November 2018

Three Essays on Health, Risk and Behavior

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THREE ESSAYS ON HEALTH, RISK AND BEHAVIOR

A Dissertation Presented

by

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Submitted to the Graduate School of the

University of Massachusetts Amherst in partial fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2018

Resource Economics

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DEDICATION

To Mamá, Abuela, Juan and Dharma. To Dad.

ACKNOWLEDGEMENTS

It is with immense gratitude that I acknowledge the support of my committee chair, Dr. Angela C.M. de Oliveira, who constantly advised me during my PhD studies and during my early career choices. Without her guidance, motivation and help this dissertation would not have been possible.

I would also like to thank my committee co-chair, Dr. Sylvia Brandt, for the support and invaluable academic and career advice.

I want to express my gratitude to my other committee members, Dr. Mark C. Pachucki at UMass Sociology and Dr. Collin B. Raymond at Purdue University for their expert advice and encouragement, as well as their willingness to teach me new perspectives and concepts. Your support has been essential to finish this dissertation.

I am indebted to Dr. John M. Spraggon, Dr. Christian Rojas and Dr. Dan A. Lass, who provided me with constant guidance and support during my doctoral studies as well as my job market preparation.

I place my sincere gratitude to Ms. Gail Fleischaker, Mrs. Eileen Keegan and Ms. Sophie Williamson for their valuable administrative and IT support while teaching, running experiments and on a day-to-day basis.

I also want to thank Dr. Ann Becker, who encouraged me to continue my research in flu vaccinations and provided me with a platform to run my field experiment. To Kathy Weilerstein and Maureen Porter, thank you for allowing me and trusting me to teach students from my own perspective and open their eyes to more than just studying to pass a class.

I want to take this opportunity to record my deepest gratitude to all the faculty members and students of the Department of Resource Economics.

I also want to thank the faculty members of the Departamento de Economía in the Facultad de Ciencias Sociales at the Universidad de la República Uruguay for allowing me to take the time off I needed to finish this PhD, in particular the Department Chairs, Dr. Patricia Triunfo and Rosario Domingo. Thank you for putting up with me although I do not always bring chocolate to the office when I go back home to visit.

I want to express my gratitude to the faculty and researchers of CINCH-Health Economics Research Center at the University of Duisburg Essen for providing me with a safe space to finish my dissertation. Thanks for helping me develop my research ideas and allowing me to practice my German. I hope you liked the empanadas!

To my best friends: Maria de los Ángeles, Ana Laura, Maximiliano, Mariana, Natalia and Lupe thank you so much for helping me get through the PhD.

Lastly, I want to thank my Mom, my Abuela and my brother Juan for putting up with me during all this years of being absent, for reminding me to take time off when I was overwhelmed and keeping up with my shenanigans when I am not at home. Thank you for believing in me and raising me to do what I said I was going to become when I was six although you might think I am capable of running a hospital and working in a bank (which I am not!). Thanks for letting me call home every day, twice a day! Thank you for making me a resilient woman who questions everything and who can achieve whatever she sets her mind to do Your support means the world to me. Although you are not here to see me graduate, thanks Dad.

Thanks Mom and Grandma for taking care of Dharma!

ABSTRACT

THREE ESSAYS ON HEALTH, RISK AND BEHAVIOR

SEPTEMBER 2018

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Health-related decisions could be explained by a variety of factors, ranging from the perception of the risk the activity involves to the knowledge of the long-term effects of the decision. An individual deciding to eat unhealthy or not to exercise could face health problems in the long-run. Individuals with health issues have been found to be more risk averse when it comes to financial decisions, such as portfolio allocation. Financial incentives to engage in healthier behaviors have been successful but short-lived.

Prior research leaves many questions such as: What are the factors that explain why an individual decides to engage in healthy or unhealthy behaviors? Are risk preferences a determinant in the decision to seek treatment for an illness? Do beliefs about the outcome of unhealthy and healthy decisions play a role? This dissertation aims at investigating the following questions: How do social aspects of risk impact health-related decisions? And, more broadly, what is the relationship between health, risk preferences and perception and behavior? I focus on three main applications: flu

vaccinations, asthma in children and the impact of chronic illnesses (and other joint risks) in risky decisions.

This dissertation investigates different ways in which risk, health and behavior interact with each other. I focus on three health-related applications: flu vaccines, asthma and how health influences individual risk preferences. The findings of these three chapters are intended to contribute to the discussion of how health impacts behavior and the perception of risk. I also analyze the effect of different sources of endogeneity, such as the beliefs about the flu vaccine and the severity of an influenza episode, beliefs about the severity of asthma or the effectiveness of treatments to tackle an asthma episode.

This research will help policy makers better understand how risk perceptions about the outcomes of different health-related behaviors. I aim at continuing the conversation about which would be the best way to incentivize healthy behaviors and modify negative views of treatments to deal with chronic illnesses.

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CHAPTER 1

INTRODUCTION

Health-related decisions could be explained by a variety of factors, ranging from the perception of the risk the activity involves to the knowledge of the long-term effects of the decision. An individual deciding to eat unhealthy or not to exercise could face health problems in the long-run (Chabris et al. 2008). Individuals with health issues have been found to be more risk averse when it comes to financial decisions, such as portfolio allocation (Edwards 2008; Rosen and Wu 2004). And financial incentives to engage in healthier behaviors have been successful but short-lived (Charness and Gneezy 2009).

Prior research leaves many questions such as: What are the factors that explain why an individual decides to engage in healthy or unhealthy behaviors? Are risk preferences a determinant in the decision to seek treatment for an illness? Do beliefs about the outcome of unhealthy and healthy decisions play a role? This dissertation aims at investigating the following questions: How do social aspects of risk impact health-related decisions? And, more broadly, what is the relationship between health, risk preferences and perception and behavior? I focus on three main applications: flu vaccinations, asthma in children and the impact of chronic illnesses (and other joint risks) in risky decisions.

My dissertation has four self-contained chapters, plus an introductory chapter. Chapter 1 is an introductory chapter. Chapter 2, titled “Health, behavior and risk preferences: a literature review”, provides background literature on risk and health and motivates the following chapters. Chapter 3, “Identity priming to reduce risk: a flu vaccination field experiment” focuses on the impact on identity priming on the decision to get a flu vaccination and on the build-up of herd immunity in a university campus. Chapter 4, "Valuing the impact of air pollution on children's asthma: a joint estimation approach of revealed and stated preferences" examines the decisions of parents regarding treatments to reduce asthma symptoms in children. I take a joint estimation approach that incorporates revealed and stated preferences. Chapter 5, "Reconciling health and wealth background risks: an analysis of risky behavior when higher-order preferences are considered", studies how risk preferences can be affected by background risk, when taking into account the individual's health and higher order risk preferences. Below I summarize the question, methodology and findings of Chapters 3 to 5.

Chapter 3 focuses how normative messaging can be used to influence the decision to get a flu vaccine. I contribute to the analysis of how norms can play a role in the provision of public health and of public goods by focusing on how herd immunity can be constructed through increases in flu vaccination decisions. Norms are only expected to affect behavior when they are salient at the time of behavior – that is, when people's attention can be drawn to the norms (Lawrence 2015).

The experiment targeted undergraduate students living on campus in the different residential areas. I focus on the individual and social benefits of getting a flu vaccine through a flu vaccination campaign that uses posters as the main way of advertising. I highlight these benefits separately and together, having three different treatments. The use of printed messages is an efficient way to communicate information to a large audience and this strategy has been shown to change health behaviors, such as exercising and eating habits (Burger and Shelton 2011; Mollen et al. 2013; Robinson et al. 2014; Schultz et al. 2007; Smith-McLallen and Fishbein 2008). We also comply with the Three

C model from the World Health Organization (2014) and its recommendations to reduce vaccine hesitancy.

The main finding is that emphasizing the individual and social benefits of vaccination together has a larger impact on vaccination turnout compared to just highlighting either individually or having no benefits emphasized at all. Being exposed to a message that highlights both benefits increases the likelihood of getting a flu vaccine by 19%. In addition, females seem to be driving the results. Women seem to respond positively to normative messaging, regarding of the benefit which is emphasized. This is in line with previous literature that argues that women are more risk averse and more sensitive to social cues that determine appropriate behavior than men (Croson and Gneezy 2009). Women tend to judge health-related risks higher than males and seem to have a higher perception of health risks (Weber et al. 2002).

Chapter 4 analyses parent's willingness to pay (WTP) for the reduction in the symptoms of their child's asthma. This study examines how beliefs about the severity of the asthma symptoms (beliefs) affects the decision for different treatments. Building up on the health literature, in this study I estimate and analyze parent's WTP for the reduction in children's asthma symptoms through a joint estimation approach.

A joint estimation approach estimates revealed preference and stated preference equations together, recognizing both the strengths and drawbacks of the two types of data (Ben-Akiva et al. 1994). This joint methodology (data enrichment or data fusing as defined by Whitehead et al. 2008) has been widely used in the environmental literature but not to measure health valuation issues. In the case of asthma, by using a joint estimation methodology, we are able to account for the attributes of the illness, socioeconomic characteristics of the household and we allow for mitigating behaviors to be endogenously determined with WTP. Given that there is a relation between severity of the illness and the treatments to reduce asthma symptoms, studying the impact of treatment decisions involves a new way of estimating the effects of both, while accounting for the dynamics between beliefs about the severity of the illness and symptom reduction.

This study builds up on two prior analyses. The first one is Alberini et al. (1997), who value the effects of air pollution on a chronic illness (asthma) through joint estimation. I account for the costs of different averting behaviors, not just the frequency of visits to a doctor. The second analysis we follow is Whitehead (2000), as I consider that beliefs about the severity of the illness affect asthma treatments and vice versa. Beliefs are endogenous in our model and enter as a third equation in our model. In addition, I focus on asthma in children, not adults. The analysis contributes to the empirical literature on the analysis of parental decisions on behalf on their children. This study provides additional evidence towards the increased prevalence of asthma morbidity among minority and low-income households.

We find that there is not a linear relationship between asthma, days of symptoms and expenditures (WTP included). When it comes to asthma, parents' degree of worry about asthma between episodes and their beliefs on what exacerbates asthma affects WTP to reduce the child's asthma symptoms. We calculate a mean WTP of $108.9 to reduce the child's asthma symptoms by 50% every month. This value increases with the degree of the parent's worry about asthma between episodes and if asthma occurs jointly with other illnesses.

Chapter 5 addresses the question of how multiple background risks affect risk preferences. The focus of our analysis is tri-fold. We first want to examine whether the risky decisions of healthy individuals and individuals with chronic illnesses ("sick") differ. Second, we want to understand whether the introduction of different exogenous financial background risks makes individuals more or less prone to making more risky decisions. Third, we want to understand if the individual's risk profile, which includes higher-order preferences is a determinant of how risky decisions are affected once exogenous background risks are included.

The existing literature has only addressed the impact of independent background risks on risk attitudes but has not examined the impact of simultaneous background risks on individual risk attitudes. The study brings together the analysis of how different types of background risks impact decisions, and how decisions could change depending on the background risk pool the individual has *a priori*. In addition, I focus on also eliciting higher order risk preferences. The analysis of risk preferences has usually focused on risk aversion (second-order risk preferences) when risk aversion is just one piece of an individual's risk-profile. An individual's risk profile is also composed of other higher-order risk aversion measures, such as prudence (third-order) and temperance (fourth-order, Deck and Schlesinger 2014, Ebert and Wiesen 2011). Our study relies on a non-parametric methodology to elicit higher order risk preferences, which allows us to have a more detailed individual risk profile.

I answer these questions using online (laboratory) experiments. An experimental methodology allows us significant control over the environment and minimizes the problem of confounding variables, helping to elicit individual preferences for risk.

Additional background risk is incorporated into the experiment by including different versions of an exogenous risky lottery (mean-zero, positive and negative expected values). The outcome of the lottery is known at the end of the experiment and subjects do not have a say in the final outcome, as it is randomized. The background risks which individuals come to the laboratory with are elicited through a questionnaire.

At an individual level, we find that both health and higher-order risk preferences explain the changes in risky decisions once exogenous financial risks have been introduced. Individuals who report having chronic illnesses become more risk averse when exposed to potential exogenous losses. However, only health or only higher-order risk preferences cannot explain changes in risky decisions alone, as sick and prudent individuals make less risky decisions when exposed to additional background risk. Temperance also plays a role, albeit indirectly.

To summarize, this dissertation investigates different ways in which risk, health and behavior interact with each other. I focus on three health-related applications: flu vaccines, asthma and how health influences individual risk preferences. The findings of these three chapters are intended to contribute to the discussion of how health impacts behavior and the perception of risk. I also analyze the effect of different sources of endogeneity, such as the beliefs about the flu vaccine and the severity of an influenza episode, beliefs about the severity of asthma or the effectiveness of treatments to tackle an asthma episode.

This research will help policy makers better understand how risk perceptions about the outcomes of different health-related behaviors. I aim at continuing the conversation about which would be the best way to incentivize healthy behaviors and modify negative views of treatments to deal with chronic illnesses.

CHAPTER 2

HEALTH, BEHAVIOR AND RISK PREFERENCES: A LITERATURE REVIEW

2.1. Introduction

Risks are ubiquitous in most individual decisions that people make for themselves and others. The extent to which individuals are willing to undertake and assume risks influence a variety of individual decisions under uncertainty, from portfolio allocation, job changes, retirement, to cheating on an exam, gambling and the use of a safety belt. Individuals resolve decisions in different ways, and one of the factors that could account for these differences is the variation of risk attitudes among individuals (Blais and Weber 2006). Understanding attitudes towards risk is linked to the theoretical modelling, empirical analysis and prediction of individual economic behavior (Dohmen et al. 2011).

In particular, risk attitudes are one of the factors that could influence decisions in the health domain, such as physical exercise, smoking, drinking and healthy eating. In the US, almost 40 percent of adults are obese (Centers for Disease Control and Prevention 2016), 17 percent of adults engage in binge drinking (Centers for Disease Control and Prevention 2016) and 79 percent of adults do not engage in regular physical activity (Centers for Disease Control and Prevention 2014). This is evidence that not every individual behaves the same way. This is also evidence that some individuals take more risks by choosing to smoke, drink or lead a more sedentary life. All these behaviors could lead to health risks in the short and long-term. Furthermore, unhealthy behaviors put pressure on the health system as well as on individuals' budgets, by having to cover the increasing expenses of treating health-related illnesses that could be avoided. So, why do many individuals engage in risky, unhealthy behaviors when it would be safer to do otherwise?

The purpose of this literature review is to summarize the literature on risk preferences and health-related behaviors, emphasizing the different perspectives health has been addressed within the risk literature. For this reason, this review has two main sections. The first section focuses on the analysis of risk preferences. Risk attitudes have been argued to be a personality trait, preferences that might be unstable and that might be domain-specific (MacCrimmon and Wehrung 1990; Dohmen et al. 2011; Blais and Weber 2006). Many theories have been developed with the aim of trying to explain changes in risk attitudes (Savage 1954; Kahneman and Tversky 1979; Quiggin 1981). There are also many ways of measuring risk preferences and each way has its advantages and disadvantages, from being simple, domain-specific or easier to implement in the field (Charness et al. 2013; Crosetto and Filippin 2016).

The second section focuses the relationship between risk preferences and health, analyzing how health can also be considered a risk itself, and how decisions for oneself and others affect individual health status and behavior. An individual not engaging in physical activity or making repeated unhealthy food choices could face health issues in the long-run (Chabris et al. 2008). Friends can influence drinking, food intake and their peers' emotional states (Fowler and Christakis 2010; Rosenquist et al. 2010; Pachucki et al. 2011 2015). Parents also decide for their children for example, when it comes to physical activity and healthy food choices. All these choices could include as one of the explanatory factors, individual attitudes towards risk. Subjective beliefs about health risks play a role in health-related decisions, but an individual never faces a single risk, and risks are correlated (Harrison et al. 2015). Within the risk and health realms, risk and health can be usually examined from a social network perspective. Decisions to interact and engage with other individuals (and thus, risky behaviors) can determine health status and can initiate contagion and dissemination patterns of different illnesses, such as the flu, sexually transmitted diseases or even obesity.

2.2. Risk

Risk has been one of the most basic concepts in economic theory (Pratt 1964; Arrow 1965). Risk and uncertainty play important roles in almost every economic decision, either social, economic or technological. Decisions are sometimes made without definite knowledge of their consequences, such as financial investments, the outcome of an operation, or a court case (Tversky and Fox 1995). Understanding risk and individual attitudes towards risk is directly linked to the analysis of economic behavior (Dohmen et al. 2009).

A growing body of research in economics and psychology has linked individual risk attitudes to a wide range of behavioral patterns and economic outcomes, such as trust, self-selection into payment schemes, financial investments and health outcomes (Lönnqvist et al. 2015). Defining risk is not straightforward, as the term “risk” has a wide range of connotations. Risk always implies that there is some uncertainty in the outcome of an action of event (either positive or negative), with the consequences affecting something of value, such as an investment or asset. In some cases, the probabilities of each consequence can be accurately defined, such as in games of chance or in mechanical devices. Sometimes probabilities can be accurately defined in the insurance realm, given the amount of data available (Zeckhauser 2014). If these probabilities can be quantified, so can individuals' attitudes towards risk, from both a theoretical and an empirical perspective. This section will discuss the main risk concepts and theories from a psychological and an economic point of view. Measuring risk aversion is ultimately an empirical issue (to what extent it exists, how it depends on the size of the stake), but there is still an ongoing debate about the best way to elicit risk preferences (Harrison and Rutström 2008). Thus, the different ways risk attitudes are elicited in practice will also be discussed.

2.2.1. Theoretical concepts

In economic theory, risk aversion is a characteristic of the standard utility function of wealth. However, in practice, the way individuals deal with risks does not identically match the standard risk attitudes theory. For example, people gamble, skydive, smoke but at the same time buy insurance for themselves and their assets. Many theories both in economics and psychology have been developed to incorporate the fact that individual risk-related decisions are heterogeneous and not necessarily stable across situations. Individual risk attitudes might depend on the type of decision, the likelihood of an outcome occurring and the framing of the situation the individual has to decide upon. This section will describe and connect the different theories in economics and psychology that have been developed up to date to model risk attitudes.

2.2.1.1. Economic perspectives

Risk has been included as a basis of the analysis of decision making under uncertainty in economics. Risk taking and risk attitudes start at the individual level, almost always with an axiomatic foundation (Machina and Viscusi 2014). The way individuals solve decisions that involve risk and uncertainty are often defined as differences in risk attitudes (Blais and Weber 2006). But differences in risk attitudes are no more than a label for the shape of the individual utility function for the relevant outcomes (Weber et al. 2002) [1]. Risk attitudes vary by the value of the parameter that describing the degree of concavity or convexity of that individual utility function (Weber et al. 2002). A commonly used measure of risk attitudes was developed by Arrow (1971) and Pratt (1964). The measure is defined as the negative of the ratio between the second and first derivative of the utility function. The Arrow-Pratt measure of risk has been part of the mainstream paradigm of Expected Utility Theory (EUT; von Neumann and Morgenstern 1944; Savage 1954). The classic EUT model involves a set of bets for a collection of events and outcomes that are mutually exclusive an exhaustive. Savage's (1954) EUT axioms define a cardinal function $U(.)$ over outcomes and a subjective probability measure over events. The individual evaluates those bets based on a linear probability or preference function that adds the outcomes, each multiplied by the probability of occurrence (Machina 2009).

[1] A risk averse utility function is concave, a risk loving utility function is convex.

EUT provides not only a way to identify risk aversion but also to measure the degree of concavity of the utility function, and hence, the strength or intensity of risk aversion. EUT models risk aversion as something that arises because the utility function over wealth is concave. However, EUT suggests a theory of positive but declining risk aversion over wealth (Quiggin 1993) and implies that people are almost risk neutral when stakes are small (Arrow 1971; Rabin 2000). Risk neutrality over modest stakes has been one of the criticisms of this theory, as differences in estimates of risk attitudes might happen not because of differences in individual risk attitudes of the target population but because of the stakes used to elicit risk attitudes (Rabin 2000).

An alternative approach, the rank-dependent expected utility model (RDU) is a generalization of the EUT that preserves some of its standard properties (Quiggin 1981, 1982; Allais 1979; Segal 1989). In particular, RDU does not rely on the axiom of independence of unrelated outcomes (Quiggin 1991, Allais 1979)[2]. The axiom states that preferences among gambles should be independent of the events for which the gambles give the same outcome (Wakker et al. 1994). The intuition behind RDU is that the weight of an outcome does not only include the probability of occurrence but also considers how favorable the outcome is compared to other possible ones. In the RDU realm, the decision weight of an outcome depends not only on whether it is better than some other outcome but also on how much better it is compared to another outcome (Diecidue and Wakker 2001). So, how an individual weighs an outcome depend on how it is ranked relative to other outcomes (how good or bad the outcome is with respect to other outcomes). RDU accounts for the violations of stochastic dominance in EUT, in which the probabilities of

[2] The axiom of independence of unrelated outcomes (or independent alternatives, IIA) states that the preference for lottery A over B will not change when a third lottery is introduced.

each outcome are transformed in a nonlinear and nonadditive fashion[3]. The probability weighting function is not linear regarding the individual outcomes but regarding the cumulative distribution function of these outcomes (Quiggin 1993). Quiggin showed that by transforming cumulative probabilities and forcing probability weights to add to one, would eliminate violations of stochastic dominance (Weber and Kirsner 1997). RDU considers both factors: the shape of the utility function (where concavity means risk aversion) and the probability transformation function used. Thus, risk attitudes are not dictated only by the shape of the utility function. Following Tuthill and Frechete (2002) a sufficiently pessimistic agent could be risk averse even if she has a convex utility function (is risk seeking). Risk attitudes could be more complex if the transformation function is S-shaped, where agents overweight low probability events and underweight high probability events.

Although EUT was the dominant way of analyzing decisions, it is a model or rational choice that assumes that individuals obey the main axioms of rationality. Prospect Theory (PT, Tversky and Kahneman, 1992; Kahneman and Tversky 1979) aimed at explicitly incorporating irrational behavior in a more realistic manner, something that was overlooked by the conventional paradigm of EUT (Kahneman 2003). It was developed by psychologists as a way to approach human thought processes. For example, people usually overweight the importance of unlikely events, and equivalent outcomes might be valued differently depending on the manner on which each outcome

[3] There are two main notions of stochastic dominance. First-order stochastic dominance happens when an individual prefers lottery A to B regardless of his utility function, as long as it is weakly increasing. This implies that A has a larger expected value than B. Second-order stochastic dominance happens when the individual prefers lottery A to G, provided he is risk averse and his utility function is weakly increasing. This implies that A has an equal or larger expected value than B.

or decision setting is described – there is a “framing” effect (Bowles 2004). Also, in the PT framework, individuals make decisions based on changes of wealth rather than total wealth, evaluating outcomes with respect to a reference point (Levy and Levy 2002; Levy 1992). Individuals do not use all available information but use successful decision rules used before (rules of thumb) to help them make decisions (Tuthill and Frechete 2002). PT has four main components: a value function that is concave for gains, convex for losses, steeper for losses than for gains (S-shaped utility function, with an inflection point at zero), and non-linear transformation of the probability weighting function that overweighs small probabilities while underweighting moderate and high probabilities (Tversky and Kahneman 1992; Levy and Levy 2002). Tversky and Kahneman (1992) introduced a new version of PT, “cumulative” PT which incorporated Quiggin’s (1982) RDU corrections of probability weightings by transforming cumulative rather than individual probabilities of occurrence (Wakker 2010). Cumulative PT also includes any number of outcomes in lotteries or events instead of only two outcomes in the traditional PT framework. All in all, PT is an improvement from EUT as it incorporates individual behaviors that are commonly used in everyday decisions. However, it is far more complicated to implement in practice.

