Predicting prostate cancer treatment choices: The role of numeracy, time discounting, and risk attitudes

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Abstract

Prostate cancer is the most common cancer among males in the United States and there is lack of consensus as to whether active surveillance (AS) or radical prostatectomy (RP) is the best course of treatment. In this study we examined the role of three overlooked determinants of decision making about prostate cancer treatment in a hypothetical experiment—numeracy, time discounting, and risk taking in 279 men over age 50 without a prior prostate cancer diagnosis. Results showed that AS was the most frequently chosen option. Furthermore, numeracy and time discounting significantly predicted participants' preference for AS, whereas a propensity to take risks was associated with a preference for RP. Such insights into the factors that affects cancer treatment preferences may improve tailored decision aids and help physicians be better poised to engage in shared decision-making to improve both patient-reported and clinical outcomes.

Keywords: treatment decision making; numeracy; prostate cancer; risk taking; time discounting.

Introduction

Prostate cancer is the most common cancer among U.S. men (Centers for Disease Control and Prevention, 2014), with an estimated 233,000 diagnosed cases and 30,000 deaths in 2014 (National Cancer Institute, 2014). There is little agreement among oncologists about the best course of treatment (Moyer & U.S. Preventive Services Task Force, 2012). Indeed, for the majority of men who have low-risk stage 1 (also called localized) prostate cancer, the two most common options—active surveillance (AS) and radical prostatectomy (RP)—have equivalent survival rates over a period of 12 years (Wilt et al., 2012). Yet, the two treatments have drastically different trade-offs (Bill-Axelson et al., 2011). Men with localized prostate cancer are faced, therefore, with the difficult question of which treatment to pursue.

Both approaches have potential benefits and risks that could influence a man's decision about which course of treatment to pursue and, consequently, his quality of life (Catalona et al., 2012). AS may involve more prostate biopsies, which can have short-term side effects such as transitory urinary incontinency (Moyer & U.S. Preventive Services Task Force, 2012). Furthermore, as AS does not involve the elimination of the tumour, it may carry the risk that it may grow more quickly than expected and become more difficult to treat later (Wilt et al., 2012). These two concerns can increase anxiety among men about their cancer status changing (Catalona et al., 2012). RP, on the other hand, reduces the possibility of future cancer growth but has notable shortcomings: About 20% of patients who undergo RP suffer from urinary incontinence (Wilt et al., 2012), and close to 60% suffer from erectile dysfunction (Boorjian et al., 2011).

Given the complexity of the treatment choices, the American Cancer Society recommends men should engage in a shared decision-making process (Aning, Wassersug, & Goldenberg, 2012) in which clinicians and patients share the best available evidence, and patients are encouraged to consider their options and arrive at their own informed preferences

(Elwyn et al., 2012). Research on prostate cancer treatment decisions has revealed that patients have misconceptions about the benefits and risks of the options they face (Beydoun et al., 2010). Prior evidence suggests that 98% of patients who chose the surgery option thought it was a guaranteed cure (Hall, Boyd, Lippert, & Theodorescu, 2003). Further, men with a higher likelihood of prostate cancer frequently misperceive their own risk, even when provided with tailored decision aids (Watts et al., 2014).

Factors that may affect patients' decision making

One vital question is what patient-level psychological factors contribute to the variation in treatment choices. Being able to make a treatment decision, such as whether to choose AS or RP, may be affected by patient's level of anxiety, his marital status, the influence of his urologist, or the use of internet to gather information about the illness or risk and benefits of the treatments (e.g., Berry et al., 2006). Additionally, one of potentially important predictor of prostate cancer treatment choice is numeracy, which refers to a person's ability to process and understand numerical information (Rudd, Colton, & Schacht, 2000). Numeracy has the potential to affect a variety of important outcomes ranging from health decision making to adherence to therapy (Reyna et al., 2009). Much of the research on the relationship between numeracy and medical decision making has been conducted with breast cancer patients, where it has been shown that less numerate women have more difficulties correctly interpreting survival and risk information (Dillard, McCaul, Kelso, & Klein, 2006); they tend to express greater confusion about treatment results (Lipkus, Peters, Kimmick, Liotcheva, & Marcom, 2010); and they are more likely to overestimate the benefit of screening (Schwartz, Woloshin, Black, & Welch, 1997). Of particular importance to trade-offs between AS and PR, numeracy relates to the ability to assess risk magnitude, compare risks, and understand probabilities—information that plays a part in the decision-making process (Burkell, 2004). In fact, Reyna, Nelson, Han, and Dieckmann (2009) argued that

