment beliefs and influences among surgeons in areas of scientific uncertainty. Am J Surg. Apr 2010;199(4):491-9. doi:10.1016/j.amjsurg.2009.04.005

- Differing surgical practices "regarding significance of positive sentinel lymph node biopsy (SNLB) and role of post-lumpectomy radiation for low-risk ductal carcinoma-in-situ (DCIS)" may have drastic effects on patient outcomes. Even more concerningly, any astute reader may pose the question, "what does expert opinion mean? Who grants these individuals the title of expert? And what are *they* basing their 'opinion' on?" Academic surgeons were found to consider published data superior to expert opinion. Pontification might yield the concern that academic physicians believe such answers are "expected" of them. Also, unless there are rigorous RCTs and/or society-based guidelines derived from such research evidence, there are times when published data may be subjected to the opinions of the reader when determining whether to apply the results to their clinical practice. Further intriguing findings of the cited paper include regional patterns of immunohistochemistry utilization (potentially indicating so-called aforementioned "practice styles"?), fewer specialty society surgeon members than non-members recommend complete axillary dissection after positive sentinel lymph node biopsy (but members offer sentinel lymph node biopsy in DCIS much more than non-members), academic surgeons were more willing to participate in clinical trials, "83% of surgeons in practice <20 years offered sentinel lymph node biopsy in DCIS as compared to 69% of surgeons in practice >20 years ($P = .002$)" while "surgeons in practice longer than 20 years were more likely to recommend adding post-mastectomy radiation [with one positive lymph node] than surgeons in practice a shorter duration (24% vs 10%, respectively; $P < .001$)," and surgeons with a larger breast cancer patient caseload offer sentinel lymph node biopsy in DCIS more often than those with smaller caseloads. There is much to unpack and speculate about here. Regardless, these areas of uncertainty amongst breast surgeons begs for gold-standards to be developed.

Rosenberg J, Fischer A, Haglind E. Current controversies in colorectal surgery: the way to resolve uncertainty and move forward. Colorectal Dis. Mar 2012;14(3):266-9. doi:10.1111/j.1463-1318.2011.02896.x

- These authors suggest that the reason for lacking surgical RCT data is because of a lack of statistical power that may be ameliorated by forming "multicenter and even multinational research groups in order to ensure accrual of sufficient sample sizes." I question where the tendency for surgical approaches to be implemented without academically sufficient research supporting such implementation came from. Could this relate to the proposition that a certain surgical technique is only as good as the surgeon utilizing it? In other words, one surgeon might pick up the technique and note that their patients are doing suddenly much better. One can understand how incentivizing this

would be for the surgeon to continue using this surgical approach despite not having rigorous scientific backing. Relative to the comment annotated above, it is reassuring, concerning, and fascinating nonetheless that surgeons are so divided over this point of establishing RCTs to guide their surgical management. It is definitely clear from other articles that the apparent lack of evidence-based medicine practiced by surgeons is a chronic tongue-in-cheek joke so widely found amusing that it has been immortalized in the medical literature.

Cristancho SM, Apramian T, Vanstone M, Lingard L, Ott M, Novick RJ. Understanding clinical uncertainty: what is going on when experienced surgeons are not sure what to do? Acad Med. Oct 2013;88(10):1516-21. doi:10.1097/ACM.0b013e3182a3116f

- It makes sense that the clinical uncertainty encountered by faculty surgeons likely decreases over time as they become more comfortable in their practice and exposed to the broad extent of surgical decisions they need to make on a regular basis. The same is true of non-surgeons. Therefore, the more novel situations with accompanying difficulty predicting the proper course of action and predicting the likely outcome are most likely to cause the greatest uncertainty for all surgeons, but especially the experienced surgeons that may otherwise be less uncertain than others by virtue of simply "being around" longer and "seeing more." Prior to entering the operating room, there may be anticipated complications that do not occur, and entirely unanticipated complications that completely derail the case – such as peculiar anatomies. As in other papers, the authors here outline various other explorations of the types of clinical uncertainty in the literature such as "inadequate understanding, incomplete information, and conflicting alternatives." There is a digression of addressing the argument from other authors that clinical uncertainty is a cause for physicians to veer into unsafe decision-making practices. Put colloquially, clinical uncertainty can purportedly make doctors act 'more cowboy.' The authors here aptly articulate that this behavior may conversely "be conceptualized as necessary deviations employed as individuals attempt to cope with conflicting demands in complex and uncertain situations," which may also lead to "long-term innovation" in the field rather than causing healthcare providers to be more accepting of rash decision-making. The operating room can be subjected to uncertainty-inducing influences that are not as expected as patient-related characteristics, such as the external factors of being on-call and having to staff new consults while operating and 'keep everything straight,' as it were. The main way that the authors noticed surgeons to respond to uncertainty is via "prioritizing alternatives, reevaluating and adapting the plan, creating innovative solutions, and seeking advice." I would argue that non-surgeons wrestle with clinical uncertainty in the same way, but the need to create innovative solutions is more uniquely surgical. Each moment that a surgeon encounters an issue that raises the requirement to respond to uncertainty, they perform "risk management, [analyze] potential outcomes, and [anticipate] technical issues" prior to performing the next intraoperative technical motion. Non-surgeons, on the other hand, often do not try to become creative with their prescription of drugs for indications they are not FDA approved for – as an example. It may be reasonable to argue here as well that creative medical actions need to be performed by surgeons much quicker on average than non-surgeons. Perhaps the largest source of intra-operative uncertainty is incomplete visualization, where no amount of overhead or headlamp light can allow a surgeon to see exactly what they want. This

requires surgeons to "operate by feel" where they use their sense of touch and knowledge of anatomy to assess the practicality of their next surgical maneuver – if it is even possible to do at all. Dealing with intra-operative uncertainty may include utilizing surgical instruments for intentions they are not routinely employed for to solve problems with unique and innovative solutions. Once again, this is often not something explored by non-surgeons outside of taking advantage of medication side effects to treat multiple conditions at once (e.g. bupropion for depression and smoking cessation or propranolol for migraine prophylaxis and social anxiety). Uncertainty in the surgical setting, when encountered by 'good' surgeons, breeds adaptation and creativity. This requires great prudence so that a moment intended to be innovative does not lead to a mistake and poor surgical outcome that would have been avoided had more standard protocols been followed – although, perhaps then the surgical outcome would have been poor anyway since the surgeon would not have had to innovate if standard protocols were working. Surgeons must be cautious to distinguish the "fine line [between] 'being innovative' from 'being lucky'."

Borg MA. Prolonged perioperative surgical prophylaxis within European hospitals: an exercise in uncertainty avoidance? J Antimicrob Chemother. Apr 2014;69(4):1142-4. doi:10.1093/jac/dkt461

- As we have discussed elsewhere, a common strategy that physicians use when encountering uncertainty is to "do more," even if accomplishing less, perhaps to make themselves feel better that they did "all they could" for their patients. This article suggests a similar conclusion amongst surgeons from cultures that score higher levels of preferring to avoid uncertainty. These uncertain surgeons were more likely to provide perioperative surgical prophylactic antibiotics for longer than 24 hours prior to surgery – an intervention that has otherwise shown little clinical benefit in the literature. There are many intricate reasons this might occur, however, as perhaps the surgical site infection rates in those 'uncertain culture's' hospitals are so high that the only way they can hope to try and bring them down is through their anecdotal/experiential evidence of providing long timescale perioperative antibiotics.

Simpson AL, Ma B, Vasarhelyi EM, Borschneck DP, Ellis RE, James Stewart A. Computation and visualization of uncertainty in surgical navigation. Int J Med Robot. Sep 2014;10(3):332-43. doi:10.1002/rcs.1541

- As I believe I have mentioned elsewhere, harnessing the power of visualizing uncertainty when possible during robotic or laparoscopic surgery undoubtedly carries huge benefit to surgeons as their perception of the uncertainty places limits on the outer bounds of what surgical maneuvers are possible. It may be advantageous for surgeons to have an understanding of what strategies have been tried before in prior surgeries, especially under uncertain circumstances, with ways to visualize safer and more dangerous technical options based on prior outcomes. One might colloquially describe this as being able to have hundreds of surgeons in their OR during every case (based on the computerized advice of their past successes and failures). In the paper presented here, the authors aptly point out that "Figure 1 shows a commercial surgical navigation system in use clinically for pedicle screw fixation. In the figure, the top right quadrant of the interface is the most interesting. The green (virtual) surgical tool is to be aligned with the yellow planned path.

Given that uncertainty exists in the computed tool position, the green virtual tool may appear to be positioned properly when, in fact, the real tool is touching critical structures." Of course, the incidence of this magnitude of error is probably quite small or else the commercial surgical navigation system would not be used so widely. The authors report here that adding visual estimates of uncertainty do not negatively impact the ability of commercial surgical navigation system users to perform the surgery.

Teunis T, Janssen S, Guitton TG, Ring D, Parisien R. Do Orthopaedic Surgeons Acknowledge Uncertainty? Clin Orthop Relat Res. Jun 2016;474(6):1360-9. doi:10.1007/s11999-015-4623-0

- Overconfidence is evidently a potential byproduct of increasing years in practice, especially within a surgical subspecialty where there are often not universal, ubiquitous evidence-based gold standard protocols for treating different pathologies with various surgeries that may be quite similar or disparate. This leads surgeons to stick with what is personally familiar and with what has the best outcome "in their hands." Greater statistical prowess may be a protective factor against neglect of uncertainty. A prudent question that might be posed is whether research-derived evidence that contradicts surgeons practicing "familiar" strategies of managing conditions they treat will actually even cause those surgeons to alter their practices. Will they simply fall deeper into their overconfidence bias and reject the research as an erratum? I was shocked at these authors pointing out that "Clinical Evidence [3] currently classifies 50% of 3000 common medical treatments as of ''unknown effectiveness'' and only 11% as proven beneficial (of the remainder 24% are likely to be beneficial, 7% a tradeoff between benefits and harms, 5% unlikely to be beneficial, and 3% likely to be ineffective or harmful)." I have heard colloquially that the reason surgeons are so confident is that such confidence is the one of the few things that allow them to operate decisively and efficiently. If they were to pause and utilize Type 2 decision-making at every fork-in-the-road, intraoperative and anesthesia times would significantly increase, carrying increased healthcare costs and morbidity/mortality risks for patients. Nonetheless, I appreciate what the authors say about overconfidence maladaptively becoming an availability heuristic paired with a confirmation bias that leads to a lack of consideration of options outside of those that immediately come to mind. In a way that might be expected, and perhaps reassuring, academic center surgeons "had the greatest awareness of uncertainty, especially compared with those working in multispecialty groups." The same was interestingly true for atheists compared to theists; the authors argue that this may be due to the tendency of believers to seek certainty and be more intolerant of uncertainty. Indeed, there may be an overall benefit to further incorporating statistical education, journal clubs, and admissions of uncertainty during surgical residency training.

Bhattacharya B, Maung A, Schuster K, Davis KA. Uncertainty Among Acute Care Surgery Providers Does Not Change with Experience. Conn Med. Mar 2017;81(3):133-139.

- This study using the Physician Reaction to Uncertainty Scale (PRU Scale) suggests that acute care surgeons do not have any more or less uncertainty dependent on gender, experience, or age. However, more experienced acute care surgeons were more reluctant to disclose their uncertainty to patients and be less worried about outcomes for their patients. The question is therefore raised whether this trend is dependent on experience in

and of itself, or whether it is a reflection of transitioning emphases on medical/residency training and the intrinsic personal qualities of newer acute care surgeons.

Moore AJ, Blom AW, Whitehouse MR, Gooberman-Hill R. Managing uncertainty - a qualitative study of surgeons' decision-making for one-stage and two-stage revision surgery for prosthetic hip joint infection. BMC Musculoskelet Disord. Apr 12 2017;18(1):154. doi:10.1186/s12891-017-1499-z

- Similar to what we have articulated before, there is good evidence to suggest what are and are not surgical problems, but there is insufficient evidence to guide the specific surgical strategy for treating these problems. Surgeons often utilize what works "in their hands," which is highly dependent on subjective factors such as where the surgeon trained, common practices of their institution, and the technical capabilities of their operating rooms. The orthopedic surgeons in this study describe the difference in their decision-making of utilizing a one-stage versus two-stage approach to the correction of prosthetic hip joint infections. Interestingly, there is new, equivocal data showing that infection recurrence is comparable between one-stage and two-stage approaches despite the two-stage approach often being the *status quo*. However, there is much nuance as the two-stage approach requires 2-3 months of walking on a loosely fixed, articulating spacer that may not be suitable for very elderly or infirm patients that may simply want to go with less surgery and try the one-stage approach or even merely starting chronic suppression antibiotics. Sometimes patients are planned to undergo a two-stage approach but decide against it, especially if they too are elderly, and so they remain walking with the aforementioned spacer. This happens much less commonly in younger patients whose greater lifespan left to live and functional capacity make them great two-stage surgical candidates. Perhaps reassuringly, there appears to be a tendency amongst surgeons to attempt extensive personalization of their surgical plans for the patients that they are operating on, considering factors like the kind of organism causing the joint infection, patient age/comorbidities, goals of care for their patient, hospital infrastructure. One might argue that if there were a certain surgery (one-stage or two-stage, in this case) that showed statistically better outcomes on a population-based scale, then surgeons would feel pressured to use that singular approach for all their patients. The question subsequently arises whether or not what is good for the population is good for the individual? Another interesting point of this paper is the discussion of how the aforementioned articulating spacer (CUMARS) being versatile enough to allow it to remain in place as a pseudo-one-stage approach. In this case, the use of a new surgical technology helped surgeons overcome the uncertainty of utilizing the previously lesser-appreciate one-stage approach that has been gaining more traction amongst orthopedic surgeons. This identifies innovations in surgical technology as potential avenues of both providing patients better biomedical products and breaking surgeons out of their shells of using familiar, but outdated and less efficacious, surgical techniques.

LaMartina J, 2nd, Christmas KN, Simon P, et al. Difficulty in decision making in the treatment of displaced proximal humerus fractures: the effect of uncertainty on surgical outcomes. J Shoulder Elbow Surg. Mar 2018;27(3):470-477. doi:10.1016/j.jse.2017.09.033

- To my knowledge, this is the first paper that analyzes the outcomes of actual patient cases relative to the degree of agreement amongst multiple different surgeons. I am fascinated

to see that there is a real difference in surgical outcomes under situations of surgical uncertainty where greater agreement amongst multiple shoulder surgeons about the best course of action leads to better outcomes and vice versa. I imagine that this reflects the degree of complexity of the surgical situation at hand – it makes sense that the most uncertain of surgical circumstances would be a matter of hot debate for shoulder specialists whereas less notably uncertain surgical circumstances still have a surgical option that edges out the others. Of course, surgery is unique in the sense that it requires a unique combination of theoretical knowledge and technical skill, and even when new surgical technology comes out with improved patient outcomes (analogous to FDA approval of a new, effective drug), there is a novel hurdle for surgeons to then learn how to use that new surgical technology. Some surgeons will pick it up, but others may not because of a lack of remaining up-to-date on the literature, because of being late in their career and consequently reluctant to put in the effort to try anything new, or because of simple stubbornness.

Mangado N, Pons-Prats J, Coma M, et al. Computational Evaluation of Cochlear Implant Surgery Outcomes Accounting for Uncertainty and Parameter Variability. Front Physiol. 2018;9:498. doi:10.3389/fphys.2018.00498

- A unique source of uncertainty within surgical fields is the extent of anatomical variability among multiple different patients with the same underlying pathology. Encountering these anatomical anomalies intraoperatively may result in complications due to a lacking knowledge of how to deal with them or due to neglecting unique considerations that they require. The example of this presented in the given article is cochlear implantation.

Ying LD, Harrington A, Assi R, et al. Measuring Uncertainty Intolerance in Surgical Residents Using Standardized Assessments. J Surg Res. Jan 2020;245:145-152. doi:10.1016/j.jss.2019.07.035

- I am very fascinated by general surgery residents having a greater intolerance of uncertainty (measured by Physician Reaction to Uncertainty and Physician Risk Attitude scales) when having a Myers-Briggs Type Indicator personality factor assessment including "Judging." It should be noted that later in the text, the authors begin to describe how "Judging" is associated with more uncertainty *tolerance*, potentially because of their pre-programmed algorithms for dealing with novel circumstances that their "Perceiving" counterparts handle too freely and not decisively enough… Despite its arguably irreducible nature, it sounds like a wise idea to integrate uncertainty intolerance into the training of medical students and physicians. I am intrigued by the application of this strategy in the Yale general surgery program that "will include invited speakers who are experts in the topic, didactic sessions where attendings discuss their personal strategies for managing uncertainty in the operating room or in perioperative care, and peer-to-peer sessions where junior residents can discuss their concerns candidly with their senior colleagues." This is especially important, as the authors identify here, because their senior residents had equivalent levels of uncertainty intolerance to their junior resident counterparts. You might hope that senior residents would become more tolerant of uncertainty as they achieve more experience and responsibilities; however, perhaps their

acquisition of more responsibilities as they overcome their deficits they had as junior residents simply causes new uncertainty to take the place of old uncertainty.

Serra-Aracil X, Montes N, Mora-Lopez L, et al. Preoperative Diagnostic Uncertainty in T2-T3 Rectal Adenomas and T1-T2 Adenocarcinomas and a Therapeutic Dilemma: Transanal Endoscopic Surgery, or Total Mesorectal Excision? Cancers (Basel). Jul 22 2021;13(15)doi:10.3390/cancers13153685

- The concern for overtreatment may be more prevalent in surgical fields than medical fields given the irreversibility of surgical actions. If "overtreatment" occurs in the non-surgical setting to the detriment of a patient, the treatment intensity can be lessened. However, a total mesorectal excision (TME) cannot be downgraded to a transanal endoscopic surgery (TES) once completed. This highlights the difficulty of new and potentially advantageous surgical techniques becoming in vogue: uncertainty can be created when applying these new techniques to patients whose indication is equivocal and may lead to overtreatment or undertreatment based on the previous "gold standard." Cohort studies such as these – if not actual randomized controlled trials – are excellent means to decrease surgical uncertainty one study at a time by comparing the outcomes of competing techniques. This is especially true given that the present study found that for uncertainty surrounding the use of TES or TME for adenoma versus adenocarcinoma resection, patients did better overall when receiving the less invasive technique first even if that meant a smaller proportion of patients had to receive the more invasive technique subsequently (contrary to what may be more typical physician instinct: just do the more invasive technique from the start if you are uncertain so that you can be sure to "get it all," which would be overtreatment in this study).

Stowers C, Lee T, Bilionis I, Gosain AK, Tepole AB. Improving reconstructive surgery design using Gaussian process surrogates to capture material behavior uncertainty. J Mech Behav Biomed Mater. Jun 2021;118:104340. doi:10.1016/j.jmbbm.2021.104340

- This article highlights the fascinating fact that uncertainty within the medical field in general changes, through either decreasing or increasing, as innovation either abolishes or creates sources of uncertainty. In this instance, computer models were used to predict how surgeons could best reduce undue stress being placed on skin flaps to reduce pathological scarring. Prior to the power of computation, surgeons had to rely entirely on their "feel" (likely being composed of heuristics, primacy/recency biases, the effects of the status quo within their institution of training, etc.) rather than present day surgeons that can – in theory based on this paper – utilize computers to reduce via calculation some "solved" uncertainties.

Waller DA, Opitz I, Bueno R, et al. Divided by an Ocean of Water but United in an Ocean of Uncertainty: A Transatlantic Review of Mesothelioma Surgery Guidelines. Ann Thorac Surg. Feb 2021;111(2):386-389. doi:10.1016/j.athoracsur.2020.10.009

- A quite fair frustration when encountering clinical uncertainty is the differences found within guidelines created by different societies that, in theory, are supposed to exemplify the authoritative recommendation. It is interesting to note that, in the example given from the current article, North American and European guidelines differ on their preferred aggression of working up and managing mesothelioma, with North Americans appearing

more comfortable with a more aggressive approach. Why might this be? Is this a byproduct of cultural differences between the members of the two societies? Differences in the patient population – perhaps the decreasing incidence and prevalence in the United States despite persisting in Europe?

