

Neurosurgical Decision-Making and the Ethical Considerations in the Treatment of
Traumatic Brain Injury

by

Jasmine Hughes

Duke Global Health Institute
Duke University

Date: _____

Approved:

Anthony T. Fuller, Supervisor

Michael M. Haglund

Deborah Koltai

Kearsley Stewart

Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Duke Global Health Institute
in the Graduate School
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2022

ABSTRACT

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Abstract

Purpose: Globally, disparities in the availability of surgical care are prevalent, and for specialty care such as neurosurgery, services are typically scarce to non-existent. In low-and-middle-income countries, most medical centers have limited resources and are not equipped to handle neurosurgical emergencies. Within the field of global neurosurgery, there has been a push to incorporate advanced technologies such as predictive modeling to facilitate triage and neurosurgical care decision-making. However, to successfully implement such technologies, it is vital to consider the ethical framework within which neurosurgical care decisions are made and how ethical challenges inform decision-making. The objective of this study was to determine whether the potential ethical challenges that neurosurgical care providers encounter are differentially important to decision-making.

Methods: This study utilized a rank-order survey to evaluate surgical risk tolerance, the relative importance of several patient-level and system-level factors to the decision to offer surgery, and perceptions of the fairness of several resource-allocation principles when surgery cannot be offered to all patients in need. Further, we assessed whether geographic, demographic, cultural, and institutional characteristics and utilitarian ethical orientation differentially impact these aspects of decision-making.

Results: The key findings of this study show there is a differential impact of ethical challenges on decision-making and there are correlations with decision-making factors and demographic information.

Conclusion: This data will allow the identification of key commonalities and differences in approaches to neurosurgical decision-making across practice settings, which will potentially facilitate ethically responsible, cross-cultural collaborations and implementations of neurosurgical decision support tools.

Dedication

I would like to take this opportunity to dedicate my thesis to my late Uncle Willie C. Hughes, as he is my inspiration for pursuing a career in global health.

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1. Introduction

Over the years, the primary objectives of global surgery have been focused on providing surgical training and medical resources to low- and middle-income countries (LMICs). While it is essential to build surgical capacity where there are significant deficits in the surgical healthcare workforce, it is also imperative to understand the current clinical conditions surgical providers are providing clinical care within. This current distinction at the current level of clinical conditions consists of surgical providers making decisions regarding either providing surgical interventions or other treatments. It is, therefore, essential to grasp a better understanding of the interplay between clinical decision-making and the ethical paradigms that exist within the context. As an ethical challenge seems to be external to the decision-maker. It is the environment that presents them with ethical challenges (i.e. limited resources, low number of beds, pressure from other people, etc.). While an ethical framework seems to be internal to the decision-making and it is the way in which the decision-maker uses their internal ethical compass to make decisions when presented with ethical challenges. This, in turn, can provide the foundation to better incorporate how to use an ethical decision-making framework that utilizes existing resources to provide the maximum quality healthcare service.

1.1 Global Neurosurgery

Globally, it is estimated that over 5 billion people lack access to affordable surgical care (1). Access to essential surgical care in LMICs can avert over 1.5 million deaths each year (1). The establishment of the Lancet Commission on Global Surgery, which highlighted disparities in the provision of surgical care between high-income countries (HICs) and LMICs, was an important step in addressing this unmet need in global health and promoting the discussion of advancing surgical care globally (2). The Lancet Commission proposed several core indicators for monitoring universal access to safe and affordable surgical care which included access to timely essential surgery, specialist surgical workforce density, surgical volume, and perioperative mortality (2).

Given that global neurosurgery is a subspeciality within global surgery, access to neurosurgical care is even more scarce in LMICs. For traumatic brain injury (TBI) in particular, the leading cause of morbidity and mortality among traumatic injuries worldwide (3). LMICs experience a disproportionate three times more TBI cases than HIC (4). This disparity is exacerbated by a shortage of neurosurgeons: on average in HICs, there is a ratio of 1 neurosurgeon per 80,000 patients, but in LMICs the ratio is 1 neurosurgeon per 10 million patients (4). Initiatives to improve global neurosurgery have included providing surgical education and resources to local providers and, more recently, developing cost-effective solutions and improving care at the system level (4). However, maximally effective implementation of global neurosurgical initiatives

requires not only training medical professionals and equipping them with low-cost, advanced medical technologies, but also a greater understanding of how surgical decisions are made and how those decisions impact patient outcomes.

1.2 Decision-Making in Global Neurosurgery Outcomes

Decision-making in global neurosurgery, as with global surgery as a whole, is complicated by inadequate infrastructure, shortage of trained personnel, and differing opinions between colleagues in regard to treatment for patients (4). The acute nature, high morbidity, and mortality, and difficult prognostication (5) of TBI makes decision-making particularly complex. Once a patient is determined to be a candidate for surgery, scarce resources often limit the number of patients on which providers can operate within a reasonable time. The impact of this and other ethical challenges on neurosurgical decision-making and patient care in LMICs has been largely unexplored.

Neurosurgical capacity has increased substantially over the past decade, largely due to ongoing partnerships with providers and institutions from high-income countries (HICs). Along with the objective of increasing neurosurgical capacity and teaching neurosurgical procedures, there has been an aim to incorporate advanced technologies such as predictive modeling to facilitate triage and neurosurgical care decision-making (6). However, in order to successfully implement prognostic calculators and other technology, it is vital to not only consider the ethical framework within which

neurosurgical care decisions are made but if there is a difference in how ethical challenges inform decision-making.

1.3 The Role of Ethics within Decision-Making

Ethical challenges provide an external dilemma for neurosurgical providers, who must utilize their internal ethical framework to make neurosurgical care decisions which are essential to consider in regard to global neurosurgical outcomes. In the previous pilot study, a qualitative approach with an interview guide was used to determine the ethical challenges presented to Ugandan neurosurgeons. The key finding from the study showed the three themes of ethical challenges: policies, resource limitations, and clinical decision-making. Given that those ethical challenges impact surgical decision-making for providers and even patients, it is essential to consider how to build an ethical framework that can be used as a foundation to improve neurosurgical practices and thus can improve neurosurgical patient outcomes.