The three main theories of risk, EUT, RDU and PT have been found to explain risk taking in different scenarios, allowing for broader interpretations on how individuals make decisions. The theories recognize that individuals might be heterogeneous within each theory, but in practice, it could happen that different individuals might be classified under different theories (Harrison and Rutström 2009). Harrison and Rutström (2009) propose a “wedding” of theories, and find that EUT and PT account for 50-50 of individual choices. This means that there could be different people making choice in different ways, weighing outcomes, gains and losses with different decision or probability weights. Different people could also make different decisions depending on how situations are framed and how risks are perceived. Individuals are not fully rational, and this would entail that psychology plays a role in how individuals make decisions as framing and perception of risk play a part on decisions. The different perspectives on risk attitudes in that field will be discussed below.

2.2.1.2. Psychological perspectives

Psychology considers risk as differing between individuals as well as between context and content (Weber et al. 2002; Johnson et al. 2004). Changes in risk attitudes depend on the individual perception of the riskiness of a situation, and not on whether individuals have more positive or negative attitudes towards risk (Deck et al. 2013; Weber 1988; Slovic 1997). The perception and acceptance of risk also have roots in cultural and social factors (Short 1984; Douglas and Wildavsky 1982; Weber and Hsee, 1998), and in many cases could be influenced by friends, family, coworkers and government officials (Slovic 1987). Differences in risk perception also vary by gender and by occupation (Slovic 1987; Finucane et al. 2000; Flynn et al. 1994; Weber et al. 2002).

Psychological research on risk perception originated in studies of probability and utility (Edwards 1961). These studies discovered a set of mental strategies or heuristics that individuals use to make decisions in an uncertain world (Tversky and Kahneman

1973). These mental strategies have been developed by experience, and are linked to emotions and affect (Slovic and Weber 2002). The idea behind these strategies is to transform uncertain or threatening aspects of the environment into affective responses, thus, representing *risks as feelings* (Loewenstein et al. 2001). Risk attitudes could also be interpreted as a personality trait under this theory (Weber 1999; MacCrimmon and Wehrung 1990). These rules or strategies are also used to reduce difficult tasks to simpler ones. However, these rules are not always valid, leading in some cases to persistent biases (Slovic 2000). Kahneman and Tversky (1979) for example, showed under PT that rare events tend to be overweighed, as the affective processing of extreme events dominate the processing of low probability events (Rottenstreich and Hsee 2001). But other studies show that once individuals are exposed to events, they start underweighting low probability events (Weber et al. 2001; Barron and Erev 2003; Slovic and Weber 2002).

Because of these systematic reversals in preferences, there is an argument towards the idea that preferences are constructed and decision making is adaptive on the context and could vary in time (Bettman et al. 1998; Lichtenstein and Slovic 2006). Preference construction could mean that preferences are not stable but context sensitive (Simonson 2008; Drolet et al. 2009). Preference construction could also represent the fact that individuals are adaptive, and preferences are calculated on the spot when making a decision, integrating different pieces of information or inputs into a judgement (Slovic 1995; Rabin 1998; Simon et al. 2008). However, not all preferences are calculated the same, but are part of complex decision processes that depend on the level of distraction of individual in a situation, the existence of time constraints and the complexity of the decision itself (Warren et al. 2011). Simon (1987, 1955) argued that individuals are *boundedly rational,* in the sense that they will try to attempt to attain a satisfactory and not maximal level of achievement in their decision making. In this light, preference construction could also mean that preferences are incomplete. This goes against the standard view of preferences, where individuals are expected to have stable, well-defined preferences among alternatives (Freeman 1993). Construction strategies include anchoring, adjustment, eliminating common elements, restructuring the decision problem and adding new attributes to a problem to bolster an alternative (Slovic 1995). Various theories also claim that preferences are reconstructed from prior decisions (Brownstein 2003).

Risk attitudes also depend on the context the individual is in. This means that risk attitudes could be specific to the domain where the decisions are made, making risk a multidimensional concept rather than a stable attitude or trait (Johnson et al. 2004; Hanoch et al. 2006; Soane and Chmiel 2005). Risk taking might be related more to the situation the individual is in rather than with attitudes towards risk (Weber and Milliman 1997; Weber 2001). Individuals have been shown to have differing risk attitudes and even have inconsistent responses across domains and situations (Schoemaker 1990; Blais and Weber 2006; MacCrimmon and Wehrung 1986). For example, an individual could be risk averse or loving depending on her viewing a lottery as a gamble or a financial investment (Weber and Johnson 2008). Managers appear to have different risk attitudes when deciding on investments involving personal or company money or when evaluating financial or recreational risks (MacCrimmon and Wehrung 1990). Evidence towards domain specificity argues against the use of risk theories such as EU, as risk attitudes should not be combined across domains (Dohmen et al. 2011).

If risk attitudes are context specific, risk attitudes should vary depending on the perceived benefits and riskiness of an activity (Weber et al. 2002; Mellers et al. 1997). Risk attitudes could then be analyzed in a risk-return framework, where individuals take risks in a way that reflects a trade-off between risk (or fear) and expected return (or hope; Weber 2001; Hu and Xie 2012; Slovic 1992; Sarin and Weber 1993). Increased perceived riskiness would be associated with a higher level of risk aversion, while increased expected benefits would be associated with a higher level of riskiness (Finucane et al. 2000). Within the risk-return framework Weber et al. (2002) developed a domain-specific risk-taking scale (DOSPERT) that measures the individual propensity to engage in risky behaviors and their perception of risks and expected benefits of each activity. The DOSPERT scale has 40 questions in five main content domains: health and safety, recreational, social, ethical, financial and gambling risks. Using the DOSPERT scale, Hanoch et al. (2006) found that individuals who like extreme sports are more likely to take recreational risks such as skydiving but were not likely to take health risks or financial risks, such as smoking or gambling. Smokers were more likely to take health risks but did not differ in their propensity to take risks in other domains (Weller and Tikir 2011). Zuniga and Bouzas (2005) found that the health and safety and recreational domain questions are good at predicting alcohol consumption among high school students. Dohmen et al. (2011) also found that risk attitudes related to a specific context are better at predicting risk attitudes in the relevant context. Overall, the DOSPERT scale has been validated in countries such as Germany, Italy, Spain and China (Johnson et al.

2004; Hu and Xie 2012) and evidence has been provided towards the reliability of the scale (Weber et al. 2002).

So, risk preferences in the psychological realm depend on many factors. Risk preferences can vary depending on the individual, context and framing of the situation. Preferences can vary with time, being unstable and inconsistent, with preferences being reconstructed every time the individual has to make a decision. Changes in risk attitudes depend on the individual perception of the riskiness of a situation and on the expected benefits that the different outcomes of the decision might bring to the individual. Risk attitudes could also be specific to the domain in which the individual is deciding, making risk a multidimensional concept. Considering that risk attitudes might be a multidimensional, changing concept opens the door to investigate a) how to better measure risk attitudes that might vary with so many different factors and b) how to take account of the potential instability of preferences over time.

2.2.2. Experimental methods to measure risk preferences

Current experimental methods of eliciting risk preferences are suited to fit a variety of scenarios or environments in the laboratory and the field. Each method has advantages and limitations, so choosing the relevant method depends on the context, the population of interest and the question to be answered (Charness et al. 2013). Also, with the diversity of methods to measure risk preferences comes the fact that measured risk attitudes vary depending on the elicitation technique (Isaac and James 2000; Dave et al. 2010). Charness et al. (2013), Holt and Laury (2014) and Crosetto and Filippin (2016) have compared experimental methods to measure risk preferences based on their degree of complexity and how easy it is for participants to understand the task. As every method has its pros and cons, and some of the methods are expected to provide more reliable estimates than others, depending on how simple the tasks are and whether tasks are incentive-compatible (Harrison and Rutström 2008).

In the health domain, studies like those conducted by Dohmen et al. (2011) and Weber et al. (2002) include questions that try to measure the relation between risk and health-related behaviors. These studies do not consider, for example, risk attitudes and its relation to chronic illnesses, but conclude that risks are domain-specific. Risk aversion measures from (experimental) hypothetical gamble questions have also been used to predict health-related risky behaviors, such as drinking and getting health insurance (Barsky et al. 1997).

Below is a discussion of some of the most used methods to elicit risk preferences. We follow Crosetto and Filippin's (2016) order of tasks to discuss each methodology.

2.2.2.1. Multiple price list

The Multiple Price List (MPL) consists of an ordered list of binary choices between lotteries. Earliest use of the MPL design for eliciting risk attitudes was done by Binswanger (1981). Holt and Laury (2002) is the most widely known implementation, used to estimate the degree of individual risk aversion as well as the risk parameters of a utility function. Subjects face a list of 10 decisions between paired gambles, with Option A (left) being safer than Option B (right). Each gamble or Option has a high and a low outcome, with probabilities adding to one. The gambles are stacked in rows, and the payoffs of gambles in Option A and Option B remain constant (Charness et al. 2013). What varies is the probability of the high and the low outcomes. The lottery pairs are also arranged by increasing expected value. For the first decision row, getting the high payoff has only a 1/10 chance, while for the last row, the high payoff has a 9/10 chance. Subjects choose one Option for each pair of lotteries, and at some point are expected to switch to the risky option (Option B). After the choices, one row is usually selected at random for payout for that subject, rather than all rows being played out (Harrison and Rutström 2008). Once one row was chosen, the chosen Option is played to determine the subject's final payoff.

The idea behind these choices is that highly risk averse subjects would choose the safer option (Option A) until the second to last or last row, while highly risk loving subjects would choose the risky option (Option B) in the first row. Risk neutral subjects would switch from Option A to Option B when the expected value of both lotteries is similar, around row four or five (Harrison and Rutström 2008). However, one of the main issues with the Holt and Laury (2002) elicitation task is that multiple choices might include multiple switching points for some subjects (Crosetto and Filippin 2016). The main reason behind this multiple switching has been attributed to failing to understand the procedure, given the complexity of the task. This would happen particularly in experiments where the population of interest are is educated or is illiterate (Jacobson and Petrie 2009; Charness and Viceisza 2011). This would make it difficult to infer or estimate risk preferences and to extrapolate the results of the experiment to other domains. In addition, Charness et al. (2013) argue that imposing consistent choices such as in Andersen et al. (2006) or Tanaka et al. (2016) – that is, a single switching point - might bias the results as well as the parameter estimations.

2.2.2.2. Ordered lottery selection

Ordered lottery selection tasks are a variation of Binswanger (1981), where subjects are asked to pick one out of an ordered set of lotteries (Crosetto and Filippin 2016). The most popular version of this method was developed by Eckel and Grossman (2002). In this elicitation task, each subject selected one from among five gambles. Each gamble had two possible outcomes, each occurring with 50 percent probability and differed in expected return and variance. Lotteries one through five have increasing expected return and increasing standard deviation. Compared to Holt and Laury (2002, 2008), the variation in expected value is done by varying the outcomes instead of the probability. In this risk elicitation task, subjects who are risk-averse would sacrifice expected payoff for reduced variance, choosing the lottery with the sure bet (lottery one). A moderately risk averse subject would choose an intermediate bet (lotteries two, three or four) while a risk-neutral or risk-loving would choose the lottery with the highest expected return (lottery five, which maximizes payoffs but has the highest risk; Eckel and Grossman 2002). A variation of this method to allow differentiation between risk-neutral and risk-loving individuals includes a sixth gamble, with the same expected return as lottery five but higher variance. A risk-neutral would in this case choose lottery five, while a risk-loving would choose lottery six. Once one lottery is chosen, the lottery is played.

This risk elicitation task allows for parameter estimation, as the chosen gamble implies an interval for the risk coefficient under a constant relative risk aversion model (Charness et al. 2013). However, it does not account for different degrees of risk-loving behavior, only being able to discriminate degrees of risk-aversion. This risk elicitation task might be easier to understand than Holt and Laury (2002), as it avoids inconsistent choices by asking to choose only one lottery and the lotteries themselves might be less complex by using a 50-50 probability set (Dave et al. 2010).

2.2.2.3. The investment game

Gneezy and Potters (1997) frame choices as an investment decision. Subjects have to choose between a safe and a risky option to invest their endowment in. In particular, the subject receives an $X amount of money and has to choose how much of it to keep for herself and how much to invest in a risky option (Charness et al. 2013). The risky option investment yields a dividend of $kx ($k>1$) with probability p and is lost with probability (1-p). In all cases, p and k are chosen so that $pk>1$. This would mean that the expected value of not investing is lower than the expected value of investing. By varying the two parameters and the endowment, Gneezy and Potters (1997) allow for a convex set of feasible decisions (Holt and Laury 2014). In terms of risk preferences, a risk-neutral or risk-seeking individual would invest the entire endowment, while a risk-averse person would invest less (Charness and Gneezy 2012).

The main critique of the investment task is the same as of Eckel and Grossman (2002). The investment task cannot differentiate between risk-neutral and risk-seeking investments. However, the task is easy to understand allowing for one or multiple decisions and has been used to address a number of different issues, such as myopic loss aversion (Gneezy and Potters 2007), gender differences (Charness and Gneezy 2010, 2012). Charness et al. (2013) argue that the simplicity of implementation of this task makes it ideal for field experiments. In fact, Dreber et al. (2011) and Charness and Viceisza (2011) have used the investment task to look at risk preferences in different developing countries.

2.2.2.4. Bomb and balloon risk tasks

The Balloon Analogue Risk Task (BART) by Lejuez et al. (2002) and the Bomb Risk Elicitation Task (BRET) by Crosetto and Filippin (2013) are choice-based elicitation methods that try to overcome the complexity of methods used to elicit risk preferences. The context and the use of familiar images or real-world situations in both the BART and BRET has an advantage over investment tasks and lottery choices. The BART (Lejuez et al. 2002) is a computerized task that consists of a small simulated balloon and a balloon pump. Each click on the pump inflates the balloon, and the individual earns money, which is deposited in a temporary account (5 cents per pump in the case of Lejuez et al. 2002). With each pump, the probability of popping increases monotonically. Three balloon types can be introduced (blue, yellow and orange), each with a different probability of exploding, for a total set of 90 decisions. However, when the balloon was pumped past its individual explosion point and exploded, all the money in the temporary account was lost and another uninflated balloon appeared. At any point the subject could stop pumping the balloon and collect the money, after which another uninflated balloon would appear. For each balloon not exploded, money was placed in a permanent account which accrued all earnings from the experiment.

The BRET is a similar task in the sense that it also uses objects that could be easily understood, involving only binary choices. The computerized version of the BRET asks subjects to decide when to stop collecting a series of 100 boxes. One of these boxes contains a time bomb, and earnings increase with the number of boxes collected. If one of the collected boxes has the bomb, earnings are equal to zero. The task proposes to the subjects 101 lotteries which are constructed based on the number of boxes collected and in which the probabilities depend on having or not the bomb among the chosen number of boxes. In terms of the dynamics of the game, each time the subject adds a box her account is credited with money. The subject can stop adding boxes the same way the BART works, but earnings are defined at the end of the experiment when they are informed about the content of the boxes.

Both tasks are designed to model situations where excessive risk-taking leads to diminishing returns (Charness et al. 2013), but also to avoid potential truncation of the data, so that subjects are free to choose any number between 0 and 100 in the BRET or any number of pumps in the BART (Crosetto and Filippin 2013). The tasks also offer a fine-grain measure of risk preferences with a design that is relatively intuitive (Dave et al. 2010), being able to precisely estimate the coefficient of risk aversion based on the number of binary choices (yes or no to add another box, yes or no to pump the balloon one more time) made by the subject.

2.2.2.5. Questionnaires

Although these experimental methods to measure risks are commonly used in economics to measure degrees of risk, they assume that the risk measured is independent of other risks. In practice, risks are imperfectly correlated across contexts (Slovic 1972), so that there could be a common underlying risk and risk attitudes which are specific to the context. Risk elicitation tasks could also be correlated with self-reported risk behaviors (Crosetto and Filippin 2016). Questionnaires are usually used to elicit individuals' self-reported propensity for risk (Charness et al. 2013).

The first data source is the German Socio-Economic Panel (SOEP; Wagner et al. 2007), which measures risk attitudes of a representative sample of the German population. The single measure is a direct question that asks the subjects to report on a 0-10 scale "Howe willing are you to take risks, in general?". This question tries to measure a general propensity to accept risks. Dohmen et al. (2011) find that the general risk question did quite well in predicting risk attitudes. However, there is evidence that suggests that measured risk preferences depend on the domains in which they are elicited (Charness et al. 2013). To capture this variation, Weber et al. (2002) developed a set of questions to assess risk preferences, the domain-specific risk-taking (DOSPERT) scale. The full DOSPERT scale has 40 behavior-based questions related to recreational, social, health and ethical risks, gambling and investment. Each question is rated on a 5-point Likert scale depending on how likely an individual is to engage in a specific behavior, such as drinking, gambling, smoking, or driving a car. The authors find that for given contexts, specific risk measures (or questions) perform better (Hanoch et al. 2006).

However, these questions are not incentive-compatible so it could be argued that they are not a good representation of the actual attitudes towards risk.

2.3. Health and behavior

Healthy and unhealthy behaviors, such as engaging in physical activity, drinking, or smoking are examples of individual behaviors that could be influenced. From a public policy point of view, physical inactivity and a poor diet, smoking and alcohol consumption are the leading causes of mortality in the US (Mokdad et al. 2000). Almost 15 percent of the United States adult population smokes (Centers for Disease Control and Prevention 2017), and around 6 percent of adults have an alcohol use disorder (National Institutes of Health 2015)[4]. Obesity is on the rise, with more than one third of American adults being obese (Body Mass Index >30; Ogden et al. 2014). Obesity, smoking and drinking are some of the unhealthy behaviors that put pressure into the health care system, through the treatment and prevention of these conditions as well as the health problems that come with them, such as diabetes, cancer or heart disease.

Many studies have shown that different demographic factors are correlated with these activities. Obesity and drinking for example, are more prevalent among men, African-American , American-Indian and low-income populations (Daw 2017; de Oliveira et al. 2016; Dave and Saffer 2008; Wang and Beydoun 2007). What is less understood is whether the decisions to eat better, smoke or drink heavily are behavioral choices related to other risk-taking decisions, such as retirement, portfolio investments or

[4] Alcohol Use Disorder is defined by the National Institutes of Health as a medical condition where an individual's drinking causes distress or harm.

even income uncertainty. The purpose of this section is analyze the current literature on health and risk, emphasizing the effect of peers and the effect of individual risk preferences in health-related decision making.

2.3.1. (un)healthy behaviors and risk preferences

People systematically over and underestimate risks of death and health decline, no matter how small the risk, as perceived risks are influenced by available and incomplete information and heuristics (Slovic et al. 1979; Tversky and Kahneman 1974). The risk of death derived from unhealthy behaviors is usually underestimated, and the potential improvements associated with a change towards healthier behaviors and activities is usually undervalued. This misestimation of the risks weakens the correlation between health-related behaviors and other (un)healthy activities (Hersch and Viscusi 1998).

One of the main questions related to risk and health is whether if the level of measured individual risk tolerance (or risk aversion) can predict individual health-related risky behaviors. Several studies have tried to analyze harmful behaviors based on the idea that these behaviors could be driven by risk preferences in other areas, such as financial risk (Galizzi et al. 2012; Anderson and Mellor 2008; Barsky et al. 1997), and have found a positive relation between risk tolerance and health-related behaviors.

Experimental research has also shown that experimental measures of risk and time preferences serve as a good predictor for individual health-related behaviors, such as food intake (Chabris et al. 2008; Weller et al. 2008) or physical activity (Leonard et al. 2013). Decisions such as being physically active and changing eating patterns entail a cost in the present, but decreased health risks in the future. The main hypothesis behind these decisions is that individuals who are more risk tolerant (or more risk loving) would be more sedentary and ingest more calories or fatty foods (de Oliveira et al. 2016). Leonard et al. (2013), for example, finds that in a low-income neighborhood in Texas, individuals who are more risk tolerant (or have more patient time preferences) are more likely to be more engaged in physical activity. de Oliveira et al. (2016) also find on the same sample, that subjects with higher risk tolerance are more likely to be obese (have a higher BMI)[5]. These results are in line with Anderson and Mellor (2008) and Sutter et al. (2013), as more risk tolerant individuals are more accepting of the future health consequences of being obese. This relationship also seems to happen at different stages in life. Sutter et al. (2013) use a sample of adolescents and find the same patterns of preferences also observed with adult subjects (Frederick et al. 2002; Dohmen et al. 2011). As adults, children and adolescents have been found to be risk averse (and also ambiguity averse and impatient) and those more risk averse are more likely to have a lower BMI.

Risk aversion is also related to the decision to smoke or drink heavily (Barsky et al. 1997; Dave and Saffer 2008; Dohmen et al. 2011). Both choices have health-related implications in the long term, trading off current gratification with future health. Dave and Safer (2008) found that risk tolerant subjects have a higher prevalence of drinking as well as a higher level of daily consumption. The authors also found differences in risk preferences among groups. Males and whites are more risk tolerant, less likely to be married and have higher levels of education. Gender differences have also been found by Harrison et al. (2010), where female smokers are less risk tolerant, but there is no

[5] In terms of time preferences, Shuval et al. (2016) find that more patient individuals are more likely to consume fast food less frequently.

significant association between smoking and men. These studies use measures derived from hypothetical gamble questions, to predict health-related risky behaviors, such as the Holt and Laury (2002) lottery choice task or from self-reported attitudes towards risk such as in Dohmen et al. (2011). Other studies use smoking-related disease prevalence (Lahiri and Song 2000) or measures of actual behavior as a proxy for risk attitudes in models of job risk-taking. Measures that have been used before include seatbelt use (Hakes and Viscusi 2007) and even other preventive health behaviors, such as tooth flossing (Hersch and Viscusi 1998). Anderson and Mellor (2008) argue that using smoking as a proxy might pose a problem as smoking decisions also have a time preference component (Fuchs 1982; Evans and Montgomery 1994). Also, using smoking or drinking as a proxy for risky behaviors might also hide the fact that risk attitudes can slightly vary between situations. However, Dohmen et al. (2011) show that although not perfectly correlated, attitudes about health, car driving, financial issues, sports and career are strongly related. So, while risky decisions in different scenarios might not be identical, they could be used as proxies for risk preferences.