Javanmard-Emamghissi H, Moug SJ. The virtual uncertainty of futility in emergency surgery. Br J Surg. Nov 22 2022;109(12):1184-1185. doi:10.1093/bjs/znac313

- The applicability of uncertainty to futility is simultaneously fascinating and terrifying. These authors identify that the concept of medical/surgical futility dates back to Hippocrates and has since permeated the minds of physicians that appear to, at the slightest notion of futility, avoid further invasive or intensive intervention. However, is futility ever certain? The authors reference Bernard Lo and his creation of the seven principles of futility that includes quantitative futility ("the statistical probability of surviving a procedure or the success of a treatment, for example application of the NELA score (https://data.nela.org.uk/riskcalculator/) or Clinical Frailty Score to predict 30-day mortality after emergency laparotomy") and qualitative futility ("the quality of benefit that surgical intervention will result in is poor"). Interestingly, there had been a push from the American College of Chest Physicians, American Thoracic Society, and European Society for Intensive Care Medicine to replace "futility" with "potentially inappropriate." This transition is likely appropriate as the constant progression of our understanding of science, medicine, and surgery optimistically turns what used to be futile into what can be possible.

Lee CW, Evans E, Vitous CA, Suwanabol PA. Living with uncertainty in surgery: integrating palliative care principles into conversations as a solution to patient and family, provider, and health system disquietude. Ann Palliat Med. Jan 2023;12(1):16-20. doi:10.21037/apm-22-1332

- "Serious illness conversations" advance the patient's understanding of their complex and inherently uncertain medical/surgical situation in addition to providing physicians an opportunity to exercise their skill of placing diagnoses and treatments into the perspective of uncertainty. The authors use surgeons as an example of a specialty that should more often initiate these serious illness conversations, even if such serious illness has not occurred yet, to prepare patients for what could happen during a surgical intervention. Conversely, previous papers have articulated the tricky position of surgeons to remain inwardly and outwardly confident in the face of uncertainty because patients will not be pleased seeing a physician who wants to non-confidently cut them open. Interestingly, surgeons are often hesitant to intervene on patients that have uncertain diagnoses and prognoses, suggesting that certainty about the likely outcome of surgery is an important consideration that surgeons make prior to consenting patients for surgery. Similar to but more extreme than medical specialists, surgeons place the "burden of proof" on patients and their pathologies to prove that they need surgery rather than performing "not unreasonable" empiric interventions that can be halted if needed. On the other hand, these authors also argue that surgeons often operate binarily with patients; that is, the surgeon does much internal processing to decide whether they want to offer this patient surgery (sometimes even deciding before beginning their interview of the patient), spending their visit either explaining why or why not surgery is the best option for them. This is done instead of ascertaining the patient's goals, values, and nonoperative options even if a

patient is a surgical candidate (this is called the "fix-it model" in the paper). The authors also describe the "Best Case/Worst Case Communication" model where physicians can employ the simple strategy of discussing the best and worst case scenario outcomes for each therapeutic option (including doing nothing at all).

Incze T, Pinkney SJ, Li C, et al. Using the Operating Room Black Box to Assess Surgical Team Member Adaptation Under Uncertainty: An Observational Study. Ann Surg. Jul 1 2024;280(1):75-81. doi:10.1097/sla.0000000000006191

- Intraoperative adverse events (IAEs) are transient moments of intensely heightened intraoperative uncertainty that these authors fascinatingly analyze to determine how the surgical team responds. Notably, "nurses adapted to IAEs by expressing more backup behavior skills (5.3× increase; 13.9 instances/hour during an IAE vs 2.2 instances/hour when no IAE) while surgeons and medical trainees expressed more psychological safety* skills (surgeons: 3.6× increase; 30.0 instances/hour vs 6.6 instances/hour and trainees: 6.6× increase; 31.2 instances/hour vs 4.1 instances/hour). All roles expressed fewer situation assessment skills during an IAE versus no IAE." Surgery is undeniably a team sport, and poor teamwork leads to a 5x higher rate of IAEs. Inexplicably, however, there does not seem to be a common thread underpinning what exactly "good teamwork" in surgery consists of which is likely due to the singular uniqueness of each intraoperative personality. This is yet another likely unique source of uncertainty for surgeons compared to non-surgeons. The differing personalities in the operating room can lead to support staff and even medical trainees to be unfortunately unsure of their intraoperative role and how those roles change when met with intraoperative uncertainty – which is a predictor of IAEs. A familiar tendency for those with OR experience was also observed in this study: a significant decrease in leadership activity by non-surgeons during IAEs, probably to allow the evident leader of the room (surgeon) to coordinate correction of the IAE. Notably, the tendency for psychological safety expression during IAEs was not observed for nurses and anesthesiologists like it was for medical trainees. The interpretation of this is tricky, but it may reflect their lack of feeling the need to apologize to the surgeon? Because of the irreducible complexity and consequent uncertainty of medicine in general, abolishing easy-to-solve sources of uncertainty should be priority number one. When confronted with overwhelming uncertainty, the least a good physician can do is take control of the uncertainty that is controllable despite still being at the mercy of the remaining, omnipresent uncertainty. The uncertainty I am referring to here consists of things like clear and closed-loop communication, setting clear expectations, clarifying team roles.
  *Psychological safety refers to "admits mistakes and shortcomings"

Murphy E, Finucane FM. Addressing uncertainty about the role of structured lifestyle modification for metabolic surgery patients. Metabolism. Feb 2024;151:155739. doi:10.1016/j.metabol.2023.155739

- Surgical fields appear to be plagued more often than non-surgical fields by the continuation of practices that are not evidence-based but have persisted in the culture for long enough that they have become dogma. This article highlights a good example being strict "structure lifestyle modification programme[s] prior to metabolic or obesity surgery" even though there are no clinical trials proving such practices to be causally

beneficial. We have already discussed the difficulty that surgery has with performing RCTs, but until it becomes the mainstay of proving the efficacy of surgical practices, I fear that many practices will remain in use simply because "it has always been that way."

Non-surgical Uncertainty

Fischer AF, Stevenson DK. The consequences of uncertainty. An empirical approach to medical decision making in neonatal intensive care. *Jama*. Oct 9 1987;258(14):1929-31. doi:10.1001/jama.258.14.1929

- Medical prognostication is one of the most difficult and uncertain skills that physicians are often expected by patients to have. Some of this uncertainty may be thwarted by attempts at reasonably standardizing the care of applicable populations, such as neonates, where the perception of medical futility is less prevalent. Nonetheless, one must consider that neonates can indeed suffer as a result of our newfound medical ability to prolong life in arguably inappropriate manner, which largely nullifies any thwarted uncertainty and affirms the massive magnitude that clinical decision making can have on a family. An attempt to avoid uncertainty as clinicians seeking pure objectivity can lead us astray from our Hippocratic Oath that is potentially more strongly upheld when we embrace the uncertainty that comes with treating each patient as a collection of interrelated, imperfectly clear circumstances.

Boreham NC. Modelling medical decision-making under uncertainty. *Br J Educ Psychol*. Jun 1989;59 (Pt 2):187-99. doi:10.1111/j.2044-8279.1989.tb03090.x

- Medical decision-making can be viewed as a cumulative byproduct of repetitious pattern-recognition where the certainty in an intervention is born out of prior encounters with a clinical problem that has been consistently solved with the same algorithmic actions. One unique avenue where expert clinicians exhibit this skill is during the delicate dosing of drugs such as phenytoin for seizure abortion/prophylaxis where loading and maintenance doses need to be selected so as to stop/prevent seizures without inducing drug toxicity. Physicians may strictly or loosely adhere to the heuristics they have developed when more novel clinical situations present themselves, perhaps partially based on their own comfort with uncertainty when a need may arise to veer away from the treatment algorithm their own repetitious pattern-recognition and problem-solving has devised.

Wolff N. Professional uncertainty and physician medical decision-making in a multiple treatment framework. Soc Sci Med. 1989;28(2):99-107. doi:10.1016/0277-9536(89)90136-6

- The enigmatic process of medical decision making can be deconstructed into the two stages of (1) technical theorizing and (2) restoration selection, but is simultaneously characterized by a seemingly irreducible complexity. This deceptively simple "two step" algorithm is influenced by almost limitless factors including what is medically available/feasible, patient preferences, and physician biases. The Wennberg Hypothesis argues that the uncertainty inherent to medicine – such that nothing can ever be trusted as completely reliable or completely unreliable – may be a major cause of physicians

adopting subjective "styles" of practice that function as reliable decision-making "safe zones."

Purtilo RB, O'Donohue WJ, Jr. Resources for medical decision-making in situations of high uncertainty. Nebr Med J. Oct 1992;77(10):277-80.

- There is a perfectionistic pressure placed upon physicians by patients. A doctor who cannot solve a problem may be said to be a bad doctor, even if that problem is not solvable even by the best doctor. And, as has been described elsewhere herein, even if a confident physician makes an exceedingly *certain* diagnostic or therapeutic choice, she simply enters a game of probability. Will this patient be the "1" of the "1 in 10" number needed to treat? Or will this patient be the "1" of the "1 in 20" number needed to harm? Our sometimes seemingly dichotomous responsibility to uphold the principles of beneficence and nonmaleficence may arguably only be rectified by informed consent. This, alongside the ever-protective nature of compassion ("good bedside manner"), appears to be the highway toward patient satisfaction even if probabilistic and unintentional medical/surgical failure happens along the way.

Wallis LA. Hormone replacement therapy: decision making in an age of uncertainty. J Am Med Womens Assoc (1972). Nov-Dec 1992;47(6):225-9.

- This paper once again highlights the source of clinical uncertainty being the uncertainty of data. There may be associations within the literature of, say, breast cancer incidence and estrogen replacement therapy; however, what does a physician do when a real risk is paired with a real benefit? It almost seems like a physician is presented with two options in these scenarios: (1) recommend one choice or another in a dichotomous decision or (2) recommend neither choice and simply offer all of the options, risks, and benefits to the patient. However, clinical practice would suggest that patients can feel unsatisfied with option (2). If given option (2), patients may ask the classic and occasionally feared question, "what would you do if I was your mother/daughter?" I think we fear this question because we know that the decision is almost too uncertain to make. For some reason, however, it seems like we are simultaneously too afraid to articulate that point. Are we stuck between the rock of uncertainty and the hard point of wanting to uphold the idealistic societal view of medicine?

Anderson JD, Jay SJ, Weng HC, Anderson MM. Studying the effect of clinical uncertainty on physicians' decision-making using ILIAD. Medinfo. 1995;8 Pt 2:869-72.

- From the age that we develop an ego, confidence wages an unending war against insecurity. While we engage in social interactions, take examinations, and make professional decisions, this war wages on. One might liken this war to the same one that occurs when physicians make uncertain clinical decisions. There may be a patient presenting with features consistent with many different diagnoses, or perhaps no known diagnoses whatsoever. Or, there may be a patient that could benefit from many different therapies with various potential adverse effects. How might a clinician rectify these competing options? Confidence evidently serves a role in making medical decisions that are beneficial to patients. This seems pretty logical, right? But how is confidence derived? Some may have the ability to conjure it out of thin air (we all know a guy), though not all of us have that ability. It seems reasonable to contend that confidence

comes from leaning into what we know. Let's say a patient presents with "XYZ" that we are unsure of how to diagnose or manage. There may be a guideline recommending diagnosis/management of "Y," but not "XYZ" specifically. If we lean into what we confidently know, the paper presented here would suggest that we make objectively better clinical decisions by, say, treating "XYZ" with the "Y" guideline (perhaps with some reasonable adjustments) rather than making up our own "ABC" strategy.

Mort EA. Clinical decision-making in the face of scientific uncertainty: hormone replacement therapy as an example. J Fam Pract. Feb 1996;42(2):147-51.

- Several interesting ideas are proposed by this article. Firstly, the idea that physician uncertainty stems from data uncertainty is revisited with a persistent lack of solution. Secondly, the assertion is made that there is evidence that some patients prefer to be given all of the options available to them – especially when meeting with a surgeon and that surgeon gives them management options that are nonsurgical – but there are other patients that may carry greater guilt if making a medical decision when only given all of their options without a formal recommendation from their physician (who may be equivocal about the next steps). I find this fascinating because, as physicians, I think we find that aforementioned selfish security in offering all of the options but refusing to offer our opinion when our clinical judgment tells us that all of the options "are as broad as they are wide." We hope that if our patient makes their decision for themselves, we will be "safe" because, in a clinically equivocal situation, we provided our patient with their options and *they* made their own decision. The burden of responsibility is relinquished from our minds but, unfortunately, it is then placed onto the spirit of our patient. By trying to avoid our own guilt – and lawsuits – we inadvertently open the windows of our glass house to throw stones at that of our patient. Finally, and as an ancillary point, there may be benefit to leaning back onto a concrete entity to provide some certainty within the uncertainty, such as the Shared Decision-Making Program that this paper discusses. The authors astutely recognize that greater certainty for many patients will not come from digestion of data, but from appreciation of the various stories from patients that have embarked on journeys similar to theirs.

Pierce SF. Neonatal intensive care: decision making in the face of prognostic uncertainty. Nurs Clin North Am. Jun 1998;33(2):287-97.

- It is easy to agree with the contention that under circumstances where a clear path for potential therapeutic benefit or therapeutic futility lies, a physician should firmly recommend action or inaction as being in the best interest of the patient. Of course, this may be at-odds with the desires of legal decision-makers, but such is how a physician upholds their moral and ethical obligation. However, circumstances change when the therapeutic outcome (benefit or futility) is uncertain. Hess' Ethic of Engagement argues that these scenarios are adept for utilization of deep engagement between the physician (whose thinking in this scenario is likely, but arguably, driven primarily by science) and the patient/family (whose thinking in this scenario is driven primarily by their knowledge of self). Ideally, this strategy appears to promote the development of a solution to the problematic uncertainty by having a joint resolution (action or inaction) fall out of the "engagement" conversation. However, I assert that it is quite rare for interactions such as these to have such a solution magically fall out of conversation. These conversations

cannot reasonably and appropriately be had without the physician (1) describing the perceived state of health of the patient and (2) providing options about what can be done for the patient including risks/benefits/possible results of action/possible results of inaction. At this point, the possible things that will likely happen are (a) the physician will recommend the option thought to be best by the healthcare team, (b) the physician will recommend no option and ask the patient/family what they think, or (c) the patient/family will interject with an option that they are adamant they want or do not want. Inevitably, a decision is rather binary. You can either choose something or not. Unfortunately, a therapeutic choice or lack thereof is not a Schrodinger's Cat that can exist as two different realities simultaneously for the patient. This article highlights that one of the most difficult and uncertain things for physicians to do, and something that often receives no attention in medical training because of the impossibility of the task (other than in very select circumstances where the natural history of a disease is very well studied and, frankly, often ends in either complete recovery or fatality), is to confidently prognosticate.

Robinson A, Thomson RG. The potential use of decision analysis to support shared decision making in the face of uncertainty: the example of atrial fibrillation and warfarin anticoagulation. Qual Health Care. Dec 2000;9(4):238-44. doi:10.1136/qhc.9.4.238

- The authors of this paper present a decision analysis model that attempts to condense population health statistics and patient's values of the expected utility for various treatment options regarding their health into a computer program that could make the "best" treatment choice for physician-patient pairs. However, I contend that population health statistics still lie at the core of making recommendations for individual patients since the data shows that if we perform a certain intervention on enough patients, we will reduce poor outcomes. This brings us back to the concept of number needed to treat. Furthermore, I think that patients use "expected utility theory" without even realizing it. As long as the physician consulting them about whether or not to start warfarin for their atrial fibrillation (being the example used in this paper) adequately discusses every detail about the pros and cons of this decision. They must articulate the small but real risk of having a stroke should patients not start warfarin. They should state the increased risk of other kinds of bleeding when taking warfarin and how those different types of bleeding may both present themselves and create difficulties in patient's lives that did not previously exist. They must disclose the cumbersome nature of patients returning frequently to the laboratory for INR checks while taking warfarin. However, they must also disclose positive things about these seemingly negative considerations: most warfarin-induced bleeds are likely reversible while a lot of strokes are not, INR checks become less frequent as you become more stable on a given warfarin dose without other medication changes. The authors cite a fantastic definition of this informed consent and shared decision-making process: "An informed decision is one where a reasoned choice is made by a reasonable individual, using relevant information about the advantages and disadvantages of all possible courses of action, in accord with the individual's beliefs." Of course, there will always be patients that may become overwhelmed and confused at how much information a physician may have to provide about starting a medication like warfarin. However, there are multiple strategies prudent physicians may use when broaching the subject. They can draw things out on a piece of paper to provide more

clarity and a long-lasting reminder of the discussion had during the visit. They could offer for patients to record the informed consent/shared decision-making conversation so that they could revisit the information later, in the comfort of their own home, and as frequently as they desire. And, of course, we should never pressure patients to make effectively non-urgent decisions during a single appointment.

Zapka JG, Moran WP, Goodlin SJ, Knott K. Advanced heart failure: prognosis, uncertainty, and decision making. Congest Heart Fail. Sep-Oct 2007;13(5):268-74. doi:10.1111/j.1527-5299.2007.07184.x

- As I have mentioned elsewhere, prognostication poses a significant challenge for all physicians. This paper interestingly explores the lacking ability of Internal Medicine physicians to prognosticate for two different heart failure patients, with lifespan estimates being well-off from a recently published computer model. Notably, this model (Seattle Heart Failure Model) is based on literature- and guideline-based criteria. The question arises then whether much of current physician prognostication is predicated simply on a sort of gestalt instinct of how sick or frail a patient is.

Habal FM, Kapila V. Inflammatory bowel disease and pregnancy: evidence, uncertainty and patient decision-making. Can J Gastroenterol. Jan 2009;23(1):49-53. doi:10.1155/2009/531638

- In concluding that drugs for IBD treatment are "effective and safe during pregnancy," the authors indirectly call attention to an interesting anecdotal point. When I was working in the OB/GYN department on my core year rotation, faculty and residents consistently emphasized use of the phrase "low risk" rather than "safe." They felt that by telling pregnant patients that their medical decisions during pregnancy were colloquially "safe" was a simplification of the truth as one can anticipate that even though 5-ASA may be "safe" in pregnancy, it would be even safer if the pregnancy were entirely normal without IBD or the need to take 5-ASA at all. Therefore, being prudent with our words can help convey our own inherent clinical uncertainty to patients that may be making medical decisions that have potentially lifelong effects on themselves or their fetuses. The decision of taking a medication regardless of how "safe" or "low risk" it is, however, nevertheless requires risk-benefit analysis which is evidently an underpinning theme of how physicians and patients alike approach medical uncertainty.

Fisher M, Ridley S. Uncertainty in end-of-life care and shared decision making. Crit Care Resusc. Mar 2012;14(1):81-7.

- Prognostic uncertainty is certainly one of the most difficult and complicated challenges faced by doctors staffing the intensive care unit with contemplation of allowing the patient an honorable, peaceful, and pain-free death versus attempting all the life-saving efforts modern medicine allows despite an appreciable likelihood for the patient to enter a life state that would be unacceptable to them. The prospect of reaching "practical certainty" despite a palpably real clinical uncertainty is fascinating nonetheless. In a way not quite encountered in other papers, the one here says that clinicians manage their uncertainty by "deindividualising the patients, denying uncertainty, redefining the problem to eliminate uncertainty, shrinking the problem to smaller dimensions, and recognising that present uncertainty will resolve in time." The way that this so-called "practical certainty" might be achieved is through a combinatorial use of severity-of-

illness scoring systems, agreement amongst fellow physicians (which is few and far between with much disagreement about the prognosis of hypothetical patients, although ICU doctors are more likely to anticipate a much worse prognosis than reality for the "sickest" patients), and facilitating family conferences. Yet another source of uncertainty in both prognosticating and advising patients on the continuation or withdrawal of care is the lack of formal cultural education that takes place in medical school. One might consider this as part of the "hidden curriculum," but a medical student, resident physician, or faculty physician may nevertheless encounter a patient who is part of a culture different than their own which the clinician is unfamiliar with. This may lead to culturally inappropriate recommendations being made at the end of life (for some cultures, withdrawing/continuing care may not even be an option). A question that I have for the advocation of this "practical certainty," however, is whether promoting such a concept is falling into the same aforementioned trap of physicians simply being in denial of uncertainty. Separately from anything this article reports, but where my mind wandered while reading this paper, I wonder how often life-saving/sustaining care is withdrawn from exceptionally sick patients due to a sort of ICU culture where patients that do not "look as good" as the others are written off as likely to die and given up on. This, of course, then frees up an ICU bed to be filled with another patient that non-ICU doctors have been repeatedly calling for the admission of.

