The Effect of Financial Incentives on Patient Decisions to Undergo Low-Value Head CT Scans

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Abstract

Background

Excessive diagnostic testing and defensive medicine contribute to billions of dollars in avoidable costs in the US annually. Our objective was to determine the influence of financial incentives, accompanied with information regarding test risk and benefit, on patient preference for diagnostic testing.

Methods

We conducted a cross-sectional survey of patients at the University of Michigan Emergency Department (ED). Each participant was presented with a hypothetical scenario involving an ED visit following minor traumatic brain injury. Participants were given information regarding potential benefit (detecting brain hemorrhage) and risk (developing cancer) of head CT scan, as well as an incentive of $0 or $100 to forego testing. We used 0.1% and 1% for test benefit and risk, and values for risk, benefit, and financial incentive varied across participants. Our primary outcome was patient preference to undergo testing. We also collected demographic and numeracy information. Then, we used logistic regression to estimate odds ratios, which were adjusted for multiple potential confounders. Our sample size was designed to find at least 300 events (preference for testing) to allow for inclusion of up to 30 covariates in fully adjusted models. We had 85-90% power to detect a 10% absolute difference in testing rate across groups, assuming a 95% significance level.

Results

We surveyed 913 patients. Increasing test benefit from 0.1% to 1% significantly increased test acceptance (adjusted Odds Ratio [AOR] 1.6; 95% Confidence Interval [CI] 1.2-2.1) and increasing test risk from 0.1% to 1% significantly decreased test acceptance (AOR 0.70; 95% CI 0.52-0.93). Finally, a $100 incentive to forego low-value testing significantly reduced test acceptance (AOR 0.6; 95% CI 0.4-0.8).

Conclusions

Providing financial incentives to forego testing significantly decreased patient preference for testing, even when accounting for test benefit and risk. This work is preliminary, hypothetical, and requires confirmation in larger patient cohorts facing these actual decisions.

Main Manuscript

Introduction

Excessive unnecessary diagnostic testing incurs tremendous costs to the healthcare system. With estimated total defensive medicine costs reaching $46 billion in the US in 2008 alone, reducing the amount of unnecessary diagnostic tests is critical to mitigating rising healthcare costs.[1] Head computed tomography (CT) scans are diagnostic tests that provide significant clinical utility when indicated, but they are often used against established clinical guidelines in situations of minor injury. Previous reports suggest that a third of head CT scans are avoidable by applying the Canadian CT Head Rule.[2] Furthermore, head CT scans expose patients to harmful radiation that is linked to an increased cancer risk.[3]

An evidence-based medicine approach is useful for avoiding diagnostic testing that is unlikely to benefit patients; however, determining what constitutes a low-value test is challenging, as the value of a given test can vary across individual patients.[4] Factors such as low health literacy, cultural power imbalances, or detachment from the medical decision-making process can all contribute to patients' hesitancy to make their concerns about testing known.[4,5] Nevertheless, it is important to engage patients to consider the benefits and risks of diagnostic testing, particularly when a test may be of low clinical value. Previous work performed by the authors of this study suggests that, when presented with a hypothetical scenario of minor traumatic brain injury (mTBI) and asked for their preferences regarding pursuing a diagnostic head CT scan, patients were most strongly deterred by increasing personal financial test cost.[6,7]

This study seeks to examine the effect, if any, that a direct financial incentive to forego a low-value diagnostic head CT scan has on patients' preferences to undergo testing in a hypothetical mTBI scenario where numerical information regarding test benefit and risk is also provided. While there is evidence to suggest that patients are financially motivated when making decisions regarding their medical care, how patients respond to payments incentivizing healthy behaviors and decisions remains highly controversial.[6-10] We hypothesized, consistent with the results of our previous study, that patients will be significantly deterred from accepting a low-value head CT scan when a financial incentive to forego low-value testing is applied, whereas test risk and benefit will not have a statistically significant effect.[7]

Methods

Overview

This is a cross-sectional survey of a convenience sample of patients from the University of Michigan Emergency Department exploring the effect that varying levels of benefit, risk, and financial incentives associated with diagnostic testing have on patients' willingness to undergo testing.