One particular ethical framework that can be applied to global neurosurgery is utilitarianism. Utilitarianism is the ethical theory that virtue is based on utility, and actions should be aimed at promoting the greatest happiness for the greatest number of people. Different forms of utilitarianism have been developed over time including classical utilitarianism, ideal utilitarianism, and consequential utilitarianism. This concept aligns with global neurosurgery when neurosurgeons in LMICs aim to provide the maximum benefit to most patients given the limited resources available.

Kahane et al. at Oxford University have recently adapted the theory of utilitarianism into the Oxford Utilitarianism Scale (OUS) (7). The OUS consists of both dissociate individual differences in the 'negative' (permissive attitude toward instrumental harm) and 'positive' (impartial concern for the greater good) dimensions of utilitarian thinking as manifested in the general population. OUS has been used to show that in the overall population, there are two independent dimensions of proto-utilitarian tendencies. This new conception of utilitarianism provides a robust way to explore the different dimensions of how this ethical framework is applied in practice. In this study, we use the OUS to understand how utilitarian neurosurgeons are and how that impacts their decision-making.

1.4 Goal of the Study

The main objective of this research study was to assess the impact of ethical challenges on neurosurgical care providers' decision-making. This study used a quantitative approach to explore the implications and the difference in importance of ethical challenges on decision-making with a bivariate analysis with OUS as an ethical framework.

Research Question

Research Question: Do ethical challenges have differential importance in the neurosurgical decision-making process?

2. Methods

2.1 Study Design

An online survey was distributed to neurosurgeons worldwide which consisted of six parts: Part 1: Demographics; Part 2: Situations in Everyday Practice, Part 3: Resource Allocation Principles; Part 4: Factors Influencing Decision-Making; Part 5: Oxford Utilitarianism Scale (OUS); Part 6: Chance of Survival. In the demographics section, information regarding age, institution type, institution size, gender, the importance of religion, and level of experience were collected from the participants. In the situations in the everyday practice section, Likert scale questions were used to assess the impact of specific potential ethical challenges. In the resource allocation principles section, rank-order questions were used as a ranking system to force respondents to rank the fairness of various resource allocation principles. Additionally, respondents provided relative weights to their ranking system decisions by distributing 100 percentage points across the ranked items. The factors influencing decision-making section consists of two parts which involved using rank order questions to rank factors in clinical decision-making with limited resources available and unlimited resources. This section also included respondents who provided relative weights to their ranking system decisions. In the OUS section, participants were given ethical dilemmas with Likert scale questions to assess their level of utilitarianism. In the last section, the chance of survival, participants were given a vignette and asked to provide the threshold of

which they were willing to operate based on the level of improvement of the patient's condition and risk of mortality. Therefore, this observational study used a quantitative approach by utilizing a rank-order and Likert scale survey to explore if there is differential importance of ethical challenges in neurosurgical decision-making.

2.2 Setting

As the aim of this study was to have a global approach to recruiting participants, the setting of the study took place virtually.

2.3 Participants

Providers in emergency medicine and general surgery provide neurosurgical care in the United States and abroad. Levels of experience include interns, residents, fellows, and consultants.

2.4 Inclusion Criteria

The inclusion criteria consist of trained surgical providers that provide direct neurosurgical care for patients in both HIC and LMIC settings such as at Mulago National Referral Hospital, Mbarara Regional Referral Hospital, Duke University Medical Center, and Stanford University Medical Center. Participants must be a neurosurgery-trained consultant or trainee (i.e., resident or intern) in the neurosurgery department or have completed a rotation in the neurosurgery or casualty department to be included. Eligible individuals were identified by the chair of the neurosurgery

department at each institution either through listing on a listserv or departmental website.

2.5 Exclusion Criteria

Healthcare professionals that do not provide direct surgical care to neurosurgical patients (e.g., medical students) were excluded from this study.

2.6 Sample Size

As the aim of this study was to have a global approach to recruiting participants, the setting of the study took place virtually.

2.7 Recruitment

Participants were recruited to participate in completing the survey by obtaining a listserv of neurosurgeons at medical centers (examples include Uganda, Kenya, and the US) from neurosurgery department chairs, distributing survey posting in neurosurgical societies newsletters, and emailing neurosurgeons directly through the contact information listed on medical centers websites.

2.8 Ethics and Consent

The ethical review board at Duke University (Pro00104325) approved an IRB exemption for the study. Before each participant began the survey, each participant provided informed consent in order to start the survey and no information provided in the survey could be connected to specific care providers as survey responses are

recorded anonymously. At the conclusion of the study, investigators and participants will all have access to the study results.

3. Results

3.1 Demographics

The survey responses were collected from October 14th, 2021 to February 15th, 2022, with a total of 113 survey responses. Of those responses, only 48 participants had a 100% completion rate, and 63 participants completed at least one section including the demographic section. While the average time to complete the survey was 5.2 hours, most participants completed the survey over a course of weeks with reminders to finish completing the survey. The basic demographics of survey participants are outlined in Table 1.