Although it is difficult to change habits and the decisions to engage in unhealthy behaviors, it is still possible to influence them. Many studies have looked at different interventions to change physical activity habits, eating habits or other bad habits such as smoking. Leowenstein et al. (2007 2012) argue that incentives should be immediate to facilitate the change in health behaviors. However, Charness and Gneezy (2009) found that just providing information or making individuals go to one exercise session did not chance exercising patterns. Requiring (and paying) for recurrent visits only makes sense for those people who do not actually exercise. Enough practice or incentive should happen for habits to change, and immediate rewards might not actually be successful at changing behaviors. Volpp et al. (2009) also find that for smokers, once incentives are taken away, smoking patterns go back to normal. Thus, incentivizing is not enough. A change in individual perceptions and valuation of the activity they are doing is necessary (Latimer et al. 2008). There is a relationship between habit formation, incentives, repeated actions and risk aversion that has not been tackled by the current literature. In particular, whether risk aversion can be modified by modifying or changing the level of risks in other areas, such as health and healthy habits has not been widely studied.

2.3.2. Background risk

Natural disasters, poor health status, being uninsured, low income and job instability are different risks that are both exogenous and undesirable for individuals. Analyzing individual behavior in the presence of risk has been a fundamental concept in a variety of disciplines. Examples of the literature focus on financial portfolio allocations are impacted by health status and health shocks, retirement, unemployment (Berkowitz and Qiu 2006; Fan and Zhao 2009; Cardak and Wilkins 2009; Love and Smith 2010; Bressan et al. 2014; Edwards 2008) or on how natural disasters affect stress levels and substance abuse (Pesko 2016). But these risks are usually examined in isolation. Exogenous risks are usually independent to the current choices an individual makes. These risks can also include gains and losses for the individual not only in terms of financial risk but on job or income stability, among others (Gollier and Pratt 1996; Kimball 1993; Eeckhoudt et al. 1996; Pratt and Zeckhouser 1987).

Although individual risks can be reduced by changes in behavior, some risks cannot be avoided or insured against, such as income uncertainty, individual morbidity (related to chronic illnesses) or natural hazards. Exogenous risks that cannot be avoided or insured against are defined as background risks (Guiso and Paiella 2008). Background risks, even if they are independent risks, interact with other sources of risk. In most cases, the presence of background risk has been shown to make individuals more risk averse (Bressan et al. 2014; Guiso et al. 1996; Quiggin 2003). Background risk has been found to affect patterns of individual savings, portfolio allocation decisions, entrance and permanence in the labor market (Heaton and Lucas 2000; Quiggin 2003; Hanaoka et al. 2015; Berkowitz and Qiu 2006). There is empirical evidence that the presence of background risk changes decisions. In particular, background risk makes individuals more risk averse. However, studies are generally based on one-time decisions and do not consider that in practice, background risk affects individual decisions as subjects gain experience in risky decision making (Cardak and Wilkins 2009; Edwards 2008; Pesko 2016; Heaton and Lucas 2000). An example of a background risk which influences other decisions is a chronic illness. Individuals have to learn how to live with the health risk while making daily decisions that encompass other types of risk, such as financial risks. Health risk could also increase as the individual ages, influencing short-term and long-term decisions in a different manner (Coile and Milligan 2009).

In theory, different types of background risks have been defined, depending on the characteristics of the risk in question. Gollier and Pratt (1996) consider an agent who starts without background risk and then faces an independent background risk. They introduce the concept of risk vulnerability and show that risk vulnerability is equivalent to the notion that an undesirable risk can never be made desirable by the presence of an independent, unfair risk. Furthermore, background risk makes the agent more risk averse. Hence, such background risk reduces the agent's demand for a risky asset, given a choice between a risky and a risk-free asset. Gollier and Pratt (1996) and Eeckhoudt, Gollier and Schlesinger (1996) derived necessary and sufficient restrictions on utility so that an increase in background risk will cause a utility-maximizing individual to make more conservative choices in other risky situations. They show that a sufficient condition for risk vulnerability is either that the absolute risk aversion of the agent is declining and convex or that the agent is standard risk averse in the sense of Kimball (1993), described below.

Risk vulnerability has to do with the effect of mean-zero risks, but other two properties or particular cases of risk vulnerability have also been derived. Proper risk aversion (Pratt and Zeckhouser 1987) and standard risk aversion (Kimball 1993) differ on the restrictions imposed on the background risk. Risk properness has to do with the effect of undesirable risks. In particular, that individually undesirable, independent risks are always jointly undesirable (Pratt and Zeckhauser 1987). Standard risk has to do with the effect of expected marginal utility increasing risks, and specifically to the class of utility functions that guarantee that an additional independent undesirable risk increases the sensitivity to other risks that make losses larger (Kimball 1993). All three properties (vulnerability, properness and standardness) yield the prediction that an unfair background risk makes individuals less willing to bear other independent risks. The restrictions found by these authors are satisfied by a wide class of commonly used utility functions.

However, all these definitions of risk assume that the addition of risk reduces welfare, as the addition of more background risk makes individuals more risk averse (Quiggin 2003). Quiggin (2003) argues that this affirmation is not always true, and it holds only for a convex set of preferences. In the case of convex preferences, the higher the level of risk, the greater the marginal cost of additional risk. But the author suggests that if the level of risk is already at a high level, people will not modify their behavior if a small background risk is added. Quiggin (2003) analyses theoretically the case of a constant risk aversion utility function and particularly, of rank-dependent preferences within a linear utility function. He finds the opposite result of Pratt and Zeckhauser (1987), Kimball (1993), Eeckhoudt et al. (1996) and Gollier and Pratt (1996) for the case of standard preferences. Rather than being substitutes, risks could be complements for some types of preferences.

Background risk has been studied very little in experimental contexts. Lee (2008) and Lusk and Coble (2008) examine how the introduction of background risk to individual endowments affects risk aversion. Lusk and Coble (2008) find that individuals tend to be more risk averse when background risk is introduced, but this also depends on the type of background risk introduced. That is, it depends on how individuals incorporate endowments as well as gains and losses into their utility functions. They use a Holt and Laury (2002) procedure to look at risk aversion, while introducing mean-zero and unfair lotteries as an exogenous background risk. Lee (2008) also finds the same relationship between background risk and risk aversion, but in the context of a chance improving decision model under risk, where individuals' winning probabilities are negatively related to potential gains. Guiso and Paiella (2008) show that the degree of individual risk aversion is positively affected by background risk and the possibility of the individual being credit constrained or having income uncertainty.

However, background risk has been widely studied in the portfolio allocation literature, relating it to income or earnings uncertainty. Several studies have shown that this type of background risk affects stock market participation, and that the demand for risky assets or for stock market participation declines as uninsurable background risks increase (Heaton and Lucas 2000; Guiso et al. 1996). However, some studies find the opposite result. Arrondel et al. (1996) show that an increase in earnings risk increased the level of stock ownership, and Alessie et al. (2001) find that there is no relationship between income uncertainty and demand for risky assets.

Environmental hazards have also analyzed as a way of modifying background risk. Studies like Pesko (2016) and Kahsay and Osberghaus (2016) have found that natural hazards like the exposure to storms and hurricanes affect the perception of background risk. Pesko (2016) finds that hurricane Katrina increased the elicited levels of individual perceived background risk, such as stress, smoking, drinking and demand for health insurance coverage, even if they were not directly impacted by the event. Eckel et al. (2009) also analyze the link between hurricane Katrina and individual risk preferences among evacuees, but find the opposite effect, a decline in risk aversion. Analogous results to Eckel et al. (2009) were found by Hanaoka et al. (2015), for earthquakes in Japan and by Kahsay and Osberghaus (2016) for storms in Germany. However, these effects towards risk loving preferences could be diluted as individuals could have emotional responses to these natural disasters.

When background risk involves the health of the individual, such as in Pesko (2016) or Hanaoka et al. (2015), many studies depend on the self-reporting of a person's background risk. For example, Bressan et al. (2014) find that poor self-reported health status negatively impacts individual portfolio allocation. Atella et al. (2012) find robust evidence that perceived health status plays a different role than objective health status in portfolio allocation decisions. Also, health-based background risk determines portfolio choices only in those countries where health care systems have less coverage or less protection. In addition, Goldman and Maestas (2013) show that having supplemental health insurance (medigap, employer-based) reduces risky asset holdings relative to having no supplemental health insurance.

Several studies show that health affects total wealth accumulation (Smith 1999; Venti and Wise 2000; Wu 2003). Berkowitz and Qiu (2006) show that poor health affects portfolio choices indirectly by reducing financial wealth, and that the diagnosis of more severe diseases also leads to a larger decrease in financial wealth. This is related to the fact that poor health entails larger out of pocket expenses and financial assets are the first ones to be affected, compared to non-financial assets. Precautionary saving has been shown to be positively related to background income and medical expenditure risks (Guiso et al. 1992; Cagetti 2003; Pang and Warshawsky 2010; Levin 1995) and specifically, that the probability medical expenditures exhausting household wealth lowers the risk in the overall portfolio allocation (Edwards 2008). Edwards (2008) argues that portfolio composition is not only affected by expenditures but by the individual's marginal utility of consumption, how risk averse they are, the rate of time preference and uncertainty over labor income. Also, while health costs can be insured, health risk exacerbates labor income risk and reduces the investment horizon through a reduction in life expectancy (Campbell 2006). Therefore, when it comes to portfolio allocation, age also matters. Rosen and Wu (2004) find that older individuals with self-reported poor health choose safer portfolio allocations. In addition, as they age, households also increase their share of liquid assets (Coile and Milligan 2009). Sick households hold less risk assets in their financial portfolios compared to healthy ones and health shocks contribute to holding more liquid assets rather than real estate or a vehicle and to change portfolio allocations towards less financial risk exposure (Edwards 2008).

Some empirical studies have used panel methods to control for unobserved heterogeneity of preferences (in contrast to using a cross-section approach) and find that there is no direct effect or a small direct effect of health status on portfolio choices (Coile and Milligan 2009; Cardak and Wilkins 2009; Love and Smith 2010; Fan and Shao 2009). In addition, Heaton and Lucas (1997) show that the correlation between labor income and stock holdings is very low, so there was not a significant variation in portfolio composition as a function of the degree of background risk. Even in the case of experimental applications of background risk not all results relate an increase of background risk with an increase in individual risk aversion (Lusk and Coble 2008). So, isolating background risk from other potential risks or sources of uncertainty is a difficult task, as many of the sources of uncertainty, such as expectations of future income or health status are based on individual choices, thus, not exogenous.

2.3.3. Risky decisions for others

Economic research has traditionally focused on individual decision making, without incorporating the influence of society on risk preferences (Füllbrunn and Luhan 2015; Dohmen et al. 2011; Eckel and Grossman 2008). However, in many contexts, decisions do not only have consequences for the individual making the decision but also for others. Several examples of these decisions can be found in real life. Financial decisions do not affect the portfolio manager only but also the investors, family finances could be affected by decisions of the household head, smoking in the car or speeding might depend on whether there are children are inside the car, doctors' treatment decisions might depend on the patient and the beliefs on the severity of the illness, political decisions affect parts or the whole population. Thus, having the responsibility for someone else's welfare, as well as one's own, affects choice behavior (Bolton and Ockenfels 2010; Füllbrunn and Luhan 2015).

The experimental literature on risky decisions on behalf of others is varied and results differ depending on the underlying experiment specification (Eriksen and Kvaløy 2010; Reynolds et al. 2011; Chakravarty et al. 2011), on whether decisions are individual or made in a group (Charness and Jackson 2009; Gong et al. 2009; Sutter et al. 2010), if there is accountability regarding the decision maker's actions (Pollman et al. 2014; Vieider 2009; Pahlke et al. 2012) or based on the underlying risk theory considered in the analysis (Charness 2000; Stoner 1968; Kahneman and Tversky 1979).

Risky decisions for others also have a social aspect that is sometimes overlooked in the case of strategic game settings. In these settings, uncertainty is the source of the risk, and the focus is not only on how risk choices vary but also on how individuals cooperate when decisions are made simultaneously and anonymously (Charness and Jackson 2009; Sutter et al. 2010). In the risky decisions for other's literature, there is also a difference in what is measured. Some studies measure standard risk aversion (Vieider et al. 2015; Humphrey and Renner 2011), while others measure loss aversion (Polman 2012; Andersson et al. 2014; Bolton et al. 2015). In addition, some studies focus on framed financial portfolio decisions (Lefebvre and Vieider 2013), while others analyze decisions based on risk aversion measurement tasks, such as the multiple price list (Holt and Laury 2002), the Gneezy and Potters (1997) investment setting or the Stag-Hunt game.

Hence, there is not a consensus on the literature on whether decisions on behalf of others involve higher or lower levels or risk when comparing decisions for oneself. Minor differences in experimental settings can lead to completely different results, thus controlling for different confounding factors in a variety of ways (Füllbrunn and Luhan 2015). For example, one of the main issues with risky decisions for others is that separating the effect of responsibility from other influences, such as fairness or spitefulness is difficult (Trautmann and Vieider 2012). Regardless of the heterogeneity of settings, the main focus of the literature on decisions for others is on situations of responsibility and accountability of an agent's decisions for one or more principals, and whether it entails a consequence to the decision maker or not, compared to the individual decisions an agent takes for herself (Vieider et al. 2015).

2.3.3.1. Responsibility and risky shifts

The analysis of risky decisions for others brings about two competing theories of risk preferences. The first one is related to whether decisions on behalf of others are more or less risky than the decisions for oneself. Stoner (1968) accrued the terms “risky shift” in the case where individuals become less risk averse, and “cautious shift” where individual risk levels decrease (individuals become more risk averse) compared to the initial levels of risk aversion. Stoner (1968) tried to argue that people would exhibit a cautious shift when deciding in front of groups (Reynolds et al. 2011) but found the opposite. In the psychological literature, risky shifts are explained through the concept of self-other distance, which is related to the perceptions of distance when individuals face other individuals, things or different moments of time (Liberman et al. 2007; Trope and Liberman 2010). Distance is something that is defined as subjective and that depends on the information the individual has on what he is trying to solve.

Current experimental outcomes regarding decisions for others are mixed. Some studies have found evidence of this risky shift when deciding for others. Charkravarty et al. (2011), Polman (2012), Andersson et al. (2014), Agranov et al. (2014), Pollman et al. (2014) find in different experimental contexts that subjects tend to make riskier decisions on behalf of others compared to decisions for oneself. However, other studies, such as Bolton and Ockenfels (2010), Eriksen and Kvaløy (2010), Reynolds et al. (2011), Füllbrun and Luhan (2015), Pahlke et al. (2015) and Pahlke (2012) find evidence of a cautious shift when looking at the same comparison. Humphrey and Renner (2011) found no effect of responsibility in deciding for others.

Not only there is variation in the results found (regardless of the underlying theory), but the experimental design used for the analysis of risky decisions for others vary widely. Eriksen and Kvaløy (2010), Sutter (2009) use an investment game based on Gneezy and Potters (1997). Chakravarty et al (2011) uses a multiple price list (Holt and Laury 2002 2005). Charness and Jackson (2009) use a Stag-Hunt game. Bolton and Ockenfels (2010) and Bolton et al. (2015), Pahlke et al. (2015) use binary decisions between a risky and a safe option. Vieider et al. (2015) use a series of certainty equivalents varying the probabilities and outcomes. Eriksen et al. (2014) use various techniques to calculate risk aversion, such as the Eckel and Grossman (2002 2008) elicitation method, where individuals choose one from a set of six gambles, a hypothetical job question (Barsky et al. 1997) and a hypothetical choice question (Dohmen et al. 2005).

Another source of variation involves taking decisions for groups instead of individuals, whether the decision maker is part of it or not. Previous studies show that group risk taking can be more conservative than individual risk taking (Baker et al. 2007; He et al. 2012), but the reasons behind it are not clear. Bolton et al. (2015) propose three different hypotheses regarding why risk aversion is reduced when interacting in groups. The first argument is that social responsibility leads to greater conservatism or higher levels or risk aversion compared to deciding for oneself (Charness 2000). A second argument is that there is some level of individual conformism to match the behavior or responses of others in the same group (Cialdini and Goldstein 2004; Cooper and Rege 2011). The third argument is that there is a set of underlying distributional preferences that drives behavior, so decisions are aimed at reaching more equal payoffs between group members (Cooper and Kagel 2013). This would also imply that group membership favors in-group at the expense of discriminating anyone outside the group (Charness et al. 2007).

At the group level, Bolton et al. (2015) find evidence for conservatism in decisions for others (higher levels of risk aversion in a group setting) and conformism (through observation of other group members' choices) but not for social fairness. The same result is found by Reynolds et al. (2011), where one individual is responsible for the payoffs of the whole group. Riskier behaviors have been found by Sutter (2009), when group identity is sufficiently strong. Charness and Jackson (2009), however, argue that there is heterogeneity of behavior even when individuals are in groups and are responsible for someone else's welfare, contrary to the findings of Reynolds et al. (2011) and Bolton et al. (2015). They find that not everyone is influenced by responsibility when in a group. However, for those who feel responsible almost 90 percent play a less risky strategy when choosing for a group, when compared to choosing for herself.

Thus, risky decisions for others when analyzed using Stoner's (1968) risk theory do not have a unique answer. Minor differences in the experimental setting could be explaining changes in risk preferences when comparing decisions for oneself and for others. Decisions with uncertain outcomes where another party bears the consequences also depends on whether decisions are hypothetical or not (Chakravarty et al. 2011). There is evidence that measures of risk aversion in hypothetical choices are lower than those which entail real consequences (Harrison 2005, Eriksen and Kvaløy 2010). In addition, if the individual is not accountable for her actions and choices are only hypothetical and with no consequences, there might be incentives to avoid taking the optimal level of risk or take excessive risks (Vieider 2009).

2.3.3.2. Responsibility and prospect theory

The second theory of risk preferences is prospect theory (PT - Kahneman and Tversky 1979; Tversky and Kahneman 1992). This theory is based on the argument that human beings are not rational economical agents, thus not complying with the classical economic theories. The idea behind PT is that individuals do not formulate utility functions but assign value to outcomes. PT was developed to deal with situation-dependent behaviors, and considers, among other things, that individuals overweigh the importance of low probability events (Bowles 2004). In addition, PT argues that individuals value and weigh losses and gains differently, being a rationality violation, and in contrast to linear probability weighing (Wakker 2010). Individuals dislike losses more than an equivalent gain (this is defined as "loss aversion") and are more willing to take more risks to prevent losses (Kahneman 2011). This defines the four-fold pattern of risk preferences: when the probability of gain is high or of loss is small, individuals are risk averse, and when the probability of gain is small and of loss is moderate, individuals are risk seeking (Harbaugh et al. 2010).

Using PT as the underlying risk theory, Vieider et al. (2015) find that for both gains and losses, probability weighting becomes more extreme when deciding for others compared to oneself. This means that there is an accentuation of risk seeking for small probability gains and large probability losses and of an increase in risk aversion for large probability gains and small probability losses. Thus, there is evidence towards an accentuation of this four-fold pattern of risk preferences. The authors argue that for the previous literature, such as Bolton and Ockenfels (2010), Andersson et al. (2015), Pahlke et al. (2015) and Humphrey and Renner (2011), as the effect of responsibility for 50-50 prospects or moderate probability gains is likely to be weaker given that results are more extreme at higher probability levels than with 50-50 prospects. Similar results were found by Pahlke et al. (2015), where the recipients of that risk seeking see the risks as more acceptable in the loss domain than for gains.

Another set of studies focuses explicitly on loss aversion when making decisions for others. Loss aversion is thought to be responsible for an important part of risk aversion (Köbberling and Wakker 2005) and is used to explain phenomena such as the endowment effect (Kahneman et al. 1991), the gap between willingness to pay and willingness to accept (Brown 2005), the equity premium puzzle (Benartzi and Thaler 1995), selling behavior in housing markets (Genesove and Mayer 2001) and labor supply decisions (Fehr and Goette 2007). Although loss aversion is robust in decision making, it has been mainly studied when subjects make decisions for themselves. Loss aversion has been shown to be influenced by psychological distance (Trope and Liberman 2003) and it has been argued that it might be an exaggerated response to fear of loss (Camerer 2003).

Among the main results in the literature for loss aversion, Pahlke et al. (2015) and Andersson et al. (2014) show that when losses are possible, decisions on behalf of others are riskier. Andersson et al. (2014) argue that this increase in risk happens because loss aversion decreases. This is backed up by the fact that individuals are less affectively engaged when making decisions for others (Albrecht et al. 2011) and because loss aversion is more driven by affective or emotional reactions than deliberate or objective decision making (Ashraf et al. 2005; Vieider 2009). Thus, when deciding for others, the authors argue that there is less affective engagement than when deciding for oneself, and especially when real money is at stake (Polman 2012). Pahlke et al (2012) also found that adding an accountability mechanism to responsibility reduced loss aversion, when the decision makers have to justify their decisions in front of the recipient.

A specific type of loss aversion is myopic loss aversion (MLA; Benartzi and Thaler 1995). MLA is one of the plausible explanations for the equity premium puzzle, and relies on two behavioral assumptions, loss aversion and mental accounting (Thaler 1985). Mental accounting is an implicit tendency to evaluate long-term investments frequently, or using as reference its short-term returns. Thaler et al. (1997), Gneezy and Potters (1997), Gneezy et al. (2003) and Sutter (2007) find evidence of MLA when individuals make their own investment choices. If MLA holds, people should take less risk the more often they evaluate their investments. Only one experimental study analyzes the existence of MLA in risky decisions for others. Eriksen and Kvaløy (2010) argue that, if investment managers are deciding for others, their decisions affect client's exposure to risk, it is relevant to analyze what happens when someone decides for another person rather than for oneself. Their main finding is that individuals behave consistently with the MLA hypothesis when deciding for others, although to a lesser extent than when deciding for their own. The authors have a similar interpretation as Füllbrunn and Luhan (2015): managers use their own MLA when investing their client's money, but incorrectly adjust their behavior to incorporate their client's preferences.

Risk is therefore affected when being responsible for someone else for both gains and losses and some of the experimental evidence is at conflict with the cautious shift hypothesis. The accentuation of the four-fold pattern of risk preferences is also contrary to social norms that exert caution in situations of responsibility, and raises issues related to how pre-existing attitudes towards risk that are brought into an experimental setting might be accentuated (Pahlke et al. 2015). Decisions for others also reduce loss aversion, and Vieider et al. (2015) show that this reduction is consistent using different assumptions, such as equality of curvature for gains and losses or linear probability weights. Reductions in loss aversion has also been found outside financial settings or experimental settings that involve payoffs or gambles, such as decisions to get vaccinated (Polman 2012). One of the criticisms of these experiments is that in these studies, the decision makers do not seem to know who they are making decisions for. Individuals might make different decisions for strangers, family and friends (Hsee and Weber 1997) and there might be cultural differences in decisions for others as well, that are not accounted for in prior research (Markus and Kitayama 1991).