Study Design

We presented participants with a hypothetical clinical scenario in which they presented to the Emergency Department (ED) following mTBI. The full scenario can be found in Appendix A. The scenarios represented low-risk injury that would not indicate obtaining a head CT scan on the basis of the Canadian CT Head Rule. Each participant also was presented with a chest pain scenario, which will be reported in a separate scientific report.

The order of receiving the chest pain or mTBI scenario was randomized, and the participants received a distinct random set of benefits, risks, and incentives for each scenario.

After consent was obtained, a script of the scenario was read aloud to all participants to limit possible issues they might have with reading, seeing, or comprehending the scenario. Participants were then asked if they would elect to receive a diagnostic head CT scan, given different levels of benefit (the chance that the head CT scan accurately detects a life-threatening brain hemorrhage), risk (the chance of developing cancer within 10 years due to ionizing radiation from the head CT scan), and incentive (a cash payment from their insurance company to forego low-value testing).

Each participant was randomly assigned a value for benefit (0.1% or 1%), risk (0.1% or 1%), and incentive ($0 or $100) associated with a head CT scan. Participants were provided with percentages (0.1% or 1%), ratios (1 in 100 or 1 in 1000), and visual depictions (Appendix A) of risk and benefit values to improve comprehension.[11,12] These values were previously used in an earlier study performed by the authors and were originally selected based on a separate preliminary study performed by the authors, as these values for risk, benefit, and cost were thought to represent the most interesting zone of variation in patients' preferences for diagnostic testing.[6,7] Additionally, values of 0.1% and 1% represent plausible benefit and risk probabilities associated with diagnostic head CT scans following situations of minor head trauma.[13]

Setting and Population

The population for this study was a convenience sample of patients at the University of Michigan Emergency Department. We recruited 913 total patients age 18 or older between May and July 2016. Patients that were presenting with chest pain, recent head trauma, or altered mental status were not approached. We did not approach patients with contact precautions or in resuscitation bays. Participants were not offered any compensation for participating in our study, and participation was completely voluntary.

Human Subjects Protection

The University of Michigan Institutional Review Board reviewed this study and determined it to be exempt survey research.

Primary Outcomes and Variables

The primary outcome for this study was the percentage of patients electing to receive a head CT scan given three major predictive variables: benefit, risk, and financial incentive. There were eight total subgroups of respondents, given that each of these three variables had two possible values.

We collected the following de-identified demographic and medical information to assess for potential confounders: age, gender, marital status, educational status, race, ethnicity, prior medical training or employment, self-reported overall health, income, and a past medical history of cancer, hypertension, diabetes, atrial fibrillation, myocardial infarction, or head trauma requiring a hospital visit. In addition, we administered a previously validated numeracy assessment to classify participants as having low, medium, or high numeracy.[14]

Data Collection

Qualtrics was used for survey administration and data collection, and SPSS (Armonk, NY Version 25) was used for data analysis. We included any participant response in which the primary outcome was collected. We compared the unadjusted proportion of respondents electing to receive a head CT scan for each combination of values for benefit, risk, and financial incentive.

Sample Size

We followed the methodology we previously reported in 2018 in the work focusing on an additional copayment for a diagnostic test.[7] Briefly, our sample size of 913 was feasible for our workforce (medical students conducting summer research) to recruit, and it conferred approximately 85-90% power to detect a 10% absolute change in the proportion of subjects desiring testing from a baseline test acceptance rate of 50% at a 95% level of significance.[6]

