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Title of Manuscript

Risk, benefit, and cost thresholds for emergency department testing: a cross sectional, scenario based study

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Abstract

Introduction: While diagnostic testing is common in the emergency department, the value of some testing is questionable. The purpose of this study was to assess how varying levels of benefit, risk, and costs influenced an individual's desire to have diagnostic testing.

Methods: A survey through Amazon Mechanical Turk presented hypothetical clinical situations: low risk chest pain and minor traumatic brain injury. Each scenario included three given variables (benefit, risk, and cost), that was independently randomly varied over four possible values (0.1%, 1%, 5%, 10% for benefit and risk and $0, $100, $500, and $1000 for the individual's personal cost for receiving the test). Benefit was defined as the probability of finding the target disease (traumatic intracranial hemorrhage or acute coronary syndrome).

Results: 1000 unique respondents completed the survey. With an increased benefit from 0.1% to 10%, the percent of respondents who accepted a diagnostic test went from 28.4% to 53.1%. [OR: 3.42 (2.57-4.54)] As risk increased from 0.1% to 10%, this number decreased from 52.5% to 28.5%. [OR: 0.33 (0.25-0.44)] Increasing cost from $0 to $1000 had the greatest change of those accepting the test from 61.1% to 21.4%, respectively. [OR: 0.15 (0.11-0.2)]

Conclusions: The desire for testing was strongly sensitive to the benefits, risks and costs. Many participants wanted a test when there was no added cost, regardless of benefit or risk levels, but far fewer elected to receive the test as cost increased incrementally. This suggests that out of pocket costs may deter patients from undergoing diagnostic testing with low potential benefit.

Main Manuscript

Introduction

Diagnostic tests have emerged as major areas of innovation within the healthcare field and are ubiquitous in emergency departments around the US.[1] Given the relative ease of obtaining advanced imaging, and patient and clinician aversion to possibly missing a diagnosis, overtesting is common.[2, 3] While diagnostic testing has increased exponentially in recent years, disease prevalence and outcomes have remained relatively unchanged.[4] Defensive diagnostic testing is a costly practice that can have potentially unnecessary and harmful side effects for patients.[5] The emergency department has emerged as a focal point for quick access to diagnostic testing.[6]

Specifically, this analysis focuses on patient preferences for diagnostic testing for low risk chest pain and minor traumatic brain injury, which are two of the most common complaints seen in the ED.[7] By providing research subjects with hypothetical scenarios in which they present to the ED with these complaints, our objective is to preliminarily characterize how these individuals consider the benefits, risks, and costs of diagnostic testing to make decisions about their care. This study aims to assess how varying levels of benefit, risk, and costs influenced an individual's desire to have diagnostic testing.

Methods

This study was a preliminary study in preparation for a larger study of patients who were in the emergency department. The goal of this study was to explore the parameter space between largely varying levels of benefit, risk, and cost, to ensure that the patients included in the subsequent in-person study were given scenarios that were in an area that was scientifically reasonable and interesting.

Setting

We conducted a cross-sectional survey where unique respondents were asked to imagine themselves in 2 hypothetical situations. Each participant was presented with two scenarios: low risk chest pain and minor traumatic brain injury. Each scenario varied three variables (benefit, risk, and cost) along four values. The benefit of the test was defined as the chance that the patient had a true positive finding on the test requiring medical intervention. The risk of the test was defined as the chance of developing cancer due to ionizing radiation within the next ten years. The cost was an additional out of pocket expense for the test. The survey was pilot tested on medical students and revised based on feedback.

For the benefit and risk variables, the four possible values chosen were 0.1%, 1%, 5%, and 10%. For the cost variable, the four possible values chosen were $0, $100, $500, and $1000. These values were independently randomly distributed amongst respondents, yielding 64 unique scenarios. A subset of the minor traumatic brain injury respondents who had children under the age of 18 were given a similar scenario, requiring them to make diagnostic testing decisions for their child. The survey is available as supplementary material.

Population/Sample Size

Adults were surveyed using Amazon Mechanical Turk (mTURK). Amazon mTurk is a crowdsourced internet marketplace that enables individuals and business to coordinate use of human intelligence to perform specific tasks. Anyone over the age of 18 with internet access was eligible to participate if they met Amazon's vetting requirements as a performer of Human Intelligence Tasks. All 1,000 surveys were completed within 1 day of posting. Each respondent has a unique identifier and account with Amazon and was unable to perform the survey more than once. We provided a reimbursement of $1 for survey completion.

Outcome and Explanatory Variables

The primary outcome measured was whether the patient elected to receive testing under varying levels of benefit, risk, and cost. The following demographic information was collected: age, sex, current marital status, number of minor children, level of education, healthcare worker or not, race, ethnicity, history of cancer, diabetes, hypertension, atrial fibrillation, heart attack, and overall self reported health status on a scale of 1-5.

Human Subjects Protection

This study was reviewed by the University of Michigan Institutional Review board and received a determination as exempt survey research.