Kirkegaard P, Risør MB, Edwards A, Junge AG, Thomsen JL. Speaking of risk, managing uncertainty: decision-making about cholesterol-reducing treatment in general practice. Qual Prim Care. 2012;20(4):245-52.

- The primary findings of this paper reiterate those that we have discussed elsewhere such that uncertainty exists within both the scientific evidence itself and in the complexity of interpersonal interaction. The advantage, or "saving grace" if you will, for non-surgeons managing medical uncertainty is that the majority of their interventions are pharmacological and can be stopped at any time with likely reversal of undesirable side effects. It may be that, as seen in this study, there are some providers that when faced with medical uncertainty, they trailblaze into the cutting edge of research and provide guidance based on whatever the newest/most reliable evidence recommends… even if this means making a different recommendation every week for each new trial that becomes published! Other providers, however, have a more cautious approach and want to wait until both short-term trials and longitudinal studies are published to better inform the recommendations they make to patients. In the meantime, then, those more cautious providers may be either (1) presenting all the options to their patients and letting them decide or (2) occupying a position of complete inaction which may result in harm for their patients. A problem identified by the general practitioners interviewed for this study is the difficulty of applying study data – which is inherently epidemiological, or population-based – to their singular patients. Furthermore, it is impossible to ever be sure of a patient's complete context, values, expectations, worries, and lifestyle to help eliminate the aforementioned "situational uncertainty." The authors nicely review the various other kinds of uncertainty that have been explored in the literature. They strongly argue that different medical situations may place a greater stress on certain forms of uncertainty, like situational uncertainty being the focus of conversations surrounding primary prophylaxis of ASCVD with statins – which in 2012 was evidently more

uncertain than it is today. The fact that many of these articles use examples of clinical uncertainty that have since become more certain is a sincere source of hope. Importantly, and interestingly, doctors appear to "recommend treatment in cases of medical uncertainty," but "patients have been shown to prefer watchful waiting over treatment when faced with medical uncertainty." More thought should be devoted to why this is. Are doctors more death averse than patients? This might make sense given all of the medical training that goes into holding off this "enemy" for as long as possible. Are patients blissfully ignorant of their likelihood of poor health outcomes if treatment is not pursued (even if uncertain); for example, even if a myocardial infarction does not result in death, it might cause debilitating heart failure or arrhythmia.

Saposnik G, Sempere AP, Raptis R, Prefasi D, Selchen D, Maurino J. Decision making under uncertainty, therapeutic inertia, and physicians' risk preferences in the management of multiple sclerosis (DIScUTIR MS). BMC Neurol. May 4 2016;16:58. doi:10.1186/s12883-016-0577-4

- Multiple Sclerosis is an unfortunately fertile ground for clinical uncertainty as there are multiple treatment options that are largely selected based on side effect/comorbidity combinations with treatment intensification based on already manifested progression of disease. MS experts have no way of predicting which patients are adequately treated and will not progress (or take longer to progress) than others, and these "experts" differ widely in how they come to their clinical decisions – some relying on their prior experience, some using risk stratification tools, and others using both. One may be able to boil down these effectively black box decision-making circumstances into "expected utility theory," which is essentially cost-benefit analysis (what appears to be the most foundational/fundamental logical process used by physicians to determine the best course of action in uncertain clinical situations). This paper proposes interesting new terminology that I have not seen in other resources: Neuroeconomics ("the science that studies the principles of how we make decisions") and therapeutic inertia ("the lack of treatment initiation or intensification in patients not at goals of care"), both of which may involve "cognitive distortions (e.g., overconfidence, tolerance to risk and ambiguity, etc.) that may lead to suboptimal decisions (e.g., therapeutic inertia)." This problem of "therapeutic inertia" likely exists far more potently in the fields of those managing conditions like Multiple Sclerosis where there is no singular gold-standard treatment, and where new treatments are constantly being reported in the press. How can one reasonably expect to see patients all day utilizing a certain paradigm, spend all night reading the literature reading about a new paradigm, and then institute that new paradigm the next day? Indeed, a difficult task is it not? Who wants to be the first "MS Expert" at an institution to adopt widespread use of a new disease-modifying therapy that may still have ambiguous datapoints?

Bories P, Lamy S, Simand C, et al. Physician uncertainty aversion impacts medical decision making for older patients with acute myeloid leukemia: results of a national survey. Haematologica. Dec 2018;103(12):2040-2048. doi:10.3324/haematol.2018.192468

- This paper identifies positive associations between intense chemotherapy for treatment of elderly AML and uncertainty aversion, lack of adherence to the expected utility model of patient case, and patient volume. Putting the interesting nature and potential causes of these findings aside, I do not believe that patients with AML would be particularly

pleased to know that such subjective and nonscientific considerations are made by their physician to guide the management of their cancer that may be life or death. One might argue that the perspective of the patient should matter more than the perspective of the physician, as data has shown intensive chemotherapy to offer the "greatest chance of complete remission but is associated with a significant risk of early death, while hypomethylating agents yield a lower chance of complete remission but lower risk of early death." What may be a fascinating, yet extremely resource-intensive endeavor (but maybe not with the rapid advancement of AI), is to culminate an inventory of every kind of patient encountered by a particular specialty, the clinical decisions made for those patients, and the outcomes such patients experience. By doing so, the best clinical decisions for those patients will become evident over time and "fall out" of the massive amount of available data.

Ivany E, Lotto RR, Lip GYH, Lane DA. Managing Uncertainty: Physicians' Decision Making for Stroke Prevention for Patients with Atrial Fibrillation and Intracerebral Hemorrhage. Thromb Haemost. Sep 2022;122(9):1603-1611. doi:10.1055/a-1789-4824

- Anticoagulating patients for the preventive treatment of stroke in the setting of atrial fibrillation is undoubtedly complicated in the patient subpopulation who have experienced bleeding diathesis pathologies such as intracerebral hemorrhage. The main themes that their decision-making utilizes to overcome this uncertainty are "computing the risks," "patient factors," and "making a decision" that may be aided by shared decision making but – from the perspective of the European physicians in this study – choosing to proceed with stroke prevention is an act that can only be finalized by the physician. Regarding risk computation, physicians reported using "reliance on existing knowledge, personal clinical experience, and awareness of patients' comorbidities and clinical risks of stroke." Regarding consideration of patient factors, physicians ranged from contemplating the cause of intracerebral hemorrhage, level of disability after intracerebral hemorrhage, age, and number of comorbidities. The process of "making a decision" with patients is complicated by their misconceptions about therapies such as warfarin simply being "rat poison," experiences their family members have had with a certain drug, or even lifestyle details such as outdoor escapades that may make death more likely with a bleeding diathesis. As we have seen articulated in other articles, the physicians surveyed here felt more comfortable advising their patients whether or not to be anticoagulated for stroke prevention in the setting of atrial fibrillation if the decision was made with multidisciplinary physician colleagues – a strategy that increases the amount of contemplation of a medical problem through parallelization and diffuses the responsibility of the patient's clinical outcome. Furthermore, the present article also references the belief that explaining the uncertainty inherent within a medical decision can cause patients to become deferential to the expertise of the physician.

Datta R, Kiwak E, Fried TR, et al. Diagnostic uncertainty and decision-making in home-based primary care: A qualitative study of antibiotic prescribing. J Am Geriatr Soc. May 2024;72(5):1468-1475. doi:10.1111/jgs.18778

- A unique source of clinical uncertainty is found outside of the confines of the hospital when medicine is performed during home-based primary care. There is no laboratory at home, patients are often cognitively impaired, and there no electronic medical record.

Home-based primary care physicians find novel factors to consider under these atypical circumstances to guide their choice of prescribing antibiotics "including those that promoted pre-scribing (desire to avoid hospitalization, pressure from caregivers, unreliable plans for follow-up) and those that inhibited prescribing (perceptions of antibiotic-associated harms, willingness to trial non-pharmacological interventions first, presence of caregivers who were trusted by clinicians to monitor symptoms)."

Comparing and Contrasting Surgical and Non-surgical Uncertainty

Mazur DJ, Merz JF. How older patients' treatment preferences are influenced by disclosures about therapeutic uncertainty: surgery versus expectant management for localized prostate cancer. J Am Geriatr Soc. Aug 1996;44(8):934-7. doi:10.1111/j.1532-5415.1996.tb01863.x

- An idea not specifically discussed in this article, but nevertheless impacted by its finding, is the supposition that we can thwart clinical uncertainty by bolstering the quality of our informed consent conversations with patients. We may be uncertain about whether to start a certain medication or perform a certain surgery, and, in those cases, we can clearly provide those options with their risks/benefits for a competent patient to decide their own course of action. However, the paper presented here may suggest that physicians do this for a selfish sense of security because they often cannot be sure that a patient deeply understands the medical information being communicated to them. Absolutely, one can use something like the "teach-back method," but the uncertainty is always inescapable. When it may be thought to be abolished, it appears elsewhere.

Moore S, Katz B. Surgical residents' scores on measures of Machiavellianism and physicians' uncertainty. Psychol Rep. Apr 1997;80(2):456-8. doi:10.2466/pr0.1997.80.2.456

- Despite the authors seeming to be surprised by these findings, I am not. It appears assumptive to predict a negative correlation between manipulative personality traits and clinical uncertainties. The argument attempted to be made in this article, I think, is that having a more manipulative personality can maybe be explained by having lower levels of social uncertainty. One might call this having higher levels of confidence or bravery? Then, the authors contend that lower levels of social uncertainty must also mean lower levels of clinical uncertainty. The leap in this logic is reflected by the statistically insignificant data that was presented. Nonetheless, this article sparked a new idea: surely, there must be different kinds of uncertainty. A single physician can be affected by multiple uncertainties at any one time. Perhaps they are uncertain about whether their patient likes them, uncertain about whether their own articulations are making sense to the patient, uncertain about their lower level of experience compared to their colleagues, uncertain about whether they actually like practicing in the setting they are working in, uncertain about their clinical knowledge surrounding the patient's presentation, uncertain about which management option might be best for their patient. Any one of these uncertainties, or all of them, can be sensed by the patient at any time and will likely be heuristically assessed as a lack of confidence held by the physician. Even if the physician is uncertain about something as noncontributory as their home-life, you can imagine how some less-than-stoic individuals may allow their less-than-confident attitude to creep into

their working persona. As a result, the physician-patient relationship, founded upon trust and confidence, crumbles.

McCulloch P, Kaul A, Wagstaff GF, Wheatcroft J. Tolerance of uncertainty, extroversion, neuroticism and attitudes to randomized controlled trials among surgeons and physicians. Br J Surg. Oct 2005;92(10):1293-7. doi:10.1002/bjs.4930

- I was hopeful prior to reading this paper that its contents would be profoundly valuable to our project. However, there was an ultimately unclear pontification of various thoughts here. The authors report that based on a survey they did of surgeons and physicians, surgeons are more extroverted, less neurotic, and more intolerant of uncertainty than their physician counterparts (which was true in their study even when controlling for sex). The authors beautifully articulate that surgeons must be tolerant of uncertainty to "make critical and irreversible decisions during an operation," but then say that "surgeons proved significantly more intolerant of uncertainty than physicians, providing support for the pre-existing hypothesis." It appears that the double negatives were confused by the authors here, since their data actually disproves their pre-existing hypothesis the way that they are describing it. Furthermore, there is an argument presented here that surgeons prefer to use their "spontaneous clinical judgment" over RCTs which is corroborated by the fact that "treatments in general surgery are half as likely to be based on RCT evidence as treatments in internal medicine." Nonetheless, the presented data shows that the attitude towards RCTs between surgeons and physicians was equivalent. If we take for face-value what the authors say about surgeons being more intolerant of uncertainty, could there be an argument to be made that being more intolerant of uncertainty actually means venturing deeper to try and find more certainty within available evidence/data rather than being comfortable shooting from the hip, so to speak? Another question of mine is whether or not surgeons are actually intolerant of uncertainty though or simply whether they refuse to believe that it exists? An intolerance of uncertainty suggests a mental anguish when presented with its existence. As the authors explicate, surgeons operate every day having to make uncertain and irreversible decisions. Sometimes they succeed greatly and sometimes they fail horribly; but after every case, there is a next one.

Mishel MH, Germino BB, Lin L, et al. Managing uncertainty about treatment decision making in early stage prostate cancer: a randomized clinical trial. Patient Educ Couns. Dec 2009;77(3):349-59. doi:10.1016/j.pec.2009.09.009

- Even when a theoretically perfect shared-decision making process is utilized for presenting patients with their medical and surgical options, there is nagging persistence of uncertainty maintaining its ubiquitous existence as physicians can never be sure if a patient truly understood the shared-decision making process. Interestingly, this paper found that patient uncertainty and decisional regret can be reduced if we employ a strategy to teach patients the biomedical and logical basics driving what information the physician is sharing and how they are going about sharing it. In the setting of cancer management, this could be established as the authors describe by having an individualized training session (being individualized by having the patients complete a standardized pre-test assessing existing and gaps in knowledge/expectations) for patients and family member(s) prior to their appointment with their medical/surgical oncologist to prime their understanding of what may be discussed. Of course, this is a very resource-

intensive endeavor with much standardization of the training session's skeleton required for various sites of clinical implementation (e.g. throughout the hospital when difficult or uncertain clinical decisions are anticipated). The authors had nurses be the main point of patient contact for the study, who were trained in coaching patients on the aforementioned items. Anecdotally, this reminds me quite a bit of the integrated, attentive, and personal role that nurses play in the coordination of evaluating patients for organ transplantation.

Politi MC, Légaré F. Physicians' reactions to uncertainty in the context of shared decision making. Patient Educ Couns. Aug 2010;80(2):155-7. doi:10.1016/j.pec.2009.10.030

- There is a positive association between anxiety levels from clinical uncertainty and being female or working fewer hours per week. However, the willingness of providers to disclose that uncertainty to patients has a negative association with possession of a graduate degree in addition to an MD. The authors further contribute to what has been said previously about the various kinds of uncertainty: "Experts conceptualize scientific uncertainty in many ways, including but not limited to: stochastic uncertainty (risk or probability of a future event); ambiguity (uncertainty about the strength or quality of risk estimates, resulting from conflicting study results or differences in study design used to calculate risk); uncertainty from unknown data; and uncertainty resulting from translating population level findings to individuals." Study participants who were more anxious about their clinical uncertainty were also more fearful of sharing those feelings with patients. The authors report that their study participants were actually naïve to the concept of shared-decision making (in 2010?) and, even more concerningly, there was a trend for folks more reluctant of engaging in shared-decision making at baseline to perform it even less after learning about it. It goes without saying that an ideal state of medical education would inculcate students with the understanding that no amount of uncertainty or lack thereof should prevent disclosure of those feelings to patients or the performance of shared-decision making.

Berger Z. Navigating the unknown: shared decision-making in the face of uncertainty. J Gen Intern Med. May 2015;30(5):675-8. doi:10.1007/s11606-014-3074-8

- Useful definitions of uncertainty are provided in the beginning of this article. Intriguingly, this paper introduces the idea of encountering clinical uncertainty as harnessing a toolbox of multiple different possibly effective strategies that can be utilized and exchanged to find the best "tool," as it were, to fit the job. An excellent table of these strategies was screenshotted and included above. Despite other articles arguing for the utility of decision aids, especially under circumstances of clinical uncertainty, the data has suggested these interventions to lack consistent evidence-based utility for bolstering healthcare provision – despite it decreasing the *feeling* of uncertainty by the provider. This draws attention to the point that uncertain clinicians do not provide worse care. One might liken this to taking a doctoral board exam: you may frequently feel uncertain about your answer choices, but you will likely do well given that you choose the "best" answer.

Santos AA, Moura JA, de Araújo JM. A Conceptual Framework for Decision-making Support in Uncertainty- and Risk-based Diagnosis of Rare Clinical Cases by Specialist Physicians. Stud Health Technol Inform. 2015;216:857-61.

- We have already discussed how clinical uncertainty often leads physicians to "to more" for patients, which can be viewed as a two-sided coin: on one side, the patient is getting thoroughly worked up so that a diagnostic/therapeutic plan can be made; on the other side, the patient is potentially paying higher healthcare costs and accumulating the risk of unnecessary procedures/tests. There may be opportunity for the IT and Clinical Decision Support Systems of hospitals to intervene when these "cures" for uncertainty (e.g. casting the widest diagnostic/therapeutic net they can) begin to be enacted by physicians.

Wasfy JH, Armstrong K, Milford CE, Sundt TM. Bicuspid aortic disease and decision making under uncertainty - The limitations of clinical guidelines. Int J Cardiol. Feb 15 2015;181:169-71. doi:10.1016/j.ijcard.2014.12.020

- Providers may deem societal guidelines to be uncertainty-reducers in the sense that they give a widely agreed upon, potential "gold standard" of care to follow. The astute reader will predict the next point, however, that guidelines are frequently a moving target and may cause confusion for patients and providers. The authors here provide the example of guidelines for surgical correction of aortic root dilatation and an example I thought of was normal ranges for cholesterol alongside statin indications. I find that in this swath of literature it is clear that we are stuck between a rock and a hard place: if we are without guidelines, there is uncertainty; if we have guidelines, there is still uncertainty. Albeit, I feel like the former uncertainty is probably greater since the intention of guidelines are to create a reasonable, largely evidence-based rule of thumb that acting upon will be beneficial for patients on the population-wide scale. The authors continue to call attention to valuable ideas such as the fact that medicine's reliance on population-based medicine is made more inaccurate by the likely extensive amount of people with the disease in question who are asymptomatic or simply never interact with the healthcare system – as in aortic root dilatation (selection bias). Even with guidelines or RCTs guiding certain clinical decisions, a prudent physician must still battle with the uncertainty of determining whether the external validity of the underlying studies apply to their singular patient. And, even if the external validity *does* apply, they must then battle with however hedging the confidence intervals supporting that $p < 0.05$ value might be. I have always been fascinated by the discussion of Type 1 and Type 2 decision-making processes with the classic example being that of medical student decision-making (Type 2, "resource-intensive, analytic deliberations") and veteran faculty physician decision-making (Type 1, "intuitive, gestalt hunches rooted in experience"). However, perhaps a little concerningly, the authors herein postulate that "when decisions that involve uncertainty with multiple parameters become too complex, physicians revert to type 1 processes — hunches rooted in experience." This simply does not make sense. If decisions are quick, easy, and follow pattern-recognition, then Type 1 processes should be utilized, but wouldn't you want your physician to truly contemplate your clinical case if you did not fit their heuristic (i.e. using Type 2 processing)? To give patients more agency under circumstances of clinical uncertainty surrounding their own healthcare decisions, accurate risk-assessing decision aids could be transitioned into the hands of patients rather than just researchers and physicians, the patients having the ability to directly input the influence of their values on the next best evidence-based diagnostic/therapeutic steps. This might solve the problem we have identified previously of patients wanting their physician to be certain when they are uncertain, despite the physician being potentially

just as uncertain and consequently only providing options rather than recommendations. I do wholeheartedly agree with the necessity of incorporating high-power computing into medicine with a cumulative assessment of multiple risk models with many different patient-specific and evidence-based parameters to determine which interventions for singular patients will have the highest benefit:harm ratio.

Bracamonte E, Gibson BA, Klein R, Krupinski EA, Weinstein RS. Communicating Uncertainty in Surgical Pathology Reports: A Survey of Staff Physicians and Residents at an Academic Medical Center. Acad Pathol. Jan-Dec 2016;3:2374289516659079. doi:10.1177/2374289516659079

- Similar to the previous article discussing this same topic, the authors here describe the preference of non-pathologists to discuss pathology results with the pathologists rather than simply reading their sometimes hedging/waffling written results in the medical record because of how significantly pathology results can guide next steps in management. The ultimate conclusion, however, is that the field of pathology *needs* to develop a standardized way of communicating the uncertainty of their final reads rather than relying on a variety of subjectively dubious phrases. I think that it is inappropriate to even suggest that management-guiding decisions based on pathology results are uncertain because of fault within the non-pathologist. Just like it is the duty of every non-pathologist physician to communicate with their patients using clear and easy-to-understand language, pathologists should develop a way of doing so (and what better way than a standardized one that can begin to be learned in medical school) for the non-pathologists that depend on them. This paper reports that "few respondents felt that one could ever be 100 percent certain. Although this is an interesting philosophical point, there is a practical legal aspect to this belief. The fear of the legal ramifications of over or under communicating a diagnosis may affect a pathologist's interpretation and use of diagnostic phrasing." I also appreciate their statement that "Consensus often only approximates truth even in ideal clinical settings."