Data Analysis

Next, we performed a series of nested multivariable logistic regression models to obtain the odds that participants would agree to receive a head CT scan, given these variable combinations. We selected four sets of variables to adjust for in the models, and all variables were specified in advance so that they would be included regardless of their significance. Sets of variables were ordered based on what we hypothesized would be most influential, with potentially more influential variables incorporated into earlier models. The fully adjusted model was limited to at most 30 variables, using a guideline of 10 outcome events per predictor. Model 1 adjusts for the benefit, risk, and financial incentive associated with testing. Model 2 additionally adjusts for income, education level, and numeracy. Model 3 additionally adjusts for age, gender, race, ethnicity, and previous healthcare training/employment. Finally, Model 4 additionally adjusts for self-reported overall health and a medical history of cancer, hypertension, diabetes, atrial fibrillation, myocardial infarction, or head trauma requiring a hospital visit. We evaluated model fit by examining the Hosmer and Lemeshow Goodness of Fit Statistic with a p value of >0.05 indicating adequate fit. In accordance with the instructions for SPSS, we fit linear regression models with indicator variables to assess for multicollinearity, with a variance inflation factor below 10 indicating a lack of meaningful multicollinearity.

The deidentified dataset, along with the model output (which includes all parameter estimates for the fully adjusted models, goodness of fit statistics, and multicollinearity diagnostics) is posted in the University of Michigan Institutional Data Repository (link pending).

Results

In total, 913 patients met inclusion criteria and completed the primary outcome portion of the survey. All of these participants' results were included in the analysis. Demographic and medical participant characteristics are displayed in Table 1. The median participant age for this study was 45 years (interquartile range 30-60), with an absolute range of 18-92 years. Patient preferences by group – representing the eight possible combinations of risk, benefit, and incentive – are shown in Table 2.

Patients elected to receive a head CT scan in 54.2% of scenarios (495 out of 913 surveyed). In the unadjusted analysis, decreased benefit, increased risk, and a financial incentive were all associated with a statistically significant decrease in odds of test acceptance (Table 3). Furthermore, the overall pattern of test acceptance in each of the adjusted regression models was similar to the unadjusted analysis in that decreased benefit, increased risk, and offering a $100 financial incentive deterred participants from accepting a head CT scan (Table 4). This similarity suggests that none of the variables present in the models 2, 3, or 4 acted as confounders influencing the observed effect of the major predictive variables on test acceptance.

Fully adjusted models (Table 4) demonstrated that patients' odds of accepting a head CT scan was significantly lower when offered a $100 incentive to forego testing versus when there was no incentive (adjusted OR [AOR] 0.59; 95%; Confidence Interval [CI] 0.44-0.79). There was a statistically significant increase in odds of test acceptance with increasing test benefit from 0.1% to 1% (AOR 1.58; 95% CI 1.18-2.13) and a significant decrease in odds of test acceptance with increased test risk from 0.1% to 1% (AOR 0.70; 95% CI 0.52-0.93).

Discussion

Our study examined the effect of test benefit, test risk, and financial incentives on patient preferences regarding pursuing low-value diagnostic testing with head CT scan in the ED. In this cross-sectional convenience sample, we found that decreased benefit, increased risk, and offering a financial incentive all significantly deterred participants from accepting low-value diagnostic testing. These findings are applicable to both healthcare providers and payers. For example, these results indicate that discussing benefits and risks of low-value diagnostic testing via head CT scan with patients, even when absolute benefit or risk is very low, may impact patients' decision-making.

Furthermore, implementation of a cash incentive to forego unnecessary diagnostic testing may prove to be a successful method to decrease healthcare costs for ED patients. Future studies involving other diagnostic tests may shed light on the generalizability of this effect across a variety of clinical situations.