Table 1: Demographics of Participants

	N	
Total Sample	63	
Gender	N	Percent
Male	53	84.13
Female	10	15.87
	Mean	SD
Age	45.33	13.16
Age (Categorical)	N	Percent
25-35	13	20.63
35-45	23	36.51
45-55	14	22.22
55-65	4	6.35
>65	9	14.29

Country	N	Percent
United States of America	45	71.43
Uganda	8	12.70
Kenya	6	9.52
Tanzania	1	1.59
Venezuela	1	1.59
Nigeria	1	1.59
Spain	1	1.59
Country (Categorical)	N	Percent
High Income Countries	46	73.02
Low and Middle Income Countries	17	26.98
Institution Type	N	Percent
Academic/Teaching Hospital (Private Funding)	21	33.33
Academic/Teaching Hospital (Public Funding)	38	60.32
Non-Teaching Hospital (Private Funding)	2	3.17
Non-Teaching Hospital (Public Funding)	1	1.59
Missing	1	1.59
Institution Size	N	Percent
<250	6	9.52
250-499	15	23.81
500-750	15	23.81
>750	26	41.27
Missing	1	1.59
Level of Experience	N	Percent
Intern or Junior Resident/Medical Officer	8	12.70
Senior/Chief Resident or Fellow	8	12.70
Attending/Consultant	45	71.43

Other	2	3.17
Attending/Consultant Years of Experience	N	Percent
<10	19	30.16
10-20	14	22.22
>20	14	22.22
Religion	N	Percent
Catholic	10	15.87
Christian	15	23.81
Jewish	4	6.35
Muslim	1	1.59
Protestant	1	1.59
Atheist	1	1.59
No specific religious belief	16	25.40
Missing	15	23.81
Religion (Categorical)	N	Percent
Yes	31	49.21
No	17	26.98
Missing	15	23.81
Religious Importance	N	Percent
Very Unimportant	12	19.05
Unimportant	4	6.35
Neither	10	15.87
Important	8	12.70
Very Important	14	22.22
Missing	15	23.81

3.2 Situations in Everyday Practice

In the first section of the survey: Situations in Everyday Practice, we compare the potential factors such as institutional pressure, sense of obligation and pressure from patients, on providers' decision to perform or offer surgery. Out of 113 participants, approximately 60 participants completed this section. In the analysis of this section, 88% of respondents had a sense of obligation to offer surgery if there is a chance a patient will survive. While, approximately, 88% have either never or rarely not recommended when they should have and 87% have never or rarely have recommended when they should not have. In regard to the experiencing pressure, the average of participants stated that sometimes they experience pressure from patients (57%), patients' families or surrogates (43%), and consulting physicians (38%). While the majority of the participants stated that they almost never or rarely experience pressure from their institution (62%). Details for the specific numbers for each Likert scale response for each question are outlined in Table 2.

Table 2: Ethical Situations in Everyday Practice

Question	Almost Never	Rarely	Sometimes	Often	Almost Always	Did not answer
I feel obligated to offer surgery if there is a chance the patient will survive	2	4	15	21	17	4
I have not recommended surgery when I should have	33	20	5	0	1	4
I have recommended surgery when I should not have	38	14	7	0	1	3
I am willing to not offer surgery even if it means a patient will die	9	10	24	10	5	5
I experience pressure from patients that can self advocate to perform surgery	4	14	34	6	3	2
I experience pressure from patients' family members or surrogates to perform surgery	6	13	26	11	5	2
I experience pressure from consulting physicians to perform surgery	9	15	23	10	3	3
I experience pressure from the institution to perform surgery	25	12	13	6	2	5

Situations in Everyday Practice

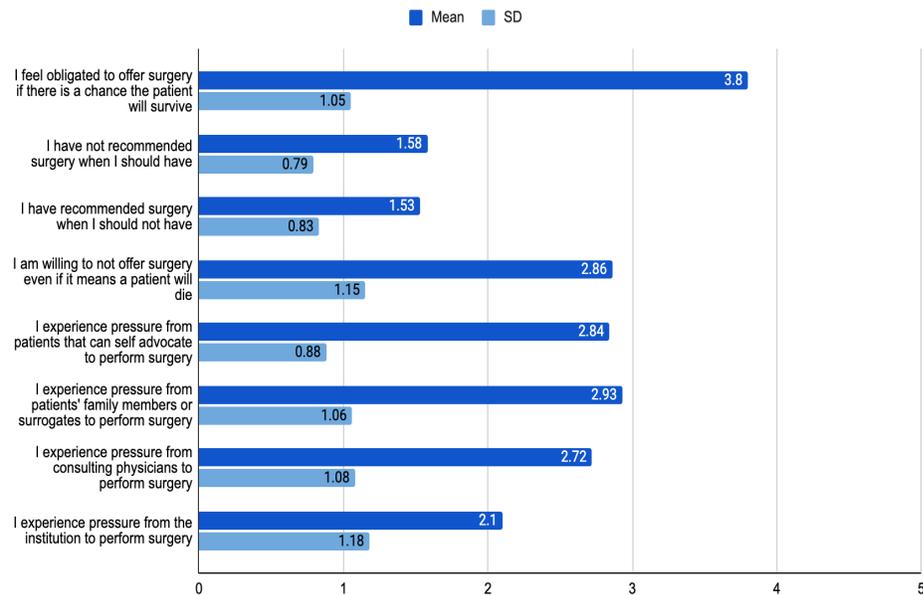


Figure 1: Analysis of Daily Neurosurgical Practice Situations

3.3 Clinical Decision-Making: Unlimited Resources

In regard to the next section which was based on the impact of unlimited resources on decision making. Out of the total 113 participants, 57 participants completed this entire section. According to the average scores of participants, the following is the order of each factor ranked: patients need for surgery (ranked 1st), the patient's likelihood to benefit from surgery (2nd), the likelihood of improvement in the patient's long-term quality of life and patient' mortality with/after surgery (both tied for 3rd), the likelihood of improvement in the patients long-term quality of life with/after

surgery (4th), the patient’s request for surgery when they can self-advocate (5th), the patient’s family member’s or surrogate’s request for surgery (6th) and other (7th).

Details for the specific response for each factor ranked and the corresponding percentage the factor has on decision-making are outlined in Table 3.