2.3.3.3. Responsibility and accountability

Another perspective on risky decisions for others analyses the changes in risk levels between decisions for oneself and others when framed as a financial decision. In financial markets, the individual is not usually making decisions for herself, but somebody else (a “money manager” for example) oversees investing decisions. As an example, there is consensus on the fact that the financial crisis of 2007-08 was due to excessive risk-taking and misaligned incentives between financial agents and investors (Cheung and Coleman 2014; Kleinlercher et al. 2014). There is evidence of a risky shift in financial markets, though this result could depend on how much money is on the line (Kaheman and Lovallo 1993; Holt and Laury 2002, 2005).

Experimental studies have found that subjects take less risk with their client's money than their own, regardless of the experimental design. Eriksen and Kvaløy (2010) study investments in a risky asset using the Gneezy and Potters (1997) setting, while Reynolds et al. (2011) and Füllbrunn and Luhan (2015) study the choices a money manager makes between risky and safe lotteries for himself as well as for different clients. However, these studies do not consider the fact that in financial markets, as well as in other situations, subjects could be held accountable for their actions. For example, CEO's stocks are generally tied to company performance and money managers might take a commission from their client's gains. It has been shown that subjects having to justify their decisions generally involves considering the options at their disposal more carefully (Lerner and Tetlock 1999). More careful decision making might reduce decision biases. Nevertheless, accountability might also lead to picking the decisions which are more easily justifiable (Simonson 1989).

Lefebvre and Vieder (2013) use a framed experiment where subjects rotate through the role of a chief financial officer (CEO). In this case, each CEO could opt between a high volatility, low expected value and a low volatility, high expected value option. However, they could be called upon to justify their decisions in front of the shareholders regarding their investment decisions and decision-making process. When accountable, subjects always take less risks. Accountability can take place when decision makers have to justify not only their actions but the actual outcome. Pollmann et al. (2014) show that justifying decisions seems to lead to more careful and constant risk strategies than justifying the outcome, bringing behavior of the decision maker closer to the preferences of the investor. Similar results were found by Pahlke et al. (2012). Therefore, accountability, even something as simple as the possibility of being called to justify a decision, and incentive structures, such as limited liability, might work to reduce risk exposure when someone has to decide for others.

Loss aversion has also been found to be reduced under accountability, regardless of the experimental settings in which the justification has to be done, whether it is to the investor (Pahlke et al. 2012) or in front of the experimenter (Vieider 2009). If decision biases such as loss aversion threaten to affect investment decisions adversely, it might help bringing some degree of accountability for principals (Pahlke et al. 2012). In practice, accountability of some sort exists and it even helps reduce or even eliminate loss aversion when agents are given the opportunity to explain their decisions (Eriksen and Kvaløy 2010).

Thus, accountability serves as a mechanism to reduce risky behaviors and potential biases in the decisions of financial managers when risk-taking is excessive from the point of view of company shareholders (Bebchuk et al. 2010). Although typically performance is judged by the outcome achieved, there is evidence that only using outcomes as a measure of accountability might be suboptimal when outcomes depend on chance (Lefebvre and Vieider 2013). Experimental evidence has found that a better system might be to hold decision makers accountable for the decision maker process, which has been defined as “behavioral monitoring” or “process accountability” (Lerner and Tetlock 1999; Ouchi and Maguire 1975). Mechanisms such as explaining the motive behind the decision maker decisions (Pahlke et al. 2012; Vieider 2009; Lefebvre and Vieider 2013) have been found to have positive results with respect to risk taking, but even inducing payoff commonality, such as evenly dividing the profit among the members of a group (Sutter 2009) changes risky decisions towards investments with higher expected gains and reduced volatility. However, not every decision for others involves financial investments. Parents make risky decisions for their children in education and health, governments decide on debt portfolios and bank failures or even when engaging in war. In this case, the ways of holding the decision maker accountable will be different, as well as the outcomes. This could include not reelecting a president or party or not being able to support elderly parents in the future, rather than a fully financial outcome of a portfolio investment. Risk, therefore, might not be only financial, but could include mortality, morbidity (when it comes to health), repetition rates in school or a decline in the percentage of voters for a specific party over time.

2.3.3.4. Responsibility and health

Risky decisions in the health realm have mostly centered around patient preferences and propensity towards risk (Mc Neil et al. 1978; van Mölken et al. 1995; Kind et al. 2009). However, physicians are usually the intermediary for patient's risk attitudes, and the ones to decide which treatment would suit the patient best. Physicians have the challenge of accurately predicting their patients' risk preferences and customize their advice and treatment to specific patient situations (Garcia-Retamero and Galesic

2012; McNutt, 2004). This is a common dilemma faced by physicians, and particularly because their own attitudes towards risk could influence diagnosis and treatments (Chandra et al. 2012). Doctors advise patients about decisions that are often personal, with important consequences, and patients might have little to no knowledge about these decisions (Chaitin et al. 2003; Garcia-Retamero and Galesic 2010). Beisswanger et al. (2003), Stone and Allgaier (2008) and Wray and Stone (2005), show that people make more risk seeking decisions or give riskier advice for others than for themselves when faced with risks the decision makers are not willing to take, and regardless of whether the decisions have positive or negative outcomes, or even where there is money on the table (Hsee and Weber 1997). This is in line with common medical practice and the experimental evidence seems to agree with it (Ubel et al. 2011; Garcia-Retamero and Galesic 2012).

Aside from the risk preferences theories discussed in the previous sections, there is a psychological component to risky decisions that is dealt with throughout the literature on health-based decisions for other. Slovic et al. (2007) argue that affect heuristics play a significant role in risky decision making. The valence of affect (feeling good versus feeling bad, for example), leads to larger self–other discrepancies when people do not have a personal relationship with the other person they are making the decision for (Hsee and Weber, 1997). There is plenty of evidence related to the amount of risk someone is likely to take depending on the positive or negative affect quality involved in decisions (e.g., Loewenstein et al 2001; Slovic et al 2007). For example, when people feel good about the situation or are in a better mood, risk is perceived to be lower and decisions made will be more risk-seeking (Finucane et al. 2000; Hogarth et al. 2011; Johnson and

Tversky 1983). Other emotions affect risky decision making, such as fear, anger, anxiety or sadness. Sadness and anger have been found to lead to more risk-seeking decisions, while fear and anxiety lead to more-risk averse decisions (Angie et al. 2011; Lerner and Keltner 2001; Raghunathan and Pham 1999).

So, in the health domain, medical decisions for others could be determined by the physician's and patient's emotions and feelings about risk. The central hypothesis of this argument is the risk-as-feelings hypothesis (Hsee and Weber 1997; Loewenstein et al. 2001; Slovic et al. 2004). The risk-as-feelings hypothesis states that assumes that doctors' decisions for their patients do not involve a conscious trade-off between benefits and drawbacks of treatments and that the doctor's own risk preferences, perceptions and feelings about risk are the prominent drivers of decisions for patients (Garcia-Retamero and Galesic 2012). This is the base of the social values theory (Stone and Allgaier 2008). In addition, people tend to underestimate the role of affective elements when predicting the decisions of others ("empathy gap"; Faro and Rottenstreich 2005; Loewenstein 1996). Other hypothesis states that when people make recommendations for others, they could tend to focus on the aspect that is easier to defend (Kray and Gonzalez 1999).

Although self-other decisions in health-related risk scenarios have received less attention than decisions for oneself, there is evidence that there are differences in what physicians would prescribe for themselves and for patients (Ubel et al. 2011; Garcia-Retamero and Galesic 2012). Garcia-Retamero and Galesic (2012) show that doctors made more conservative decisions for then patients compared to decisions for themselves (for example, a safer medical treatment), although patients would have liked a riskier treatment than the one selected. Thus, there is a discrepancy in self-other physician decisions, as they did not reflect or incorporate patient's preferences. Similar results were found by Stone et al. (2013) in a non-medical framed experiment. When faced with physical safety scenarios, such as deciding to take diet pills or getting in a car with a drunk driver, subjects made more risk-averse decisions for others than for themselves. Zhang et al. (2016) argues that these results are based on the fact that people are more risk-seeking in life-saving decisions when a strong affective component is involved, regardless of whether there is a gain or loss framing. In this case and based on the risk-as-feelings theory, in situations where the decision maker ends up feeling bad or uncomfortable, decisions would be more risk averse.

Risk-aversion also depends on the situation or diagnosis. Arrieta et al. (2016) find that although risk aversion prevails in all medical decisions, risk preferences for decisions involving life expectancy (for example, months of life recovered) are different from those involving quality of life (reduction in pain or symptoms). A cautious shift seems to be more prominent when it comes to reduction in the symptoms experienced by another individual compared to decisions regarding life expectancy. This result contributes to the experimental evidence on context-dependent risk attitudes in the health sector (van der Pol and Ruggeri 2008; Ruggeri and van der Pol 2012), as it also happens in other areas such as insurance purchasing (Barseghyan et al. 2011) or in the financial domain (Galizzi et al. 2016). Nevertheless, it is important to consider that these experiments do not include any type of accountability for those making decisions. Also, there are no real outcomes but just hypothetical. This could bias the results towards a more risk averse decision, as in practice, physicians face a medical review board if a patient could have been saved or a better treatment could be applied and the patient's health declines.

2.3.4. Social networks and health

Social networks are networks in which the vertices are individuals and the ties that join them represent some form of interaction (Newman 2010). Social networks refer to substantive role relations (friendship, kinship, marriage), interpersonal sentiments (respect, trust), behavioral interaction (advice, social support, gift exchange) as well as opportunity structures (Kitts 2014). Thus, relations defined by linkages are the main components of social network theory. Actors are viewed as interdependent units and ties are channels for transferring resources, this being the main difference with non-network explanations of a process. In addition, network analysis conceptualized the structure of the network as a series of lasting patterns of relations among actors (Wasserman and Faust 1994). Network analysis in a social context can be used to study the process of change within a group over time, to describe regularities or patterns, to understand features of individual units. Granovetter (1973) argues that the analysis of interpersonal networks and small-scale interactions can be translated into large-scale patterns, linking micro and macro levels through demography, coalitions and mobility structures.

In economics, social networks are used to explain patterns of diffusion of resources, information, learning and social capital (Currarini et al. 2015; Kirchkamp and Nagel 2007), team production (Fatas et al. 2010), job search (Holzer 1987; Montgomery 1992), cooperation among different networks and network structures and among other topics (Bramoullé and Kranton 2007; Carpenter 2007; Choi and Lee 2014; Leibbrandt et al. 2014). The idea that economic outcomes depend on network structure has been widely discussed, but individual decision-making and incentives are also important for the formation of a network.

When it comes to health, social interactions can shape preferences for healthy behaviors, such as physical activity, eating habits and vaccination decisions, but also for risky behaviors, which can lead to a sexually transmitted diseases (STD), obesity and even mental health issues like depression, self-esteem or anxiety. As individuals are connected, their health is connected as well (Smith and Christakis 2008). Social relationships also affect the cognitive development of an individual, altering self-perception as well as how individuals interpret rewards and threats, reciprocation and sensitivity to others' decisions (Pachucki et al. 2015). From a global network perspective, some behaviors, such as the decision to get vaccinated, can have a bigger impact than just in the individual's closest social circle, as it involves the transmission of a disease from one person to another throughout the network (this is called "percolation" in the network literature). Other behaviors, such as obesity or smoking have also been shown to percolate through the network like a cold (Christakis and Fowler 2007, 2008). There are three perspectives from which to look at health-related behaviors. The first perspective is a global one, analyzing the network as a whole (sociocentric) and looking at patterns of diffusion and transmission that encompass the whole set of interactions. The second perspective is a dyadic one, looking at pairs of individuals and their interaction. The third perspective is an egocentric one, where the focus is on the individual and only those connected to her, including the ties among these individuals.

2.3.4.1. Diffusion and contagion in networks

Diffusion and contagion in networks literature are usually looked at from an epidemiological perspective, which tries to explain how densely connected a network should be for an infection to reach critical levels, who is most likely to become infected and how widespread an infection is likely to be (Jackson and Yariv 2010). Diffusion is also related to the analysis of how a piece of information, such as gossip, percolates through a network. This implies that prior knowledge of the network structure is necessary in order to identify key positions and how these can influence how information or diseases flow (Banerjee et al. 2014). Disease and the transmission of ideas and information can be modeled as probabilistic models of diffusion based on how individuals take decisions and care about the behavior of their peers and neighbors. This includes the adoption of technologies, education decisions, learning a language or voting. There is also diffusion in labor markets, which was pioneered by the ideas of Granovetter (1973, 1985, 1995), who showed that even casual acquaintances play an important role in diffusing information. Other initial studies in labor market diffusion of job openings include Rees (1966) and Rees and Schultz (1970).

Understanding diffusion is important for epidemiological reasons. For example, Christakis and Fowler (2007) found that social contact influences obesity levels. In their study, an individual’s chance of becoming obese increased by almost 60 percent if she had a friend or a sibling who became obese in the timeframe of the study. The authors conclude that obesity could spread as a disease through social ties, so policies and support that targets not only the individual but his peers would be more successful than those who do not. In addition, the position of the individual on the network seems to affect obesity. Overweight adolescents were found to be more isolated and peripheral (Strauss and Pollack 2003), while for adults, the higher the network social capital (position of the individual and prestige of the job), the higher the chance of being obese (Moore et al. 2009). Cohen-Cole and Fletcher (2008) argue that there is also an environmental component to the spread of obesity, related to the place in which individuals live, such as the opening of a restaurant or a gym near a school or other shared surroundings. In fact, some studies have shown that in school-based friendship networks friends have similar measures of physical activity as well as food consumption (de la Haye et al. 2010; Feunekes et al. 1998; Monge-Rojas et al. 2002; Unger et al. 2004) and that people with similar body mass index tend to cluster together into groups (Bahr et al. 2009).

Other health behaviors have been widely studied in a social network framework, such as smoking, drug use and sexually transmitted diseases (STDs). Networks of drug use are networks of high-risk of disease transmission, and a high probability of disease contagion is not uniquely determined by the fact that two individuals share drugs or needles or a sexual relation but also involves patterns within the network that might increase the risk of contagion (Adams et al. 2013). In particular, the influence between individuals within the social network might facilitate the transition from a social tie to a drug tie between two individuals, especially if they have spatially close interactions (Salathé et al. 2010). This paired with individual characteristics could increase the risk of contagion (Adams et al. 2013; Bearman et al. 2004; Neaigus et al. 2006; Havens et al.

2013). Affected individuals also face other issues, like social marginalization and poverty.

Models of STD transmission show that there is usually a densely interconnected core that disseminate the disease to other, less active parts of the network, and that the efforts to stop the disease should be directed and not global (Laumann and Youm 1999). However, networks from these studies are usually gathered through ego-centered studies or snowball sampling, losing global network properties that might impact the spread of the disease. Bearman et al. (2004) show that there could be more fragility in the disease transmission depending on the network structure. Specifically, if the network is composed of different spanning trees, the breaking down of one tie could halt the spread of the disease as it could break the network into different parts. Thus, the most effective strategy to control the spread of STDs is a global control program that targets the entire population, managing to break the network into different and independent sub-networks, and halting the overall transmission. This is also in line with Helleringer and Kohler (2007), who also argue towards a global network analysis. The authors find that individuals report few sexual partners, but as a whole, the network is structured into a large interconnected hub. Specific targeting to halt the disease would not be effective in reducing disease transmission. Although not related to STDs, the study on tuberculosis outbreaks by Klovdahl et al. (2001) suggests another potential way of using targeted health policies, analyzing areas or specific places where outbreaks of the disease occur.

When it comes to individual ties, Granovetter (1973) argued that it is weak ties, such as colleagues, contacts or friends of friends, and not strong ties that increase the chances of, for example, someone getting a job or catching a disease. The argument behind this is that weak ties tend to expand the network of an individual, playing important roles in disseminating information, increasing mobility and reducing the fragmentation of a network. A network only composed of strong ties would be relatively small and highly fragmented. Disease transmission in social networks and in particular, disease transmission among drug users are one of the riskiest aspects of networks composed of only weak ties. Rothenberg et al. (1998) find that lack of disease transmission is due to the position of infected people within the network. Transmission might be impeded if the personal networks of infected people are small and not connected to other denser components of the network. Neaigus et al. (1995) show that people displaying high-risk behaviors are more likely to be infected with HIV. The authors argue that networks of drug injectors are unstable as they are formed by weak ties and these ties are usually short-term relationships. These weak ties might increase the probability of exposure to diseases such as HIV. In addition, early prevention in low incidence areas could be more successful than in high prevalence areas (Price et al. 1995).

Assortative mixing and clustering have been found in contagion networks (Christakis and Fowler 2008). Homophily (Lazarsfeld and Merton 1954) also plays a key role in drug use. There is evidence that acknowledges that homophily and contagion are confounded in observational settings. This is due to the presence of individuals and her connections' – ego and alters - unobserved confounds and homophily between the confounds themselves (Shalizi and Thomas 2011). Specifically, that the formation of race-based homphilous ties seems to be persistent in time (Mollica et al. 2003). Aral et al. (2009), show that homophily explains more than 50 percent of the perceived behavioral contagion, supporting the hypothesis that peer effects are an important contagion component. In addition, DiMaggio and Garip (2011), argue that homophily stimulates positive network effects when adopters share networks. Segregation effects are also present, where lack of income or employment is paired with already poor neighborhoods, low social capital and high-income inequality (Fuller et al. 2005; Latkin et al. 1995).

Lastly, network studies have not only focused on physical transmission of diseases but also on mental issues and health-related emotional states, such as depression (Rosenquist et al. 2011), self-esteem (Pachucki et al. 2015), happiness (Fowler and Christakis 2008; Hill et al. 2010), social isolation (Mc Pherson et al. 2006) and suicide (Bearman and Moody 2004; Mueller and Abrutyn 2015). Depression has been found to be contagious through interactions with friends, family and strangers (Joiner and Katz 1999). Happiness could also be thought of as a form of social infection, as interacting with people who are happy increases the likelihood of being happy in the future (Fowler and Christakis 2008). As an example, Bearman and Moody (2004) found that the friendship environment during adolescence affects suicidality. Having a friend who committed suicide or having low self-esteem increased the likelihood of suicidal ideation and knowing someone who attempted suicide was a significant predictor from ideation to action. This is evidence of how ties influence health-related emotional states. In addition, the authors found that individuals who are isolated in the network may be more likely to consider suicide, as isolation can lead to low self-worth.

Network influences health through many channels. Its structure can influence contagion, even without individuals having to interact daily. One of these examples is the spread of severe acute respiratory syndrome (SARS, Colizza et al. 2006, 2007). Network structure can determine how fast and broadly HIV or an STD can spread and individual analysis of interactions helps quantify the influence that those who are close to the individual exert. This is essential when looking at the influence of friends and family on self-esteem, happiness or even obesity. However, analysis of individual interactions is not enough from a policy point of view. Global or complete networks, in contrast to ego or snowball determined networks have their advantages when it comes to determining whether solutions to the problem should be targeted or should be aimed at the whole network (Zhang et al. 2015). Thus, network perspectives are not unique and vary depending on the issue tackled, especially when it comes to health issues.

2.3.4.2. Peer effects and risky behaviors

Daily interactions that individuals have include friends and family. When looking at how networks affect individual behavior, it is not only relevant to look at how the network as a whole affect individuals but also how kin and the nearby social environment of the individual can influence behaviors. For example, friendship has been shown to be important because it influences the social, cognitive and emotional development, especially during childhood and adolescence. In particular, adolescents are more susceptible to get influenced by their peers, shaping their social norms, behaviors and expectations (Duncan et al. 2001; Maxwell 2000). Peers can affect others' endowment or choice sets, including the exposure and transmission of information (Duflo and Saez 2002), classroom disruption (Lazear 2001), educational outcomes (Kremer and Levy 2003; Hanushek et al. 2003), worker productivity (Mas and Moretti 2009) and even teen pregnancy (Evans et al. 1992; Crane 1991).

The pioneer study on peer effects (Manski 1993) distinguishes between three different effects arising from one's peers, which might be correlated with individual behavior. The first effect is the exogenous or contextual effect, which includes the influence of peer characteristics on individual behaviors (Cohen-Cole and Fletcher 2008). The second effect is the correlated effect as individuals in the same group tend to behave similarly because they face a common environment or are alike (Christakis and Fowler 2007). The third effect is the endogenous effect, which includes the influence of peers on individual behaviors. However, the individual can also shape his peers' behaviors, as there is evidence of assortative mixing, homophily or a preference to be around individuals similar to oneself (McPherson et al. 2001). Manski refers to this as "the reflection problem". As a whole, the endogenous influence of peers is what is termed "peer effects" in the literature.

Several studies have shown that peers can influence risky behaviors, such as smoking, drinking and doing drugs, especially for adolescents and college students. Lundborg (2006) found positive and significant peer effects for all three activities in a sample of 12 to 18 year olds. In the case of smoking, a wide number of studies have determined that adolescent smoking can be predicted by peer influence, although the magnitude of the effect varies (Conrad et al. 1992; de Vries et al. 2003; Kobus 2003; Leventhal and Cleary 1980; Maguir et al. 2000; McAlister et al. 1979). The analysis of friendship networks, in particular of close friends, suggests that face to face interactions have a higher impact, as these situations can potentially serve as norm transmitting situations (Valente and Davis 1999; Rowe and Rodgers 1991; Urberg et al. 1997). At the school level, peers who smoke, especially popular students increase the likelihood of someone starting smoking, and the impact is larger in those schools with high smoking prevalence (Alexander et al. 2001). So, there is potential to target those individuals who are more central to a network, as transmission through the networks has to go through these specific and more popular students. Ali and Dwyer (2011) also find that for adolescents, the peer effect on smoking behaviors is not only significant on that stage, but also transitions into adulthood. The same transitioning effect has been found for drinking behaviors (Kremer and Levy 2008), as well as for conforming to peer drinking norms (Balsa et al. 2011). Although the literature on substance abuse and drinking is pretty large, the effects found are similar. Interaction with substance-using friends predicts increasing substance use for oneself, and this effect is larger when looking at close friendships (Arnett 2007; Bauman and Ennett 1996; Ennett and Bauman 1996; Ennett et al. 2008; Knecht et al. 2011; Kobus and Henry 2010; Poelen et al. 2007; Urberg et al. 2003).