numeracy is crucial in those medical contexts where the decision-making process is shared between the practitioner and the patient, as may be the case for localized prostate cancer treatment.

In addition to numeracy, time discounting is another crucial determinant of treatment choices and, therefore, it may also play a pivotal role in localized prostate cancer treatment decisions. Time discounting refers to decisions involving trade-offs among costs and benefits at now versus later (Frederick, Loewestein, & O'Donoghue, 2002, p. 351). In the context of health, time discounting refers to preference for smaller, more immediate vs. larger, more distant health benefits (Frederick, Loewenstein, & O'Donoghue, 2002; Khwaja, Silverman, & Sloan, 2007;Frederick et al., 2002). Higher discount rates have been linked to impulsive decision making (Wittmann & Paulus, 2008), which may lead to an overestimation of both risks and benefits in the decision-making process (Zimmermann, 2010). Earlier examinations of time discounting have mainly focused on risky health behaviours (Bradford, 2010). For instance, investigations focusing on smoking suggested that people with higher discount rates are more likely to smoke (Mitchell, 1999). A study using the Health and Retirement Survey data from the United States has shown that those who exhibit higher discounting rates are also less likely to undergo mammography or prostate cancer screening (Bradford, 2009). Given that patients who are considering AS and RP have to evaluate the time trade-off between the two options (i.e., RP offers an immediate treatment and, potentially, more immediate consequences, whereas AS relies on delay taking action), we expected that time discounting may play a role in patients' decision to opt for AS or undergo RP.

Differences in the decision-making processes that involve risk and uncertainty may also emerge from individual differences in risk attitude (Blais & Weber, 2006). Tendencies to engage in a risky behaviour or treatments—for example, smoking or undergoing knee

replacement surgery to treat arthritis—depend on a person's willingness to bear the risk of an uncertain or potentially harmful outcome (Butler et al., 2012). As such, willingness to pursue one localized prostate cancer treatment option over another might depend on a patient's risk attitude towards the potential health and quality of life benefits and consequences each decision confers. Despite the potential importance of numeracy, time discounting and risk attitudes evaluating trade-offs (Blais & Weber, 2006; Reyna et al., 2009; Zimmerman, 2010), there is a lack of data on how these factors relate to localized prostate cancer treatment decisions.

The Present Research

This study was designed to examine whether numeracy, time discounting and risk attitudes might help distinguish between men who opt for AS and men who decide to undergo RP in a hypothetical experiment. The use of similar hypothetical scenarios is a methodology that has been used successfully in previous literature on medical decision making (e.g., Fagerlin, Zikmun-Fisher, & Ubel, 2005; Gavaruzzi, Lotto, Rumiati, & Fagerlin, 2011). We hypothesized that high-numeracy individuals would choose AS more often as their preferred treatment option. We believe that higher numeracy individuals would choose AS for two main reasons. First, higher numeracy is associated with better comprehension of lifetime risk of developing prostate cancer (Rolison, Hanoch, & Miron-Shatz, 2012). Secondly, it has been shown (Peters, Västfjäll, Slovic, Mertz, Mazzocco, & Dickert, 2006) that low numeracy individuals are more likely to be swayed by affective factors, in our case knowledge that they have cancer. Our second hypothesis was that high discount rates would prefer to delay treatment choices and would be more likely to choose AS as their preferred treatment option. In this regard, we expected that people high in time discounting would place more decision weight on avoiding RP as it offers more immediate consequences (i.e., surgery, erectile dysfunction) and more distant benefits (i.e., cancer survival), whereas AS

relies on more immediate benefits (i.e., avoiding surgery) and more distant consequences (i.e., potential for the cancer to spread). Finally, as the mortality risks of AS and RP are equivalent but morbidity risks vary substantially, we remained agnostic about the relationship between risk attitudes and participants' choices.