Table 3: Factors within Clinical Decision-Making with Unlimited Resources

Question	Almost Never	Rarely	Sometimes	Often	Almost Always	Did not answer
I feel obligated to offer surgery if there is a chance the patient will survive	2	4	15	21	17	4
I have not recommended surgery when I should have	33	20	5	0	1	4
I have recommended surgery when I should not have	38	14	7	0	1	3
I am willing to not offer surgery even if it means a patient will die	9	10	24	10	5	5
I experience pressure from patients that can self-advocate to perform surgery	4	14	34	6	3	2
I experience pressure from patients' family members or surrogates to perform surgery	6	13	26	11	5	2
I experience pressure from consulting physicians to perform surgery	9	15	23	10	3	3
I experience pressure from the institution to perform surgery	25	12	13	6	2	5

Clinical Decision Making: Unlimited Resources

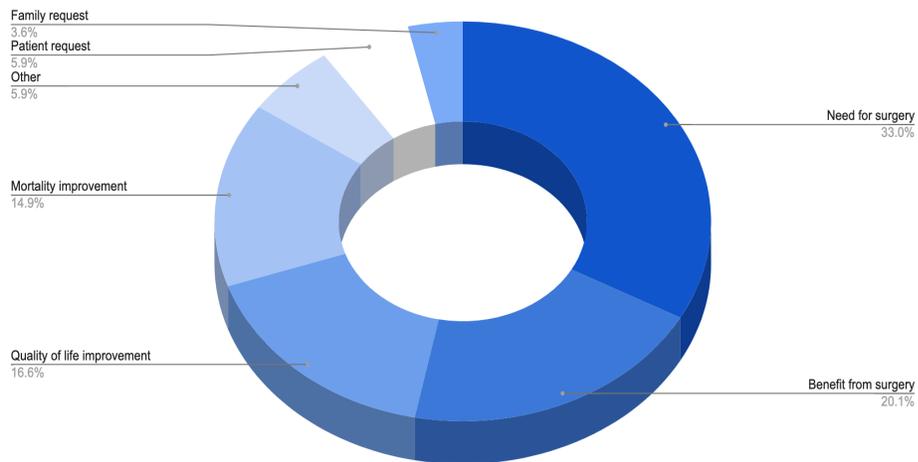


Figure 2: Factors within Clinical Decision-Making: Unlimited Resources

3.4 Clinical Decision-Making: Limited Resources

In the next section which was based on the impact of limited resources on decision making, 50 of the 113 total participants completed this entire section. According to the average scores of participants, the following is the order of each factor ranked: the availability of operating theater space to perform the operation (ranked 1st), the availability of resources other than operating theater space to perform an operation (2nd), the availability of bed space for recovery after surgery (3rd), the availability of resources other than bed space for recovery after surgery (4th), the expected financial burden/medical expenses to the patient (5th and 6th) and other (7th). Details for the

specific response for each factor ranked and the corresponding percentage the factor has on decision-making are outlined in Table 4.

Table 4: Factors within Clinical Decision-Making with Limited Resources

	Ranked 1st	Ranked 2nd	Ranked 3rd	Ranked 4th	Ranked 5th	Ranked 6th	Ranked 7th
The expected financial burden/medical expenses to the patient	2	3	1	4	29	10	0
The expected financial burden/medical expenses to the institution	0	1	1	0	12	34	1
The availability of operating theater space to perform the operation	34	7	3	4	1	0	0
The availability of resources other than operating theater space to perform the operation	7	22	13	4	2	1	0
The availability of bed space for recovery after surgery	3	10	18	13	4	1	0
The availability of resources other than bed space for recovery after surgery	2	6	13	24	1	3	0
Other	1	0	0	0	0	0	48

Clinical Decision Making: Limited Resources

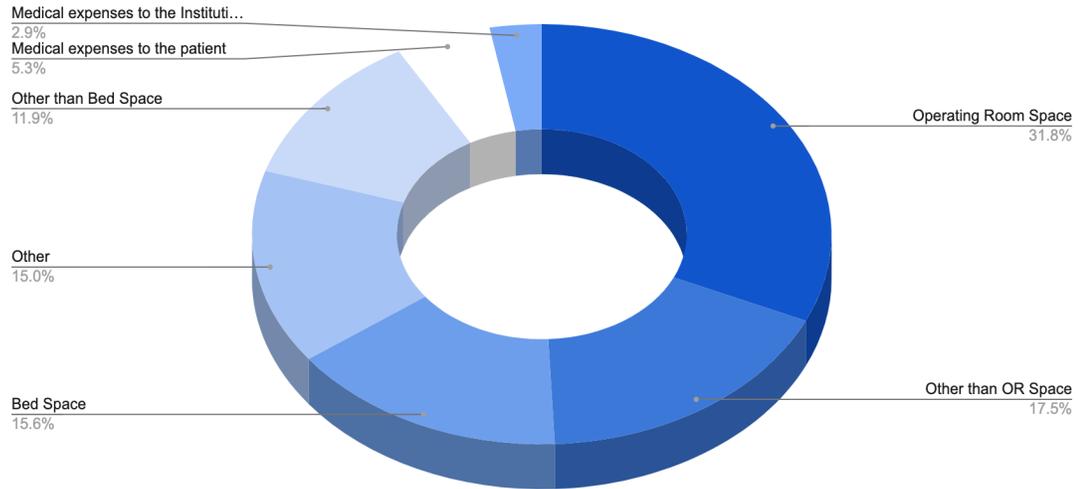


Figure 3: Factors within Clinical Decision-Making: Limited Resources

3.5 Chance of Survival

We aimed to determine the threshold at which providers are willing to operate based on their patient's chance of survival. The average risk of mortality at which respondents would operate was determined to be 67.14% (with a total of 49 responses) and the average decreased risk of mortality for the same patient was 18.91% (with a total of 45 responses). Details for the complete percentiles, standard deviations, and minimum and maximum ranges are outlined in Table 5.

Table 5: Chance of Survival Threshold

	Mean	SD	p25	p50	p75	Min	Max
For this patient with TBI, what is the highest risk of mortality at which you would operate? (You would withhold surgery if the patient had a baseline risk of mortality above this threshold.)	67.87	31.54	50	80	90	1	100
For this same patient, if surgery were to decrease the risk of mortality, what is the minimum percent decrease in risk of mortality at which you would operate? (You would withhold surgery if the patient had a decrease in risk of mortality below this threshold.)	18.89	19.13	5	10	22.5	1	90

3.6 Oxford Utilitarianism Scale

In the Oxford Utilitarianism Scale section, which ranged from 1 to 7 (with 1 correlating with the lowest level and 7 correlating with the highest level for utilitarianism) the average score ranged from 2 - 4, with the average score of 3 being most represented in the questions. 55 of the total 113 participants completed this entire section. Details for the specific numbers for each Likert scale response for each question are outlined in Table 6.