Peers also influence obesity and physical activity patterns. Several studies have shown that food consumption patterns can be influenced by peers, such as fast food and high-fat snacks (Feunekes et al. 1998; Monge-Rojas et al. 2002; Pachucki and Goodman 2015), and that even weight loss behaviors can be influenced. In addition, incorporation of norms about physical activity and fast food consumption patterns have been shown to be associated with higher peer group acceptance (Unger et al. 2004). Yakusheva et al. (2011) analyze college students weight gain and show that weight gain is negatively correlated with the roommate’s initial weight. In addition, females were more likely to adopt weight-loss behaviors (in terms of both eating and exercising) from roommates. Peers actually alter the perceptions of how acceptable weight is defined, especially among females and adolescents with higher body mass index (Crawford and Campbell 1999; Trogdon et al. 2008). Specifically, support from friends has been shown to influence the levels of physical activity (Duncan et al. 2001; Voorhees et al. 2005). However, weight has also been shown to be a predictor of marginalization and social stigma (Strauss and Pollack 2003).

Social interaction has been shown to affect the emotional state and mental health of individuals. From a global perspective, Hill et al. (2010) show that emotional contagion can percolate throughout a network over time like an infectious disease, not only by direct contact, but also by media exposure (Joiner and Katz 1999). From an individual perspective, "emotional contagion" (Hatfield et al. 1994) has been shown to happen between people with close contact, such as family or roommates (Howes et al. 1995; Larson and Almeida 1999) and also in experimental settings (Fowler and Christakis 2010). There is a gender bias however, as women seem to respond to depressive symptoms and less self-esteem by reducing their social interactions when compared to men (Pachucki et al. 2015) and where female friends are more influential in spreading depressive symptoms from one person to another (Rosenquist et al. 2011). There is also gender bias when analyzing suicidality. Bearman and Moody (2004) find that females who were socially isolated were more likely to have suicidal thoughts.

Peer effects are important when it comes to policy interventions and the possibility of amplifying these throughout the network (social multiplier effects). If the social multiplier is large, policies such as changing the minimum age to drink, smoke, legalizing drugs or even campaigns to get vaccinated, to donate blood or even to exercise might have larger effects even when the interventions are small. However, the relevant peer group for an individual is sometimes difficult to determine. Although classrooms, residence hall floors or student cohorts might be valid peer groups in which to study behavior, these groups might not actually represent the friendship network of an individual (Halliday and Kwak 2012). Also, if these groups are actually the relevant networks to study peer effects, there is a socioeconomic component, relevant to the environment of the individual, which has to be controlled for to tease out the actual peer effect.

In addition, there is some degree of endogeneity when analyzing peers, as individuals in most cases decide who to associate with and individual characteristics tend to be similar to their peers. While peer selection is related to similarity among individuals, peer effects or influence are related to peer behavior (Ali and Dwyer 2011). One of the ways to overcome this issue is to draw a sample of individuals for whom ties are randomly assigned. For example, the assignment of college students' roommates or random assignment of school students to the different classrooms (Kremer and Levy 2008; Sacerdote 2001; Yakusheva et al. 2011). From an econometric perspective, this problem has been addressed by using fixed effects (Trogdon et al. 2008), instrumental variables (Halliday and Kwak 2012) or Bayesian approaches (Goldsmith-Pinkham and Imbens 2013). Disentangling the influence of the correct peer group and reducing the impact of peer selection is important when trying to assess policy impacts, as otherwise estimates could be biased. Another way of disentangling the correct peer group is to estimate spillover effects and adjust for interference (Ogburn and Van der Weele 2014; Christakis and Fowler 2008; Cohen-Cole and Fletcher 2008). That is, accounting for the impact of one's and the peer's decisions on the individual's outcome.

2.4. Discussion

The purpose of this literature review was to summarize the literature on risk preferences and health-related behaviors, emphasizing the different perspectives health has been addressed within the risk literature. Our focus was two-fold. We first analyzed the different ways risk attitudes have been modelled and measured. Second, we summarized the literature linking risk preferences with health-related behaviors.

Experimental research has shown that experimental measures of risk and time preferences serve as a good predictor for individual health-related behaviors. Individuals who are more risk tolerant would be more prone to unhealthy behaviors, and incentives to change unhealthy behavior patterns are short-lived once the incentives are taken away. Moreover, there is a relationship between habit formation, incentives, repeated actions and risk aversion that has not been tackled by the current literature. Future research should focus on finding and analyzing incentives that help individuals reduce the frequency or eliminate unhealthy behaviors in the long-run. In addition, individual health has also been shown to impact decisions in other domains, such as individual portfolio allocation and wealth accumulation. Isolating the risk that health entails from other potential sources of risk is a difficult task, as many of the sources of uncertainty, such as expectations of future income or current health status are based on individual choices.

Risk preferences could affect decisions related to other individuals' health. Medical decisions for others could be determined by the physician's and patient's emotions and feelings about risk. There is evidence that there are differences in what physicians would prescribe for themselves and for patients, with doctors making more conservative decisions for their patients. Risk preferences could also affect health of others within a network setting. Individual analysis of interactions helps quantify the influence that those who are close to the individual exert. Research has shown that food choices, obesity and alcoholism could percolate through a network. However, analysis of individual interactions is not enough from a policy point of view. Global or complete networks, in contrast to ego or snowball determined networks have its advantages when it comes to determining whether solutions to the problem should be targeted or should be aimed at the whole network. Separating the influence of different peer groups and tackling the biases encountered in peer selection are two of the main research questions in this topic.

CHAPTER 3

AN (UN)HEALTHY SOCIAL DILEMMA: USING NORMATIVE MESSAGING TO INCREASE FLU VACCINATIONS

3.1. Introduction

Yearly seasonal influenza (flu) epidemics can seriously affect populations through rapid spreading of the disease, particularly in crowded areas such as schools or college residences (WHO 2009). During the 2018 season, flu activity increased sharply starting in November 2017 and peaked only by the end of February 2018, when it commonly peaks between December and February (Center for Disease Prevention and Control (CDC) 2018). Flu also reached epidemic levels for more than a month. The severity and the length of the 2018 season is evidence that flu seasons can be unpredictable and that prevention before the flu season begins is one of the most important measures against the flu.

Vaccination is the most effective way to prevent infection and related illnesses caused by influenza viruses, and safe and effective vaccines have been used for at least 60 years[6]. The CDC recommends the flu vaccine for everyone six months or older, regardless of the level of effectiveness against one or more of the flu viruses[7]. Yet, vaccination coverage is far below the public policy objectives, as more than half of the population is usually unprotected against the flu when the target is 70 percent (CDC 2016). Flu vaccines are a joint product, with individual and social benefits. With joint

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[6] Although the vaccine does not prevent getting the flu, it reduces the chances of getting the illness by 40-60 percent among the overall population when the circulating viruses are well matched to the viruses in the vaccine. Flu vaccination can also reduce the severity of the illness, reducing hospitalizations or doctors' visits among at risk populations (CDC 2017).

[7] The flu vaccine protects against three or four viruses that research suggests will be most common for the flu season (CDC 2018).

products, individuals may care about individual benefits, social benefits, or both. We test the ability of a non-pecuniary mechanism, normative messaging, to increase vaccination rates.

With vaccinations, individuals have an incentive to free ride, avoiding the cost of the vaccine and indirectly benefiting from others getting the vaccination. Herd immunity is therefore a social dilemma, as vaccinations help the individual and others, but it is costly for someone to get the vaccine. One non-pecuniary mechanism which could influence vaccination decisions is normative messaging (Allen et al. 2009). We incorporate normative messages into an established university flu campaign. We examine whether highlighting each of the vaccination benefits influences the decision to get vaccinated.

If messaging is successful in changing the decision to get a vaccine, it would provide a one-year benefit to the individual, as the flu vaccine protects the individual until the next flu season. In the health domain, prior experimental research has focused on repeated decisions with short-term effects, such as exercising or changing food habits (Charness and Gneezy 2009; Burger et al. 2010). From a public policy perspective, increases in vaccination coverage could provide incremental public health benefits, reducing the cost of medical care (Jarrett et al. 2015). In the United States, Molinari et al. (2007) estimated that the total economic burden of annual influenza epidemics amounts to $87 billion, with $10.4 billion flu-related direct costs (hospitalization and outpatient visits) and $16.3 billion on lost days and lost productivity due to illnesses and loss of life. This means that influenza does not impact only the health system but also affects businesses as well as the education system.

Our experiment focuses on using normative messaging to increase flu vaccinations on a university campus, highlighting both the individual and social benefits of the vaccine. Normative messaging is done indirectly through the use of posters that inform students about the flu vaccination campaign around campus. Posters were located in each floor in each residence, to maximize exposure to the messages. We find that normative messaging which emphasizes the benefits of the vaccine helps increase the percentage of students getting the flu vaccine compared to no message. Highlighting both the individual and social benefits of vaccination has the strongest impact on vaccination turnout. Women seem to be driving the results, as any message that highlights either the benefits of the vaccine or both at the same time is positively related to the vaccination rate. This is consistent with previous literature suggesting that women are more sensitive to social cues that determine appropriate behavior than men and have stronger emotional reactions to risky situations, especially in anticipation of negative outcomes, such as getting the flu (Croson and Gneezy 2009; Harris et al. 2006; Weber et al. 2002). Risk loving students are more likely to get vaccinated, valuing avoiding getting sick and disrupting school or work attendance more than the side effects of the vaccine itself.

From a theoretical perspective, we contribute to the literature on public good provision by extending Andreoni's (1990) impure altruism model. We explicitly incorporate the impact of normative messaging on the decision to contribute to a joint product, the vaccine. Each individual's decision to vaccinate provides a private benefit and also increases the level of herd immunity. Additionally, we focus on the discrete decision to contribute (receive the vaccine or not) as opposed to a continuous contribution decision, such as charitable giving.

3.2. Previous literature

There are two main strands of literature relevant to our study. The first one is related to the influence of social norms on health-related behaviors. The second one is the literature on voluntary public goods provision. We briefly discuss these literatures below.

3.2.1. Influencing health-related behaviors

Public health interventions attempt to influence the way people consciously think about their behavior. If it is possible to induce a beneficial habit such as exercising or quitting smoking through the adjustment of perceptions of social norms, the implications for public policy could be significant in terms of cost reduction of health care provision (Charness and Gneezy 2009; Zimmerman 2009).

One of the ways behaviors could be modified is by using normative influence[8]. However, norms are only expected to affect behavior when they are salient at the time of behavior – that is, when people's attention can be drawn to the norms (Lawrence 2015). In the case of health-related behaviors, normative influence has been used to incentivize increases in physical activity (Burger and Shelton 2011), healthier food consumption (Burger et al. 2010; Lally et al. 2011; Yun and Silk 2011; Smith-McLallen and Fishbein 2008) and reductions in alcohol consumption (Neighbors et al. 2004; Clapp et al. 2003). The difference between these behaviors and the decision to receive the flu vaccine is that

[8] Normative influence can be defined as a form of influence that uses perceived behavioral patterns as well as approval and disapproval social norms as a way of modifying behavior (Cialdini et al. 1990).

deciding to exercise, eat or drink are daily repeated decisions with short-lived effects, while getting a vaccine is a yearly one-time decision with longer-term effects (protection from the virus). Getting a flu vaccine is a suitable decision for a normative-based intervention as the norm should change the behavior once to have a year-long effect.

Normative influence could happen directly through social interactions but also indirectly using signs, posters, printed messages or electronic communications. Indirect methods are particularly useful when the target audience is large and harder to reach and where interactions are repeated, such as hotel guests or college students. As an example, Mollen et al. (2013) use descriptive and injunctive messages to indirectly incentivize healthy food choices at an on-campus food court[9]. They find that healthy descriptive messages resulted in more healthy food choices compared to no message, the unhealthy descriptive or the injunctive message. Similar results have been found by Burger and Shelton (2011), who use descriptive norm manipulations to analyze the choice between taking the elevator and using the stairs. For our analysis, we use messaging that is injunctive and prescriptive to emphasize the individual and social benefits of the flu vaccine. Our normative messages are part of an established flu campaign that uses posters placed in university residence halls.

[9] Norms can be either injunctive or descriptive. Descriptive norms provide information about how to act in a certain situation while injunctive norms refer to conducts that the majority of individuals approve or disapprove of (Cialdini et al. 1990; Mollen et al. 2013; Cialdini and Goldstein 2004). In addition, injunctive messages can be of the prescriptive or proscriptive type. Prescriptive messages tell people what they should do, while proscriptive messages tell people what they should not do (Winter et al. 2000; Bergquist and Nilsson 2016).

3.2.2. Voluntary public goods provision: the case of vaccinations

From a standard economic perspective, an individual deciding to receive a vaccine or not would go through a cost-benefit analysis, where she gets vaccinated if the perceived costs are lower than the perceived benefits of the vaccine (Chen and Stevens 2016). An individual getting a flu vaccine does so with the aim of protecting herself from the illness. However, an individual who gets vaccinated generates a positive externality on other individuals, reducing the chances of the spreading of the disease (Böhm et al. 2016). Therefore, getting vaccinated contributes to building herd immunity, protecting children, pregnant women, older adults or immunocompromised individuals from a flu outbreak. Vaccination would also protect classmates, roommates, friends and anyone living in the same residential hall as the student getting the flu vaccine. Herd immunity is our public good, as nobody can be excluded from benefiting from it and everyone receives the benefits (non-rivalry).

Vaccinations are joint products, with both individual benefits and characteristics of a public good. Although some individuals might voluntarily seek to get a vaccination to contribute to the community, there is an incentive to free ride and not get vaccinated (Ibuka et al. 2014; Vietri et al. 2012; Chapman et al. 2012). For example, several studies find that there are parents who believe that their children do not need a vaccine argue that this is because other children already received the vaccine (Benin et al. 2006; Meszaros et al. 1996; Hershey et al. 1994). Free riders avoid the cost of getting a vaccine, while indirectly benefiting from others getting vaccinated (Serpell and Green 2006; Vietri et al. 2012; Chapman et al. 2012). Therefore, herd immunity could be thought of a social dilemma (Dawes 1980): getting the vaccine helps protect others through increased herd immunity, but it is costly for an individual to get a vaccine. In our flu vaccination campaign, we focus on both the individual and social benefits of the flu vaccine in terms of risk reduction, with the aim of examining which benefit has a greater impact on vaccination turnout.

The perception of risk about the disease (the belief about potential harm) also affects the decision to get vaccinated, with those individuals who perceive they will have a higher chance of getting the flu being more likely to receive the vaccine (Brewer et al. 2007; Norman et al. 2005). Perceived risk is associated with a range of anticipated emotions before getting the vaccine, such as fear, regret or worry (Betsch and Schmid 2013; Weinstein et al. 2007). Some misconceptions regarding that the flu vaccine are that it will give people the flu or will get people sick, that vaccines do not work or that a vaccine is unnecessary because one is at a low risk of infection. All of these misconceptions have been found to negatively impact vaccination rates (Nyhan and Reifler 2015; Chen and Stevens 2016). We thus incorporate individual's beliefs about the effectiveness and safety of the vaccine to our analysis as well as the individual's general risk preferences. The posters used in the campaign additionally include a flu fact emphasizing the way an individual might get the flu from others.

3.3. Theoretical model

Our theoretical model is a model of impure altruism, a special case of the joint products model (Andreoni 1990, Cornes and Sandler 1984). Receiving a flu vaccine has both private and public benefits, as it protects the individual and helps build herd immunity[10]. Therefore, the individual's utility depends on both their private benefit as well as the community benefit of the vaccine. Our outcome variable is discrete and with two alternatives (get vaccinated or not) and our utility has both private (vaccination) and collective goods (herd immunity) as arguments (Deacon and Shapiro 1975). The focus of this model is to understand the impact of normative messaging that highlights the individual and social benefits of the flu vaccine on the individual decision to receive the vaccine.

Consider a situation with one private good, x_i and one public good, H (herd immunity). Individuals have an endowment w_i that they can allocate between the consumption of the private good and their contribution to the public good, v_i, the vaccine. The decision to get vaccinated, v_i, is binary, and it takes the value 1 if the individual gets a flu vaccine and 0 if she does not. N is the total number of individuals, and $H = g(v_1, \dots, v_i, \dots, v_N)$ the level of herd immunity, which depends on the number of vaccinated individuals ($\frac{\partial H}{\partial v_i} > 0, i = 1, \dots, N$). The decision to vaccinate and the level of herd immunity positively impact the individual's health, $_i$ ($\frac{\partial h_i}{\partial v_i} > 0, \frac{\partial h_i}{\partial H} > 0$).

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[10] Herd immunity is a situation in which "a sufficient proportion of the population is immune to an infectious disease to make its spread from person to person unlikely" (CDC 2016). Building herd immunity is done through individuals deciding to vaccinate (or vaccination being mandatory). Therefore, we could think of the level of herd immunity as dependent on the number of individuals vaccinated against a disease.

individual gets a flu vaccine and 0 if she does not. N is the total number of individuals, and $H = g(v_1, \dots, v_i, \dots, v_N)$ the level of herd immunity, which depends on the number of vaccinated individuals ($\frac{\partial H}{\partial v_i} > 0, i = 1, \dots, N$). The decision to vaccinate and the level of herd immunity positively impact the individual's health, $_i$ ($\frac{\partial h_i}{\partial v_i} > 0, \frac{\partial h_i}{\partial H} > 0$).

Individual vaccination enters the utility function by impacting the individual's health, affecting the individual's self-image and through the cost of vaccination. Individual vaccination affects the individual's health through two channels: as part of the herd immunity and as a private good. Getting a vaccine is an action aimed to protect the individual from the illness, but an individual could also decide to get a vaccine for altruistic reasons, contributing to herd immunity and to reduce the likelihood of others getting the illness.

The individual decides whether or not to vaccinate based on the cost of vaccination, θ. The cost of vaccination is defined in the interval $[0,1]$ and has an inverse relationship with utility ($\frac{\partial U}{\partial \theta} \leq 0$), so that the smaller θ is, the more likely the individual is to vaccinate $\left(\frac{\partial^2 U}{\partial v_i \, \partial \theta} < 0\right)$.

The utility function can be written as:

$$U_i = U_i(x_i, \ _i(H, v_i), I(v_i, s, c, \rho), \theta v_i) \qquad i = 1, \dots, N; \ s = 0,1; \ c = 0,1$$

$$= U_i(x_i, \ _i(g(v_1, v_2, \dots, v_n), v_i), I(v_i, s, c, \rho), \theta v_i) \qquad (1)$$

The individual's self-image positively impacts utility ($\frac{\partial U}{\partial I} > 0$). From a psychological point of view, self-image includes the perception of oneself and her behaviors and is shaped by how the individual interacts with her community (Baumeister 1999; Lewis 1990). In our model, self-image is therefore affected by the individual self-interest for different activities, decisions and behaviors and by the individual perception of interactions between the individual and the community (Rogers et al. 1977).

Self-image is an increasing function of the decision to vaccinate ($\frac{\partial I}{\partial v_i} > 0$), the normative messages targeting the individual's self-interest ($s, \frac{\partial I}{\partial s} > 0$), and the individual's "community-mindedness" ($c, \frac{\partial I}{\partial c} > 0$) regarding the vaccine. Self-image also depends on a set of factors, ρ, which includes individual characteristics such as gender, peer effects, risk attitudes and other-regarding preferences. We assume that individual characteristics do not change in the short-run ($\frac{\partial I}{\partial \rho} = 0$).

Research suggests that normative influence can also affect individual behavior (Cialdini et al. 1990; Mollen et al. 2013; Cialdini and Goldstein 2004). Norms can be used to influence healthy behaviors. In the case of flu vaccinations, normative messages can target the individual's self-interest (s), the individual's "community-mindedness" (c) or both at the same time.[11] In this model, both benefits of the vaccine could influence the individual's vaccination decision through modifying the individual's self-image.

We normalize the price of the private good to 1. In the case of the decision to receive the vaccine, there is a cost to do so, b, which has a negative impact on utility

[11] The concept of "community-mindedness" is used by Kessler and Milkman (2016) to refer to the idea of helping others through priming social cohesion and affinity. Liberman et al. (2004) showed that priming "community-mindedness" increased cooperation in a prisoner's dilemma framework, while Kessler and Milkman (2016) find an increase in charity donations when the same concept is implemented.

($\frac{\partial U}{\partial b} > 0$). The individual cost of getting a flu vaccine, depends on the decision to receive the vaccine as well as on a set of factors, Z, which includes the price of the vaccine as well as individual characteristics such as gender, beliefs about the vaccine, the transportation cost of getting the vaccine, peer effects in vaccination decisions, risk attitudes and other-regarding preferences ($\frac{\partial b}{\partial Z} > 0$).

The individual would therefore maximize her utility by choosing her level of consumption for the private good, x_i and her decision on whether to vaccinate or not, v_i:

$$\begin{aligned} \max_{x_i, v_i} U_i = U_i(x_i, \quad _i(H, v_i), I(v_i, s, c, \rho), \theta v_i) \\ s.t.\ x_i + b(Z, v_i) = w_i \\ H = g(v_1, \dots, v_i, \dots, v_N) \\ v_i = \{0,1\} \end{aligned} \tag{2}$$

As receiving the flu vaccine is a discrete decision, an individual considering a vaccination would compare her utility level from getting and not getting the vaccine ($v_i = 1$ versus $v_i = 0$). Thus, an indifferent individual would equate:

$$U^1 = U(w_i \quad b(Z,1), \quad _i(g(v_1, \dots, 1, \dots, v_N), 1), I(1, s, c, \rho), \bar{\theta} \quad 1) =$$

$$U(w_i \quad b(Z,0), \quad _i(g(v_1, \dots, 0, \dots, v_N), 0), I(0, s, c, \rho), \bar{\theta} \quad 0) = U^0 \tag{3}$$

Where $\bar{\theta}$ is the vaccination cost level for the indifferent individual. We assume that if the individual does not get the vaccine, there is no change in her self-image and therefore no change in utility ($\frac{\partial U^0}{\partial I} = 0$).

To analyze the impact of normative messaging, we use the total derivative of the utility equation (3) for the indifferent individual:

$$\frac{dU^1}{dw_i}dw_i \quad \frac{dU^1}{db}\frac{db}{dZ}dZ + \frac{dU^1}{d\;_i}\frac{d\;_i}{dH}\sum_{j\neq i}\frac{dH}{dv_j}dv_j + \frac{dU^1}{dI}\left(\frac{dI}{ds}ds + \frac{dI}{dc}dc + \frac{dI}{d\rho}d\rho\right) + \frac{dU^1}{d\bar{\theta}}d\bar{\theta} =$$

$$\frac{dU^0}{dw_i}dw_i \quad \frac{dU^0}{db}\frac{db}{dZ}dZ + \frac{dU^0}{d\;_i}\frac{d\;_i}{dH}\sum_{j\neq i}\frac{dH}{dv_j}dv_j \qquad (4)$$

Our hypotheses are directly related to the individual behavior when exposed to the messages. Based on equation (4), if we highlight only the individual benefits of the vaccine ($ds > 0$) and hold income, peer vaccinations and costs constant, the vaccination cost for the indifferent individual increases ($d\bar{\theta} > 0$). If the indifferent type cost increases, this means that it is more likely for the individual to get vaccinated (more individuals get vaccinated). There is a similar impact on the decision to vaccinate if only the social benefits of the vaccine are emphasized ($dc > 0$).