Methods

Participants

Participants (n=277) who were male, age 50 and older, and without a prostate cancer diagnosis were recruited from Amazon Mechanical Turk (https://requester.mturk.com/) and received a token payment of 0.25 U.S. dollars. The reliability of the Amazon Mechanical Turk participant sample has been validated elsewhere by comparisons with other samples and recruitment methods (Mason & Suri, 2012).

Materials

Treatment option. To examine treatment preference, participants read a short scenario that provided them with general information about prostate cancer, such as its prevalence in the population, mortality rates, and that there is no one treatment option for low-risk (localized) prostate cancer (see Appendix 1). They were then provided with more in-depth information about two treatment options: AS and RP. The information about each treatment option included data on the possible risks and benefits. Next, they were told that recent studies have found similar mortality rate for the two treatment options. After reading the scenario, participants were asked to imagine that they had been diagnosed with prostate cancer and to indicate which of the two treatment options they would prefer. To mitigate recency and primacy effects, the presentation of the information was counterbalanced, such that half of the participants read about AS first and half of the participants read about RP first.

Information about prostate cancer and treatment options was taken from the National Cancer Institute website.

Numeracy. Respondents completed four items from a validated objective numeracy measure (Lipkus, Samsa, & Rimer, 2001), which examines individuals' capacity to solve basic probability and ratio problems. These numeracy questions have been used in multiple studies, across diverse populations, and in multiple medical-decision-making domains. Its psychometric properties are well established. Questions were scored as either correct (coded "1") or incorrect (coded "0"). We combined the scores for the four questions and treated the overall numeracy scores as a continuous variable (range from 0 to 4).

Time discounting. To evaluate time discounting, participants were asked four questions about preferences for winning and losing various amounts of money now vs. year from now (i.e., win $20 vs. $30, lose $20 vs. $30, win $1,000 vs. $1,500, lose $1,000 vs. $1,500). The questions were taken from a study by Khwaja et al. (2007) where this measure was validated in predicting risky health behaviors. The time discounting measure was constructed by summing the responses where individuals preferred smaller, more immediate winnings and larger, more distant losses across the four questions. Individuals who reported they would rather win less money now and lose more money later were considered to have higher discount rates and thus higher scores on this 0–4 scale.

Risk attitudes. Participants also responded to items from the Domain-Specific Risk-Taking Scale (DOSPERT; Blais & Weber, 2006) to assess their risk attitudes. The survey included only three of the DOSPERT's five domains (i.e., health, investment, and gambling). We only included the three domains that previous literature linked with medical decision-making (e.g., Rosman, Garcia, Lee, Butler & Schwartz, 2013). For each item in a domain, participants indicated their likelihood of engaging in the risky activity (e.g., riding a bicycle without a helmet in the health domain, betting a day's income in the gambling domain,

investing 10% of their income in a speculative stock in the investment domain). All responses were on a 7-point Likert scale ranging from 1 (*extremely unlikely*) to 7 (*extremely likely*), where higher values indicated greater risk taking. Responses were averaged across questions in each of the three domains.

Procedure

First, participants completed a simple demographic questionnaire. They then read the information about prostate cancer and the benefits and risks associated with AS and RP. Next, participants were asked to imagine that *they* had been diagnosed with prostate cancer and were asked to choose either AS or RP as a treatment. Finally, participants were asked if they had been tested for prostate cancer as well as the numeracy, time discounting, and risk attitude assessments.