Cottin V. Lung biopsy in interstitial lung disease: balancing the risk of surgery and diagnostic uncertainty. Eur Respir J. Nov 2016;48(5):1274-1277. doi:10.1183/13993003.01633-2016

- In words better than I could write myself, the author here explains step-by-step the multidisciplinary approach to the diagnosis of idiopathic pulmonary fibrosis in a way that minimizes uncertainty as much as possible: "As stated in international guidelines [5], in the appropriate clinical setting with all possible causes of ILD ruled out, the presence of a definite usual interstitial pneumonia (UIP) pattern on chest computed tomography (CT) is sufficient for the diagnosis of IPF. In the absence of a UIP pattern on CT, establishing a secure diagnosis of IPF requires a surgical lung biopsy [5]. This approach, therefore, relies heavily on the CT appearance of ILD that is stratified into three categories, namely UIP, possible UIP and inconsistent with UIP. In theory, a lung biopsy should be contemplated in patients with a pattern of possible UIP or inconsistent with UIP. All possibly relevant information available is then synthesised during the multidisciplinary discussion among clinicians, radiologists and pathologists, all being experts in the field of ILD, a process that increases the accuracy of the diagnosis [6] and impacts management [7]. The multidisciplinary discussion also allows the diagnosis to be made with higher confidence than by clinicians or radiologists alone (although reproducibility between

different teams needs to be optimised for diagnoses other than IPF [8]), and has become the gold standard for the diagnosis of ILD." The unfortunate reality of getting diagnostic lung biopsy is that they appear to be under-performed given the nature of the procedure combined with the age/comorbidities of patients that often need these diagnostic lung biopsies. Similar to the article above on risks of aortic root dilatation, data on the risk of lung biopsy to confirm IPF is uncertain because an unfortunately numerous amount of patients who qualify as low-risk candidates for lung biopsy never receive one.

Libert Y, Canivet D, Ménard C, et al. Predictors of physicians' satisfaction with their management of uncertainty during a decision-making encounter with a simulated advanced stage cancer patient. Patient Educ Couns. Jul 2016;99(7):1121-1129. doi:10.1016/j.pec.2016.01.008

- In a rather unique style, this article assessed how physicians *felt* after managing uncertainty during a hypothetical simulated clinical decision-making scenario. The authors found that the two predictors of physicians being satisfied by their clinical performance was (1) "their anxiety due to uncertainty" and (2) "their perceived empathy." The first of these findings makes sense; if a physician has a lower tolerance of uncertainty, one can clearly see how those physicians will be less comfortable and satisfied following an uncertain clinical situation. Furthermore, I have heard in passing that tolerance of uncertainty has been factors that have influenced faculty physicians' initial choice of specialty. For example, a pediatric hematologist once told me that he wanted to be a surgeon until he realized how anxiety-inducing the finality of surgery is – once you cut something, you cannot always un-cut it. Perhaps a little ironically, the satisfaction of physicians in this study with the care that they provided to the simulated patient was not correlated with the satisfaction of the simulated patient. There is concern, however, that those physicians who have less anxiety due to uncertainty and are more satisfied with the clinical performance could actually be inadequately managing uncertainty in a way that is, in a way, blissfully ignorant. Three strategies that could very well prove useful for the future training of physicians are (1) "assess[ing] the patient's preferred level of involvement in the treatment decision, (2) "assess[ing] the patient's desire for information and the method of delivery for that information", and (3) "us[ing] direct expressions of uncertainty about their patient's outcome." These are quite nuanced and nontrivial questions to ask patients, especially because such questions kind of break down the fourth wall, so to speak, of the social contract that the patient expects when seeing their physician.

Dhawale T, Steuten LM, Deeg HJ. Uncertainty of Physicians and Patients in Medical Decision Making. Biol Blood Marrow Transplant. Jun 2017;23(6):865-869. doi:10.1016/j.bbmt.2017.03.013

- Medical oncology carries the unique challenge of needing to combine population-based, statistical evidence with personalized medicine so that therapeutic strategies (chemoradiation, targeted agents, immunotherapy) can be effective for a singular patient after it has been proven to be safe and effective for a cohort of patients. This becomes even more difficult with the exceptional amount of information that patients have at their fingertips and can research prior to their oncology appointment to bring with them – physically or mentally – and achieve a sense of control over their new cancer diagnosis. However, this information is frequently so nuanced that only the oncologists themselves

have the insight to interpret it and apply it to individual patients. The authors aptly quote Sir William Osler: “Medicine is the science of uncertainty and the art of probability.” Another unique consideration within oncology is the high amount of toxicity and symptomatology of their therapies that may not carry an exceptional survival benefit. Therefore, the uncertainty of physicians in this situation is multiplied by the uncertainty of patients deciding if an extra year of life with an otherwise uncurable cancer is worth the side effects of their treatment – something that is difficult for a physician to advise a patient on. There is a new description of uncertainty provided in this article, with it being any combination of “lack of familiarity with the necessary information, unavailability of relevant information, inability to assess the impact of patient or disease characteristics on outcome with one versus another treatment strategy, and poor understanding of patient preferences or priorities.” Furthermore, “at its most basic level, uncertainty can be defined as a cognitive state characterized by an awareness of incomplete understanding of a situation or event [7,12]. To be uncertain implies a relative or absolute inability to accurately establish a diagnosis, predict response to treatment, or estimate future events.” Mishel’s Theory of Uncertainty in Illness, that has been briefly mentioned elsewhere, further “posits that uncertainty arises from complexity, unpredictability, ambiguity, and lack of information.” All of this uncertainty is exasperated independently by the patient, provider, or both. Patients contribute to clinical uncertainty by their “inability to provide a complete history, unpredictable response to treatment, varying preferences for information, and desire to participate […], ability to comprehend quoted risk estimates particularly if their numeracy (i.e., numeric literacy) is limited, […], their age, educational status, illness coping mechanisms, and priorities for future care, [ultimately] making some patients more tolerant of uncertainty than others.” Physicians contribute to clinical uncertainty by varying abilities to explain concept medical concepts to patients with varying levels of health literacy, inconsistent adherence to remaining abreast of cutting-edge research. The difficulty of all these intricacies is relentless such that uncertainty itself is even uncertain. Here lies the limit of what should probably be shared with patients since research has shown that when there is too much uncertainty surrounding a treatment, for example – even if that treatment has been shown in the literature to be superior to placebo or a previous gold standard – patients may exhibit “ambiguity aversion” and forego a treatment that may be beneficial for them out of fear of being unable to conceptualize the associated risk. This is an appropriate time to pose the question of the acceptability of “coercing” patients. A difficult conundrum exists for physicians where some patients may abhor healthcare uncertainty because it exposes their own overestimation of how many problems medicine truly has a “solution” for, disappoints them as they feel like they are “paying the big bucks” for nothing, and paralyzes them in the sense that there is no clear best therapeutic option for something like their cancer care. Conversely, other patients might be grateful for medical uncertainty because the glass appears half full to them – rather than half empty – and they interpret the lack of certainty as reassurance that they may indeed “make it” despite their terminal diagnosis. Either way, this chasm needs to be bridged through objective and validated, yet personalized patient education initiatives and improved uncertainty training for physicians.

Kidane B. Stereotactic body radiation therapy versus video-assisted thoracoscopic surgery in stage I lung cancer: Honesty in the face of uncertainty. J Thorac Cardiovasc Surg. Jan 2018;155(1):365-366. doi:10.1016/j.jtcvs.2017.08.059

- I found one quote from this short piece to be significant: "We must be cautious not to use evidence such as this article (although it may align with our biases) to make inappropriate claims with overzealous finality about the definitive superiority of surgery." Indeed, it is quite easy, as many of us are aware at this point, to agree with mediocre research that resounds what we already experientially believe to be true. This experiential basis of truth is apparently quite prevalent in surgery, and I would contend that a good surgeon may rely on this experiential truth (since it is so commonplace and, on average, patients do fine) but a great surgeon believes in good research when it tells them to put their knife down.

Timmermans S, Yang A, Gardner M, et al. Does Patient-centered Care Change Genital Surgery Decisions? The Strategic Use of Clinical Uncertainty in Disorders of Sex Development Clinics. J Health Soc Behav. Dec 2018;59(4):520-535. doi:10.1177/0022146518802460

- This article provides a very interesting portrayal about how clinical uncertainty can be leveraged as a means of coercing parents of children with disorders of sex development (DSD) to choose the course of action for their children that the physician most agrees with. Indeed, it is easy to imagine how a room full of mirrors can become even more disorienting when smoke is introduced. Then, of course, the guiding light of surgery's potentially more optimistic outcome will be acted upon. A unique challenge is undoubtedly created when the "patient" being implicated in an uncertainty-laden shared-decision making process cannot make medical decisions for themselves. The fact of surgery's irreversibility is also strongly embedded in this discussion since, with the surgical correction of DSD, patients cannot necessarily "go back." The authors here seem to be suggesting that patients who receive a surgical correction of DSD tend to do just fine, and the vast majority of DSD patients do receive surgery since parents are often specifically requesting it. However, there is a subset of DSD advocates that call for there to be greater clinical uncertainty surrounding surgical correction of DSD since they see a real benefit of either not having their DSD corrected or being able to participate in such aspects of their healthcare at a later date outside of infancy – which is very understandable. However, one might aptly question whether it is appropriate to judge this weighty decision as one that a child can/should make. One inherent issue is the apparent lack of evidence as to the superiority of surgical versus nonsurgical management of DSD, especially since such surgical techniques change so frequently that any long-term follow-up studies would be relatively meaningless to the present-day DSD surgeon. A potentially useful strategy to effectively approach this conversation with parents is to emphasize that there is often no necessity to make any surgical decisions urgently or rashly, making it helpful to schedule consultation visits over many weeks-months to build in time for families to ponder their decision.

Shelton RC, Brotzman LE, Crookes DM, Robles P, Neugut AI. Decision-making under clinical uncertainty: An in-depth examination of provider perspectives on adjuvant chemotherapy for stage II colon cancer. Patient Educ Couns. Feb 2019;102(2):284-290. doi:10.1016/j.pec.2018.09.015

- I wonder if there is a combinatorial effect occurring as a cause of this article's findings: first, medical and surgical oncologists do an insufficient job of remaining fully abreast of all the newest research and clinical guidelines in the same way as they did when they were trainees. Second, there is a certain predisposition burned into the minds of faculty medical and surgical oncologists to perpetuate the teachings they learned wherever they trained, even if that contradicts the newest guidelines (especially if they perceive their patients as doing fine overall). Nonetheless, this paper reiterates themes that have "fallen out" elsewhere: it is unwise to assume numerical competency amongst patients and it is probably the most prudent idea to make patients aware of when recommendations are being made on the basis of certain versus uncertain data. Providers should continue eliciting from patients their baseline healthcare literacy and their desire to be involved in the decision-making process through both direct and indirect means prior to engaging in the most substantial aspects of the question being plagued by clinical uncertainty. This way, that question can be discussed in a way that is tailored to the patient and their clinical situation. Indeed, these authors state that "it may be important for providers and practitioners to revisit assumptions about the use and dynamics of SDM models in the context of heightened clinical uncertainty, when decisions are preference-sensitive rather than evidence-driven, as in the case of stage II colon cancer. In particular, it is not only the provider that shapes this decision, but the team of providers or multiple providers when patients receive 2nd opinions, as well as family members and caregivers. As such, it is critical to understand their influence and perspectives, and recognize that decision-making is rarely dyadic."

Lampalzer U, Briken P, Schweizer K. Dealing With Uncertainty and Lack of Knowledge in Diverse Sex Development: Controversies on Early Surgery and Questions of Consent. Sex Med. Sep 2020;8(3):472-489. doi:10.1016/j.esxm.2020.03.002

- The finality of surgical intervention is a consistent source of its uncertainty amongst multiple different subspecialty-focused articles; surgical correction for diverse sex development is no different. As I mentioned elsewhere, one significant source of such uncertainty is that children cannot "go back" once they are old enough to participate in their own sexual-medical decision-making. This creates an ethical conundrum of parents making decisions for their children regarding pursuing or foregoing the correction of DSD for the sake of typical sexual function, alignment of birth sex and genital construct, and fear of social ridicule. While it is definitely true that "positive acceptance of bodily variance is an important prerequisite" to these conversations, there is yet to be data that definitively shows surgical or nonsurgical correction to be superior overall for children with DSD. I would be curious to know whether this "widely accepted" notion is more due to the sociopolitical controversy of such medical data than due to its lack of presence… Medicine should not be subject to the frivolities of sociopolitical controversy, but physicians, patients, and researchers are all simply flawed humans at the end of every day.

Lee JY, Jang Y, Kim S, Hyung WJ. Uncertainty and unmet care needs before and after surgery in patients with gastric cancer: A survey study. Nurs Health Sci. Jun 2020;22(2):427-435. doi:10.1111/nhs.12677

- Surgeons can contribute to reducing uncertainty within their patients – which, as we have described elsewhere, is one of many potent sources of uncertainty within any clinical encounter – by providing them expectations of when they will have uncertainty and what kinds of uncertainty they will experience when they have it. Notably, this paper showed that patients with gastric cancer had (albeit predictively) higher physical/daily living domain uncertainty after surgery versus higher information, psychological, and support uncertainty prior to surgery.

Ford CM, Regan H, Dwyer M, Patel G. Adenomyoepithelioma of the breast: a rare diagnosis complicated by surgical emergency and diagnostic uncertainty. BMJ Case Rep. Feb 8 2022;15(2)doi:10.1136/bcr-2021-246390

- Under clinical instances of higher than usual uncertainty, multidisciplinary collaboration often leads to diagnostic and therapeutic conclusions given the value of having multiple brilliant minds from various specialty disciplines (each having their own biases) weigh-in. And as we have explored previously, there is often a necessity of veering away from typical guidelines/management pathways when atypical cases present themselves. There seems to be a trend within doctoring as a whole to be much more general in the diagnostic and therapeutic approach when uncertainty is prevalent. In surgery, this may involve "cutting out more," and, in medicine, this may involve empirically covering for a broader array of pathogens with antibiotic treatment prior to receiving culture results.

Duval M, Zewdie M, Kapadia MR, et al. How to say "I don't know": development and evaluation of workshops for medical students and surgical residents on communicating uncertainty using the ADAPT framework. Global Surg Educ. 2023;2(1):1. doi:10.1007/s44186-022-00075-4

- The ADAPT framework developed by the authors stands for "assess the patient's knowledge, disclose uncertainty directly, acknowledge patient emotions, plan next steps, and temper expectations" so that uncertainty can be disclosed safely to patients without running as high of a risk of harming the therapeutic relationship. The authors then cite that "in one analysis of over 1000 encounters, PCPs and surgeons discussed the uncertainty surrounding their treatment plan in 1% of encounters for basic decisions, 6% for intermediate decisions, and 17% for complex decisions" which significantly limits the ability for patients to actively and appropriately engage in their own decision making when they might not even be aware of the looming uncertainty. Interestingly, and perhaps expectedly, there may be a positive association between the confidence a provider has in addressing uncertainty with patients and the subjective interpretation of that expression of uncertainty. I am curious whether this is due to an objective increase in the ability to convey uncertainty (making the confidence a byproduct of known skill) or whether simply imbuing the act with confidence makes patients take it better.

Lin E, Crijns TJ, Ring D, Jayakumar P. Imposter Syndrome Among Surgeons Is Associated With Intolerance of Uncertainty and Lower Confidence in Problem Solving. Clin Orthop Relat Res. Apr 1 2023;481(4):664-671. doi:10.1097/corr.0000000000002390

- The primary finding of this paper was that "imposter syndrome may be modestly to notably associated with modifiable factors, such as difficulty managing uncertainty and lack of confidence in problem-solving," and the authors identify that finding ways to "sustain a surgeon's mindset" may be the preventive and corrective response to surgeons

experiencing imposter syndrome and its sequelae. Importantly, clinical uncertainty can result in variations of care provided to the same patient by different providers simply based on the subjective experience of that uncertainty by the providers. While this may be understandable in the surgical setting since different surgeons may have different technical strengths/weakness affecting their surgical recommendations, this should not be occurring in the world of general practitioners (unless due to a simple lack of knowledge) and especially not medical specialists. These authors conclude by mentioning "surgical coaching programs such as the Wisconsin Surgical Coaching Program and the Harvard Surgical Coaching for Operative Performance Enhancement might also help ameliorate feelings of imposter syndrome in part by increasing comfort with uncertainty and confidence in problem solving." This made me realize a source of uncertainty that is more esoteric than the others we have previously discussed: uncertainty caused by one being relatively confident that a medical or surgical decision is likely appropriate, but being unsure of whether one's medical or surgical superior will approve of that decision. There are many times in medicine, especially as a trainee, where there are multiple objectively correct ways to diagnose or treat a pathology; however, there is often one singular preference of the senior resident, fellow, or attending.

Gwilym BL, Twine CP, Bosanquet DC. Information Provision to Facilitate Vascular Surgery Shared Decision Making in the Face of Uncertainty. Eur J Vasc Endovasc Surg. May 27 2024;doi:10.1016/j.ejvs.2024.05.032

- A properly performed shared-decision making event regarding surgery should include surgeons providing a prognostication of the likelihood of common adverse events as well as the life-threatening adverse events. Like we have previously discussed, the ability for physicians to prognosticate is quite underwhelming and is affected by "availability heuristic (events that provoke negative emotion in our memories are more readily recalled), self-serving bias, and confirmation bias." Even if a statistical model was derived to predict a more objective adverse event rate for a particular patient, that prediction is uncertain within the field of surgery given that the statistical model does not know the strengths/weaknesses of the surgeon, who else will be in the OR and what their strengths/weaknesses are, and other small butterfly effects influencing the patient's outcome. It goes without saying that even the most advanced prediction model will still be too simplistic for the multitudinous factors affecting clinical decisions. The single most important question this paper should aim to comment on is whether or not surgeons and/or non-surgeons should openly disclose their uncertainty to patients pending the conclusion that some patients prefer physicians to disclose their uncertainty while other patients hate it and view it as a marker of incompetence. My initial instinct is to suggest that non-surgeons should be more open about their uncertainty given the possibility for them to stop medications that do not work; however, surgeons would scare away all of their patients if they freely expressed their uncertainty to the same extent that they likely feel it. Patients must have more confidence in the person who is going to irreversibly cut them open while they lay asleep and completely vulnerable than they do the person who is going to prescribe them a reversible medication. Surgeons may be better able to express their uncertainty through strategies like the framing effect which involves "framing risk information in a positive manner, e.g., a one in six chance of preventing a stroke with carotid endarterectomy, rather than a five in six chance of carotid

endarterectomy being unnecessary". These authors underscore another point that has been made elsewhere: pre-visit decision aids can help walk patients through the decision-tree that physicians will be making with them during their upcoming consultation appointment. Priming patients with this information can allow them to better "speak the language" of their specialist in addition to allowing them time to think of the right questions to ask and consider beforehand so that they do not rashly and regretfully consent themselves to surgery.

The Patient Perspective

Redeker NS. The relationship between uncertainty and coping after coronary bypass surgery. West J Nurs Res. Feb 1992;14(1):48-61; discussion 61-8. doi:10.1177/019394599201400104

- The sphere of uncertainty's influence evidently extends beyond those making the medical decisions and shapes the experience of those being affected by the medical decision-making. This appears to carry a potentially greater weight during surgical interventions since to undergo surgery means to become completely vulnerable under the hands and minds of surgeons that one often does not know as well as, say, their primary care physician. We may appreciate the uncertainty within the technicalities of a particular surgery, or even a medical intervention, but imagine how that patient feels when agreeing to subject themselves to something that may be beneficial, may be equivocal, or may be harmful.