It could also be the case that norms that focus on the individual and the community benefits of the vaccine together also have a positive effect on increasing the likelihood of getting a flu vaccine ($ds > 0$ and $dc > 0$). If the individual and the community benefits are complements ($\frac{\partial^2 I}{\partial s \partial c}$>0), there would be no crowding out. Normative messaging that includes both benefits together would have a positive impact on the likelihood of getting the vaccine by increasing the vaccination cost for the indifferent individual, $\bar{\theta}$ ($d\bar{\theta} > 0$) (Betsch et al. 2013). We hypothesize that:

H_1: Messaging that highlights any of the benefits of the vaccine (individual, community or both) has a positive effect on the decision to get vaccinated.

If normative messaging of any type is successful at increasing the likelihood of getting vaccinated compared to no messaging, the next question is: which of the three messages increases the likelihood of getting vaccinated the most? The difference in the strength of the norm which only highlights the individual or only the community depends on how much weight the individual places on the community ("others") versus herself, which should vary among individuals (Kessler and Milkman 2016). However, Betsch et al. (2013) show that emphasizing the community component of herd immunity could have a stronger effect than just the individual benefits when vaccination costs are low. Thus, in our model, we assume that $\frac{\partial I}{\partial c} > \frac{\partial I}{\partial s} > 0$. From equation (4), the increase in the vaccination cost for the indifferent individual would be larger in the case the community benefits of the vaccine are emphasized, making it more likely to get vaccinated than when only the individual benefits are highlighted. We hypothesize that:

H_2: Messaging that only highlights the social benefits of the vaccine has a larger positive effect on the decision to get vaccinated compared to messaging that only highlights the individual benefits.

In addition, we assume that highlighting both benefits of the vaccine has a stronger effect than highlighting one benefit only ($\frac{\partial^2 I}{\partial s \partial c} > \frac{\partial I}{\partial c} > \frac{\partial I}{\partial s} > 0$). In this case, the increase in the likelihood of receiving the vaccine – the increase in the vaccination cost for the indifferent individual $\bar{\theta}$ – when both benefits are highlighted together should be larger. We hypothesize that:

H_3: Messaging that highlights both the individual and social benefits of the vaccine together has a larger positive effect on the decision to get vaccinated compared to highlighting only one of the benefits of the vaccine (either individual or community).

We conduct a field experiment to test these hypotheses. In what follows, we first discuss the experimental design and the implementation. We next go over the results in terms of vaccination turnout and impact of the messages on the vaccination decision.

3.4. Design and implementation

In this section, we will first discuss the assignment of participants and treatments, then describe the design of the experiment and the associated flu drive posters, as well as the process of data collection.

3.4.1. Participants

The experiment took place during the Fall 2016 semester and was directed to undergraduate students living on campus in six different residential areas at the University of Massachusetts Amherst. Around 11,100 students were included in the baseline and treatments, with an almost even split between male and female students (Table 3.1). Participants did not know that they were part of an experiment by being exposed to the informational posters, they just saw posters promoting the flu drives. This reduced any potential social desirability bias (Lacetera et al. 2016; Levitt and List 2008; List 2008).

Table 3.1: Intention to treat. Number of individuals per treatment

	Baseline	Self	Others	Both	Total
Total	2,197	2,232	4,049	2,648	11,126
Female	1,129	975	1,975	1,229	5,308
Male	1,068	1,257	2,074	1,419	5,818

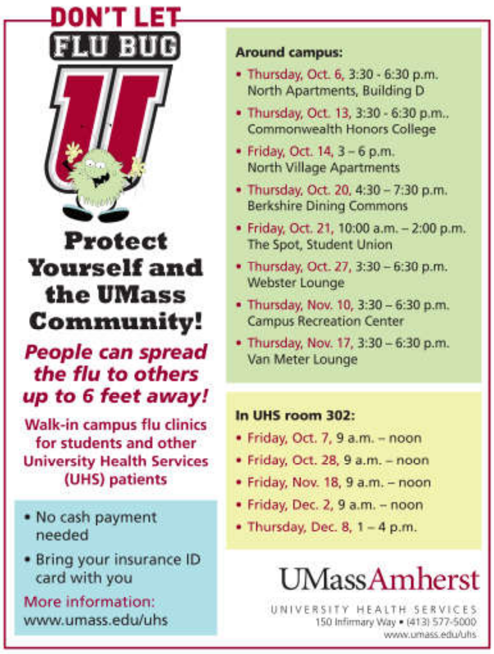
Note: We are excluding 1,400 students who belong to the University's honors college. They were exposed to the baseline. As we want to analyze students with similar characteristics, living in standard residence halls, we did not include them in this case.

3.4.2. Design

The study was conducted as part of the University Health Services campaign to vaccinate students, faculty and staff at the university. Four different posters were used, which differed in the message and the flu fact included in each. Our *Baseline* included no message and no fact, only information about the time and place of the flu clinics, as well as the traditional flu campaign logo used in previous Fall flu campaigns. The aim of the *Baseline* is to be as neutral as possible, with no message. The treated posters used the *Baseline* poster and added a message and a flu fact. Both message and flu fact were positioned to make them as prominent as possible. The use of printed messages is an efficient way to communicate information to a large audience and this strategy has been shown to change health behaviors, such as exercising and eating habits (Burger and Shelton 2011; Mollen et al. 2013; Robinson et al. 2014; Schultz et al. 2007; Smith-McLallen and Fishbein 2008).

As previously discussed, the messages used in this experiment are injunctive and prescriptive. That is, they explicitly encourage an action to protect the subject and other individuals in the community from catching the flu (Cialdini et al. 1990; Winter et al. 1998). The messages varied in terms of the normative message target we wanted students to be exposed to. The *Self* treatment included the phrase “Protect yourself!”, the *Others* treatment the phrase “Protect the UMass community!” and the *Both* treatment the phrase “Protect yourself and the UMass community!”. Thus, the *Both* treatment includes both *Self* and *Others* messages together, while *Self* or *Others* include just one message.

Figure 3.1: Poster for *Both* treatment



In addition, we used one single fact about flu, with the wording modified to match the normative message. The position of the flu fact is always below the message. The aim of the flu fact is to reinforce the idea of the protection of health in the messages. The *Baseline* has no flu fact. The *Self* and *Others* treatments included the fact "You can get the flu from others up to 6 feet away!" while the *Both* treatment included the fact "People can spread the flu to others up to 6 feet away!". As an example, the *Both* poster is in Figure 3.1. The *Baseline, Self* and *Others* posters are in Appendix A. The way the information is presented has the objective of modifying the perception of risk about the flu and the flu vaccine, using short and concise messaging and avoiding the clarification of misconceptions about the vaccine (Chen and Stevens 2016; Nyhan and Reifler 2015; Betsch et al. 2013).

The availability of the flu drives around campus (discussed below) as well as the posters with the messages and flu facts together have the aim of addressing the WHO

(2014) recommendations to reduce vaccine hesitancy. Vaccine hesitancy includes three factors (the "Three C model"): complacency, convenience and confidence. Complacency is addressed by using both the message and flu fact in the posters, addressing that the risk of getting a flu vaccine is preventable and vaccines are a preventive action (MacDonald and SAGE working group 2015). Convenience is addressed by making flu drives available in different places on campus. This reduces potential barriers or costs to get the vaccine if the individual has a positive intention to vaccinate againts the flu (Betsch et al. 2015). Confidence involves trusting the effectiveness and safety of the vaccine, the system of health professionals and health services as well as the public health objectives behind the vaccinations (MacDonald and SAGE working group 2015). The flu vaccines and flu drives are all sponsored by University Health Services, which provides comprehensive medical care to students on campus, and should be a trusted source to receive medical care. As effective communication is an integral part of health promotion strategies, messages are more likely to have an impact if they come from a credible source for the population being targeted (Glik 2007; Vlaev et al. 2016). In our case, this is University Health Services.

Once each treatment (including the *Baseline*) was assigned to each residential hall, posters for that treatment were placed in the common areas of each residential hall floor, where the stair entrance and elevators are located, as well as the main entrance boards of each hall. The aim of the poster location in each residential hall is for it to be as easy as possible to locate and to be looked at by the students. By placing posters in each residential hall floor, we want to make sure students are exposed to the posters. When assigning treatments to the residential halls, each treatment corresponded to a set of contiguous buildings, so that each floor and entrance board had the same poster in a defined area of the University's residential areas. Although we cannot ensure that there is no contamination between residence halls (students from one residence hall visting another residence hall), the treatments were assigned with the aim of avoiding as much contamination between residence halls as possible. For this reason, there are not equal numbers of students intent to treat per treatment (see Table 2.1). Regarding potential contamination, entrance to residence halls by students who do not live there is subject to strict guidelines, with specific times of entrance as well as identification procedures. If contamination occurs and it is significant, it will bias the results against finding an effect of the message.[12] *Baseline* posters and table tents were also used in common areas of the University, such as the campus center dining area, to avoid contamination between messages. A geographical split of the treatments can be found in Appendix B.

3.4.3. Flu drives and data collection

University Health Services held both open and closed flu drives during the Fall 2016 semester. In non-targeted or open drives, anyone could drop in. These were the drives advertised in the posters and the focus of our study. Closed or targeted drives were also held on demand for specific types of students, such as nursing students, sports teams or laboratory teams visiting hospitals. Most of the closed drives occurred at the beginning

[12] Although we do not have information for the Fall 2016 campaign, the data for the Fall 2017 campaign shows that visiting rates differ between treatments: excluding their own treatment area, 16% of the students surveyed (vaccinated and non-vaccinated) visited the areas with the Baseline treatment, 21% of students visited the areas with the Self treatment, 22% visited the areas with the Others treatment and 35% of students visited the areas with the Both treatment (which is the largest residential area on campus and our largest treatment for 2017).

of the semester. We do not include in our study the responses of students taking part of the targeted drives, as for them it was either mandatory (for nursing students and laboratory students) or highly recommended by coaches (for sports teams), but we gathered surveys in all drives. There was an additional open drive targeted at graduate students and their families living in university family housing. Researchers and the research assistants attended all drives.

Drives spanned from September to December 2016 around campus. Most flu drives took place before Thanksgiving break and were scheduled so they did not happen before main holidays and long weekends (see Appendix C for the dates and type of flu drive). Non-targeted drives were held in different areas of the University, such as dining commons, residential areas and University Health Services to reduce the cost and time of going to get vaccinated (see Appendix D for the location of each drive around campus). The aim behind the location of each drive was to reach as many people as possible. A mass campus email was sent prior to the first non-targeted drive, using neutral language and stating all the dates of the non-targeted flu drives.

Students coming to the flu drives to receive the vaccine were able to do so at no cost as flu vaccines are covered by most insurance plans. So, it is financially "cost-free", the only cost being going to the flu drive and getting the vaccine. Once they arrived students were greeted by one of the researchers or research assistants of the project and given a clipboard with the insurance forms and a survey. The survey was collected for the purposes of this experiment. Although our study focuses on undergraduate students living on-campus, surveys were handed out in all the drives to all students. We used a script with neutral language to suggest students complete the survey. The survey was paper-based and included questions on health, socio-demographics, beliefs about the vaccine and its effectiveness as well as social preferences. A consent form was added before the survey. It took around 5 minutes to complete the survey and other 5 minutes to complete the rest of the paperwork. Once they completed the paperwork, the subjects handed the clipboard back to check that everything was completed correctly (including the insurance forms) and take out the survey before handing the paperwork in to University Health Services assistants. Paperwork was handed in to the assistants, who checked whether the individual's health insurance was approved. Insurance was checked and after clearance individuals were called one by one to get their flu vaccine. After that, they were able to leave and could take a small "gift" with them (candy or condoms). University Health Services kept the insurance forms for their own record.

We also collected information for those students who decided not to get a flu vaccine during the semester. An online survey similar to the one handed out at the flu drives was implemented for those students who did not get a flu vaccine. All students in the residence halls were mailed invitations to complete the survey. The mailing of the surveys was done through the University's internal mailing procedures and system by mid-October. We incentivized completing the surveys by raffling two $100 Amazon gift cards. Once the surveys and the flu drives were completed for the semester, we discarded the online surveys of those students who went to the flu drives and also filled the online survey.

Given the short amount of time students had to complete the surveys at the drives, we ran a second wave of the flu vaccination campaign during the Fall 2017 to get additional information on vaccination decisions. We included questions aimed at understanding where students were getting their flu vaccines apart from the flu drives as well as the reasons why students might not want to receive the vaccine. We also incorporated questions to understand the degree of contamination between treatments. The main difference between the Fall 2016 and the Fall 2017 posters is that only the normative message was kept in the posters to avoid confounding effects of the normative message and the additional information. The treatments were assigned to different residential areas of campus. We use survey data from Fall 2017 to answer these specific questions but do not analyze the treatment data because some of the flu drives during that semester were switched to mengingitis drives due to an outbreak.

3.5. Results

Turning to the results, we will first examine vaccination turnout by treatment. Second, we will focus the likelihood of getting the flu vaccine and the impact of each treatment. Third, we will analyze turnout and vaccination by gender. As explained above, we focus on the Fall 2016 data, unless otherwise specified.

3.5.1. Vaccination turnout by treatment

The highest social return in this public good (herd immunity) happens when everyone who is able to get the flu vaccine receives it. However, the rates of flu vaccinations are low in our sample, with 5.3 percent of the total intent to treat students getting vaccinated (590 undergraduate students of the 11 thousand intent to treat, see Table 3.2). Vaccination numbers are far from the average undergraduate student age cohort vaccination coverage rate in the United States, which is almost 30% (CDC-BRFSS 2016; vaccination rate for age cohort 18-24 years). In the case of our target community, although individuals who receive the vaccine are protected against the flu, the level of herd immunity is low. This means that students who are at risk during the start and take up of the flu season are not protected.

As stated in the previous section, for the Fall semester timeframe it is highly unlikely that students are getting vaccines anywhere else during the academic semester, given that the alternative with the lowest cost is getting the vaccine on campus. Flu drives span around campus to cover all residential areas and areas with high transit of students (campus center, university health services, dining commons) and all forms of insurance cover the vaccine for students on campus, reducing as much as possible the transportation and monetary costs related to getting the vaccine. Although during the Fall 2016 wave we did not account for where the students got vaccinated, we know that for the Fall 2017 wave, only 7.5% of the vaccinated surveyed students indicated that they received the vaccine outside the University flu campaign. Thus, we believe that our vaccination turnout numbers are an accurate representation of the vaccinated undergraduate students on campus for the Fall semester.

Another reason for the low vaccination turnout for the Fall semester is that students could be receiving the flu vaccine during the Winter period, when they return home. This would bring our vaccination rates closer to the CDC average. However, the recommendation is to get vaccinated before the flu activity begins. Specifically, the CDC recommends receiving the flu vaccine by the end of October if possible, as it takes two weeks for the body's immune response to fully respond and be protected by the start of the season (CDC 2018). In the case students are receiving the vaccine during the Winter period, the decision is not influenced by our treatments and could be a family-based decision. In addition, receiving the vaccine after the Fall term ends leaves students fully exposed to the virus during the take-up of flu activity for the season (November to January).

Comparing the different treatments, the *Baseline* is the treatment with the least number of students (66 students vaccinated and surveyed, see Table 3.2). The *Others* treatment has a higher turnout than *Self* (197 versus 113 students). The *Both* treatment achieves the highest number of the students getting the flu vaccine, with 214 of the intent to treat undergraduates. In this case, when both benefits of the vaccine are emphasized together (in the *Both* treatment) we had more students getting a flu vaccine.[13]

In terms of probability of vaccination (number of vaccinated students over intent to treat in each treatment), initial numbers show that the *Both* treatment achieves a higher response to the treatment, with 8.1% of the intended to be treated in the *Both* treatment getting the vaccine. The *Self* treatment follows with 5.1% of the intended to be treated in that category getting a flu vaccine, 4.9% of the intended to be treated in *Others* and 3% of the intended to be treated in the *Baseline.* Compared to the *Baseline,* all treatments are significantly different in terms of the proportion of vaccinated students (proportion tests: *Self* = *Baseline*, p<0.01; *Others* = *Baseline*, p<0.01; *Both* = *Baseline*, p<0.01). Thus, highlighting the vaccination's social and individual benefit at the same time seems to

[13] In terms of percentages of the intended to be treated, initial numbers show that the *Both* treatment achieves a higher response to the treatment, with 8.1% of the intended to be treated in the *Both* treatment getting the vaccine. The *Self* treatment follows with 5.1% of the intended to be treated in that category getting a flu vaccine, 4.9% of the intended to be treated in *Others* (although *Others* has a higher number of vaccinated students) and 3% of the intended to be treated in the *Baseline*.

help the most in incentivizing students' decision to go to a flu drive and receive the vaccine.

Table 3.2: Number of vaccinated and surveyed individuals, probability of vaccination

Vaccinated					
	Baseline	Self	Others	Both	Total
Total	66	113	197	214	590
Female	34	68	110	126	338
Male	32	45	87	88	252
Surveyed and Vaccinated					
	Baseline	Self	Others	Both	Total
Total	44	79	83	177	383
Female	26	46	42	101	215
Male	18	33	41	76	168
Probability of Vaccination (in each category, %)					
	Baseline	Self	Others	Both	Total
Total	3.0%	5.1%	4.9%	8.1%	5.3%
Female	3.0%	7.0%	5.6%	10.3%	6.4%
Male	3.0%	3.6%	4.2%	6.2%	4.3%

Note: Probability of vaccination is defined as the number of students intent to treat over the number of students vaccinated in each category

3.5.2. Likelihood of getting a flu vaccine

We next analyze the impact of the normative messaging treatments on the likelihood of getting a flu vaccine. A total of 895 undergraduate students participated in this study, 393 getting the flu vaccine and filling out the survey in the drives and 502 not getting the vaccine and filling out the survey[14]. Characteristics for both sub-populations are reported in Table 3.3. A comparison between both sub-populations is in Appendix E.

The results of logit specifications for the full sample of vaccinated and non-vaccinated students are reported in Table 3.4. Based on our model, the dependent variable is the decision to get vaccinated or not. We define our dependent variable as equal to 1 if the subject got a vaccine during the flu drive season and 0 otherwise. In addition, given that the subjective price of getting the vaccine in our model is dependent on individual characteristics, we have four specifications. We first incorporate the normative messages. We then incorporate factors which would affect the psychological cost: socio-demographic variables, preferences and beliefs about the vaccine and vaccination history. We do not include the financial cost of the vaccine as it is fully covered by insurance. Likewise, we do not include the transportation cost to get the vaccine as we make this cost roughly constant across students by holding flu drives throughout campus. We discuss each set of variables below.

We report the marginal effects set for the relationship between getting a flu vaccine and the normative messaging treatments. These marginal effects are interpreted as the percentage point change in the likelihood of an individual getting a flu vaccine. We did not cluster the errors by treatment or residential hall given that we have a few clusters (less than 30). Cameron et al. (2008) argue that in the case of a few clusters, the critical values used to test hypotheses will be a poor approximation to the ones that should be used. This would lead to over rejecting the null hypothesis.

[14] The 10-subject difference between the number of vaccinated students completing our survey in Table 3.3 and Table 3.4 is due to students not disclosing their gender or stating that they did not fit into the male/female categorization.

Table 3.3: Descriptive statistics of survey respondents, vaccinated versus non-vaccinated

	Vaccinated	*Not Vaccinated*
N	393	502
Age (mean)	19.19	19.38
Female (%)	55.64	54.91
Race (%)		
White Non-Hispanic	69.72	76.86
African American	3.98	2.83
Asian	21.51	17.22
Other	4.78	3.08
Hispanic	6.67	4.18
Self-reported health (%)		
Good or very good	88.78	75.1
Satisfactory	9.18	21.71
Poor or bad	2.04	3.19
Illness prevalence (%)		
Asthma	19.55	13.87
Migraine	4.17	8.03
Depression	6.09	9.67
Other	13.13	50.18
No illness	57.05	18.25

The first set of variables are the normative messages included in the experiment. The variables of primary interest are *Self*, *Others* and *Both*, which are dummy variables that correspond to whether the subject lived in the residence hall of the respective treatments, being exposed to a specific message. Our baseline is the *Baseline* poster, with no message and no flu fact. We would expect, based on our hypotheses that the *Both* treatment has a higher impact on the likelihood of getting the vaccine compared to *Self, Others* and *Baseline.*

For the full sample, the estimated marginal effect of the normative messaging treatments is marginally significant for the Others treatment and significant at the 1% level for the Both treatment. Being exposed to the message that emphasizes the social benefits of the vaccine increases the likelihood of getting a flu vaccine by 13%, while being exposed by the message that highlights both the individual and social benefits increases this likelihood by 19%. However, a coefficient test between Others and Both concludes that both coefficients are not different from each other (Wald test on the equality of coefficients, p=0.17)[15]. One possible interpretation of this result is that emphasizing the social benefits to the University community has a stronger effect on decisions that could affect other members of the community itself, such as getting a flu vaccine compared to only emphasizing the individual benefits of the vaccine (Chen and Li 2009). In both of these treatments, the community benefits of the vaccine are highlighted. In addition, higher levels of community identification would reduce individual free riding in a public good situation such as in the case of flu vaccination and building herd immunity.

The second set of variables includes socio-economic factors, including gender, race and health-status. *Female* is a dummy variable equal to 1 if the subject is female. We would expect this variable to be positive. Given previous findings by Byrnes et al. (1999), Finucane et al. (2000) and Flynn et al. (1994), women tend to judge risks more harshly than males, particularly when it comes to health risks. Weber et al. (2002) and Harris et al. (2006) also found that women perceive risks to be greater, in particular in the

[15] A power test with α=0.05 and β=0.8 gives a sample size for each population of 585, when our current survey sub populations are 83 and 177 for *Others* and *Both* respectively. However, in this case, increasing the sample size is not possible as we are already targeting the whole population of undergraduate students living on campus.

health domain. In addition, several studies find that women have general been found to be more risk averse than men (Croson and Gneezy 2009) and have stronger emotional reactions to risky situations while men are more sensitive to price. In our regression, *Female* is not statistically significant. This could be related to the fact that men and women in our sample are responding differently (to the 4 messages) and causing the gender variable to be insignificant. We explore this in the next section.

White Non-Hispanic is a race dummy variable equal to 1 if the subject describes herself as white non-hispanic. The CDC reports that White non-Hispanic adults have one the highest of flu vaccinations in the United States compared to Black-non Hispanic adults and other non-Hispanic races and ethnicities (CDC 2017). Based on this, we predict that the sign of *White Non-Hispanic* is positive. However, in our regression, the variable is not statistically significant. One of the reasons why this could happen is that once socioeconomic status is controlled for, the effect on race/ethnicity could diminish significantly (Egede 2006, Williams 1996). In our case, every student who has been exposed to the posters has a similar accommodation (in a residential hall, most of them in shared rooms), meal plan and health coverage and accounting for these characteristics might reduce the disparities among students significantly.