Statistical Approach

Univariate statistics were used to describe the sample. Bivariate associations between choosing AS vs. RP and demographics were assessed using Chi-square tests. Adjusted associations of treatment choices were examined using logistic regression, where 1 indicated choosing RP and 0 indicated choosing AS.

Results

Sample Characteristics

By design, all participants were male. Most participants chose AS (80%) over RP (20%) (Table 1). Concerning education, 11% had finished high school, 27% had obtained an associate's degree, 48% a bachelor's degree, and 14% a master's or doctorate degree. Regarding race and ethnicity, 80% were Caucasian, 8% were Latin-American and 12% were African-American. Participants ranged in age from 50–76 years (mean 56.22; *SD* = 5.46). Forty-nine percent of participants reported having undergone prostate cancer screening in the past.

[INSERT TABLE 1 HERE]

Associations of Treatment Choice, Education, and Prior Screening

Next, we tested whether education level influenced the choice of treatment. The results showed that there were no differences in treatment choice among the different education levels, $\chi^2_{(6)} = 6.68$, $p = .36$. Having been screened for prostate cancer was also found to have no effect, such that participants who had been tested (79% who chose AS vs. 21% who chose RP) and those who had not (82% who chose AS vs. 18% who chose RP) made similar treatment decisions, $\chi^2_{(1)} = .57$, $p = .55$.

Associations of Treatment Choice, Numeracy, Time Discounting, and Risk Attitudes

As there were no unadjusted differences in the treatment choice and demographics, these variables were not included in the regression analysis. Thus, the adjusted logistic regression model presented below included only numeracy, time discounting, and the three risk domains of the DOSPERT.

[INSERT TABLE 2 HERE]

Our adjusted results found that more numerate individuals were less likely to choose RP over AS compared to those with low numeracy skills (Table 2). Each one-point increase on the numeracy scale was associated with 0.663 times the odds of choosing RP ($p < .05$). Time discounting was also negatively associated with the odds of choosing RP over AS such that each one-point increase in preference for smaller, more immediate gains and larger, less immediate losses was associated with 0.683 times the odds of choosing RP ($p < .05$). Conversely, the propensity to engage in risky gambling behaviours was positively associated with the odds of choosing RP in that each one-point increase in risk taking in the gambling domain was associated with 1.103 times the odds of choosing RP ($p < .05$).

Discussion

More men are being diagnosed with localized prostate cancer and the American Urological Association (Thompson et al., 2007) has recommended that these patients be informed about the treatment options available to them. Men diagnosed with localized prostate cancer are thus faced with a very difficult dilemma: which option to pursue. Although some earlier studies explored patients' reasons for choosing one option over the other (e.g., Anandadas et al., 2010; Bekker-Grob et al., 2013), there is a paucity of empirical data on the psychological variables that may explain these decisions (Watts et al., 2014).

Results from our study showed that numeracy was one of the main predictors of participants' treatment choices. In line with our hypothesis, high-numeracy individuals were significantly more likely to opt for AS than RP. This may be due to the way highly numerate individuals interpret the risk and benefits associated with each option. Our data, thus, provide further support to a growing corpus of evidence highlighting the vital role numeracy plays in a wide range of health and medical decision-making. Indeed, while earlier investigations focused on the link between numeracy and understanding risk information and screening decisions, especially concerning breast cancer, our findings, along with Lipkus et al.'s (2001) work, show that numeracy plays an important role in prostate cancer treatment decisions. Although we did not find an effect of education, it is possible the high level of education in our sample attenuates these effects. Future research should investigate the link between numeracy, education, and treatment choices further.

Concerning time discounting, our results demonstrated the predicted trend: individuals with higher discount rates were more likely to choose AS. Given that one of the key features of RP is the uncertain mortality benefit and the high-probability risks of the surgery (i.e., incontinence and impotence), it is likely than those who are more present oriented would want to avoid such risks unless it is necessary to reduce mortality (Frederick

et al, 2002). Similarly, earlier studies investigating prostate cancer screening found that higher time discounting was associated with lower screening likelihood (Bradford, 2009).