Table 6: Oxford Utilitarianism Scale

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree	Missing
If the only way to save another person's life during an emergency is to sacrifice one's own leg, then one is morally required to make this sacrifice	14	20	4	4	3	4	3	11
From a moral point of view, we should feel obliged to give one of our kidneys to a person with kidney failure since we don't need two kidneys to survive, but really only one to be healthy	14	16	7	3	7	5	0	11
From a moral perspective, people should care about the well-being of all human beings on the planet equally; they should not favor the well-being of people who are especially close to them either physically or emotionally	4	12	12	2	11	5	6	11
It is just as wrong to fail to help someone as it is to actively harm them yourself	6	11	12	2	6	8	7	11
It is morally wrong to keep money that one doesn't really need if one can donate it to causes that provide effective help to those who will benefit a great deal	3	12	12	5	6	9	5	11
It is morally right to harm an innocent person if harming them is a necessary means to helping several other innocent people	21	16	7	4	1	3	0	11
If the only way to ensure the overall well-being and happiness of the people is through the use of political oppression for a short, limited period, then political oppression should be used	18	19	2	3	4	4	2	11
It is permissible to torture an innocent person if this would be necessary to provide information to prevent a bomb going off that would kill hundreds of people	19	12	6	5	5	4	0	11
Sometimes it is morally necessary for innocent people to die as collateral damage—if more people are saved overall	10	13	8	8	9	4	0	11

Oxford Utilitarianism Scale

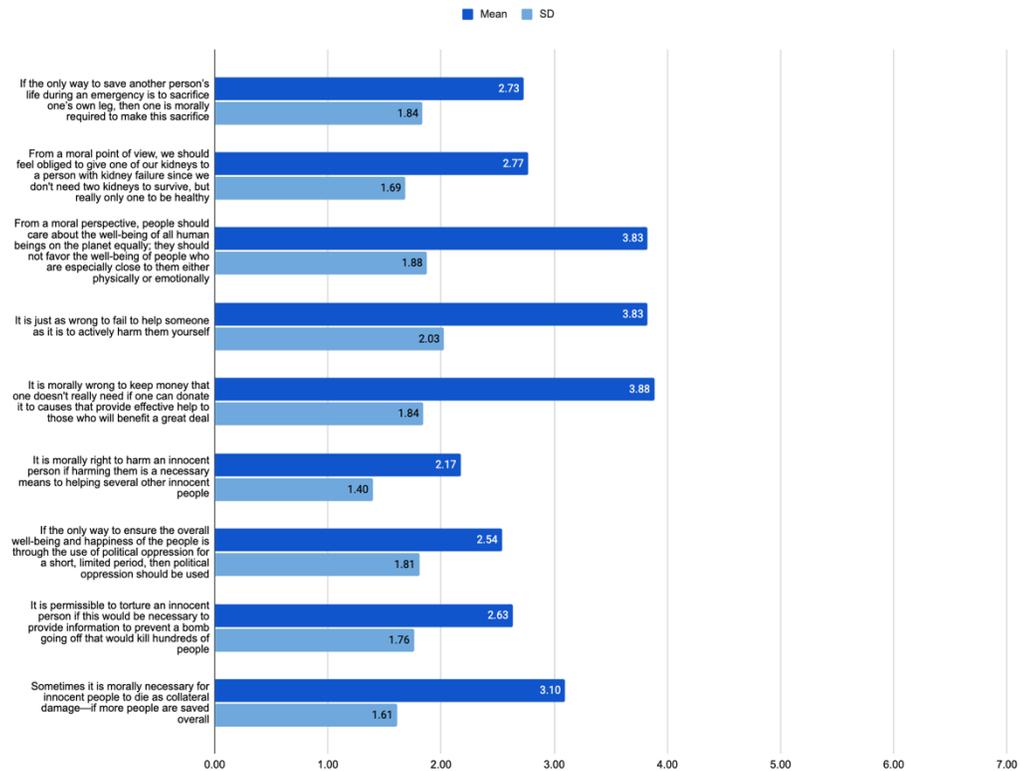


Figure 4: Oxford Utilitarianism Scale Analysis

3.7 Bivariate Analysis

Based on the cutoff significant level of 0.05, there were correlations between several factors in decision-making and demographic factors based on the participants' responses. Details for the specific numbers and responses for each question are outlined in Table 7.

Table 7: Bivariate Analysis with Demographics

Situations in Everyday Practice	Gender	Age (Categorical)	Country (Categorical)	Institution Type	Institution Size	Level of Experience	Attending/Consultant Years of Experience	Religion (Categorical)	Religious Importance
I feel obligated to offer surgery if there is a chance the patient will survive	0.784	0.444	0.115	0.53	0.988	0.039	0.823	0.248	0.572
I have not recommended surgery when I should have	0.707	0.803	0.572	0.763	0.506	0.212	0.566	0.661	0.535
I have recommended surgery when I should not have	0.277	0.539	0.939	0.868	0.434	0.068	0.471	0.834	0.587
I am willing to not offer surgery even if it means a patient will die	0.459	0.642	0.003	0.009	0.805	0.616	0.018	0.056	0.041
I experience pressure from patients that can self-advocate to perform surgery	0.13	0.782	0.03	0.209	0.292	0.211	0.267	0.432	0.148
I experience pressure from patients' family members or surrogates to perform surgery	0.028	0.664	0.284	0.126	0.719	0.794	0.197	0.127	0.365
I experience pressure from consulting physicians to perform surgery	0.209	0.554	0.989	0.341	0.765	0.16	0.521	0.011	0.424
I experience pressure from the institution to perform surgery	0.495	0.473	0.251	0.872	0.727	0.629	0.752	0.936	0.494