Illness is a dummy variable equal to 1 if the subject reported having at least one chronic illness and equal to 0 if the subject has no chronic illnesses reported. One of the main groups at risk of getting the flu are the ones with chronic illnesses. We expect this coefficient to be positive, as it is recommended by the CDC that individuals with chronic illnesses should get vaccinated every season. However, in our regression, the variable is not statistically significant. One caveat of this study is whether students could be getting vaccinated somewhere else. Although a small percentage of students are vaccinated somewhere else during the Fall semester, we argue that many students could be receiving the vaccine during the Winter period, which would leave them exposed to the flu during the take up of flu activity. If those students with chronic illnesses get the vaccination during the Winter period, these students would be at a higher risk of having complications from the flu. Thus, we would expect the effect of having chronic illnesses during the Fall to be insignificant.

The third model incorporates self-reported preferences. The first variable we consider is risk attitudes. As a proxy for individual risk attitudes, we include *Risk,* a self-reported measure of the subjects' degree of risk aversion. *Risk* responds to the hypothetical question "How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?". In this case, the value 1 means 'not at all willing to take risks' and the value 10 means 'very willing to take risks'.[16] Although the survey is not incentive compatible, the question has been shown to correlate with both experimental measures and real-world risky behaviors (Dohmen et al. 2011).

[16] Given the timeframe between the subjects filled the forms out and the moment they got the flu vaccine, we could not implement a full questionnaire with enough time to financially incentivize risk preference questions. Although the self-reported risk question does not perfectly substitute using paid lottery experiments (Holt and Laury 2002) to elicit risk preferences, the question has been used in several studies such as Dohmen et al. (2011) and Weber et al. (2002), which claim that self-reported answers can be a valid low-cost substitute for incentivized lottery schemes (Crosetto and Filippin 2016).

Table 3.4: Impact of treatment on likelihood of getting a flu vaccine

	Messages	Socio-demographics	Preferences	Beliefs	Prior vaccination
Self	0.09	0.08	0.09	0.09	0.09
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Others	0.13*	0.12*	0.11*	0.13*	0.13*
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Both	0.20**	0.20**	0.21**	0.19**	0.19**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Female		-0.00	-0.00	0.03	0.03
		(0.03)	(0.03)	(0.04)	(0.04)
White Non-Hispanic		0.06	0.05	0.05	0.04
		(0.04)	(0.04)	(0.04)	(0.04)
Illness		-0.04	-0.05	-0.05	-0.05
		(0.03)	(0.04)	(0.04)	(0.04)
Risk (self-reported)			0.02*	0.02^{+}	0.02^{+}
			(0.01)	(0.01)	(0.01)
Altruism			0.02^{+}	0.02	0.02
			(0.01)	(0.01)	(0.01)
Flu effective?				0.18**	0.14**
				(0.03)	(0.03)
Flu safe?				0.04*	0.03
				(0.02)	(0.02)
Vaccinated previously					0.30**
					(0.04)
N	*848*	*848*	*848*	*848*	*848*
Pseudo-R2	*0.02*	*0.02*	*0.03*	*0.08*	*0.10*
Likelihood Ratio	*18.96*	*22.78*	*31.62*	*92.70*	*122.15*

Notes: Dependent variable is 1 for the subject getting a vaccine, 0 for not. Marginal effects are reported. Standard deviation between parentheses. $^{+}$ *p=0.10 * p=0.05 ** p=0.010.*

Prior work on risk and health-related behaviors (Anderson and Mellor 2008; Sutter et al. 2013; Dave and Saffer 2008), the risk variable had a negative sign, as higher levels of risk aversion reduced the likelihood of engaging in risky behaviors such as smoking or drinking. However, Tsutsui et al. (2010) argues that in the case of flu vaccinations the effect of risk aversion is, a priori, ambiguous, as risk aversion may affect the decision to receive the flu vaccine in two opposing ways. Some individuals might worry about the consequences of getting the flu and therefore decide to receive the vaccine, while others might worry about the side effects of the vaccine itself and might decide not to get vaccinated. This is in line with the Health Belief Model (Becker et al. 1974; Janz and Becker 1984), which proposes that the decision to vaccinate is a function of both the perceived risk of the disease (which could differ from the real risk of the disease) and the concern about the vaccine benefits and side effects (Sadique et al. 2013; Binder and Nuscheler 2017). In our case, we find that we find that *Risk* is significant and positive, implying that the impact of the estimated side effects of the vaccine itself dominate the impact of the perceived effectiveness of the vaccine. Risk loving students would be more likely to get vaccinated, regardless of the treatment they were exposed to, valuing avoiding getting sick and disrupting school or work attendance more than the side effects of the vaccine itself.

To measure altruism, we asked students the question "How willing are you to give to good causes without expecting anything in return?", where 1 corresponded to very unwilling to do so and 10 to very willing to do so. Given that the flu vaccine has individual and social benefits, the psychic cost of getting the vaccine for altruistic individuals should be lower if they receive the vaccine, as altruistic individuals care for others as well as for themselves. However, the impact of altruism is not straightforward. Altruism shifts vaccination decisions away from individual self-interest and towards the community welfare, protecting not only the vaccinated subject but also those who are around her. But the impact of altruism has been found to be lower than the impact of self-interest (Shim et al. 2012). Prior evidence also suggests that treatments emphasizing altruism, like we do in our *Others* and *Both* treatments, might not increase individual altruism (Hershey et al. 1994). These could be some of the reasons why the *Altruism* coefficient in our regressions is not significant. The next set of variables is related to the individual beliefs with respect to the safety of the flu vaccine and its effectiveness. *Flu Effective?* responds to the question "How effective do you think the flu vaccine is?", where responses are based on a five-point Likert scale with 1 being very ineffective and 5 very effective. *Flu Safe?* responds to the question "How likely do you think you are to get a bad reaction from the flu vaccine?". The variable is also a five-point Likert scale, where 1 is very unlikely and 5 very likely. Responses for both questions are proxies for flu vaccine acceptance predictors on healthy adults and have been found to have a positive impact on vaccination decisions (Chapman and Coups 1999). Prior literature has also shown that having a negative attitude towards the flu vaccine - a larger psychic cost - is a major barrier towards higher vaccination uptake (Schmid et al. 2017; El Khoury and Salameh 2015). Following the Health Belief Model (Becker et al. 1974; Janz and Becker 1984), we expect both coefficients to be positive, as vaccination decisions are affected by the perceived risks of the vaccine: individuals who think that the flu vaccine is safer and more effective should be more likely to get the flu vaccine (Dubov and Phung 2015; Takahashi et al. 2003). The variable *Flu effective?* is positive and significant at the 1% level. An increase in one point in the individual response (Likert scale) on flu vaccine effectiveness would increase the likelihood of getting a flu vaccine by 18%. *Flu safe?* is also positive but marginally significant. An increase of one point in the beliefs about the safety of the vaccine increases the likelihood of getting a flu vaccine by 4%.

However, it could be argued that these two variables are endogenous with respect to the decision to get vaccinated. If an individual thinks the vaccine is effective or safe she might get the vaccine. The outcome of her decision (having an adverse reaction from the vaccine, getting the flu) will affect her beliefs about the effectiveness or safety of the vaccine in the next flu season. None of our potential instruments, however, were strong enough to reduce the potential bias in the estimations. The impact of the normative messages on the likelihood of vaccination, however, seems to be unaffected by the inclusion of these variables.

One of the reasons why someone would think that the flu vaccine is "safe" could be related to their history of flu vaccinations. It is more likely that an individual gets the vaccine during the current flu vaccination campaign if they have gotten the flu vaccine in prior flu seasons. Several studies have shown that past behavior is a strong predictor of flu vaccine acceptance (Schmid et al. 2017; Yeung et al. 2016). For this reason, the history of prior vaccination could be a relevant explanatory variable for the decision to get vaccinated. We define *Vaccinated Previously*, which has the value 1 if the student responds positively to whether he has gotten a flu shot before. In the last specification in Table 3.4, *Vaccinated Previously* is significant and positive. Individuals who got a flu shot before are 67% more likely to get vaccinated in the current season.

3.5.3. Likelihood of vaccination by gender

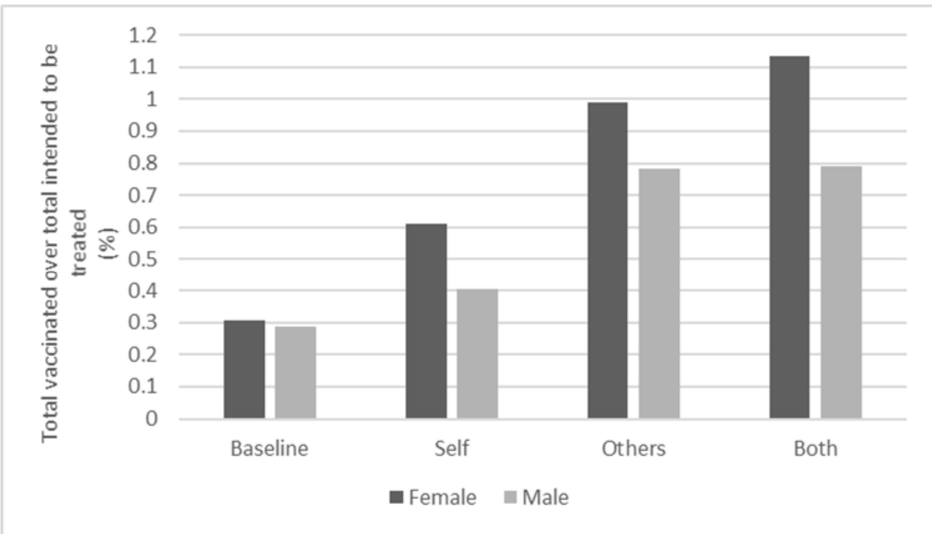
Figure 3.2 presents the percentage split of vaccinated students by gender and treatment over the total intent to treat students. Posters with messages bring about a higher number of students to receive the flu vaccine against the flu compared to posters with no message, and females seem to be getting vaccinated at a higher percentage than males, regardless of the treatment. Compared to the *Baseline*, any message seems to significantly increase the number of female students getting vaccinated. For men however, this only happens for the *Both* treatment, which incorporates both the individual and community benefits of the vaccine. Further statistical analysis can be found in Appendix F.

Table 3.5 presents the regression results by gender. Females are driving the treatment results, as the marginal effects for the normative messages are positive and significant. A test of equality of coefficients concludes that the three treatments seem to have the same impact on the likelihood of getting a flu vaccine (Wald coefficient test, p=0.60). This means that for women, any normative messaging significantly increases the likelihood of getting a flu vaccine for this sub-sample. This is regardless of whether the benefits of the vaccine are highlighted separately or together.

One explanation for this result could be based on the difference the perception of risk by gender. Croson and Gneezy (2009) argue that often, women are more sensitive to social cues than men in terms of determining the appropriate behavior (Gilligan 1982). In addition, women have been in general, socialized to be nurturers and caregivers, which might affect their perception of risk (Steger and Witt 1989; Davidson and Freudenburg 1996; Arch 1993). The risk of getting the flu might be impacting women and men differentially, eliciting a stronger response for women to take action and protect those who surround them. In fact, Weinstein et al. (2007) find that gender significantly predicts vaccination behavior, with women being more likely to get vaccinated. Men have been found to often be more overconfident in uncertain situations than women. Men could be underestimating the likelihood of flu contagion, which could explain the lower turnout for men to receive the flu vaccine at the clinics.

An alternative explanation for this result is related to health care usage by gender. Compared to men, women live longer but usually report worse self-perceived health or symptoms as well as greater morbidity and disability, making greater use of health care-services (Salganicoff et al. 2014; Redondo-Sendino et al. 2006; Verbrugge and Wingard 1987; Macintyre et al. 1996). In particular, women tend to use more preventive and diagnostic services, including flu vaccinations (Gómez 2002).

Figure 3.2: Percentage of vaccinated and surveyed students by gender and treatment



3.5.4. Limitations

One of the limitations of this study is that students could receive the vaccine somewhere else, for example in a pharmacy nearby or at home. Getting the vaccine somewhere outside campus would involve a higher transportation cost than going to a University flu drive, which are targeted to reach as many students as possible. In addition, the bulk of students getting flu vaccines do so before Thanksgiving, which is the main school break during the Fall. The number of students getting the vaccine after students' return is relatively low compared to the number of students vaccinated between September and November. So, our experiment should account for most of the students getting a flu vaccination during the Fall.

We were not able to gather information to elicit peer effects or family history during the Fall 2016. However, there is evidence on the impact of peer effects on flu vaccinations, as students coordinate vaccination decisions with their friends at the college level, with friends exchanging information and shaping each other's beliefs about the flu virus and the vaccine (Rao et al. 2007). Family also exerts a similar influence, either by recommending the vaccine to other family members or by setting an example and getting the vaccine (Takahashi et al. 2003). Family background, such as history of family chronic illnesses could also impact the likelihood of getting the vaccine.

3.6. Discussion

In this study, we set up a field experiment to investigate the impact of normative messaging on individual's decisions to get a flu vaccine. We aim at building on the literature that uses normative influence to study how individuals' behavior could be influenced to make healthier decisions (Mollen et al. 2013; Burger and Shelton 2011; Neighbors et al. 2004). We incorporate normative messaging to an already established flu vaccination campaign at University of Massachusetts Amherst. The posters promoting the campaign had normative messages that highlighted the individual and the social benefits of the flu vaccine. Our field experiment allows us to look at actual vaccination decisions instead of the intention to receive the vaccine.

Table 3.5: Impact of treatment on likelihood of getting a flu vaccine by gender

	Female	Male
Self	0.22*	-0.06
	(0.08)	(0.09)
Others	0.17^{+}	0.06
	(0.08)	(0.09)
Both	0.24**	0.13
	(0.07)	(0.08)
White Non-Hispanic	0.04	0.07
	(0.06)	(0.06)
Illness	-0.08^{+}	0.00
	(0.05)	(0.06)
Risk (self-reported)	0.02	0.02
	(0.01)	(0.02)
Altruism	0.01	0.02
	(0.02)	(0.02)
Flu effective?	0.21**	0.14*
	(0.04)	(0.04)
Flu safe?	0.05	0.03
	(0.03)	(0.03)
N	*467*	*381*
Pseudo-R2	*0.11*	*0.06*
Likelihood Ratio	*71.71*	*30.69*

Notes: Dependent variable is 1 for the subject getting a vaccine, 0 for not. Marginal effects are reported. Standard deviation between parentheses. $^{+}$*p=0.10 * p=0.05 ** p=0.010.*

We find that normative messaging increases the number of students getting the flu vaccine compared to no message. In line with Kessler and Milkman (2016) we find that strategically selected messages can increase public goods provision. A larger number of individuals getting vaccinated means a higher level of herd immunity, which in the end contributes to protecting populations at risk, such as older adults, children and individuals with chronic illnesses. Second, when the individual and community benefits of the vaccine are emphasized together, the likelihood of getting a vaccine significantly increases. More risk tolerant are more likely to get vaccinated. Third, women seem to be driving the results for flu vaccinations. This is in line with previous research showing that women are generally more sensitive to social cues than men. The risk of getting the flu might be impacting the likelihood of getting a vaccine differentially for women and men, eliciting a stronger response in the case of women.

Our results suggest that normative messaging could be used as a non-pecuniary policy instrument for increasing the number of vaccinated individuals within a large community, particularly for women. Normative messaging might have behavioral and health consequences, as it could help modify individual behavior. In line with Mollen et al. (2013) and Burger and Shelton (2011), a campaign highlighting healthy behaviors (getting a vaccine) and making salient the outcome of the behavior from a social point of view (protecting the individual and the community) could be an effective and low-cost strategy to promote behavior changes.

The experiment was successfully implemented within a University community, with undergrad students being repeatedly exposed to the messages posted in each floor of a residential area. The intervention was easy to implement and a low-cost strategy to modify behaviors, but we still see a small percentage of students receiving the vaccine outside the university clinics. It could happen that students could receive the vaccine at home during the Winter period, but that falls outside the recommended timeframe to receive the flu vaccine to be fully protected before the start of the flu season in November.

In addition, following Mollen et al. (2013), there might be a gap between exposure to the message and actual behavior which might dilute the effectiveness of the messages in modifying vaccination decisions. We tried to reduce this gap by exposing the students to the messages as much as possible, setting posters in each entrance to each residence hall floor and by reducing the costs of getting the vaccine, setting up flu-drives around campus. Given that vaccination decisions are "one-time" yearly decisions, this implies that vaccination campaigns to increase vaccination rates should be done every year to ensure that the effects of the campaign are not short-lived.

Further research on flu vaccinations at the campus level should be directed at teasing out the impact of peer effects and family background (family history of chronic illnesses, vaccinations and at-risk population) from the impact of normative messaging. In addition, contamination between residence halls should be addressed further to tease the effects of visiting another residence hall and the frequency of those visits, as students could go from one residence hall to another and be exposed to different messages.
More broadly, with flu seasons being difficult to predict and ranging from mild to severe, flu vaccinations are the first barrier of protection against the flu as well as against complications from the illness. A 70% of the population vaccination target for the current year compared to less than half of the United States population actually getting the

vaccine implies that the level of coverage against the illness was low and populations at-risk were impacted by the low level of herd immunity. From a public policy point of view, developing strategies and campaigns to increase vaccination on a yearly basis should be a priority. These campaigns should tackle the perception of risk related to the vaccine as well as the myths and lack of education and information surrounding flu vaccination. Moreover, the protection of others who are vulnerable or at-risk is one of the key elements of vaccination. If tailored normative messages can be used to increase vaccination rates in a population of young, healthy and insured individuals, a natural step should be to extend low-cost but high-impact campaigns to other at-risk communities where the number of background risks is much larger (chronic health issues, job and income instability and without health insurance). Normative messaging could be part of a bigger flu vaccination strategy plan to reach vaccination coverage targets in the United States.

CHAPTER 4

VALUING THE BURDEN OF ASTHMA ON CHILDREN: A JOINT REVEALED AND STATED PREFERENCES APPROACH

4.1. Introduction

Asthma is a chronic condition that affects all ages and is one of the most common burdens on American families. Approximately 6.3 million children have asthma (National Institutes of Health 2017) and the US Environmental Protection Agency has designated the illness as a key outcome for policy evaluation. The costs of asthma are high and comprise both direct and indirect costs. Direct costs include medication, medical care and non-medical goods and services that reduce asthma triggers. Indirect costs include as missed school days for children or work absenteeism for adults (United States Environmental Protection Agency 2018). The annual economic cost of asthma is estimated to be more than $56 million: $50 million in direct costs and $6 million in indirect costs (United States Environmental Protection Agency 2018, Barnett and Nurmagambetov 2011).

Direct and indirect costs underestimate the true burden of asthma. A child's asthma affects not only his/her own physical health, but also his/her quality of life as well as the quality of life among family members (Weiss et al. 2000). There is disutility when experiencing asthma symptoms such as difficulty breathing, coughing, wheezing or waking up at night (Brandt et al. 2008). Asthma can negatively impact a child's perception of self and one's social functioning (Newacheck and Halfon 2000). Caregivers report high levels of stress caused by a sense of lack of control of the illness and the need for daily management (Brandt et al. 2008). Even the household behaviors to reduce asthma triggers can be unpleasant or burdensome (Peterson-Sweeney et al. 2010, Kurnat and Moore 1999, Fiese et al. 2007, Fiese et al. 2005). Because asthma is a chronic condition that has periods of acute physical symptoms, uncertainty about a future an attack is present even when the symptoms are not (Brandt et al. 2012, Brandt et al. 2008, Rönmark et al. 2007, Westerhof et al. 2014). Asthma triggers, symptoms and treatments have a complex, non-linear relationship, that is not directly observable and which creates uncertainty (Frey 2008, Tobias et al. 2004). Thus, non-market valuation of the quality of life impacts of asthma is essential to measuring the true burden of asthma.

There are two approaches to non-market valuation: revealed preference (RP) or contingent valuation (CV). RP methods use observed behavior or real-world choices to infer preferences and estimate parameters of an underlying utility maximization subject to income constraints (Freeman et al. 2014). An advantage of the RP approach is that is uses actual data, and thus it is thought to be less likely to capture hypothetical bias (as opposed to the CV method, which uses a hypothetical scenario). Conceptually, one could estimate a willingness to pay to reduce asthma symptoms using data individuals' purchases of goods and services and resulting levels of asthma symptoms. An implicit assumption of the RP approach is that there is a well-defined health production function that is known by the individual in which different levels of health can be produced by given levels of health inputs. These tangible health inputs must be available for purchase at a known market price. The CV approach is implemented by using a hypothetical scenario that specifies a change in health and directly eliciting individual’s willingness to pay (WTP).

The hypothetical scenario can describe a product or policy that is hypothesized to provide the stated change in health. An advantage of CV is that the researcher can specify the levels and attributes of the good that one is valuing. Because the change in health is specified by the researcher, there is not the presumption that a known health production function exists.

In practice it is difficult to implement the RP approach to value asthma. Maximizing a health production function might not be attainable in the case of asthma, as there is not a clear and observable relationship between behaviors, medical goods and services and asthma status (Halm et al. 2006). Furthermore, the medical goods and services and asthma management behaviors themselves affect utility directly and through the production of health and directly, thus violating necessary conditions for calculating willingness to pay using parameters from a RP model. There is no real market for medical goods and services with known prices, thus exogenous factors in the healthcare sector, not preferences or income constraints usually dictate the quantity consumed. Last, it is unlikely that there is a choke price, meaning that parents are willing to pay what is necessary to ensure their child’s asthma attacks are less frequent and their symptoms are reduced.

Through careful design, the attributes of a hypothetical good and resulting changes in health can be communicated in a way that willingness to pay can be directly elicited in a CV survey and the shortcomings of RP avoided. Although it is a flexible methodology, one criticism of CV is the potential for hypothetical bias because no payment for the good is actually made. One approach to deal with this potential is to use certainty equivalence in which respondents are asked to rate their certainty about their response and those rating are used recode responses (Cummings et al. 1995, Blumenschein et al. 1998, Blomquist et al. 2009). However, estimating willingness to pay using CV responses alone does not account for the endogeneity between current asthma management behaviors households, and perceptions about asthma treatments and symptom relief. Although the RP and CV methods have usually been considered as substitutes (Whitehead et al. 2010, Hanley et al. 2003, Bateman et al. 2005, Brandt et al. 2012, Liu et al. 2000, Zillich et al 2002, Kling 1997, Freeman et al. 2014), a joint model of RP and CV can potentially address the limitations of each methodology alone (Hanley et al. 2003, Louviere et al. 2000). Our study is novel as prior valuation of asthma has been done under an RP or a CV approach, leaving out the key aspects that make asthma a chronic illness, such as the stress related to the disease and the uncertainty about attacks, symptoms and triggers (Alberini et al. 1997, Liu et al. 2000). In addition, joint estimation has been widely used in environmental and valuation of recreational amenities, but not in health (Von Haefen and Phaneuf 2008).