This research was a follow-up to a similar published study in which we evaluated the influence of benefit, risk, and out-of-pocket cost on patient preference for low-value diagnostic testing in the context of mTBI.[11] Both of these studies have shown a trend of decreased test acceptance with decreased test benefit and increased test risk. Furthermore, both approaches to financial intervention – increasing cost to patients versus offering an incentive – were effective in decreasing test acceptance. In the current study, there was a 9.3% drop in test acceptance (58.9% to 49.6%) with decreased test benefit, a 10.2% drop (59.3% to 49.1%) with increased risk, and a 11.7% drop (60.0% to 48.3%) with a financial incentive. In the 2018 work, a subset of parents with children received a modified scenario where they were asked to decide on testing for a child with mTBI. From this study, in the cohort of adults deciding on testing for themselves, there was a 6.2% drop (67.0% to 60.8%) in head CT scan acceptance with decreased benefit, a 3.0% drop (65.5% to 62.5%) with increased risk, and a 17.4% drop (72.9% to 55.5%) with increased cost to the patient. However, in contrast with our current study, the effects of variable test risk and benefit failed to reach statistical significance in the prior study, which may be attributable to variation between the data sets and about a 12% smaller sample size in the prior work. Examination of the findings of both studies in parallel suggests that financial measures may serve as a more effective deterrent against patient preference for diagnostic testing than discussing risks and benefits of testing, although further investigation is required to better characterize these effects.

Limitations

Our study has several limitations that should be taken into consideration while interpreting our results. Importantly, although participants were patients in the ED, the survey consisted of hypothetical scenarios – patients presenting with an acute medical problem may make decisions differently. Also, the true benefit and risk of a diagnostic test varies substantially across patients based on their individual traits and clinical presentations, and it would be unlikely that patients could be provided with an exact numeric representation of their individual test risk and benefit. Participants in our study may also have incorporated their own perception of risk for brain hemorrhage in the context of mTBI, although our study instructions clearly indicated that participants should disregard their known medical comorbidities and that the numeric benefit and risk provided in the scenario accounted for their specific risk factors. For example, patients on anticoagulation therapy may have been told in the past that they should always receive a diagnostic head CT scan, even in the event of minor trauma, whereas in our study such patients could be assigned a 0.1% expected chance of a serious intracranial injury. Furthermore, in our study we contrasted the benefit of detecting an immediate medical condition (brain hemorrhage) against the risk of acquiring another medical condition (cancer) several years in the future. The difference in time of onset for benefit and risk may have affected participants' preferences. In addition, the true risks of CT scans are likely lower than the 0.1% and 1% assigned in these scenarios; however, had we used much smaller risks, we would not have had symmetry with the values for potential benefit. Another potential limitation of our study is that 25% of participants reported working in a healthcare environment. While this encompassed many professions (full list in Appendix A) and was not unexpected for our usual ED population, it is possible that increased medical knowledge or experience could have influenced survey responses for some of these participants. Finally, the role of a financial incentive as a deterrent against diagnostic testing described in this study is restricted to the survey scenario – a low-risk, low-value test. Patients may respond differently to a financial incentive applied to another diagnostic test. Factors such as familiarity with the diagnostic test, perception of the importance of potential medical conditions that could be detected, and understanding the implications of future risk may all influence patient preference.

Conclusions

This cross-sectional survey of patients in the ED suggests that a direct financial incentive is an effective deterrent against patient preference for low-value diagnostic testing in the context of mTBI. While we also found that decreased potential benefit and increased risk associated with testing reduced patient preference for head CT scan, consideration of our results in conjunction with findings in a previous published work by the authors suggests that financial factors may be more influential to patients than estimates of test benefit and risk in scenarios where testing is considered to be of low value. Further study of the impact of financial incentives on patient decision-making across other clinical scenarios and in non-hypothetical patient situations is needed to better describe this relationship.

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Table 1: Characteristics of Study Participants (N = 913)

Characteristic	% (n)
Age, years	
18-25	16% (146)
26-40	23.1% (211)
41-55	25.6% (234)
56-65	15.0% (137)
66-75	10.7% (98)
> 76	5.1% (47)
Unreported	4.4% (40)
Sex	
Male	39.6% (362)
Female	56.1% (512)
Other/Transgender	0.1% (1)
Unreported	4.1% (38)
Marital status	
Married	49.8% (455)
Divorced	7.6% (69)
Single/never married	32.0% (292)
Separated	1.2% (11)
Widowed	5.0% (46)
Unreported	4.4% (40)
Highest level of education	
Some high school	3.9% (36)
High school graduate	15.4% (141)
Some college	31.5% (288)
College graduate	26.4% (241)
Post-graduate	16.1% (147)
Unreported	6.6% (60)
Works in healthcare	24.5% (224)
Hispanic	5.3% (48)
Race	
American Indian/Alaska Native	0.5% (5)
African American	12.0% (110)
Caucasian	77.1% (704)
Asian	2.1% (19)
Native Hawaiian/Pacific Islander	0.2% (2)