Clinical Decision Making: Unlimited Resources	Gender	Age (Categorical)	Country (Categorical)	Institution Type	Institution Size	Level of Experience	Attending/Consultant Years of Experience	Religion (Categorical)	Religious Importance
The patient's need for surgery (i.e., surgery is indicated)	0.972	0.749	0.024	0.002	0.01	0.981	0.981	0.116	0.103
The patient's likelihood to benefit from surgery	0.152	0.212	0.653	0.187	0.762	0.006	0.147	0.024	0.26
The patient's request for surgery when they can self-advocate	0.363	0.599	0.325	<0.001	0.035	0.463	0.359	0.575	0.466
The patient's family member's or surrogate's request for surgery	0.338	0.505	0.37	0.004	0.061	0.05	0.425	0.159	0.232
The likelihood of improvement in the patient's long-term quality of life with/after surgery	0.286	0.653	0.89	0.946	0.065	0.662	0.787	0.301	0.161
The likelihood of improvement in the patient's mortality with/after surgery	0.289	0.656	0.253	0.006	0.549	0.108	0.196	0.68	0.769
Other	0.69	0.749	0.56	0.87	0.692	0.132	N/A	0.454	0.648

Clinical Decision Making: Limited Resources	Gender	Age (Categorical)	Country (Categorical)	Institution Type	Institution Size	Level of Experience	Attending/Consultant Years of Experience	Religion (Categorical)	Religious Importance
The expected financial burden/medical expenses to the patient	0.195	0.851	0.095	0.299	0.257	0.7	0.7	0.507	0.337
The expected financial burden/medical expenses to the institution	0.967	0.609	0.379	0.748	0.1	0.633	0.241	0.527	0.374
The availability of operating theater space to perform the operation	0.547	0.099	0.011	0.437	0.461	0.766	0.004	0.61	0.446
The availability of resources other than operating theater space to perform the operation	0.017	0.779	0.358	0.288	0.502	0.638	0.387	0.158	0.32
The availability of bed space for recovery after surgery	0.332	0.081	0.374	0.127	0.081	0.862	0.127	0.338	0.802
The availability of resources other than bed space for recovery after surgery	0.508	0.41	0.425	0.817	0.289	0.472	0.146	0.836	0.75
Other	0.68	0.062	0.565	0.88	0.329	0.92	0.176	0.172	0.547

Chance of Survival	Gender	Age	Country	Institution Type	Institution Size	Level of Experience	Attending/Consultant Years of Experience	Religion	Religious Importance	OUS Total	OUS IB	OUS IH
For this patient with TBI, what is the highest risk of mortality at which you would operate? (You would withhold surgery if the patient had a baseline risk of mortality above this threshold.)	0.04	0.692	0.012	0.078	0.188	0.805	0.838	0.993	0.881	0.177	0.972	0.012
For this same patient, if surgery were to decrease the risk of mortality, what is the minimum percent decrease in risk of mortality at which you would operate? (You would withhold surgery if the patient had a decrease in risk of mortality below this threshold.)	0.799	0.949	0.262	0.822	0.904	0.74	0.748	0.432	0.772	0.348	0.325	0.529

Oxford Utilitarianism Scale	Gender	Age (Categorical)	Country (Categorical)	Institution Type	Institution Size	Level of Experience	Attending/Consultant Years of Experience	Religion (Categorical)	Religious Importance
If the only way to save another person's life during an emergency is to sacrifice one's own leg, then one is morally required to make this sacrifice	0.489	0.607	0.595	0.241	0.196	0.94	0.15	0.75	0.188
From a moral point of view, we should feel obliged to give one of our kidneys to a person with kidney failure since we don't need two kidneys to survive, but really only one to be healthy	0.127	0.698	0.393	0.026	0.391	0.379	0.146	0.018	0.264
From a moral perspective, people should care about the well-being of all human beings on the planet equally; they should not favor the well-being of people who are especially close to them either physically or emotionally	0.95	0.746	0.213	0.15	0.732	0.38	0.283	0.838	0.553
It is just as wrong to fail to help someone as it is to actively harm them yourself	0.675	0.79	0.127	0.06	0.32	0.341	0.95	0.505	0.179
It is morally wrong to keep money that one doesn't really need if one can donate it to causes that provide effective help to those who will benefit a great deal	0.632	0.706	0.049	0.66	0.033	0.417	0.139	0.24	0.168
It is morally right to harm an innocent person if harming them is a necessary means to helping several other innocent people	0.673	0.645	0.755	0.815	0.262	0.625	0.434	0.808	0.117
If the only way to ensure the overall well-being and happiness of the people is through the use of political oppression for a short, limited period, then political oppression should be used	0.589	0.566	0.676	0.977	0.424	0.095	0.712	0.815	0.72
It is permissible to torture an innocent person if this would be necessary to provide information to prevent a bomb going off that would kill hundreds of people	0.333	0.934	0.836	0.075	0.801	0.558	0.574	0.766	0.612
Sometimes it is morally necessary for innocent people to die as collateral damage—if more people are saved overall	0.474	0.483	0.4	0.798	0.225	0.491	0.587	0.872	0.69
Oxford Utilitarianism Scale Total Score	0.63	0.879	0.176	0.07	0.174	0.827	0.216	0.049	0.163
Oxford Utilitarianism Scale Instrumental Benefit Subscale	0.271	0.133	0.093	0.043	0.519	0.255	0.013	0.004	0.009
Oxford Utilitarianism Scale Instrumental Harm Subscale	0.417	0.357	0.427	0.422	0.12	0.242	0.477	0.173	0.474

4. Discussion

4.1 General

This analysis of ethical challenges to neurosurgical providers' decision-making process evaluated the differential impact of potential challenges. The analysis measured the impact of several ethical challenges including situations in everyday practice, ranking of resource allocation principles, and comparing how limited vs unlimited resources impact neurosurgical decision-making. This study also investigated the participants' score on the oxford utilitarianism score and how it correlated with their responses to their threshold of providing surgical intervention based on their patients' chance of survival. It is clear from the results, that there is a differential impact of ethical challenges on neurosurgical providers' decision-making.