Finally, we found evidence that risk taking in the gambling domain, but not in the investment or health domain, was associated with a preference for RP. Prosser and Wittenberg (2007) had similar findings reporting that individuals tend to be risk neutral in the health domain. In contrast, however, Prosser, Kuntz, Bar-Or, and Weinstein (2002), reported that risk attitude was associated with treatment choice for patients with multiple sclerosis, such that more-risk-seeking individuals were less likely to choose to be treated. However, the two treatment options for prostate cancer differ substantially from those for multiple sclerosis. In our study, the treatments presented to our participants have similar mortality risk but present different morbidity risks.

The present study has several notable limitations. First, our sample was one of convenience and it is difficult to make valid generalizations to the treatment decisions of clinical population at risk for prostate cancer. For instance, our data revealed that the majority (80%) of participants would opt for active surveillance. Conversely, a study by Anandadas et al. (2010) with prostate cancer patients found that only 8% chose AS as their preferred option, and Cooperberg et al. (2007) found that RP seemed to be the most preferred option. Supporting our findings, however, Bekker-Grob et al. (2013) found that a similar percentage of men would choose AS. In fact, 77% of the urologists in their study and 76% of patients without anxious/depressed feelings chose AS as their preferred option. Furthermore, a U.S. National Institutes of Health Consensus and State-of the-Science panel argued that AS should be offered to men with low-risk prostate cancer (Penson, 2012). It is possible, thus, that the rate of men opting for AS might increase.

Second, our study was hypothetical in nature; however, participants did not differ in their hypothetical treatment choice and actual screening history. Future studies should

examine the role of numeracy, time discounting, and risk taking in the clinical setting prior to screening and after diagnosis to establish their relationship to actual treatment decision. We did not, furthermore, present participants with the entire spectrum of treatment options currently available. One rationale for this restriction rests on the fact the Wilt et al.'s (2012) work focused on comparing survival rates of only two options. Indeed, deciding which option to pursue is a far more complex process and involves more information than we could present in this study. Despite these limitations, our study allowed us to examine, for the first time to our knowledge, the role of numeracy, risk taking, and time discounting in men's decisions about prostate cancer treatment.

Our results also provide important insights about the factors that might affect men's treatment preferences. We found some evidence of an influence of discount rates and gambling risk attitudes in treatment decisions but more studies are needed before determining whether clinicians should address these patient-level factors. However, our findings could have important implications for the design of decision aids and the information included when communicating options in the clinical setting. Indeed a number of studies have shown that prostate cancer patients do not receive the necessary information to make an informed decision (e.g., Steginga, Occhipinti, Gardiner, Yaxley, & Heathcote, 2002). Yet there is growing evidence that decision aids can help patients adopt an active role in the decision-making process, decrease their anxiety levels, and reduce their sense of uncertainty (Lin, Aaronson, Knight, Carroll, & Dudley, 2009). Addressing numeracy levels in prostate cancer decision aids may help increase their efficacy even further by ensuring information is tailored to patients ability to understand risks and probabilities common in treatment decision.

Over 80% of prostate cancer diagnoses in the United States are for localized prostate cancer (Thompson et al., 2007). As such, the majority of males diagnosed with localized prostate cancer fit the clinical criteria for both AS and RP. In fact, The National

Comprehensive Cancer Network (Mohler et al., 2010) identified AS as the only treatment option for men with less than 20 years' life expectancy or men with low-risk disease with less than 10 years' life expectancy. With insight into the factors that affects men's treatment preferences, health practitioners may be in a better position to help men make a decision that is more closely aligned with their values and wishes. Such knowledge will enable practitioners to design better decision aids and facilitate shared decision-making in the clinical setting.