Other	2.0% (18)
Prefer not to disclose/Unreported	6.0% (55)
History of cancer	13.2% (120)
History of diabetes	15.1% (137)
History of hypertension	29.2% (264)
History of atrial fibrillation	7.7% (70)
History of heart attack	5.0% (45)
History of head injury requiring ED visit	20.5% (184)
Self-reported overall health	
Excellent	10.6% (97)
Very good	26.2% (239)
Good	28.3% (258)
Fair	18.4% (168)
Poor	9.1% (83)
Unreported	7.5% (68)
Household income level	
Less than $10,000	5.1% (47)
$10,000 – $14,999	2.8% (26)
$15,000 – $24,999	3.6% (33)
$25,000 – $34,999	7.3% (67)
$35,000 – $49,999	6.0% (55)
$50,000 – $74,999	9.7% (89)
$75,000 – $99,999	7.4% (68)
$100,000 – $149,999	10.0% (91)
$150,000 – $199,999	3.2% (29)
$200,000 or more	5.4% (49)
Unreported/Prefer not to disclose	39.3% (359)

Table 2: Patient Preferences by Subgroup

Incentive = $0

		Risk	
		0.1%	**1%**
Benefit	**0.1%**	Accept Test: 59.7% (71 of 119)	Accept Test: 48.5% (50 of 103)
	1%	Accept Test: 70% (84 of 120)	Accept Test: 60.3% (70 of 116)

Incentive = $100

		Risk	
		0.1%	**1%**
Benefit	**0.1%**	Accept Test: 46.2% (54 of 117)	Accept Test: 43.6% (51 of 117)

Table 3: Unadjusted Patient Preferences[*]

	N = 913 % (n) accepting test
Benefit	
0.1% (ref)	49.6% (226)
1%	58.9% (269)
OR (CI 95%)	1.471 (1.128-1.917)
Risk	
0.1% (ref)	59.3% (271)
1%	49.1% (224)
OR (CI 95%)	0.661 (0.507-0.861)
Incentive	
$0 (ref)	60.0% (275)
$100	48.3% (220)
OR (CI 95%)	0.636 (0.488-0.828)
Total	54.2% (495)

[*] OR = odds ratio; CI = confidence interval
All odds ratios are unadjusted

Table 4: Nested Logistic Regression Model*

	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)	Model 4 AOR (95% CI)
Benefit (1% vs. 0.1%)	1.47 (1.13-1.91)	1.46 (1.10-1.94)	1.48 (1.11-1.98)	1.58 (1.18-2.13)
Risk (1% vs. 0.1%)	0.66 (0.51-0.86)	0.71 (0.53-0.94)	0.70 (0.53-0.93)	0.70 (0.52-0.93)
Incentive ($100 vs $0)	0.64 (0.49-0.82)	0.61 (0.46-0.82)	0.61 (0.46-0.81)	0.59 (0.44-0.79)

* Model 1 adjusts for benefit, risk, and incentive associated with testing. Model 2 additionally adjusts for income, education level, and numeracy. Model 3 additionally adjusts for age, gender, race, ethnicity, and previous healthcare training or employment. Model 4 additionally adjusts for self-reported overall health and a medical history of cancer, hypertension, diabetes, atrial fibrillation, myocardial infarction, and head trauma requiring hospital visit. Hosmer and Lemeshow Goodness of Fit p-value ranged from 0.8 to 0.2, indicating that model fit was adequate. Variance inflation factors for each included variable ranged from 1 to 1.4 (with values less than 10 indicating a lack of meaningful multicollinearity). AOR = adjusted odds ratio; CI = confidence interval.