4.2 Implications for Policy and Practice

Based on the results, the potential implications for policy and practice include incorporating prognostic technologies based on an ethical framework for neurosurgical decision-making in LMICs. It is clear based on the analysis, that there is a difference in the impact of ethical challenges on the decision-making process, therefore addressing that differential impact within a prognostic model could be used to aid in the decision-making process in low resources settings.

4.3 Implications for Further Research

Further research is needed to investigate how ethical frameworks vary by neurosurgeons in different countries, religions, and resource limitations. Before the implementation of prognostic models to aid in neurosurgical decision-making in LMICs, there needs to be a better understanding of how ethical frameworks can differ. This is especially important given that ethical frameworks based on a HIC perspective can have a more individualistic approach compared to ethical frameworks based on the LMIC perspective. Ethical frameworks utilized in LMICs can consist of a community-based or collective approach. Therefore, to avoid potential bias in future studies, it is essential to consider how this dynamic within LMIC and HIC ethical frameworks can vary and determine the best possible solution for implementing diagnostic technologies (developed by HIC researchers) in LMIC settings.

4.4 Study Limitations

As the survey questions focused on neurosurgeons' experiences with situations in everyday practice and factors influencing decision-making, only negative experiences were captured in the responses. As a result, it may be perceived that some participants may have felt their responses reflected poorly on their countries' government, health system, medical institution, and staff which might have caused them to alter their responses in a way that does not genuinely reflect their experiences within their

institutions. This in turn could also indicate that not all the providers' decision-making experiences with ethical challenges were captured in their survey responses.

Based on the survey responses and expected responses, there also seems to be a lack of understanding of the chance of survival questions: "For this patient with TBI, at what percent chance of mortality without surgery would you consider withholding surgery? For the same patient, what is the maximum relative percent improvement in mortality with surgery at which you would consider withholding surgery?".

Participants reported a higher chance of mortality thresholds than expected for withholding surveys and lower improvement of mortality thresholds. This finding was similar in pilot studies at both Uganda and Duke University Medical Center. It was also evidence of participants' confusion on the chance of survival questions, given the experience of survey responses mentioned participants were not sure if they answered the chance of survival questions correctly. There this could result in a lack of true thresholds from providers who would be willing to withhold surgery at a particular percent chance of mortality or maximum relative percent improvement in the hypothetical TBI patient.

Additionally, the recruitment of the participants involved using social media platforms such as Twitter and contacting neurosurgical societies to send the survey out to their members. The use of social media platforms could lead to participants who are not neurosurgical providers participating in the survey. Therefore, the results could not

be truly reflective of neurosurgical providers' experiences. Another concern is given that only neurosurgical societies that were contacted were able to send out the survey to their members. This could potentially lead to biased responses in which primarily neurosurgeons in the United States had access to the survey. Although participants range from all over the world, the majority of participants were located in the United States. This could cause a skew of results favoring a country with a high level of resources in comparison to low-and-middle-income countries. This would not reflect the true global neurosurgery ethical challenges in decision-making if only high-income country participants completed the survey. It is important to note that providers' experiences highlighted in this study may or may not reflect experiences surrounding other disease emergencies such as the COVID-19 pandemic and other forms of trauma and further research is necessary to elucidate this. This study did not also investigate the effects of ethical challenges on the mental health of providers.

4.5 Study Strengths

One particular strength of this study is the utilization of the Oxford Utilitarianism Scale which was developed by Kahane et al. As mentioned previously, the OUS consists of subscales of instrumental benefit and instrumental harm. The positive dimension of utilitarianism reflects impartiality. This core component of utilitarianism lies in the impartial maximization of the greater good of society. On the other hand, the negative dimension of utilitarianism consists of harming and breaking rules. This allows

us to go beyond the scaling of different ethical challenges in decision making and provides insight into the providers' potential overall ethical framework. The OUS also serves as a tool to measure the degrees of individual differences in utilitarian tendencies instead of the traditional all-or-nothing construct. According to Kehane et al, the OUS is designed to address the limitations of prior philosophical methods, including measuring the 'utilitarian' judgments with sacrificial dilemmas such as in the trolley scenario. The design of the OUS ensures that it is conceptually accurate without the bias of imposing abstract philosophical notions on the moral thinking of non-philosophical participants. Thus, we can be able to determine if there are any additional factors not mentioned which may be influencing their decision-making framework.

5. Conclusion

Global health focuses on addressing inequalities in healthcare in developing and developed countries around the world. Globally, disparities in the availability of surgical care are prevalent, and for specialty care such as neurosurgery, services are typically scarce to non-existent. In low-and-middle-income countries, most medical centers have limited resources and are not equipped to handle neurosurgical emergencies. Within the field of global neurosurgery, there has been a push to incorporate advanced technologies such as predictive modeling to facilitate triage and neurosurgical care decision-making. However, to successfully implement such technologies, it is vital to consider the ethical framework within which neurosurgical care decisions are made and how ethical challenges inform decision-making. Several components of decision-making interact with each other and contribute to the construction of potential solutions.

Moving forward, healthcare workers and policymakers must pay attention not only to the ethical challenges of patients but also to their providers. These data will allow the identification of key commonalities and differences in approaches to neurosurgical decision-making across practice settings, which will potentially facilitate ethically responsible, cross-cultural collaborations and implementations of neurosurgical decision support tools.