White RE, Frasure-Smith N. Uncertainty and psychologic stress after coronary angioplasty and coronary bypass surgery. Heart Lung. Jan-Feb 1995;24(1):19-27. doi:10.1016/s0147-9563(05)80091-3

- Mishel's Model of Uncertainty in Illness asserts that stress arises when uncertainty persists. The authors of this paper go on to discuss that the reason for angioplasty patients having higher levels of uncertainty than bypass grafting patients is because of a reported 30% 6-month risk of coronary vessel restenosis in the former group. This is an interesting finding because one might presume bypass grafting patients would be more uncertain given that their procedure is a far more invasive surgery. However, the more definitive nature of bypass grafting must counterbalance the intensity of the surgery, perhaps making it less uncertain in the minds of patients. An interesting question poses itself: how often are we doing patients harm by engaging in routine informed consent, discussing all the important risks and benefits? For the sake of argument, let's say we are giving 100% of our angioplasty patients heightened uncertainty about the risk of restenosis even though 70% of them will be just fine. Is that 6-months of waking up every day not knowing if you are going to have another heart attack really worth it? Obviously, to not disclose a known risk of a procedure being performed for a given benefit is unbecoming of a virtuous physician. However, I feel that what I have questioned above is still an interesting thought experiment. I was also impressed by the self-evident nature of social support reducing uncertainty and psychological stress for patients. Would the same be true for the uncertainty and psychological stress encountered by physicians when they make uncertain decisions? Is the hospitalist who has a loving spouse at home a better,

more confident, less uncertain doctor? Does the surgeon with supportive parents, in-laws, children operate more decisively and with better outcomes?

Staples P, Jeffrey J. Quality of life, hope, and uncertainty of cardiac patients and their spouses before coronary artery bypass surgery. Can J Cardiovasc Nurs. 1997;8(1):7-16.

- While focusing on the uncertainty that leads up to a medical decision being finalized in the minds of a physician and patient is important, the uncertainty that primarily plagues patients following that decision also deserves emphasis. The power of patients having storing social networks when encountering medical uncertainty has already been underscored, but presents an interesting problem here. We have already discussed that one more reliable than not method of ameliorating clinical uncertainty is educating the patient and, utilizing a robust informed consent procedure potentially even including thorough teach-back, getting them as involved in their own medical care as they want to be. How does that strategy change when a patient has their spouse there with them? What about when their spouse wants to be more involved in the medical decision making than the patient does? What if the patient and spouse disagree about the best course of action for the patient? Even if we perfectly execute our robust informed consent procedure with perfect understanding and buy-in from our patient for a certain surgical or medical intervention, the disagreement of their spouse may theoretically induce so much disagreement that any quality-of-life improvement we could offer our patient is obfuscated.

Bliton MJ. Parental hope confronting scientific uncertainty: a test of ethics in maternal-fetal surgery for spina bifida. Clin Obstet Gynecol. Sep 2005;48(3):595-607. doi:10.1097/01.grf.0000169660.80698.a8

- Very interestingly, this article questions the patient's ability to reason through uncertainty even if the scientific data available to them is certain. More specifically, the patient they question the ability of is not just any patient, but a pregnant mother attempting to decide whether to receive maternal-fetal surgery to repair spina bifida. The paper was written before the conclusive evidence of the Management of Myelomeningocele Study (MOMS) trial, but argues that uncertainty surrounding this decision will remain pervasive as parents attempt to decide whether to move forward with a surgery that, despite (potentially) evidence shows is effective and safer-than-not, there are still risks. The parents may make a decision that is predicated on hope, and the question to wrestle with is whether such a decision-making state of mind is one that can participate in informed consent competently.

Lien CY, Lin HR, Kuo IT, Chen ML. Perceived uncertainty, social support and psychological adjustment in older patients with cancer being treated with surgery. J Clin Nurs. Aug 2009;18(16):2311-9. doi:10.1111/j.1365-2702.2008.02549.x

- Logically, patients experience increasing levels of uncertainty as invasive medical interventions such as surgery draw near. This uncertainty tapers, however, as patients recover postoperatively and are healed by the passage of time, so-to-speak. I would imagine these decreasing levels of uncertainty are manifold in origin, being derived from a combination of feeling better in the long-run and escaping surgical complications that patients reason will likely crop up sooner than later following surgery. Given that

"significant relationships were found among uncertainty and anxiety and depression" amongst patients, it would be fascinating to examine if the same were true amongst physicians. Do surgeons or non-surgeons have a higher prevalence of anxiety and depression? Does such prevalence exacerbate the objective quantity or subjective quality of clinical uncertainty?

Fraenkel L. Uncertainty and patients' preferred role in decision making. Patient Educ Couns. Jan 2011;82(1):130-2. doi:10.1016/j.pec.2010.02.026

- There is an argument to be made regarding the value of physicians first assessing which decision style their patient prefers (whether they would like to take a strong leading role, be an active co-participant, follow whatever their doctor advises, or anywhere else along this spectrum) prior to approaching with a style of sharing information that is individualized for their patient. Being older or sicker may predispose patients to take on a more passive decision-making role, but medical decisions whose outcomes carry heavy consequences tend to motivate patients to be more of an active participant or leader. This may prove to be an important difference in the way that surgeons versus non-surgeons encounter patients where one may be able to posit that patients view surgery as carrying heavier consequences than starting most medications than can simply be stopped alongside their side effects. Importantly, though, it is easy to perceive that the role patients want to take in the shared-decision making process has multifactorial influences such as previous experiences with healthcare, health literacy, values, personality, perspective(s) of trusted loved ones, and so forth. It would be interesting to see if the certainty of a physician affects the role that *they* prefer to play in medical decision-making. I anticipate that it would, with certain doctors preferring to lead the patient encounter and uncertain doctors tending to give all of the options to patients for the patients to then decide. There is an obvious disconnect here as patients tend to prefer a greater amount of physician input when clinical circumstances are uncertain.

Politi MC, Clark MA, Ombao H, Dizon D, Elwyn G. Communicating uncertainty can lead to less decision satisfaction: a necessary cost of involving patients in shared decision making? Health Expect. Mar 2011;14(1):84-91. doi:10.1111/j.1369-7625.2010.00626.x

- Unfortunately for the movement of motivating physicians to exemplify honesty with their patients about their uncertainty regarding certain healthcare decisions, this study showed that patients experience higher rates of dissatisfaction with their decision when physicians voiced their clinical uncertainty. Fortunately for this movement, however, this effect was tempered by involving patients in their medical decisions. This should be expected given the preponderance of evidence and logic supporting utilization of shared-decision making whenever it is possible. It is also expected that patients receiving cancer care (the population surveyed in this study) would be especially disappointed when they go to a cancer doctor hoping for hope and receiving honest yet equivocal physician uncertainty.

Stone AM, Lammers JC. The uncertainty room: strategies for managing uncertainty in a surgical waiting room. Perm J. Fall 2012;16(4):27-30. doi:10.7812/tpp/12-028

- I am admittedly flabbergasted that much research has gone into something as unexpected as how to minimize the amount of uncertainty one experiences inside of a waiting room

based on how it is organized. Justifiably, a strong source of uncertainty amongst the family members of patients receiving surgery was due to miscommunication or inadequate communication from surgeons. For example, the authors here nicely highlight the fact that patients/family members will commonly ask how long the surgery will take. Surgeons will likely respond with the intraoperative time, not noting that it will be *longer* until the family and the patient can be reunited – which is often what the patients/family members are asking. This may cause much undue familial anxiety as they question "why it is 'taking so long.'" There is a point in this article where "distraction" is described as a strategy to "manipulate the uncertainty of others." I wonder how that plays into our research here?

Masuda M, Oishi H, Yamamoto M. Uncertainty in patients with unruptured intracranial aneurysms undergoing endovascular surgery: a qualitative and inductive study. Nurs Res. Sep-Oct 2014;63(5):366-74. doi:10.1097/nnr.0000000000000050

- The continual progression in radiologic image resolution and diagnostic power will undoubtedly lead to more "incidentalomas," as it were, that are not currently causing patients problems now but may in the future. Patients, knowing they have one of these "incidentalomas," then has to live with the resultant uncertainty unless they approach a doctor – probably a surgeon – about what can be done for management. They parlay their uncertainty onto the supposedly all-knowing physician for a cure, but I imagine that the patients feel the weight of that uncertainty quickly returned to their shoulders as most "incidentalomas" probably do not have strong indications or contraindications for surgery versus medical management. I appreciate how the authors discuss that the categories of thought affecting the uncertainty that patients experience following the diagnosis of unruptured intracranial aneurysm are "Nature of the Disease, Treatment Characteristics, Information, Decision-making, Course of the Future, and Living with UIA." I would like to imagine that the same categories are considered by physicians when determining whether to treat or not to treat.

Chuang MF, Tung HH, Clinciu DL, et al. The effect of an integrated education model on anxiety and uncertainty in patients undergoing cervical disc herniation surgery. Comput Methods Programs Biomed. Sep 2016;133:17-23. doi:10.1016/j.cmpb.2016.05.003

- It goes without saying that efficacious patient education, especially prior to invasive surgical interventions that cannot simply be discontinued or reversed like most medical interventions, is exceptionally important for reducing patient uncertainty. This article is quite similar to others that I have annotated above, and it highlights the theme that preoperative appointments should be buttressed with e-learning (or other validated platforms) for patients that they can take home with them to study, re-study, and contemplate according to their own desire so that they may have an improved literacy of what they are subjecting their bodies to.

Schapira MM, Aggarwal C, Akers S, et al. How Patients View Lung Cancer Screening. The Role of Uncertainty in Medical Decision Making. Ann Am Thorac Soc. Nov 2016;13(11):1969-1976. doi:10.1513/AnnalsATS.201604-290OC

- Lung cancer screening is a preventative intervention that many patients undergo, potentially without a complete understanding of what may lie ahead should the results of

their screening procedure lead to the diagnosis of malignancy. A prudent physician should assess for how uncertain patients might be following the results of these screening procedures and, most importantly, if a patient would even want to know or intervene if they had lung cancer. Notably, it appears from this article that patients who tolerate uncertainty less were more likely to desire lung cancer screening – not dissimilar from our previous discussions of uncertain physicians wanting to order more tests for their patients in an effort to gain some semblance/modicum of certainty.

Pergolotti M, Bailliard A, McCarthy L, Farley E, Covington KR, Doll KM. Women's Experiences After Ovarian Cancer Surgery: Distress, Uncertainty, and the Need for Occupational Therapy. Am J Occup Ther. May/Jun 2020;74(3):7403205140p1-7403205140p9. doi:10.5014/ajot.2020.036897

- It is unfortunate that women experience continuing uncertainty after receiving surgery for ovarian cancer. I would be unsurprised to learn that this is due to the unsure nature of surgery for ovarian cancer regarding its curative property. However, in addition to "integrating in-home or community-based occupational therapy into routine care" for women receiving surgery for ovarian cancer, surgeons should ask themselves whether something about the operation that they gave these women can provide them improved post-operative quality of life without sacrificing, in this instance, success of cancer resection.

Conclusions

Politi MC, Street RL, Jr. The importance of communication in collaborative decision making: facilitating shared mind and the management of uncertainty. J Eval Clin Pract. Aug 2011;17(4):579-84. doi:10.1111/j.1365-2753.2010.01549.x

- In a way that could not be said better myself, the authors argue herein that "Strategies such as providing clear explanations, checking for understanding, eliciting the patient's values, concerns, needs, finding common ground, reaching consensus on a treatment plan, and establishing a mutually acceptable follow-up plan can facilitate collaborative decision making." It should be the goal of the reasonable physician to make the best clinical decisions possible for their patients which may be accomplished by employing evidence-based diagnosis/treatment, being mindful of the patients' values/goals/expectations, utilizing those patient values/goals/expectations to help them occupy the role in clinical decision-making that is most agreeable to them, and can be reasonably enacted. The requirement of clinicians to have "cognitive and communicative capacity" to "engage in collaborative decision making," which includes "knowledge of the patients' context and perceptions of the patient" makes this endeavor arguably more difficult for surgeons. Some may content that surgery is the specialty with the littlest continuity of care; patients present with a problem needing fixing, surgeons fix that problem, and the patients *maybe* have one surgical follow-up appointment. Surgeons therefore have to know their patients as well as their respective context and perceptions very quickly (e.g. within perhaps one appointment) and probably incompletely relative to non-surgeons where managing medical problems are usually more chronic in nature.

Unlike medical management, ongoing conversation about the uncertainty of surgical management cannot occur after the surgery has been performed and the "damage has been done," so to speak – although hopefully the damage was helpful. The likely truths presented here to explain why doctors may be hesitant to communicate their uncertainty with patients (i.e. displaying confidence to gain trust, fearing the complexity is too much for the patient to understand and that they might just give up, resorting to a paternalistic defense mechanism) can be added to with conceptualization of the state of modern medicine. Seemingly at a higher and higher frequency, patients might prefer alternative or homeopathic therapies if they are available in addition to patients exhibiting growing vaccine hesitancy. Physicians who prefer a more strictly allopathic practice style may be worried that admitting any uncertainty in their "evidence-based" Western medicine will exacerbate the homeopathic tendencies in their patients and worsen their health outcomes. Another intriguing point was addressed in this paper which is the capacity for different physician specialties to address clinical uncertainty in different ways according to how their specialty might prefer to approach a problem, simply on the basis of familiarity. The engagement of patients with academic medicine may further their uncertainty if "a radiation oncologist might recommend radiation as a first line treatment for prostate cancer, a surgeon might recommend surgery, and a gerontologist might recommend active surveillance."

Gustafson A. Reducing Patient Uncertainty: Implementation of a Shared Decision-Making Process Enhances Treatment Quality and Provider Communication. Clin J Oncol Nurs. Feb 1 2017;21(1):113-115. doi:10.1188/17.Cjon.113-115

- There is an unfortunately irreducible nature to clinical uncertainty that carries varying weights depending on the specific circumstance that such uncertainty is impacting. Under dire circumstances, like a new cancer diagnosis with a guarded prognosis, the weight of uncertainty upon patients is undoubtedly immense. Providers must exhibit role flexibility to easily transition between roles of objective information provision to subjective emotional support according to the needs of the patient. The assessment of patients' needs is accomplished by therapeutic communication and active listening. However, even when these strategies are perfectly executed, patients may still have decisional conflict that can negatively affect their quality of life and satisfaction with care; the Decisional Conflict Scale can be used to ascertain the turmoil of choice within the minds of patients. I appreciate how this author says "providers [must] equip patients with as much information as needed and tolerated…" which creates a great goal for physicians, but also further complicates their already difficult responsibility. I can imagine many less-interested physicians simply giving up, as it were, and encountering patients in ways that conserves the expenditures of their own mental economy so that their workdays may progress smoother and without as much emotional exhaustion. I say this because the astute reader will realize that to perfectly encounter each patient, a physician must become a clean slate and recursively restart, prior to each patient visit, the process of (1) knowing what background information to give a patient and how to deliver it, (2) assessing how that patient might most prefer to receive and interact with that information, (3) engage in therapeutic communication and active listening to shift their roles between objective information provision to subjective emotional support if needed, and (4) leading the discussion of while also letting the patient be in control of – to the extent that they

wish to be –therapeutic decision-making. The author suggests that use of the Decisional Control Scale may be helpful in parsing through some of these patient preferences ahead of time.

Manuscript Submitted to *BMC Medical Ethics*

Approaches to Clinical Uncertainty Among Physicians in Surgical versus Non-surgical Medical Specialties

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Key Words: Uncertainty, surgery, general medicine, informed consent, shared decision-making, medical education

ABSTRACT

Uncertainty is a ubiquitous entity in clinical practice that indiscriminately impacts all medical specialties. Physicians encounter this uncertainty when caring for every patient, every day. There appears to be relatively little published literature in this area considering the pervasive nature of uncertainty in the medical field. There are even fewer papers published regarding the specific uncertainties that surgeons (compared with non-surgeons) encounter and attempt to overcome in their daily practice. To my knowledge, this is the first review article to assess, juxtapose, and rationalize approaches to uncertainty in clinical judgment and medical decision-making among physicians in surgical versus non-surgical medical specialties. The literature suggests that surgeons are uniquely affected by uncertainty caused by the necessity of making rapid intraoperative decisions with little data, the inability to undo surgical actions after they have been committed, and reliance on research that is typically lower on the classic "evidence pyramid" than non-surgeons. Surgeons overcome these uncertainties through operating "by feel," relying on teachings from their residency/fellowship training that gave them their "practice style," and utilizing instruments for novel purposes they were not originally designed for. By contrast to surgical uncertainty, non-surgical uncertainty derives more singularly from the inability to know anything completely, with prognostication being a prime example. Informed consent and shared-decision making are the most reliable strategies to overcome surgical and non-surgical uncertainty, which is often aided by the ability to stop non-surgical interventions with few repercussions if those interventions (such as medications) are unsuccessful or intolerable. Because uncertainty is inherent to medical practice, medical education should strive to more readily and widely expose trainees to the uncertainty that awaits them so that they are more prepared to manage it the best they can.

BACKGROUND

Uncertainty is an irreducible and unavoidable entity in daily living. In the philosophical sense, every decision is colored by at least an inkling of doubt. Put simply, one can never be entirely sure of any future outcome. This esoteric truth becomes complicated in the realm of science and medicine where the pursuit of knowledge aims to elucidate the underpinnings and innerworkings of nature, especially as it pertains to the human body. The ubiquity of uncertainty does not discriminate, and its effects are felt especially in medicine where absolute certainty escapes us and the health of our patients hangs in the balance. The Uncertainty Taxonomy of Hal identifies the source of uncertainty to be threefold: probability, ambiguity, and complexity (1). Furthermore, there are three main types of uncertainty accepted in the medical literature: technical, personal, and conceptual (2). Technical uncertainty is the most pervasive as it defines the uncertainty inherent in every clinical decision; no physician can ever truly *know* that an intervention (medical or surgical) they are recommending for a patient will actually be beneficial. They can be *confident* in the *likely* benefit of such an intervention, but it is never *guaranteed*. Personal and conceptual uncertainty are more nuanced, with their simplest definitions being uncertainty regarding a patient's autonomous preferences and uncertainty regarding the applicability of population-based clinical guidelines to an individual patient, respectively (2).

The Dual Process Theory outlines the difference between Type 1 and Type 2 reasoning. Type 1 reasoning utilizes the efficacious and efficient mental heuristics of physicians to generate

diagnostic and therapeutic plans with minimal mental effort and maximal pattern recognition. This reasoning strategy is typically used to describe the reasoning harnessed by experts within a field, like attending physicians. Type 2 reasoning is comparably much slower and methodical with much deliberation and mental effort that largely excludes heuristics. This reasoning strategy is generally attributed to trainees within a field, like medical students (3). One might expect that more uncertain and unusual clinical situations that do not fit nicely within the pre-existing heuristics of the aforementioned experts would initiate a Type 2 reasoning response. However, literature suggests that physicians nonetheless attempt to apply their cognitive biases to overcome uncertainty, leading to recency bias, anchoring bias, patterning behaviors based on prior outcomes (that would have potentially occurred regardless of the intervention that was made), emotionally weighty medical factoids/clinical memories being recalled easier, and the tendency for feared negative outcomes – despite being rare in reality – to be discussed and avoided as if they were more common (2, 3).

The Prospect Theory, on the other hand, exemplifies a cost-benefit analysis where, put simply, less severe situations require less severe interventions and more severe situations may require more severe interventions (3). This theory is supported by the tendency for physicians to order more tests when they are uncertain as they attempt to collect more data and catch their fish with a large net as it were (1, 2). Plenty of physicians cannot recognize their own uncertainty – this provides great value in the Boschetti model that classifies uncertainty as a four-quadrant spectrum on an X and Y axis of uncertain to certain and unaware to aware, respectively. The Han model then simplifies uncertainty into three descriptors: source (probability, complexity, ambiguity), issue (practical, scientific, personal), and locus (patient, family member, and/or physician). The tension created by these factors existing in competition as different "stakeholders" may also create uncertainty, which can only be managed by a cost-benefit analysis that analyzes each stakeholder perspective to determine the solution that "transcends the tensions" (4).

Even if these processes are perfected, the algorithm may be vulnerable to knowledge gaps within the patient/family or the physician that can be known or unknown. Another vulnerability is the constraint of time and how decisions can be rendered more certain within the mind if allowed more time for their consideration. Approaches that can be taken to counteract these counterweights (uncertainties) unbalancing the delicate scale of reasonable clinical decision-making are intuitive (e.g. heuristics), protocol-driven (e.g. guidelines), team-based (e.g. in a multidisciplinary healthcare team), and shared (e.g. between patient and physician) strategies. The most prudent physicians then reflect on the decisions they are currently making and have made *for* and *with* patients – even including the effects of their decisional outcome if such information is available upon later assessment – to improve their uncertain clinical choices in the future.