Analysis

Univariate associations between accepting a diagnostic test and the test variable (benefit, risk, and cost) were performed. To test for independent associations, each test variable was measured against the lowest value scenario for each category. We fitted multivariable logistic regression models to estimate odds ratios for agreeing to testing while adjusting for the other predictors (simultaneously coming up with an adjusted estimate for benefit, risk, and cost.) Three models for the acceptance of a diagnostic test were created. The first model in our study looked at all respondents-- this included all subjects asked about the scenario of chest pain as well as all subjects to the scenario of minor traumatic brain injury. This model used a generalized estimating equation to account for the two responses between each individual. The second model only looked at those respondents who were asked the chest pain scenario. The third model looked at subjects who were asked about both adult or child minor traumatic brain injury. All process factors for a univariate significance test result with an odds ratio compared to reference of lowest-value scenario were used to find statistical significance. The analytic dataset, with identifiers removed, is archived and available for download at doi:10.7302/Z2FQ9TJK or https://deepblue.lib.umich.edu/data/concern/generic_works/47429913s. We conducted the analysis with SPSS.

Sample Size

We estimated an overall event rate of approximately 50%. With 2000 total responses, this would give us approximately 1000 events. Using the guideline of 10 events per predictor for multivariable regression studies, this would allow for approximately 100 covariates; given our assignment of each predictor as a category we used nine indicator variables.

Results

We received surveys from 1000 unique respondents resulting in 2000 decisions regarding diagnostic testing (each respondent was presented CP and TBI scenarios). The sample was slightly less than half female, with a median age of 33 (Table 1).

The overall proportion of subjects agreeing to the diagnostic test was 39.7% (Table 2). The proportion accepting the test in each of the 64 unique combinations of benefit, risk and cost is provided as figure 1. The first logistic regression model included the combined data from the CP and TBI scenarios. Here, increasing the cost from any value greater than $0, increasing risk from any value greater than 0.1%, were significantly negatively associated with test acceptance. Increasing benefit from any value greater than 0.1% was associated with an increased odds of test acceptance. When increasing the benefit from 0.1% to 10%, the test acceptance proportion increased from 28.4% to 53.1%. [adjusted odds ratio (AOR): 3.42 (2.6-4.5)] As risk increased from 0.1% to 10%, the test acceptance proportion decreased from 52.5% to 28.5%. [AOR: 0.33 (0.3-0.4)]. Increasing cost from $0 to $1000 had the greatest change in test acceptance from 61.1% to 21.4%, respectively. [AOR: 0.15 (0.1-0.2)]

When considering the magnitudes of the associations when the data was split into the TBI and CP subsets, the associations between benefit, risk and cost were generally similar, with one exception. For the minor traumatic brain injury scenario with respondents presented scenarios regarding testing for their children, the proportion accepting the test did not change meaningfully across the presented costs.

Discussion

Cost appeared to be the most influential factor in this survey of the general public regarding hypothetical testing in the emergency department. We found that the benefits, risks, and costs of testing are all important factors that patients consider. When participants realized that a diagnostic test was unlikely to yield actionable results, the majority of subjects declined testing. Additionally, most participants wanted a test when there was no added cost, regardless of benefit or risk levels, but far fewer elected to receive the test as cost increased incrementally. This suggests that out of pocket costs may deter patients from undergoing diagnostic testing with low potential benefit. In addition, we demonstrated that it is feasible to quickly conduct population based surveys using the mTurk online tool. We are unaware of previous reports of the use of mTurk in the emergency medicine literature, however it has been used in numerous other studies. Our findings have informed the starting points for our predictors of benefit, risk and cost for future, in-person interviews in the emergency department.

Limitations

Our work has several important limitations. First, the absolute proportions of people agreeing to testing under the given situations reflect a population who is not seeking medical care at that moment; therefore the relative changes across differing levels of risk, cost, and benefit are likely to be more reliable estimates. These scenarios were designed to mimic real life circumstances. However, the surveys were hypothetical, completed on a computer, which is not reflective of the stressful environment in an emergency department. Therefore, the respondents may have had different mindsets and made different decisions if they were actually presenting emergently to the ED. We also assumed that the emergency physician could confidently and precisely provide the estimated probabilities that the patient had the target condition and the attendant risks of imaging; even correctly declaring cost for self-pay patients is not currently feasible in most U.S. healthcare settings. Patients were not queried to ensure they understood they could die from the target conditions and that the diagnostic testing would likely prevent these deaths. Additionally, there is likely a sample bias in our study, as while real ED patients have made the decision to see an emergency physician for their situation and deal with the financial consequences of their visit, our survey sample may have included participants completely unwilling to visit the ED under any circumstance. These are two very distinct subgroups, the latter of which would be less inclined to receive testing, potentially skewing results. Our hypothetical situations had a potential upfront serious disease (head bleed or heart attack) but a downstream 10 year risk of a radiation induced cancer. An additional limitation is that we did not provide greater detail on the type or seriousness of cancer. The risks presented seem generally higher than what is currently believed to be the risks of radiological testing; however it is also known that very small risks are difficult to understand (i.e. the difference between 1 in 10,000 and 1 in 100,000) and we felt it would be unhelpful to explore very low risk levels. Finally, by using the Amazon platform we collected data from U.S. respondents seeking human intelligence tasks for reimbursement on one particular day; a population less likely to be employed and generally younger than the general emergency department population.