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Table 1

Sample Characteristics

Mean participant age in years (*SD*)	Treatment choice		Screened for prostate cancer		Numeracy *M* (*SD*)	Time discounting *M* (*SD*)	Domain-Specific Risk-Taking Scale		
							Health *M* (*SD*)	Investment *M* (*SD*)	Gambling *M* (*SD*)
	AS	RP	Yes	No					
56.22 (5.46)	80%	20%	49%	51%	2.22 (0.96)	1.37 (0.85)	2.72 (1.03)	3.41 (1.54)	3.41 (1.54)

Note. AS: active surveillance. RP: radical prostatectomy.

Table 2

Adjusted Associations of Choosing Radical Prostatectomy Over Active Surveillance, Numeracy, Time Discounting and Risk Taking

Predictor	β	*SE*	Wald χ^2	*df*	*p*	Odds ratio
Numeracy	-.411	.164	6.259	1	.012	0.663
Time discounting	-.381	.185	4.226	1	.040	0.683
Risk taking, health	-.016	.038	0.169	1	.681	0.984
Risk taking, investment	-.006	.019	0.098	1	.755	0.994
Risk taking, gambling	.098	.050	3.832	1	.050	1.103

Note. Logistic regression was used to test for adjusted associations. The treatment outcome was coded "1" for radical prostatectomy and "0" for active surveillance.

Appendix 1

Information presented to the participants of the study (Presentation of treatment options was counterbalanced). Source: http://www.cancer.gov/

About 17 out of every 100 men in the United States will be diagnosed with prostate cancer in their lifetime. However, fewer than 3 out of every 100 men in the US will die from prostate cancer. This is because prostate cancer often grows slowly, and men die of other causes such as heart disease.

Most men with low-risk prostate cancer generally live long after their diagnosis. They have no or few symptoms, even without treatment. Men who have been diagnosed with low-risk prostate cancer have a treatment choice. Active surveillance or surgery are two standard therapy choices for men with low-risk prostate cancer. Each has benefits (how treatments can help) and risks (problems treatment may cause). There is rarely just one best treatment choice.

If a man chooses active surveillance, his doctor watches his cancer carefully. He will have regular check-ups that might include lab tests, ultrasounds, and biopsies. If his test results change, he can then choose to begin a treatment to remove or destroy his cancer. One of the benefits of active surveillance is the avoidance of surgery and the side effects associated with this surgery. However, the person may feel anxious or worried about not treating his cancer. There are risks involved in choosing active surveillance. With active surveillance, the cancer is not taken out or destroyed, so the cancer may grow and spread. If the cancer grows or spreads, it may no longer be curable, which can lead to death.

Active surveillance my not be the best choice for everyone with low-risk prostate cancer. Some men may not want to make regular visits for testing. Others are not comfortable with the idea of continuing to have cancer, even if it is low-risk. Your other option is to undergo an immediate treatment, where you start treatment right away to try to remove your cancer.

One possible treatment is surgery. The benefit of surgery is that the prostate cancer is eliminated by removing as much of the prostate as possible. The surgery, however, has short-term and long-term side effects and drawbacks. The side effects and drawbacks include:

1. There are risks with any major surgery, such as pain, bleeding, infection, heart problems, or death.
2. After surgery, a tube will be inserted into your penis. The tube allows urine to drain from your bladder while the urethra is healing from the surgery. You'll have the tube for 5 to 14 days.
3. After surgery, some men may lose control of the flow of urine (urinary incontinence). Most men regain at least some bladder control after a few weeks. For some men, however, incontinence may be permanent. Studies have reported that about 14% of men undergoing surgery experience urinary incontinency 5 years after the surgery.
4. Surgery may also damage nerves near the prostate and cause erectile dysfunction. Sexual function usually improves over several months, but for some men, this problem can be permanent. One study reported that about 60% of men reported some sexual dysfunction 18 months after the surgery.

Recent studies show that surgery and active surveillance result in similar survival rates. In other words, men who choose to undergo active surveillance live as long as those who choose immediate treatment with surgery. Now, we would like you to imagine that YOU have been diagnosed with low-risk prostate cancer. Which of the two treatment options would you prefer? (order of answer was counterbalanced):

1. Immediate surgery
2. Active surveillance