The present era is dominated by the value of data, the reign of scientism, and the preoccupation with all things Science, Technology, Engineering, and Mathematics (STEM). Despite this, uncertainty reigns supreme; and as a byproduct of human nature, we tend to privately shy away from the things we incompletely understand especially when there is a public expectation of expertness. The dichotomy between the "public" and "private" experiences of uncertainty by clinicians is interesting, as there appears to be a general aversion amongst physicians for disclosing their uncertainty when it arises. Perhaps it is in the personal interests of health institutions and their doctors to not "break the fourth wall," so to speak, and uphold patient trust by steadfastly appearing confident. However, reasonably so, there are many who

argue that disclosing clinical uncertainty when it arises is actually the recipe for creating more physician-patient trust. This could be an increasingly true idea, especially in American culture, with increasing numbers of patients anecdotally just wanting doctors to tell them "I don't know" when they truly do not know something. Clearly, there is a gap in formal medical education where medical students are not directly taught how to engage patients with clinical uncertainty (2, 5).

Practicality would likely conclude that though patients may be generally prudent, they are not always so in making medical decisions that they incompletely understand. An ethical model of clinical uncertainty suggests that physicians should take their best understanding of the patient's basic values and interests to promote deliberation of medical decisions that would otherwise be "nondeliberative," allowing differences between diagnostic/therapeutic pathways taken by physician-patient pairs to be minimized and less influenced by the "practice styles" of different physicians. If we place the patient in charge of deliberation and effectively delimit the physician's impact (e.g. "deprofessionalize"), then we would be nullifying the role of the position that a physician has earned. Herein lies a bottom-line that is not unique within this field of literature, which is for physicians to simply lay-out all of the "medically reasonable alternatives" *without* recommending any particular option when working with a patient to make a medically uncertain clinical decision. The primary issue with this is that it is under these circumstances that patients want their doctor to take the lead despite it being "easiest" and more "risk-free" (especially from the legal perspective) for doctors in this position to *not* take the lead (6, 7). There is debate within the literature surrounding this topic, as other authors contend that even when clinical uncertainty is high, patients do not necessarily seek clear treatment recommendations from their providers since it limits their shared decision-making (8). However, the readiness of patients to actively participate in their own healthcare with an *a priori* understanding of their uncertainty may be dependent on patients' combined health literacy, the familiarity of a given healthcare topic to the general population, and the availability/accuracy of online information about a given health matter.

Honesty should be used with patients regardless, maintaining an openness of communication that makes it clear to them that the physician is not confident there even is a diagnostic/therapeutic option that would be better than the others. The literature shows that doctors and nurses alike report the most uncertainty when encountering unfamiliar situations surrounding patient care. These situations are unfamiliar because they do not align with the heuristics they have encoded from their training and, especially for resident physicians, approaching colleagues for help is a mainstay of clinical problem-solving. There is a tendency for doctors and nurses to be hesitant about recognizing and expressing uncertainties, which may propose an argument about how human nature operates within the professional setting, with healthcare professionals being fearful of being wrong, being ridiculed by their peers, being seen as weak, and being seen as lacking some supposedly necessary sense of stoicism (9). The implicit contract of healthcare received at teaching hospitals dictates that, whether they know it or not, patients are receiving care from resident physicians – arguably more often than they are an attending physician despite the latter's general oversight. One can therefore anticipate that higher levels of uncertainty will characterize the medical decisions being made by residents, and there is a cultural tendency amongst resident physicians to save consultation of their attending physician as a "last resort" option. Undeniably, this is one of the many influences of the "hidden curriculum" in medical education that stokes an unfortunate fear of being negatively perceived (10).

Clinician uncertainty is found very strikingly in the difficulty of prognostication, and this can be problematic for patients and their family members wanting to establish care-planning or determine whether to continue life-sustaining treatment. It may be wise to perform interventions that *prepare* patients via a standardized approach to receive the clinical information they need to make a decision on. When constructing end-of-life plans, the arguably worst possible outcome is patients or families making legal decisions predicated on uncertainties and misunderstandings that go unreported on their part and uninvestigated by the physician, leading to end-of-life care enactments that may not truly be what the patient and family wants (11). Interestingly, there had been a push from the American College of Chest Physicians, American Thoracic Society, and European Society for Intensive Care Medicine to replace "futility" with "potentially inappropriate." This vocabulary transition is likely appropriate as the constant progression of our understanding of science and medicine optimistically turns what used to be futile into what can be possible. The COVID-19 Pandemic represented a state of such potent uncertainty that it serves as an excellent example of how physicians augment their problem-solving to maintain efficacy in the absence of supporting data. Such complexity within the Pandemic was exacerbated by the public assignment of moral, ethical, and sociopolitical value to decisions about COVID-19, including its prevention and treatment. Within normal levels of uncertainty (outside of situations like the COVID-19 Pandemic), the knowns are known and the unknowns are also known because of extensive research into the matter, allowing physicians to sufficiently explore the unknowns that interact with their decision-making. The reported "critical decision-making uncertainty" occurs during healthcare crises such as the COVID-19 Pandemic where knowns and unknowns are largely unknown (1, 12).

A strategy not unfamiliar to most – if not all – physicians is "hedging" on one's wording when documenting their medical decision-making. The "hedging" wording used by clinicians is *not* universal and is therefore subject to misinterpretation by all clinicians relying on accurate and precise diagnostic results and therapeutic recommendations. Some of these phrases are "suggestive of", "worrisome for", "cannot rule out", "highly suspicious for", "favor", "indefinite for," and "moderate to severe." While the degree of one's own uncertainty is difficult to standardize, a groundbreaking solution to the further uncertainty-inducing "hedging problem" in medicine may be to report a numerical value estimating a level of certainty in addition to ambitiously creating societal guidelines for wordage in diagnostic results and therapeutic recommendations nationwide (13, 14). There have nonetheless been efforts to objectively measure uncertainty for research purposes, with the Anxiety Due to Uncertainty Scale (15) and The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) (6) being two prominent examples. Interestingly, artificial intelligence (AI) has the ability to quantify its confidence – whether or not this quantification is true can be debated – whereas humans have a simple, nonnumerical "feel" of how confident they are in their diagnosis, treatment, and prognosis. Entities such as AI may be adept at measuring our uncertainty at some future point, but AI is still in the phase of being trained on data that already exists so that it may, in small leaps, extrapolate what it "knows" to novel situations in ways that are as cumulatively intelligent as the data that was fed into its creation (16).

Whether human or computer, uncertainty in the clinical setting is predicated on pre-test and post-test probabilities. When a patient presents with a chief complaint, the physician develops their own pre-test probability estimates as to what the diagnosis of the condition might be. For some conditions, the pre-test probability by a reasonable physician's history-taking and physical examination will be so high that little further diagnostic investigation is necessary. Of

course, however, there is still some uncertainty tied into a pre-test probability of nearly 1.0. There are other conditions that require more of a diagnostic work-up including laboratory testing and radiologic imaging because the "differential diagnosis," or pre-test probabilities of multiple different conditions, are high enough to deserve serious consideration. Often, physicians will order multiple different tests to investigate the multiple different conditions on their differential diagnosis. Based on the results of those tests and how sensitive/specific their results are for the diagnosis of the given condition they are connected with, the physician will be left with post-test probability estimates that will ideally lead to the correct diagnosis of the patient's condition (17). But physicians do not pull a chart out of their pocket every time a patient tells them a symptom or they receive a new test result to see what their pre-test probability was and how their post-test probability is affected by the positive or negative likelihood ratios. With enough research-based validation, there could be clinical prediction scores and risk models that could harness in tandem the entire clinical picture of a patient (including laboratory tests, radiologic imaging, etc.) to give uncertain physicians more clinical certainty (18) (**Figure 1**).

However, with more inherent research-based uncertainty comes more practical uncertainty. It is undoubtedly valuable to have a sense of the uncertainty within the data that is going to guide clinical decision-making; for example, a confidence interval for relative risk ranging from 1.5 to 90 says something much different than one ranging from 2 to 4 (19). Research serves as a more insidious cause of uncertainty when considering the evidence pyramid of research subtypes. There is a particularly obscure and underappreciated struggle with uncertainty in specialties without many comparable practices based on randomized-controlled trials (RCTs), systematic reviews, or specialty society guidelines. Clinical practices based on lesser evidence types such as cohort studies likely provide a false sense of certainty to affected decisions that, given the lack of evidence, is actually uncertain in reality (20). At a superficial level, the data presented by a RCT or meta-analysis may appear to be management-guiding; however, the design choices of the study can obscure the certainty of the results. Meta-analyses, considered the most authoritative research that can be realistically performed, is even subject to a hidden uncertainty given the potential for unpublished, null-hypothesis-accepting data to exist (21, 22). Medical specialties tend to have more clinical practices predicated on research subtypes near or at the top of the evidence pyramid compared to surgical specialties. This is understandable, since it is far more difficult to design appropriate and ethical studies (double-blinded, placebo-controlled, and randomized) for surgical interventions than medical interventions.

I now reach the purpose of this paper: there is little published literature analyzing physician approaches to uncertainty in clinical judgment and medical decision-making among physicians in surgical (compared with non-surgical) specialties. My aim is to review published literature addressing physicians' approaches to uncertainty in clinical judgment and medical decision-making, juxtapose approaches to uncertainty among physicians in surgical versus non-surgical specialties, and suggest explanations for the differences in approaches to uncertainty (or lack thereof) among physicians in surgical versus non-surgical specialties. For the sake of clarity, when discussing "surgeons" and "surgical uncertainty," I will focus on the distinctively procedural aspects of their specialty, despite their concomitant appreciable adeptness at medical management and the respectable ability of "non-surgeons" to also engage in their specialty-specific procedures.

MAIN TEXT

Operating with Surgical Uncertainty

The frequency of clinical uncertainty encountered by faculty surgeons decreases over time as they become more comfortable in their practice and exposed to the broad extent of surgical decisions they need to make on a regular basis. The same is true of non-surgeons. Therefore, the more novel situations with accompanying difficulty predicting the proper course of action and likely outcome may cause the greatest uncertainty for all surgeons, but especially the experienced surgeons that are otherwise less uncertain than others by virtue of simply "being around" longer and "seeing more." There may be anticipated complications that do not occur, and entirely unanticipated complications that completely derail the case – such as peculiar anatomies (23). Unfortunately, clinical uncertainty is a potential cause for physicians to veer into unsafe decision-making practices. The operating room can also be subjected to uncertainty-inducing influences like being on-call and having to staff new consults *while* operating. Cristancho et al., eloquently state that surgeons respond to uncertainty by "prioritizing alternatives, reevaluating and adapting the plan, creating innovative solutions, and seeking advice" (24). Non-surgeons undoubtedly wrestle with clinical uncertainty in similar ways, but the need to create innovative solutions is more uniquely surgical. Each moment that a surgeon encounters an issue that raises the requirement to respond to uncertainty, they perform a sort of risk-benefit analysis prior to performing the next intraoperative technical motion. Furthermore, it may be reasonable to argue that creative medical actions need to be performed by surgeons much quicker on average than non-surgeons. Perhaps the largest source of intra-operative uncertainty is incomplete visualization, where no amount of overhead or headlamp light can allow a surgeon to see exactly what they want. This requires surgeons to "operate by feel" where they use their sense of touch and knowledge of anatomy to assess the practicality of their next surgical maneuver.

Dealing with intra-operative uncertainty may include utilizing surgical instruments in non-routine ways to solve problems that require unique and innovative solutions. Once again, this is often not something explored by non-surgeons outside of taking advantage of ancillary medication effects to treat multiple conditions at once (e.g. bupropion for depression *and* smoking cessation or propranolol for migraine prophylaxis *and* social anxiety). Uncertainty in the surgical setting, when encountered by "good" surgeons, breeds adaptation and creativity. This requires great prudence so that an innovative action does not lead to a mistake and poor surgical outcome that would have been avoided had more standard protocols been followed – although, perhaps then the surgical outcome would have been poor anyway since the surgeon would not have had to innovate if standard protocols were working. Increasing complexity in the healthcare setting indiscriminately causes there to be more uncertainty regardless of a physician's specialty (25). However, there is something particularly surgical about not being able to "un-cut" something after it has been cut (26). For example, a total mesorectal excision (TME) cannot be downgraded to a transanal endoscopic surgery (TES) once completed (27). This highlights the difficulty of new and potentially advantageous surgical techniques becoming in vogue: uncertainty can be created when applying these new techniques to patients whose indication is equivocal and may lead to overtreatment or undertreatment based on the previous "gold standard." This identifies an important surgical concept: when uncertain about the size, depth, and distribution of a pathological entity, it may be advantageous to simply resect more to "get all of it." Or, under circumstances where "resecting more" is judged as more dangerous than

doing nothing, the patient is left with their pathological entity remaining *in situ* because of their surgeon's uncertainty. It goes without saying that developing predictive models and testing strategies to plan the span of a surgical dissection/resection will reduce operative uncertainty and put more patients on the operating table to receive the definitive management they desire and deserve (28).

Even the principle of surgical margins has a surprising degree of uncertainty. Authors have proposed that there are oncological downsides to performing a more radical resection given the release of tissue healing factors that are actually tumor facilitators, making minimalistic resections potentially better (as long as the margins are negative) (29). Even when having negative margins, though, there can be a high chance of recurrence when dealing with a cancer that has one or more surgical stay-side subfoci that were locally out-competed by the cancer that became the primary malignancy being surgically resected. Further complicating the matter is that even when there are negative margins, histologic identification of negative margins is only correct 50% of the time (29). One important coping mechanism employed by surgeons and non-surgeons alike to manage the ubiquity of these uncertainties is through the adoption of particular practice styles, as I previously introduced.

There is substantial evidence to suggest that surgeons frequently do not follow gold-standard and evidence-based procedures such as double-gloving, intraoperative cholangiography during cholecystectomy, and venous thromboprophylaxis (30). One explanation for this is that the location of a surgeon's training did not emphasize such procedures as imperative, leading to a "practice style" that excludes these protocols from the surgeon's routine heuristics. Tubbs et al. elucidate a fascinating point about how physicians may distill clinical risk-taking: they choose the option through an uncertain lens that they feel like they will regret the least (30). An intuitive method of attempting to reduce uncertainty is to order more tests to gain more information that may provide a greater sense of certainty or simply to reassure oneself that "I did everything I could in my role as this patient's physician." Indeed, it may be accurate for surgery more than for other specialties, that there is a tendency for surgeons to adhere strictly to a "tried and true" method of performing their clinical duties with an aversion to change – even if that change may improve the outcomes of their patients. The finality of their role as surgeons with the irreversibility of their actions may dictate that they find comfort in their pattern of prior actions that did not result in poor patient outcomes (31). Even if there are ways to improve the perioperative process for these surgeons via better techniques/technology, those new things are untrustworthy and need to prove themselves within surgeons' minds (32). The conundrum being, of course, that the new, potentially beneficial, but untrustworthy surgical strategy or tool may never receive the opportunity to prove itself.

Surgical specialties appear to be plagued more often than non-surgical specialties by the continuation of practices that are not evidence-based, but have persisted in the culture for long enough that they have become accepted practice and therefore dogma. One example of this is bariatric surgeons requiring strict adherence to a diet/exercise program prior to bariatric surgery even though there are no clinical trials proving such practices to be beneficial (33). Overconfidence is a potential byproduct of increasing years in practice, especially within a surgical specialty where there are often not universal, evidence-based gold standard protocols for treating different pathologies. This leads surgeons to stick with what is personally familiar and with what has the best outcome "in their hands." Some contend that the reason surgeons are so confident is that such confidence is one of the few things that allow them to operate decisively and efficiently (34). If surgeons were to pause and utilize Type 2 decision-making at every fork-

in-the-road, intraoperative and anesthesia times would significantly increase, carrying increased healthcare costs and morbidity/mortality risks for patients.

Rosenberg et al. postulate that the reason for lacking surgical RCT data is because of a lack of statistical power that may be ameliorated by forming "multicenter and even multinational research groups in order to ensure accrual of sufficient sample sizes" (35). But where did the tendency for surgical approaches to be implemented without rigorous, supportive academic research come from? Could this relate to the proposition that a certain surgical technique is only as good as the surgeon utilizing it? In other words, a surgeon might pick up the technique and note that their patients are doing suddenly much better. One can understand how motivating this would be for the surgeon to continue using this surgical approach – and for others to learn about it – despite not having the scientific backing that may come later. It is generally difficult to perform RCTs for surgical specialties given the complexity with randomizing patients who *need* surgery to either getting the surgery or not. And, in cases when blinding might be recommended or required, it is next to impossible to ethically blind a patient to whether or not they received surgery. Surgeons seem to depend largely on outcome-based cohort studies to guide their practice (36). The complexity and uncertainty that nonetheless bubbles to the surface when applying a "generally good" RCT-derived recommendation *is* complex and uncertain because the singular patient is more irreducibly complex than the cohort. Uncertainty within the medical field is constantly changing – either decreasing or increasing – as innovation either abolishes or creates sources of uncertainty. Guidelines may be buttressed with the budding development of computer models that can, for example, predict how surgeons may best reduce undue stress placed on skin flaps to reduce pathological scarring (37). Future surgeons might – in theory – utilize computers to nullify via calculation some "solved" uncertainties, which already occurs in some "Stealth" procedures.

A unique source of uncertainty within surgical fields is the extent of anatomical variability among multiple different patients with the same underlying pathology. Encountering these anatomical anomalies intraoperatively may result in complications due to a lack of knowledge of how to deal with them or due to neglecting unique considerations that they require (23). Harnessing the power of visualizing surgical uncertainty whenever possible, especially during robotic or laparoscopic surgery, likely carries huge benefit to surgeons as their perception of the uncertainty places limits on the outer bounds of what surgical maneuvers are possible. It may be advantageous for surgeons to have an understanding of what strategies have been tried before in prior surgeries, especially under uncertain circumstances, with ways to visualize safer versus more dangerous technical options based on prior outcomes (38). By repetitiously modeling the path that is frequented by surgeons performing a particular task, the uncertainty within the task can be interfaced and used by future individuals performing that same task to minimize the mistakes others have committed. This is the value of introducing computerized capabilities of visualizing technical uncertainty within surgery, allowing one to begin constructing a way to computationally visualize safe and unsafe technical decisions in the operating room (39).

Differing surgical practices may have drastic effects on patient outcomes, especially when so-called "expert opinions" of societal guidelines differ. Furthermore, an understandable frustration when encountering clinical uncertainty arises from differences found within guidelines created by different societies that, in theory, are supposed to exemplify authoritative recommendations. North American and European guidelines, for example, differ on their preferred aggression of working up and managing mesothelioma, with North Americans

appearing more comfortable with a more aggressive approach (40). But what does "expert opinion" even mean? Who grants these individuals the title of expert, and on what grounds? Academic surgeons were found to consider published data superior to expert opinion (41). There are times when published data may be subjected to the opinions of the reader when determining whether to apply the results to their clinical practice, particularly when data contradicts a surgeon's "practice style" that their hands have become accustomed to. LaMartina et al. published a compelling paper that analyzes the outcomes of actual patient cases relative to the degree of agreement amongst multiple different surgeons (42). They found that a greater agreement amongst multiple shoulder surgeons about the best course of action leads to better outcomes and vice versa. This may reflect the degree of complexity of the surgical situation at hand, as it makes sense that the most uncertain of surgical circumstances would be a matter of debate for shoulder specialists whereas less notably uncertain surgical circumstances have a surgical option that is superior.

One way to reduce the height of the surgical uncertainty hurdle is to incorporate uncertainty tolerance training into undergraduate and graduate medical education. General surgery residents have a greater intolerance of uncertainty (measured by Physician Reaction to Uncertainty and Physician Risk Attitude scales) when having a Myers-Briggs Type Indicator personality factor assessment including "Judging." In the same paper, it was discussed that the Yale General Surgery Residency Program found their senior residents to have equivalent levels of uncertainty intolerance as their junior resident counterparts (43). One might hope that senior residents would become more tolerant of uncertainty as they achieve more experience and responsibilities; however, perhaps their acquisition of more responsibilities as they overcome the deficits they had as junior residents simply causes new uncertainty to take the place of old uncertainty. The persistence of uncertainty continues onward to plague attending physicians as well, with studies using the Physician Reaction to Uncertainty Scale suggesting that acute care surgeons do not have any more or less uncertainty dependent on gender, experience, or age. However, more experienced acute care surgeons were more reluctant to disclose their uncertainty to patients and be less worried about outcomes for their patients (44).