Conclusion

In conclusion, we found that the potential risks, benefits, and costs of diagnostic testing can strongly influence desire for these tests. Future work should focus on the lower ends of benefit, risk, and personal cost as these are most likely to reflect realistic values. In addition, it will be valuable to evaluate the desire for testing in emergency department patients.

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Tables

Table 1: Characteristics of respondents

Characteristic	n (%)
Age in yrs (range)	33 (18-75)
Female sex	451 (45.1)
Have children under 18	276 (27.6)
Marital Status	
Married	386 (38.6)
Divorced	58 (5.8)
Single/never married	534 (53.4)
Separated	10 (1)
Widowed	11 (1.1)
Highest level of Education	
Some high school	5 (0.5)
High school graduate	116 (11.6)
Some college	363 (36.3)
College graduate	419 (41.9)
Post-graduate	97 (9.7)
Works in healthcare	105 (10.5)
Hispanic	77 (7.7)
Race	
Native American	7 (0.7)
African American	72 (7.2)
Caucasian	803 (80.3)
Asian	70 (7)
Other	48 (4.8)
History of cancer	36 (3.6)
History of diabetes	31 (3.1)
History of hypertension	120 (12)
History of atrial fibrillation	27 (2.7)
History of heart attack	8 (0.8)
Self-Reported Overall health	

Excellent	135 (13.5)
Very good	381 (38.1)
Good	353 (35.3)
Fair	106 (10.6)
Poor	25 (2.5)

Table 2: mTURK Results Data

	All respondents		CP		mTBI all		mTBI-adult	mTBI-child
	N=2000 (%)	AOR (CI 95%)	N=1000 (%)	AOR (CI 95%)	N=1000 (%)	AOR (CI 95%)	n=856	n=144
Benefit %								
0.1	142 (28.4)	Reference	67 (26.8)	Reference	75 (30)	Reference	54 (26.9)	21 (42.9)
1	175 (34.8)	1.47 (1.1-2)	89 (35.5)	1.59 (1-2.4)	86 (34.1)	1.39 (0.9-2.1)	75 (33.5)	11 (39.3)
5	212 (42.6)	2.35 (1.8-3.1)	103 (41.5)	2.59 (1.7-3.9)	109 (43.6)	2.19 (1.5-3.3)	94 (42.5)	15 (51.7)
10	265 (53.1)	3.42 (2.6-4.5)	127 (50.6)	3.4 (2-4.6)	138 (55.6)	3.83 (2.7-5.7)	114 (54.3)	24 (63.2)
Risk %								
0.1	262 (52.5)	Reference	132 (52.8)	Reference	130 (52)	Reference	111 (51.2)	19 (57.6)
1	222 (44.5)	0.72 (0.6-0.9)	118 (47.2)	0.75 (0.5-1.1)	104 (41.8)	0.68 (0.5-1)	82 (39.4)	22 (53.7)
5	167 (33.4)	0.44 (0.3-0.6)	72 (28.8)	0.34 (0.2-0.5)	95 (38)	0.54 (0.4-0.8)	79 (35.3)	16 (61.5)
10	143 (28.5)	0.33 (0.3-0.4)	64 (25.6)	0.27 (0.2-0.4)	79 (31.5)	0.41 (0.3-0.6)	65 (31.4)	14 (31.8)
Cost $								
0	306 (61.1)	Reference	153 (61.2)	Reference	153 (61)	Reference	134 (61.2)	19 (59.4)
100	233 (46.6)	0.54 (0.4-0.7)	116 (46.2)	0.51 (0.4-0.8)	117 (47)	0.58 (0.4-0.9)	99 (46)	18 (52.9)
500	148 (29.6)	0.25 (0.2-0.3)	66 (26.4)	0.21 (0.1-0.3)	82 (32.8)	0.29 (0.2-0.4)	65 (31.1)	17 (41.5)
1000	107 (21.4)	0.15 (0.1-0.2)	51 (20.5)	0.14 (0.1-0.2)	56 (22.4)	0.16 (0.1-0.2)	39 (18.3)	17 (45.9)
Total	794 (39.7)		386 (38.6)		408 (40.8)		337 (39.4)	71 (49.3)

Abbreviations are as follows: CI, confidence interval; CP, chest pain scenario; n, number of respondents; AOR, adjusted odds ratio. Note for a given row (i.e. benefit of 10%) the absolute proportion accepting the test includes subjects with the full range of the other predictors (risk and cost). See the figure for the absolute proportion accepting the test in each of the 64 discrete situations.

Figure 1: mTURK Results