Appendix A

Table A. 1: Demographic Analysis

	N	
Total Sample	93	
Gender	N	Percent
Male	76	81.72
Female	17	18.28
	Mean	SD
Age	44.72	14.4
Age (Categorical)	N	Percent
25-35	25	26.88
35-45	29	31.18
45-55	19	20.43
55-65	7	7.53
>65	13	13.98
Country	N	Percent
United States of America	64	68.82
Uganda	9	9.68
Kenya	8	8.6
Colombia	3	3.23
Tanzania	2	2.15
Venezuela	2	2.15
Angola	1	1.08
Nigeria	1	1.08
Paraguay	1	1.08
Spain	1	1.08
United Kingdom	1	1.08

Country (Categorical)	N	Percent
High Income Countries	66	70.97
Low and Middle Income Countries	27	29.03
Institution Type	N	Percent
Academic/Teaching Hospital (Private Funding)	31	33.7
Academic/Teaching Hospital (Public Funding)	57	61.96
Non-Teaching Hospital (Private Funding)	2	2.17
Non-Teaching Hospital (Public Funding)	2	2.17
Institution Size	N	Percent
<250	13	14.13
250-499	24	26.09
500-750	19	20.65
>750	36	39.13
Level of Experience	N	Percent
Intern or Junior Resident/Medical Officer	17	18.28
Senior/Chief Resident or Fellow	12	12.9
Attending/Consultant	61	65.59
Other	3	3.23

Attending/Consultant Years of Experience	N	Percent
<10	23	37.7
10-20	18	29.51
>20	20	32.79
Religion	N	Percent
Catholic	10	20.83
Christian	15	31.25
Jewish	4	8.33
Muslim	1	2.08
Protestant	1	2.08
Atheist	1	2.08
No specific religious belief	16	33.33
Religious	N	Percent
Yes	31	64.58
No	17	35.42
Religious Importance	N	Percent
Very Unimportant	12	25
Unimportant	4	8.33
Neither	10	20.83
Important	8	16.67
Very Important	14	29.17

Table A. 2: Situations in Everyday Practice Analysis

Question	Mean	SD	p25	p50	p75	Min	Max
I feel obligated to offer surgery if there is a chance the patient will survive	3.8	1.05	3	4	5	1	5
I have not recommended surgery when I should have	1.58	0.79	1	1	2	1	5
I have recommended surgery when I should not have	1.53	0.83	1	1	2	1	5
I am willing to not offer surgery even if it means a patient will die	2.86	1.15	2	3	4	1	5
I experience pressure from patients that can self advocate to perform surgery	2.84	0.88	2	3	3	1	5
I experience pressure from patients' family members or surrogates to perform surgery	2.93	1.06	2	3	4	1	5
I experience pressure from consulting physicians to perform surgery	2.72	1.08	2	3	3	1	5
I experience pressure from the institution to perform surgery	2.1	1.18	1	2	3	1	5

Table A. 3: Clinical Decision-Making with Unlimited Resources Analysis

	Mean	SD	p25	p50	p75	Min	Max
Need for surgery	33.00	24.78	17.5	30	50	0	100
Benefit from surgery	20.10	15.84	10	20	30	0	70
Quality of life improvement	16.63	13.77	5	17.5	22.5	0	60
Mortality improvement	14.94	17.07	5	10	20	0	100
Other	5.90	23.52	0	0	0	0	100
Patient request	5.87	9.01	0	3	7.5	0	50
Family request	3.56	7.36	0	1	5	0	50

Table A. 4: Clinical Decision-Making with Limited Resources Analysis

	Mean	SD	p25	p50	p75	Min	Max
Operating Room Space	31.76	25.04	20	25	50	0	90
Other than OR Space	17.53	12.53	10	20	20	0	50
Bed Space	15.58	16.39	5	15	20	0	100
Other	15.00	35.15	0	0	0	0	100
Other than Bed Space	11.92	9.66	3	10	20	0	30
Medical expenses to the patient	5.32	6.30	0	4	10	0	25
Medical expenses to the Institution	2.90	5.08	0	0	5	0	20

Table A. 5: Oxford Utilitarianism Scale Analysis

Question	Mean	SD	p25	p50	p75	Min	Max
If the only way to save another person's life during an emergency is to sacrifice one's own leg, then one is morally required to make this sacrifice	2.73	1.84	1	2	4	1	7
From a moral point of view, we should feel obliged to give one of our kidneys to a person with kidney failure since we don't need two kidneys to survive, but really only one to be healthy	2.77	1.69	1	2	4	1	6
From a moral perspective, people should care about the well-being of all human beings on the planet equally; they should not favor the well-being of people who are especially close to them either physically or emotionally	3.83	1.88	2	3	5	1	7
It is just as wrong to fail to help someone as it is to actively harm them yourself	3.83	2.03	2	3	6	1	7
It is morally wrong to keep money that one doesn't really need if one can donate it to causes that provide effective help to those who will benefit a great deal	3.88	1.84	2	3	6	1	7

It is morally right to harm an innocent person if harming them is a necessary means to helping several other innocent people	2.17	1.40	1	2	3	1	6
If the only way to ensure the overall well-being and happiness of the people is through the use of political oppression for a short, limited period, then political oppression should be used	2.54	1.81	1	2	3.5	1	7
It is permissible to torture an innocent person if this would be necessary to provide information to prevent a bomb going off that would kill hundreds of people	2.63	1.76	1	2	4	1	7
Sometimes it is morally necessary for innocent people to die as collateral damage—if more people are saved overall	3.10	1.61	2	3	4.5	1	6
Instrumental Beneficence Questions	3.41						
Instrumental Harm Questions	2.61						
Oxford Utilitarianism Scale Scoring	Mean	SD	p25	p50	p75	Min	Max
Total Score	27.48	8.54	23	27	32.5	11	55
Instrumental Beneficence Questions	17.04	6.70	12.5	15.5	22	5	33
Instrumental Harm Questions	10.44	5.03	6.5	10	14	4	26

Utilitarianism Total	N	Percentage					
Not Utilitarian	37	71.15					
Utilitarian	15	28.85					
Utilitarianism Instrumental Beneficence	N	Percentage					
Not Utilitarian	32	61.54					
Utilitarian	20	38.46					
Utilitarianism Instrumental Harm	N	Percentage					
Not Utilitarian	41	78.85					
Utilitarian	11	21.15					

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