"Serious illness conversations" advance patients' understanding of their complex and inherently uncertain medical/surgical situation in addition to providing physicians an opportunity to exercise their skill of placing diagnoses and treatments into the perspective of uncertainty. Surgeons should initiate these serious illness conversations, even if such serious illness has not occurred yet, to prepare patients for what could happen during a surgical intervention as part of the informed consent process. Importantly, surgeons are appreciated to be in an ethically complicated position to remain inwardly and outwardly confident in the face of uncertainty because patients may not be pleased seeing a physician who wants to non-confidently operate on them (45). Surgeons are often hesitant to intervene on patients that have uncertain diagnoses and prognoses, suggesting that certainty about the likely outcome of surgery is an important consideration that surgeons make prior to consenting patients for surgery. Similar to but more extreme than medical specialists, surgeons place the "burden of proof" on patients and their pathologies to prove that they need surgery rather than performing "not unreasonable" empiric interventions that can be halted if needed. On the other hand, authors also argue that surgeons often operate binarily with patients; that is, the surgeon does much internal processing to decide whether they want to offer this patient surgery (sometimes even deciding before beginning their interview of the patient), spending their visit either explaining why or why not surgery is the best option for them (34).

Intraoperative adverse events (IAEs) are transient moments of intensely heightened intraoperative uncertainty that alter how a surgical team coordinates itself. Poor surgical teamwork leads to a 5x higher rate of IAEs (46). Inexplicably, however, there does not seem to be a common thread underpinning what *exactly* "good teamwork" in surgery consists of, which is likely due to the singularity of each intraoperative personality. This is another likely unique source of uncertainty for surgeons compared to non-surgeons. The differing personalities in the operating room can lead to support staff and even medical trainees to be unfortunately unsure of their intraoperative role and how those roles change when met with intraoperative uncertainty – which is a predictor of IAEs. There is also a significant decrease in leadership activity by non-surgeons during IAEs, probably to allow the surgeon leaders to coordinate correction of the IAE. Because of the irreducible complexity and consequent uncertainty of medicine in general, abolishing easy-to-solve sources of uncertainty should take precedence. This includes closed-loop communication, setting clear expectations, and clarifying team roles. When confronted with overwhelming uncertainty, the least a good physician can do is take control of the uncertainty that is controllable despite still being at the mercy of the remaining, omnipresent uncertainty. One certainty is that both surgeons and non-surgeons encounter sources of uncertainty that are simultaneously similar and different (**Table 1**).

Rounding with Non-Surgical Uncertainty

The enigmatic process of medical decision making can be deconstructed into the two stages of (1) technical diagnostic/therapeutic theorizing and (2) practical diagnostic/therapeutic selection. This deceptively simple "two step" algorithm is influenced by almost limitless factors including what is medically available/feasible, patient preferences, and physician biases. The Wennberg Hypothesis argues that the uncertainty inherent to medicine may be a major cause of physicians adopting subjective "styles" of practice that function as somewhat reliable decision-making "safe zones" (47). Medical decision-making can be viewed as a cumulative byproduct of repetitious pattern-recognition where the certainty in an intervention is born out of prior encounters with a clinical problem that has been consistently solved with the same algorithmic actions. Physicians may strictly or loosely adhere to the heuristics they have developed when more novel clinical situations present themselves, perhaps partially based on their own comfort with uncertainty when a need may arise to veer away from the treatment algorithm their own pattern-recognition and problem-solving has devised (48). This technique is not unique to non-surgeons, as discussed above, but a notable difference between non-surgical and surgical uncertainty is that non-surgeons can stop medical interventions if they turn out to not work or not be tolerated by patients. The advantage for non-surgeons managing medical uncertainty is that the majority of their interventions are pharmacological and can be stopped at any time, usually (but not always) with reversal of undesirable side effects. Practice styles affect medication choices because there are some providers that, when faced with medical uncertainty, trailblaze into the cutting edge of research and provide guidance based on whatever the newest/most reliable evidence recommends. Other providers, however, have a more cautious approach and wait until both short-term trials and longitudinal studies are published to better inform the recommendations they make to patients. In the meantime, then, those more cautious providers may be either (1) presenting all the options to their patients without a formal recommendation, (2) presenting all the options to their patients with a subjective recommendation, or (3) occupying a position of complete inaction which may result in harm for their patients (49, 50).

Some patients prefer to be given all of the options available to them in the presence of clinical uncertainty, but there are other patients that may carry greater guilt if making a medical decision when only given all of their options without a formal recommendation from their physician (51, 52). We may find a self-protective security in offering all of the options but refusing to offer our opinion when our clinical judgment tells us that all of the options are equivocal. We hope that if our patient makes their decision for themselves, we will be "safe" because we provided our patient with their options and *they* made their own decision. The burden of responsibility is relinquished from our minds but, unfortunately, it is then placed onto the patient. It is also common that greater certainty for many patients will come from appreciation of the various stories from patients that have embarked on journeys similar to theirs. Patients may ask the classic and occasionally feared question, "what would you do if I was your family member?" We fear this question because we know that the decision is almost too uncertain to make. For some reason, however, it seems like we are simultaneously too afraid to articulate that point. Are we stuck between the rock of uncertainty and the hard point of wanting to uphold the idealistic societal view of medicine? There is a perfectionistic pressure placed upon physicians by patients. A doctor who cannot solve a problem may be said to be a bad doctor, even if that problem is not solvable even by the best doctor. And even if a confident physician makes an exceedingly *certain* diagnostic or therapeutic choice, she simply enters a game of probability. Will this patient be the "1" of the "1 in 10" number needed to treat? Or will this patient be the "1" of the "1 in 20" number needed to harm? Our sometimes seemingly dichotomous responsibility to uphold the principles of beneficence and nonmaleficence may arguably only be rectified by informed consent. This, alongside the ever-protective nature of compassionate bedside manner, appears to be the highway toward patient satisfaction even if probabilistic and unintentional medical/surgical failure happens along the way (53).

A common example of these complexities manifesting themselves in non-surgical uncertainty is the question of anticoagulating patients for the preventive treatment of stroke in the setting of atrial fibrillation within the subpopulation who have experienced bleeding diatheses. The main themes guiding these shared decisions according to Ivany et al. are "computing the risks," considering "patient factors," and actually "making a decision" (54). Regarding risk computation, physicians reported using "reliance on existing knowledge, personal clinical experience, and awareness of patients' comorbidities and clinical risks of stroke." Regarding consideration of patient factors, physicians ranged from contemplating the cause of intracerebral hemorrhage, level of disability after intracerebral hemorrhage, age, and number of comorbidities. The process of "making a decision" with patients is complicated by their misconceptions about therapies such as warfarin simply being "rat poison," experiences their family members have had with a certain drug, or even lifestyle details such as outdoor activities that may make death more likely with a bleeding diathesis. The surveyed physicians felt more comfortable advising their patients whether or not to be anticoagulated for stroke prevention in the setting of atrial fibrillation if the decision was made with multidisciplinary physician colleagues – a strategy that increases the amount of contemplation of a medical problem through parallelization and diffuses responsibility for the patient's clinical outcome (54).

Combining population health statistics and patients' values into a modern, potentially artificial intelligence-powered computer program could create the opportunity to make the "best" treatment choice for physician-patient pairs. Population health statistics will still likely lie at the core of making recommendations for individual patients since the data shows that if we perform a certain intervention on enough patients, we will improve outcomes. Robinson and Thompson

cite a helpful definition of this informed consent and shared decision-making process: "An informed decision is one where a reasoned choice is made by a reasonable individual, using relevant information about the advantages and disadvantages of all possible courses of action, in accord with the individual's beliefs" (55). Of course, there will always be patients that may become overwhelmed and confused at how much information a physician may have to provide about starting a medication like warfarin. However, there are multiple strategies prudent physicians may use when broaching the subject. They can draw things out on a piece of paper to provide more clarity and a long-lasting reminder of the discussion had during the visit. They could offer for patients to record the informed consent/shared decision-making conversation so that they could revisit the information later, in the comfort of their own home, and as frequently as they desire. And, of course, we should never pressure patients to make effectively non-urgent decisions during a single appointment. There is immense difficulty and thus uncertainty in applying study data – which is inherently epidemiological and population-based – to individual patients. Furthermore, it is impossible to ever be sure of the patient's complete context, values, expectations, worries, and lifestyle that might help eliminate uncertainty. Importantly, and interestingly, doctors appear to "recommend treatment in cases of medical uncertainty," but "patients have been shown to prefer watchful waiting over treatment when faced with medical uncertainty" (49). More thought should be devoted to why this is. Are doctors more death averse than patients? This might make sense given all of the medical training that goes into holding off the "enemy" of death for as long as possible. Are patients blissfully ignorant of their likelihood of poor health outcomes if treatment is not pursued? For example, even if a myocardial infarction does not result in death, it might cause debilitating heart failure or arrhythmia.

Although non-surgeons can stop some medications if they have undue side effects for patients, other medications may have lasting side effects or quickly induce a dire state of health that cannot be undone – similar to surgery. Intensive chemotherapy for acute myelogenous leukemia gives the highest chance of cure while also carrying a high chance of premature death (56). These nuances to non-surgical care should be conveyed to patients, highlighting the importance of and power in our choice of words when communicating clinical uncertainty to patients. Rather than saying that drugs are "effective and safe during pregnancy," we can say that those same medications are "low risk" to confer our admission that nothing is without risk. Telling pregnant patients that their medical decisions during pregnancy are colloquially "safe" can be an over-simplification that distorts the truth (57). The decision of taking a medication regardless of how "safe" or "low risk" it is, however, nevertheless requires risk-benefit analysis which is evidently an underpinning theme of how physicians and patients alike approach medical uncertainty. In a sea of things we do not know, there may be immense confidence derived from returning to the small raft of things we *do* know. Let us say a patient presents with "XYZ" that we are unsure of how to diagnose or manage. There may be a guideline recommending diagnosis/management of the "Y" component, but not "XYZ" specifically. If we lean into what we confidently know, we may make objectively better clinical decisions by, say, treating "XYZ" with the "Y" guideline (perhaps with some reasonable adjustments) rather than making up our own "ABC" strategy (58).

Non-surgical specialties have a greater preponderance of clinical evidence near the top of the evidence pyramid given the greater ease of randomizing, double-blinding, and placebo-controlling clinical trials predicated upon medical interventions. Nonetheless, questions remain about who defines a non-surgeon expert and on what grounds. Multiple Sclerosis (MS) is an unfortunately fertile ground for clinical uncertainty as there are multiple treatment options that

are largely selected based on side effect/comorbidity combinations with treatment intensification based on already manifested progression of disease. MS experts have no way of predicting which patients are adequately treated and will not progress (or take longer to progress) than others, and these "experts" differ widely in how they come to their clinical decisions – some relying on their prior experience, some using risk stratification tools, and others using both (59). One may be able to boil down these effectively black box decision-making circumstances into "expected utility theory," which is essentially risk-benefit analysis. Saposnik et al. suggest that these uncertain circumstances are under the influence of two factors: neuroeconomics ("the science that studies the principles of how we make decisions") and therapeutic inertia ("the lack of treatment initiation or intensification in patients not at goals of care"), both of which may involve "cognitive distortions (e.g., overconfidence, tolerance to risk and ambiguity, etc.) that may lead to suboptimal decisions (e.g., therapeutic inertia)" (59). This problem of "therapeutic inertia" likely exists far more potently in the fields of those managing conditions like Multiple Sclerosis where there is no singular gold-standard treatment, and where new treatments are constantly being reported. How can one reasonably expect to see patients all day utilizing a certain paradigm, spend all night reading the literature about a new paradigm, and then institute that new paradigm the next day?

An impressive amount of non-surgical uncertainty is caused by an act performed by surgeons and non-surgeons alike: prognostication. Prognostic uncertainty is certainly one of the most difficult and complicated challenges faced by doctors staffing the intensive care unit. Therein, the dichotomy of allowing the patient an honorable, peaceful, and pain-free death versus attempting all the life-saving efforts modern medicine allows – despite an appreciable likelihood for the patient to enter a life state that would be unacceptable to them – is deeply contemplated. One might consider these considerations an attempt at reaching "practical certainty" in the face of palpably real clinical uncertainty. "Practical certainty" might be achieved through a combinatorial use of severity-of-illness scoring systems, agreement amongst fellow physicians (despite much proven disagreement about the prognosis of hypothetical patients, and ICU doctors being more likely to anticipate a much worse prognosis than reality for the "sickest" patients), and facilitating family conferences (60). Internal Medicine physicians have been shown to inaccurately prognosticate for two different heart failure patients, with lifespan estimates being well-off from a recently published computer model (61). Notably, this model (Seattle Heart Failure Model) is based on literature- and guideline-based criteria, raising the question of why so much of current physician prognostication is predicated simply on a sort of gestalt instinct of how sick or frail a patient is. Yet another source of prognostic uncertainty is the lack of formal medical education regarding cultural diversity. One might consider this as part of the "hidden curriculum," but a medical student, resident physician, or faculty physician may nevertheless encounter a patient who is part of an unfamiliar culture. This may lead to culturally inappropriate recommendations being made at the end of life since, for some cultures, withdrawing or continuing care may not even be an option.

Some prognostic uncertainty may be thwarted by attempts at reasonably standardizing the care of applicable populations, such as neonates, where the perception of medical futility is less prevalent. One must consider that neonates can indeed suffer as a result of our newfound medical ability to prolong life in arguably inappropriate manners when a prolonged life also prolongs suffering (62). It is easy to agree with the contention that under circumstances where a clear path for therapeutic benefit or therapeutic futility lies, a physician should firmly recommend action or inaction as being in the best interest of the patient. This may be at-odds with the desires of legal

decision-makers, but physicians must uphold their moral and ethical obligation as circumstances change when the therapeutic outcome (benefit or futility) is uncertain. Hess' Ethic of Engagement argues that these scenarios are adept for deep engagement between the physician (whose thinking in this scenario is likely, but arguably, driven primarily by science) and the patient/family (whose thinking in this scenario is driven primarily by their knowledge of self) (50). Ideally, this strategy develops a solution to uncertainty by having a joint resolution (action or inaction) fall out of the "engagement" conversation. A unique source of clinical uncertainty is found outside of the confines of the hospital when medicine is performed during home-based primary care and a proper engagement conversation cannot be performed. There is no laboratory at home, patients are often cognitively impaired, and there is no electronic medical record. Home-based primary care physicians find novel factors to consider under these atypical circumstances to guide their choice of prescribing antibiotics: "including those that promoted prescribing (desire to avoid hospitalization, pressure from caregivers, unreliable plans for follow-up) and those that inhibited prescribing (perceptions of antibiotic-associated harms, willingness to trial non-pharmacological interventions first, presence of caregivers who were trusted by clinicians to monitor symptoms)" (63). Uncertainty is a nuanced entity that can appear microscopic or enormous depending on the extent to which it is examined. Its invisible universality requires surgeons and non-surgeons to overcome uncertainty in ways that make becoming accustomed to its influence a necessary part of medical education (**Table 2**).

Suturing Surgical and Non-surgical Uncertainty Together

I have discussed how multidisciplinary collaboration may lead to diagnostic and therapeutic conclusions given the value of having multiple minds from various specialty disciplines (each having their own potentially counter-weighing biases) weigh-in. There is often a necessity of veering away from typical guidelines/management pathways when atypical cases present themselves which can be aided through multidisciplinary collaboration, combining the forces and expertise surgeons and non-surgeons. I have also analyzed how there seems to be a trend within doctoring as a whole to be much broader in the diagnostic and therapeutic approach when uncertainty is prevalent. In surgery, this may involve "cutting out more," and, in medicine, this may involve empirically covering for a broader array of pathogens with antibiotic treatment prior to receiving culture results (64). To reiterate another important point, efficacious patient education – especially prior to invasive surgical interventions that cannot simply be discontinued or reversed like most medical interventions – is exceptionally important for reducing patient uncertainty (65). Surgery in general may be more uncertainty-inducing for patients than non-surgical, medical interventions. Logically, patients experience increasing levels of uncertainty as invasive medical interventions such as surgery draw near. This uncertainty tapers, however, as patients recover postoperatively and escape surgical complications (66). Using surgical oncology as an example, one can imagine the anxiety a patient feels subjecting themselves to irreversible surgical changes with no surefire way of knowing if their cancer will be cured (67). Preoperative appointments should be buttressed with validated systems such as online pre-learning for patients to study and contemplate so that they may have an improved literacy of what they are consenting to (65).

Surgeons and non-surgeons should properly conduct informed consent and shared decision-making by providing estimated likelihoods of common and life-threatening adverse events. Like I have previously discussed, the ability for physicians to prognosticate is quite

underwhelming and is affected by availability heuristics, self-serving bias, and confirmation bias (68). Even if a statistical model was derived to predict a more objective adverse event rate for a particular patient, that prediction is surgically uncertain given that the statistical model does not necessarily know attributes of the surgeon and operating room staff, and cannot account for the limitless other small butterfly effects influencing the patient's outcome. The question remains whether surgeons and non-surgeons should openly disclose their uncertainty to patients, especially because some patients prefer physicians to disclose their uncertainty while other patients view it as a marker of incompetence (69). Priming patients with nuanced information that may be discussed during their visit can allow them to better "speak the language" of their physician in addition to allowing them time to think of the right questions to ask and consider beforehand so that they do not rashly and regretfully consent themselves to surgery (70). There is likely an aspect of clinical uncertainty we can thwart by bolstering the quality of our informed consent conversations with patients. However, physicians often cannot be sure that a patient deeply understands the medical information being communicated to them even with the "teach-back method" (71). The power of patients having strong social networks when encountering medical uncertainty has been underscored in the literature (72), but uncertainty remains in the patient's ability to reason through uncertainty even if the scientific data available to them is certain. Patients may make decisions that are predicated on hope, and the question becomes whether such a decision-making state of mind is one that can participate in informed consent with the complete competency that physicians seek. Overall, data may be interpreted differently between patients and physicians (73).

There is an argument to be made regarding the value of physicians first assessing which decision style their patient prefers (taking a strong leading role, being an active co-participant, following whatever their doctor advises, or anywhere else along this spectrum) prior to approaching with a style of sharing information that is individualized for their patient. Being older or sicker may predispose patients to take on a more passive decision-making role, but medical decisions whose outcomes carry heavy consequences tend to motivate patients to be more of an active participant. This may prove to be an important difference in the way that surgeons versus non-surgeons encounter patients where one may posit that patients view surgery as carrying heavier consequences than starting most medications. The role patients want to take in the shared-decision making process has multifactorial influences such as previous experiences with healthcare, health literacy, values, personality, perspective(s) of trusted loved ones, and so forth (74). Medical oncology carries the unique challenge of needing to combine population-based, statistical evidence with personalized medicine so that therapeutic strategies can be effective for a singular patient after it has been proven to be safe and effective for a cohort of patients (75). Another unique oncologic consideration is the high amount of toxicity and symptomatology of their therapies that may not carry an exceptional survival benefit. Therefore, the uncertainty of physicians in this situation is multiplied by the uncertainty of patients deciding if an extra year of life with an uncurable cancer is worth the side effects of their treatment. Surgeons and non-surgeons exacerbate these complexities through inconsistent adherence to remaining abreast of cutting-edge research and varying abilities to explain medical concepts to patients with different levels of health literacy (4).

The literature suggests that when there is too much uncertainty surrounding a treatment, even if that treatment has been ultimately shown to be superior to placebo or a previous gold standard, patients may exhibit "ambiguity aversion" and forego a treatment that may be beneficial for them out of fear of being unable to conceptualize the associated risk. This is an

appropriate time to pose the question of the acceptability of persuading patients. A difficult conundrum exists for physicians where some patients may abhor healthcare uncertainty because it: exposes their own overestimation of how many problems medicine truly has a "solution" for, disappoints them as they feel like they are "paying the big bucks" for nothing, and paralyzes them in the sense that there is no clear best therapeutic option for something like their cancer care. Conversely, other patients might be grateful for medical uncertainty because the glass appears half full to them – rather than half empty – and they interpret the lack of certainty as reassurance that they may indeed "make it" despite their terminal diagnosis. Either way, this chasm needs to be bridged through objective and validated, yet personalized patient education initiatives alongside improved uncertainty training for physicians (75, 76). Ethical complications quickly arise when the patient is a child and the consenters are parents, especially as it pertains to the surgical versus non-surgical treatment of disorders of sexual development (DSD) where there is a lack of evidence as to the superiority of surgical versus nonsurgical management of DSD (77). Clinical uncertainty can then be leveraged as a means of persuading parents of children with DSD to choose the course of action for their children that the physician most agrees with; conversely, parents may demand surgical correction even if the physician is presenting the equivocal evidence.

Surgeons can further contribute to reducing uncertainty within their patients by providing them expectations of when they will have uncertainty and what kinds of uncertainty they will experience (78, 79). For example, patients/family members will commonly ask how long the surgery will take. Surgeons will likely respond with the intraoperative time, not noting that it will be *longer* until the family and the patient can be reunited – which is often what the patients/family members are asking. Non-surgeons may encourage patients to undergo routine screening procedures and other preventative interventions without a complete understanding of what may lie ahead should the results of their screening procedure lead to the diagnosis of malignancy (80). A prudent physician should assess for how uncertain patients might be following the results of these screening procedures and, most importantly, if a patient would even want to know or intervene if they had a diagnosis like lung cancer. The ADAPT framework is a program that works to help medical trainees learn how to "assess the patient's knowledge, disclose uncertainty directly, acknowledge patient emotions, plan next steps, and temper expectations" so that uncertainty can be disclosed safely to patients without risking harm to the therapeutic relationship (81). There may be a positive correlation between the confidence a provider has in addressing uncertainty with patients and the subjective interpretation of that uncertainty expression. This may be because simply imbuing the act of uncertainty disclosure with confidence makes patients interpret it better. As one might expect, physicians who are more anxious about their clinical uncertainty are also more fearful of sharing those feelings with patients (82). One important bottom-line is that uncertain clinicians do not provide worse care (83).

Physicians with lower tolerances of uncertainty will be less comfortable and satisfied following an uncertain clinical situation (84). Therefore, it is apparent that the magnitude and types of uncertainty commonly experienced by different specialties may influence the specialty that medical school graduates choose to pursue. In other words, the personalities of medical students may lead them to select a surgical versus non-surgical residency. When surgeons are compared to non-surgeons, surgeons are more extroverted and less neurotic (85). McCulloch et al. corroborate our prior discussions that surgeons prefer to use their "spontaneous clinical judgment" over RCTs which is corroborated by the fact that "treatments in general surgery are

half as likely to be based on RCT evidence as treatments in internal medicine" (85). Other authors have asserted that surgeons have a unique level of confidence relative to non-surgeons which, combined with surgical stoicism, allows them to better manage the higher degree of uncertainty they experience. Clinical uncertainty can result in variations of care provided to the same patient by different providers simply based on the subjective experience of that uncertainty. While this may be understandable in the surgical setting since different surgeons may have different technical strengths/weakness affecting their surgical recommendations, there seems to be less room for rationalizing these discrepancies in the world of general practitioners and medical specialists (86). Yet another more esoteric form of uncertainty exists among surgeon and non-surgeon trainees: the uncertainty caused by one being relatively confident that a medical or surgical decision is likely appropriate, but being unsure of whether one's medical or surgical superior will approve of that decision. There are many times in medicine, especially as a trainee, where there are multiple objectively correct ways to diagnose or treat a pathology; however, there is often one singular *preference* of the senior resident, fellow, or attending. What is perhaps even more unfortunate is the tendency for junior trainees to sometimes avoid involving the senior members of their team until they are truly stumped or the patient's condition has deteriorated further – which could have been avoided.

A single physician can be affected by multiple uncertainties at any one time. Any one of these uncertainties, or all of them, can lead to a poorer clinical performance and patient satisfaction (87). I have already discussed how clinical uncertainty often leads physicians to "do more" for patients, which can be viewed as a double-edged sword: on one edge, the patient is getting thoroughly worked up so that a diagnostic/therapeutic plan can be made; on the other edge, the patient is potentially paying higher healthcare costs and accumulating the risk of unnecessary procedures/tests (88). There may be opportunity for the Clinical Decision Support Systems of hospitals to intervene with physician order delimiters or appropriateness criteria when these "cures" for uncertainty (e.g. casting the widest diagnostic/therapeutic net possible) begin to be enacted by physicians. Ordering more to diagnose and treat better, as it were, will undoubtedly lead to the discovery of more "incidentalomas" (89). Patients, knowing they have one of these "incidentalomas," then have to live with the resultant uncertainty until they receive a potentially unnecessary subsequent workup. A common strategy employed by uncertain surgeons and non-surgeons is calling the radiology reading room to further discuss complicated cases. Given the aforementioned degree of uncertainty in pathology results with "hedging" wordage, there is a similar protective tendency for non-pathologists to discuss pathology results with the pathologists directly because of how significantly the results can guide next steps in management (90). Pathologists and radiologists should consider developing a standardized, universal way of quantifying and qualifying the uncertainty in their reports.

Providers may deem societal guidelines to be uncertainty-reducers in the sense that they give a widely agreed upon, potential "gold standard" of care to follow (91). Medicine's reliance on population-based evidence to derive these guidelines is made more inaccurate by the likely extensive amount of people with the disease in question who are asymptomatic or simply never interact with the healthcare system (92). Even with guidelines or RCTs dictating certain clinical decisions, a prudent physician must still battle with the uncertainty of determining whether the external validity of the underlying studies applies to their singular patient. It is quite easy to slip into agreeing with mediocre research that supports what we already experientially believe to be true, but this confirmation bias serves as a foe standing between all physicians, surgeon or non-surgeon, and a greater sense of objective certainty (93). Similarly, to revisit the concept of

"practice styles," there is a certain predisposition burned into the minds of medical and surgical faculty to perpetuate the teachings they learned wherever they trained, even if that contradicts the newest guidelines (4). There may be moments where maintaining these predispositions are advantageous, while other moments may prove these predispositions to be disadvantageous to patients. The question, of course, lies in when surgeons and non-surgeons should "trust their gut" or follow the guidelines (**Figure 2**).

CONCLUSIONS

It should be the goal of the reasonable physician to make the best clinical decisions possible for their patients, which may be accomplished by employing evidence-based diagnosis/treatment, being mindful of the patients' values/goals/expectations, and utilizing those patient values/goals/expectations to help them occupy the role in clinical decision-making that is most agreeable to them – and can be reasonably enacted. The requirement of clinicians to have "cognitive and communicative capacity" to "engage in collaborative decision making," which includes "knowledge of the patients' context and perceptions of the patient" makes this endeavor arguably more difficult for surgeons (94). Some may contend that surgery is the specialty with the least continuity of care; patients present with a problem needing fixing, surgeons fix that problem, and the patients *maybe* have one surgical follow-up appointment. Surgeons therefore have to know their patients as well as their respective context and perceptions very quickly (e.g. within perhaps one appointment) and probably incompletely relative to non-surgeons, where managing medical problems is usually more chronic in nature. Unlike medical management, ongoing conversation about the uncertainty of surgical management often does not occur post-surgically because the "damage has been done," so to speak – although hopefully the damage was helpful. The likely truths presented here to explain why doctors may be hesitant to communicate their uncertainty with patients (i.e. displaying confidence to gain trust, fearing that the complexity is too much for the patient to understand, resorting to a paternalistic defense mechanism) are furthered by considering the tendency for different physician specialties to address clinical uncertainty in different ways according to how their specialty might prefer to approach problems, simply on the basis of familiarity.

There is an unfortunately irreducible nature to clinical uncertainty that carries varying weights depending on the specific circumstance that the uncertainty is impacting. Under dire circumstances, like a new cancer diagnosis with a guarded prognosis, the weight of uncertainty upon patients is undoubtedly immense. Providers must exhibit role flexibility to easily transition between roles of objective information provision to subjective emotional support according to the needs of the patient. The assessment of patients' needs is accomplished by therapeutic communication and active listening. However, even when these strategies are perfectly executed, patients may still have decisional conflict that can negatively affect their quality of life and satisfaction with care. To optimally encounter each patient, a physician must become a clean slate and recursively restart, prior to each patient visit, the process of (1) knowing what background information to give a patient and how to deliver it, (2) assessing how that patient might most prefer to receive and interact with the information, (3) engaging in therapeutic communication and active listening to shift roles between information provision and emotional support, and (4) leading the discussion while also letting the patient be in control of therapeutic decision-making – to the extent that they wish to be (95). Rather than avoiding uncertainty as something undesirable, there is likely benefit in embracing it as a necessity that is ubiquitous and

can be better managed by encountering it more often. There is a principal importance of practicing the cyclical approach to clinical uncertainty like exercising a muscle (96), and the universality of uncertainty is contrasted by the day-to-day similarities and differences between physicians practicing medical specialties and surgical specialties.

FIGURES

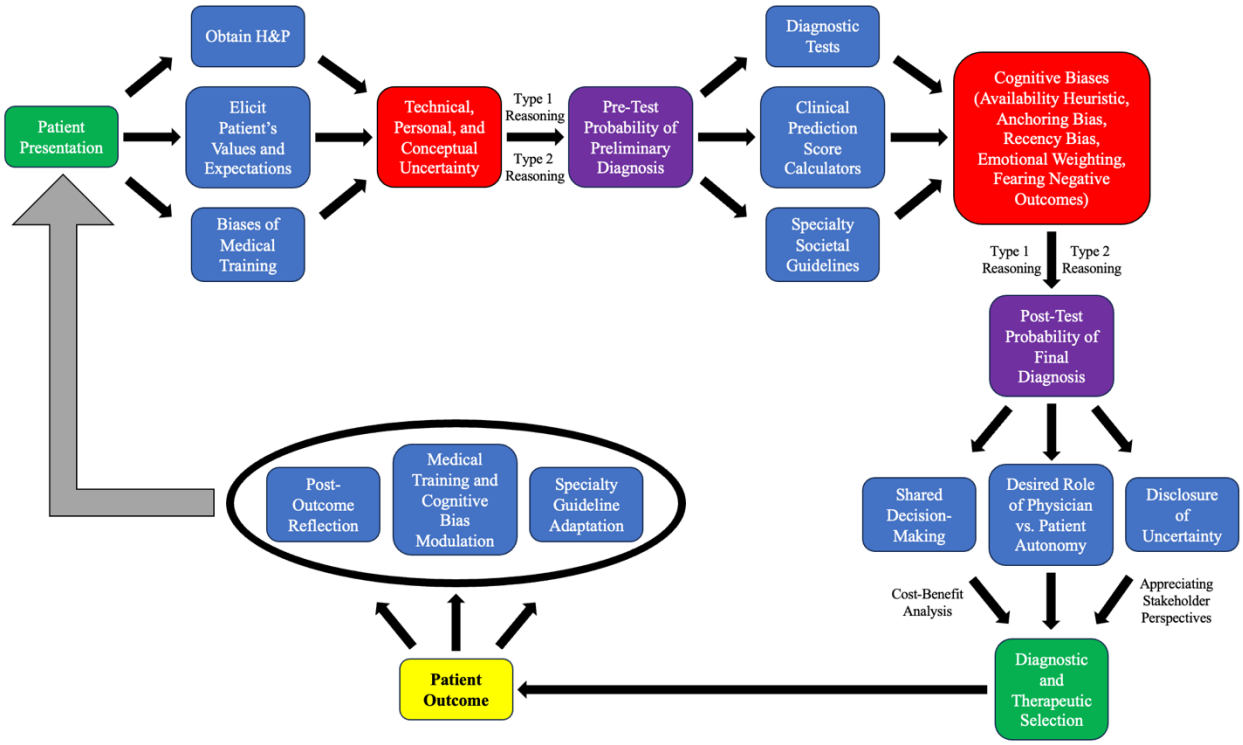

Figure 1. The basic workflow of diagnostic and therapeutic selection under the effect of omnipresent clinical uncertainty. H&P: history and physical examination.

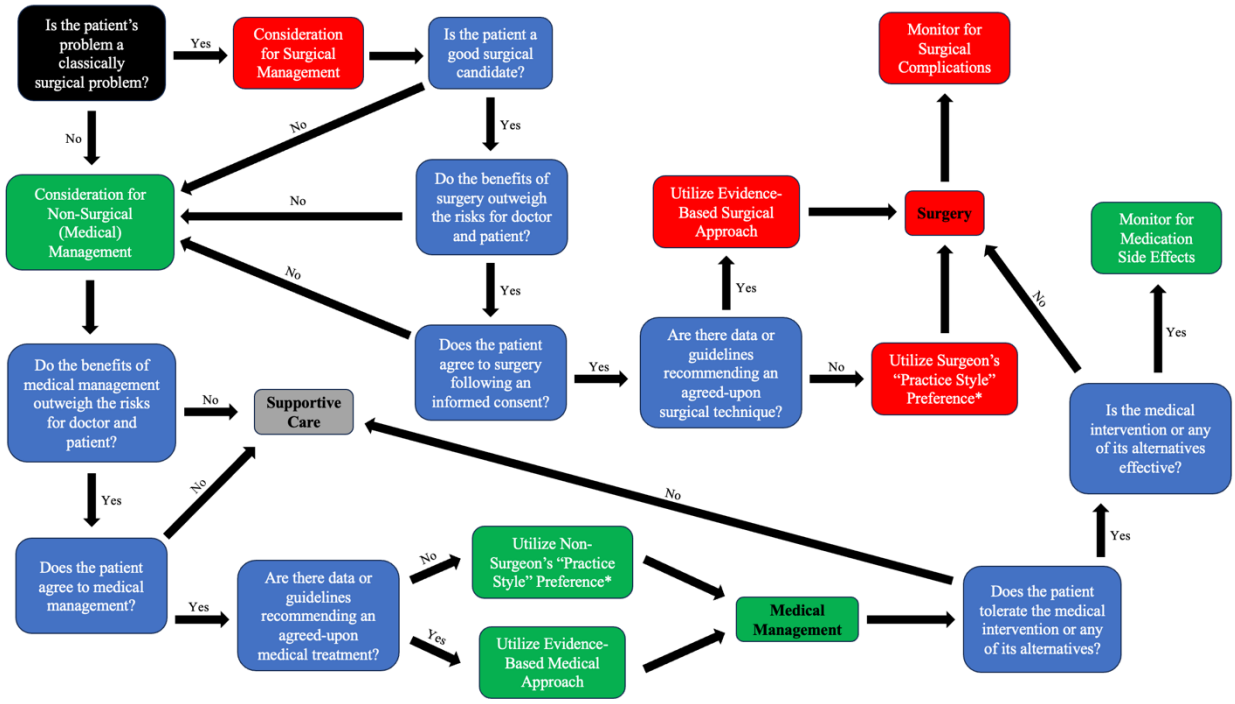

Figure 2. Uncertainty exists within every branch of the connected surgical and non-surgical decision trees. *As long as this "practice style" preference was discussed with and approved by the patient during informed consent/shared decision-making.

TABLES

Table 1. Comparing and contrasting the sources of uncertainty for surgeons and non-surgeons.*

Uncertainty Category	Surgeons	Non-Surgeons
General and Systemic[1]	Hedging in reports; overconfidence with experience; knowledge gaps in novel intra-operative situations; can never be entirely sure of anything; hospital-wide uncertainties (e.g. COVID-19 Pandemic)	Hedging in reports; overconfidence with experience; applying guidelines to atypical cases; can never be entirely sure of anything; hospital-wide uncertainties (e.g. COVID-19 Pandemic)
Evidence and Guidelines[3]	Reliance on lower-evidence studies (e.g. cohort studies over RCTs due to ethical challenges in surgical trials); differing societal guidelines; lack of truly universal protocols	Higher reliance on top-of-evidence-pyramid data (e.g. RCTs for medical interventions); but challenges in external validity to singular patients; therapeutic inertia
Anatomical and Pathological Variability[3]	High anatomical variability among patients; uncertainty in surgical margins (e.g. risks of positive margins,	Struggles with applying population-based data to individual patients with comorbidities (e.g.

	recurrence even with negative margins); equivocal indications for new techniques leading to over/undertreatment	anticoagulation in atrial fibrillation with bleeding history); few pathological entities can be considered/treated in isolation
Intra-operative and Procedural[2]	Incomplete visualization requiring "operating by feel"; unanticipated complications exacerbated by intra-operative time pressures; on-call distractions while operating; irreversibility of actions (e.g. cannot "un-cut" after resection)	Broad differentials that may or may not require procedures (e.g. headache potentially indicating lumbar puncture); inability to fully reverse some interventions (e.g. chemotherapy side effects); variable ability to practice procedural skills
Prognostication and Outcomes[1]	Difficulty predicting outcomes (e.g. futility in surgical intervention, positive cancer margins and “subfoci” risks); cultural differences in care	Difficulty predicting outcomes (e.g. futility and withdrawing care, heart failure lifespan estimates); cultural differences in care
Patient-Related[2]	Patient readiness for surgery; uncertain diagnoses and prognoses leading to hesitation in intervening; patient/family misconceptions in serious illness	Patient preferences, health literacy, and misconceptions (e.g., warfarin as "rat poison"); lifestyle factors; incidentalomas from over-testing

*There is a low[1], medium[2], or high[3] degree of difference in the extent that uncertainty is felt by surgeons versus non-surgeons in the presented categories, as delineated by the respective superscripts.

Table 2. Strategies for uncertainty reduction employed by surgeons and non-surgeons.*

Uncertainty Category	Surgeons	Non-Surgeons
General and Systemic	**Consulting pathologists and radiologists for results; seeking advice from colleagues with multidisciplinary collaboration; improving team communication** (e.g., closed-loop, clear roles during IAEs); reluctance to disclose uncertainty (especially experienced surgeons); **embracing adaptation/creativity;**	**Type 1 (heuristic) or Type 2 (deliberative) reasoning; risk-benefit analysis** (e.g., "computing risks" for anticoagulation); **watchful waiting; stopping reversible interventions** (e.g., medications); **consulting pathologists/radiologists for results**; disclosing uncertainty variably; **reflection on decisions**; using "practical certainty"; **avoiding therapeutic inertia**

	uncertainty tolerance training	
Evidence and Guidelines	**Using predictive models, computer visualizations, or repositories of past surgeries for safe/unsafe maneuvers; following societal guidelines or expert opinions** (though varying); **incorporating RCTs where possible; mindfulness of biases in applying evidence; forming multicenter research groups for better RCTs**	**Strict adherence to guidelines** (e.g., top of evidence pyramid for medical interventions); **balancing recommendations with patient factors; AI/computer programs for personalized decisions; Clinical Decision Support Systems to limit over-ordering**; standardizing care where uncertainty is high
Anatomical and Pathological Variability	**Operating "by feel"; relying on imaging to prepare for difficulties encountered intra-operatively; utilizing equipment for advantageous purposes not originally intended; remembering prior situations where similar operative circumstances were encountered**	Ordering more tests to narrow differentials; **using clinical prediction scores/risk models** (e.g., Seattle Heart Failure Model); **consulting multidisciplinary teams or colleagues**
Intra-operative and Procedural	**Prioritizing alternatives, reevaluating/adapting plans, creating innovative solutions with surgical team involvement; risk-benefit analysis before each maneuver**; adhering to "tried and true" methods or personal "practice styles"; resecting more to ensure negative margins	**Prioritizing alternatives, reevaluating/adapting plans, creating innovative solutions with support team involvement; risk-benefit analysis before each maneuver**; adhering to "tried and true" methods or personal "practice styles"
Prognostication and Outcomes	**Family conferences for prognostication with disclosure of uncertainty; usage of prediction scores; comparison with prior patients cared for**	**Family conferences for prognostication with disclosure of uncertainty; usage of prediction scores; comparison with prior patients cared for**
Patient-Related	**Deep engagement with patients/family; serious illness conversations**;	**Deep engagement with patients/family; assessing patient values/goals/role**

	framing effects/priming; **shared decision-making with emphasis on informed consent; assessing patient role preferences; online learning for preoperative education**	**preferences; shared decision-making (presenting options, teach-back method); drawing explanations or allowing recordings; online learning for illness education**

*Not all of these strategies are necessarily recommended, but were observed as patterns within the literature reviewed herein. **Bolded** strategies are those that are recommended. Un-bolded strategies should be used according to the purview of each individual physician.

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