The burden of asthma, which includes encompassing the pain/discomfort of the physical symptoms, stress and uncertainty between exacerbations and disutility of asthma management, drives both the observed expenditures on asthma-related goods (i.e., the outcome of a revealed preference model) and the response to a hypothetical scenario (i.e., the outcome of a contingent valuation model). In addition, the burden as experienced by the family is part of an endogenous system of current asthma management as well as beliefs about asthma severity, triggers and attributes of asthma. For example, asthma management today (averting behaviors) affect current and future asthma symptoms hence shaping perceptions of the effectiveness of said behaviors and beliefs about the disease itself (i.e. the degree to which asthma can be controlled, the risks associated with asthma, etc.) (Kaptein et al. 2010, Ungar et al. 2015, Still and Dolen 2016, Rand and Manns Butz 2000). To address this endogeneity, we include a third equation on our model. This equation explicitly models the burden of asthma as a function of perceived attributes of asthma.

The daily experience of living with a chronic illness affects WTP, thus this joint approach could be used for other chronic illnesses such as diabetes or heart disease. Our analysis follows Alberini et al. (1997) as we are valuing the burden of asthma, but the focus of our paper is on children. This paper also follows Whitehead (2005) as beliefs about the severity of the illness affecting the treatments and vice versa are included in our model.

4.2. Methodology

In this section we define our study sample, the RP and CV approaches as well as the theoretical model and econometric estimation.

4.2.1. Study sample

Our study sample include the participants of the Fresno Asthmatic Children's Environmental Study (FACES). FACES was a five-year, observational epidemiological study of the factors that affect the development of asthma in children aged 5 to 11 who had already been diagnosed with asthma (FACES, 2006). Through a research agreement with the principal investigators of FACES we were allowed to recruit FACES participants to take two additional surveys. The respondents for both surveys we collected were parents or guardians of children with asthma, as they are aware of household purchases and the tradeoffs between child and parental health as well as the consumption of other goods (Viscusi et al. 1987, Alberini et al. 2010, Alberini et al. 1997, Agee and Crocker 1996, Dickie 2005, Gerking and Dickie 2013, Nastis and Crocker 2007).

In the first survey we collected detailed information on socioeconomic characteristics, asthma management practices, and asthma-specific expenditures, health care utilization, symptoms (including frequency and severity of asthma attacks, emergency medical care and activity limitations), burden, and beliefs. Many of these variables are relevant for a household production function model, as we include behaviors related to current asthma as well as goods and services consumed (and the amount paid). A total of 222 households completed this initial "asthma Beliefs and Behaviors" survey (Brandt et al., 2012).

The second survey included additional questions on asthma symptoms, burden and beliefs, as well as the hypothetical scenario and willingness to pay elicitation. A total of 149 households completed the second survey.

There are three salient features of the hypothetical CV scenario. First, the hypothetical good has to reduce acute symptom episodes (the physical effect) and the chronic stress caused by the uncertainty about current asthma status and risk of developing an exacerbation (the psychosocial effect). Second, it should avoid medication, as households’ opinions on medication and their possible side effects from the pilot study were mostly negative, a result which has been shown in prior studies (Hanemann and Brandt 2006). Third, households in the sample were already engaging in a wide range of behaviors to reduce asthma episodes and felt that added more activities or changing routines would be unattractive and would involve more work (Brandt et al. 2012).

The hypothetical final product that met these criteria and was acceptable to participants in focus groups and a pilot study was an oxygen monitor (called “BreatheRight”) that could be worn as a watch and would provide immediate, objective information about the child’s asthma status (the child’s blood oxygen level). By providing real-time information, it was explained, the watch enabled parents to preempt exacerbations by taking timely preventive measures. This watch was deemed credible by those in the focus groups and pilot study in large part because its principle was similar to using peak flow meters and following asthma action plans. The concept of measuring oxygen saturation was familiar to the study population, all of which had seen fingertip oxygen monitors used on their children. Asthma action plans were well known in those population, but generally felt to be inferior because a peak flow meter is difficult and cumbersome to use and therefore does not provide of real-time reliable information. The asthma watch resolved those shortcomings.

The CV survey identified individuals who were interested in the hypothetical watch and those who were not. Only those interested were presented with a price, and their responses were recorded using a one-and-one-half bounded dichotomous choice approach (Cooper et al. 2002). In this approach, respondents were presented with two prices, and told that the cost of the item ranges between these two prices. The initial price given to the respondent was randomly selected (Brandt et al. 2012). These responses provided a range for the WTP and separated responses into three different groups: (no, no) for those respondents who refused to pay both the low and high prices, (yes, no) for those respondents who were willing to pay the low price but not the high price, (no, yes) for those not willing to pay the high price but willing to pay the low price and (yes, yes) for those respondents willing to pay the high price.

From the CV survey, we collected the bid prices and responses, the cost of averting behaviors, symptom frequency and severity, attitudes and beliefs about asthma, asthma triggers and socioeconomic characteristics as covariates of interest.

4.2.2. Econometric model

In this section we will define the three-equation model that is the base of our analysis. Detailed descriptions of the RP, SP and burden of asthma equations are below.

4.2.2.1. Revealed preference equation

We model the parental WTP for children's health using the approach of Alberini et al. (1997), Agee and Crocker (1996), Dickie (2005) and Gerking and Dickie (2013). Parental utility depends on the consumption of a composite market good X, which consists of parent and children consumption, $X = X_p + X_c$ where the subscript p indicates the parent and the subscript c indicates the child. Utility is continuous and increasing at a decreasing rate in the consumption of the composite good ($U_X > 0, U_{XX} < 0$).

Utility is determined by the parent's perception the severity of asthma in the child (R), after averting and mitigating actions are taken (A). Utility is decreasing on the parental perception of the severity of asthma ($U_R < 0, U_{RR} > 0$) and is non-decreasing on the protection activities, A ($U_A \geq 0, U_{AA} < 0$).

Parental perception of their child's asthma (R) is endogenous, as parents' decisions on averting and mitigating actions to reduce the severity of asthma impacts their perception of the illness ($R_A < 0,\ R_{AA} > 0$). Perception of asthma also depends on the child's level of exposure to the triggers ($R_T > 0, R_{TT} < 0$) and on the parents' beliefs about their child's asthma (B).

The perception of the severity of the child's asthma can be written as:

$$R = R(T, A, B; Z) \tag{5}$$

Socio-economic characteristics of the parent and children are included in vector Z. For this study, we focus on household income.

The child's exposure to triggers (T) is defined as a continuous and decreasing function of averting actions ($T_A < 0, T_{AA} > 0$). The exposure to triggers can be written as:

$$T = T(A) \tag{6}$$

The perception of the severity of asthma of the children and the parent enters the household utility function (Whitehead, 2005) through a measure of asthma burden, I ($U_I < 0, U_{II} > 0$). The burden of asthma, I, captures both the frequency and severity of the attacks, as well as the uncertainty that happens between the attacks ($I_R > 0,\ I_{RR} < 0, I_T > 0, I_{TT} < 0, I_{RT} > 0$). Therefore, the burden of asthma equation can be written as:

$$I = I(R, T; Z, I\ ) \qquad (7)$$

Where I is the parents' perception of asthma if the child did not have the illness. Parents' utility can be therefore written as:

$$U = U(X, R, A, T, I;\ Z, I\ ) \qquad (8)$$

The household's budget constraint assumes that the time parents and children spend ill affects the time left to work. Time spent working and in other activities are perfect substitutes. We can write the full-income constraint as the sum of the expenditure between goods consumption and investments to reduce the severity of the child's asthma.

$$Y = N + w(H \quad G\ ) = p_X X + p_A A \qquad (9)$$

where p_A the price for averting and mitigating actions and p_X is the price for market goods. Total income Y, is composed of non-wage income, N, and work-related income, where w is the wage rate, H is total time and G is the working time lost by parents due to their own or their children's illnesses. From equation (9), $(H \quad G)$ is the time spent working by the parent.

In this model, the parent wishes to maximize utility of the household (8) subject to the budget constraint (9). This consumer problem is solved for mitigating and averting actions (A) as well as consumption of market goods (X_p, X_c).

If the properties of the above model hold, the indirect utility function $V(.)$ exists and is continuous and increasing in total income (Y). The indirect utility function can thus be inverted to find the expenditure function $E(.)$, that satisfies the following condition:

$$U = V(p_X, p_A, w, H, N, Z, E(p_X, p_A, w, H, N, Z, I \ , U \ )) \qquad (10)$$

It is the expenditure function $E(.)$ from equation (10) and its determinants which are the focus of our RP equation (to be estimated). U is the parents' desired level of utility to be achieved.

4.2.2.2. Stated preference equation

Consider a CV scenario with a hypothetical good that could reduce the child's burden of asthma from I^1 to $I^0 (I^0 < I^1)$. When presented with the CV scenario, the parent evaluates its indirect utility under the two states of the world: the status quo (or current situation) and the CV scenario.

In our model, the WTP for the change in the child's burden of asthma could be measured as the change in indirect utility (V), which is a function of the burden of asthma and the payment for the CV scenario (p_{A_CV}, the price of the hypothetical good). If we assume that the indirect utility is additively separable, we can write the change as:

$$V = \beta_0 + \beta_1 \ I + \beta_2 p_{A\_CV} \tag{11}$$

Because asthma and asthma attacks are not a binary event (you can have or not an asthma attack, but asthma differs in the frequency and severity of the attacks), the change in the burden encompasses both a change in the frequency of the attacks, the severity of the attacks and the parental perception of the child's asthma, its triggers and their level of worry between episodes. Therefore, it includes both physical and psychosocial effects.

Based on equation (11), we can write the average WTP for a hypothetical good that reduces the burden of asthma for child i as a function of:

$$mean(WTP) = \frac{\beta_0 + \beta_1 \ I}{\beta_2} \tag{12}$$

In our case, the WTP to reduce the burden of asthma in a child is a combination of the WTP to reduce the number of symptom days by fifty percent (the physical effects) and the WTP to avoid a month of worsening of the perception of the associated risk of the illness (the psychosocial effects). Our objective is to understand which are the determinants of the WTP to reduce the burden of asthma. The CV equation to be estimated will be based on equation (12) and includes the perception of the severity of the illness as well as the potential asthma triggers. As there is endogeneity between the hypothetical CV responses and the actual expenditures, we will also include the total cost (expenditures) of mitigating and averting behaviors in the estimation of this equation.

4.2.2.3. Burden of asthma equation

The complex, often unpredictable, episodic nature of asthma creates uncertainty about the severity of the disease and beliefs about the effectiveness of averting or mitigating behaviors (Rand and Manns Butz 2000). In this setting of uncertainty, parents make decisions to take (or not take) averting and mitigating behaviors based on their beliefs about asthma and perception of asthma symptom frequency and severity. The subsequent asthma symptom frequency and severity then reinforces or changes beliefs about the effectiveness of those behaviors and thus the choice of behaviors in the future. Thus, a person's choice of averting behavior is based on his perception of the resulting health effects and behaviors over time, which might differ from the assessments made by experts (Dickie and Gerking 2002). The burden of asthma is defined in equation (5) of our model. This is the third equation to be estimated. The perception of asthma severity will depend on the mitigating and averting actions taken by the family, the asthma triggers and socioeconomic characteristics of the family.

4.2.3. Estimation procedure

As there is endogeneity between in our model, not accounting for it would lead to inefficient estimators. We approach this issue by jointly estimating the RP, CV and burden of asthma (BoA) equations using a three-stage least squares (3SLS) estimation procedure (Zellner and Theil 1962). 3SLS estimates are consistent have better finite-sample properties than the optimal generalized method of moments estimator (GMM), which is the one that is typically used (Woolridge 2002, Greene 2003). A CV-only approach is conditional on actual expenditures, and we capture this part of the endogeneity by including the RP equation. Beliefs about the severity of the illness affect both actual and hypothetical purchases, so we capture this part of the endogeneity by including the BoA equation. The joint model also allows us to incorporate other perception variables, which might be determinants only for one of the decisions or only for the level of worry about asthma between episodes. We also compare the joint model results to a CV-only equation.

Our dependent variables are continuous for the RP equation and discrete for the CV and the BoA equations. For the RP equation, we use the logarithm of the total cost of asthma-related expenditure by households in our survey (*Total Cost)*. This includes both fixed (*Fixed Cost)* and variable costs (*Variable Cost)*. Fixed costs include the purchase of air conditioners, mattress covers, humidifiers and air cleaners, among others. Variable costs include both prescribed and over the counter medication for asthma and allergies, alternative medicines and alternative health care providers, among others. Other explanatory variables which might have an impact on monthly expenditures include different triggers (*Cold Air* and *Pollen*), parental experience, as parent dealing with asthma could have economies of scale in expenditures and a better knowledge of how to treat the illness (*Parent Asthma*) and the number of symptoms the child experiences per month (*Days Symptoms* and *Days Symptoms Squared*). We include the square of the days of symptoms as there could be decreasing returns in the asthma expenditures.

In the prior literature, the RP dependent variable has usually been discrete, such as the number of trips to a site or the number of visits to a doctor. However, asthma is a complex chronic condition and managing it requires a multifaceted approach. Medication and medical visits are only type of input and reducing triggers is as important as the medical side of treating asthma. All these inputs are also in different units and could be either continuous or discrete (for example, money spent, amount of medication, number of visits). For these reasons we use the total expenditure (*Total Cost*) as an aggregate measure of total mitigating and averting behaviors.

In order to estimate the system using 3SLS, we redefine the CV equation to have a binary outcome. Each respondent will have two observations in this equation. The first observation is a yes/no binary response to the low (high) price offered, while the second is a yes/no binary response to the high (low) price offered. Therefore, the dependent CV variable is a dummy variable defined as 1 if the respondent was willing to pay the suggested price and 0 if not (*WTP answer*). We include the bids asked to each respondent (*Bid)* as an explanatory variable. Given that we modified the way bids are presented for the purposes of the CV equation, we include which of the bids was asked first (*Bid First*) to capture ordering effects. We also include the *Variable Cost* as CV responses should be conditional on the actual expenditures on the illness. We do not include fixed costs in this case as we focus on the ongoing part of asthma management, which could have an impact in current attitudes and beliefs about asthma. The variable *Summer* is included to account for asthma triggers which might be relevant for the decision on whether to pay for the hypothetical watch.

The psychological side of the burden of asthma involves more than one perspective about how asthma affects the daily life of the child. For this reason, we include several measures of beliefs about asthma, including whether asthma is present all the time (*Asthma Present),* if it is seasonal (*Asthma Seasonal*) and if the illness happens with other conditions (*Asthma Joint*).

The dependent variable for the BoA equation (*Worry*) addresses the parent's beliefs about the severity of their children's asthma between episodes. Although parent's worry about asthma episodes when they take place, the uncertain nature of asthma is one of the main sources of worry related to asthma attacks, given the degree of disruption in terms of money, family dynamics and job stability that the attacks entails. We defined the dependent variable *Worry* as a binary variable with 1 if they worry often or sometimes between asthma episodes, 0 otherwise. We include *Worry* as a dependent variable in the BoA equation and as an explanatory variable in the CV and RP equations to account for the endogeneity of beliefs about asthma severity, symptoms and behaviors. We also include triggers which might impact the level of worry between asthma episodes (*Physical Activity Rank, Cold Air*) and the number of days with high symptoms (*Days Symptoms High*), as more days with symptoms might positively affect the level of parental worry. We account for the beliefs about the severity of asthma which might impact parents worry between episodes. In particular we include how dangerous parents believe asthma is (*Asthma Dangerous*), and how highly ranked it is compared to other illnesses (*Asthma Rank*). Lastly, we include *Income* as a measure of worry. If the income of the household is too low, it might negatively impact the BoA, as parents have to prioritize other purchases rather than fully treating asthma (for example, food and housing).

As a summary, the equations estimated are defined as follows:

$$WTP\ answer_i = \beta_0 + \beta_1 Bid_i + \beta_2 Worry_i + \beta_3 Summer_i + \beta_4 Last\ Time\ Bad\ Asthma_i + \beta_5 Asthma\ Joint_i + \beta_6 Asthma\ Seasonal_i + \beta_7 Asthma\ Present_i + \beta_8 Variable\ Cost_i + \beta_9 Bid\ First_i + \varepsilon_i^{CV} \quad (13)$$

$$Total\ Cost_i = \delta_0 + \delta_1 Parent\ Asthma_i + \delta_2 Cold\ Air_i + \delta_3 Pollen_i + \delta_4 Worry_i + \delta_5 Days\ Symptoms_i + \delta_6 Days\ Symptoms\ Squared_i + \varepsilon_i^{RP} \quad (14)$$

$$Worry_i = \alpha_0 + \alpha_1 Physical\ Activity\ Rank_i + \alpha_2 Income_i + \alpha_3 Cold\ Air_i + \alpha_4 Days\ Symptoms\ High_i + \alpha_5 Asthma\ Dangerous_i + \alpha_6 Asthma\ Rank_i + \varepsilon_i^{BoA} \quad (15)$$

Definitions of the dependent and explanatory variables for each equation in the model can be found in Table 4.1. We estimate the WTP directly from the CV equation (equation (13)), conditional on the RP and beliefs about the burden of asthma (equations (14) and (15)).

4.3. Results

We present the results of our joint estimation model, a CV-only equation and the mean parental WTP estimates for a reduction in the child's asthma symptoms.

4.3.1. Study sample

Descriptive statistics for our sample population are given in Table 4.1, including statistics for our explanatory variables. Of the 315 FACES households, we have 113 complete RP/CV questionnaires for all the relevant questions in our analysis. There are 75 FACES households that declined to answer the CV survey. By design, all FACES and CV survey respondents have children with asthma. Children covered in our data range from 6 to 11 years at the beginning of the study[17]. Almost half of the children are White/Caucasian. A large percentage of Hispanic (30%) and around 15% are Black/African American. Our sub-sample of FACES children is representative of the population of interest (children with asthma in Fresno, CA, Brandt et al. 2012).

In the CV survey, the set of prices offered for the watch was (5, 15, 20, 30, 55, 60, 65, 80, 90, 100, 125). From our subset of responses, 49 respondents were willing to pay both prices offered, 20 were not willing to pay any of the two prices and 45 were willing to pay the low but not the high price.

4.3.2. Joint estimation

Table 4.2 reports estimates for the joint model. Recall that in this model we are jointly estimating three equations: one for the RP data, one the CV data and one for the BoA. Incorporating the endogeneity between beliefs about the severity of asthma and the impact of different mitigating behaviors should allow us to tease out the effects of the frequency of attacks, the experience of living with the illness and different triggers.

As expected, in the RP equation, total expenditures (*TotalCost*) related to the child's asthma, increase with environmental changes such as *Cold Air* or *Pollen* and if the parent worries about the child's asthma between episodes (*Worry*). Total cost decreases

[17] For our study, we recruited participants after the study started, so children were older than the original bracket recruited by FACES.

when the parent has asthma (*Parent Asthma*). This could be related to the fact that if the parent has asthma, she could have a better idea of how to manage the illness and whether some treatments are effective or not based on their own asthma experience. There could also be economies of scale in some investments, such as home improvement fixed costs to better manage asthma for both the parent and the child. Total costs increase the higher the number of days of asthma symptoms per month (*Days Symptoms*). However, the increase in costs happens at a decreasing rate the higher the number of days of symptoms (*Days Symptoms Squared*). Families can make a number of investments to improve the asthma symptoms, but there is a limit in terms of the cost and the availability of options.

In the BoA equation, we find that parents worry (*Worry*) more if they rank asthma as a primary stressor (*Asthma Rank*), if symptoms are frequent (*Days Symptoms High*, if the child has over 20 days of asthma symptoms in a month) and if they believe asthma episodes are troublesome but not dangerous (*Asthma Dangerous*). However, parents worry less if there are other more predominant stressors in the family, or if the child has triggers that are easier to avoid. If physical activity (*Physical Activity Rank*) or cold air (*Cold Air*) are asthma triggers, parents could reduce exposure, for example, to activities outdoors, such as sports, visits to playgrounds and so on. Furthermore, low family income (*Income*) seems to have a negative effect on how much parents worry about their child's asthma. A potential explanation for this result is that low income families might have other worries that could take priority over the child's asthma, such as making ends meet.

Table 4.1: Descriptive statistics and definition of explanatory variables

Variable name	Description	Mean	St. Dev.
DEPENDENT VARIABLES			
Total Cost	Logarithm of the total cost of averting and mitigating the child's asthma	5.759	1.084
WTP answer	Is the parent willing to pay for the hypothetical good (watch)? 1 if yes	0.625	0.485
Worry	Does parent worry about asthma between episodes? 1 for often or sometimes	0.664	0.474
AVERTING AND MITIGATING COSTS			
Variable Cost	Logarithm of the variable cost of averting and mitigating the child's asthma	4.608	0.891
CONTINGENT VALUATION			
BID	Bid value	44.867	25.298
Bid First	1 if the bid was presented first	0.440	0.497
HEALTH STATUS			
Days Symptoms	Number of days with symptoms in the past 30 days	8.373	7.049
Days Symptoms High	Child has over 20 days of asthma symptoms in the last 30 days? 1 for yes	0.107	0.309
Last Time Bad Asthma	Length of time since last bad day: 1 for less than 3 months	0.507	0.502
ATTITUDES AND BELIEFS			
Asthma Rank	Is asthma ranked as a primary stressor? 1 for yes	0.327	0.471
Asthma Dangerous	Asthma episodes may cause problems but they are not harmful or dangerous. 1 if strongly disagree	0.514	0.502
Asthma Seasonal	Asthma is an illness that happens at a certain time of the year. 1 for yes	0.120	0.326
Asthma Joint	Asthma is an illness that happens along with something else, like colds, flu or allergies. 1 for yes	0.220	0.415
Asthma Present	Asthma is an illness that is present and the child has symptoms all of the time. 1 for yes	0.527	0.500
SOCIO-ECONOMIC CHARACTERISTICS			
Income	Is income less than $40,000 a year? 1 for yes	0.387	0.489
WEATHER AND ENVIRONMENT			
Summer	1 if asthma gets worse in the Summer	0.193	0.396
Cold air	1 if cold air affects asthma	0.046	0.211
Pollen	1 if pollen affects asthma	0.725	0.447

We next examine the relevant variables in the CV equation. As found in prior research, the bid variable (*Bid*) is of the expected sign. WTP is significantly affected by the bid value: the larger the bid, the lower the WTP. WTP is positively affected when parents worry about the child's asthma between episodes (*Worry*) and if the last time the child had an exacerbation of asthma was more recently (*Last Time Bad Asthma*). WTP also increases when asthma is seasonal (*Asthma Seasonal*) or happens jointly with other illnesses (*Asthma Joint*). Higher variable costs (*Variable Cost*, medication for asthma and allergies, doctors' visits, etc) also increase WTP.

Table 4.2: Joint and contingent valuation only estimations

	Joint specification		Contingent valuation only	
CONTINGENT VALUATION EQUATION				
BID	-0.009**	(0.001)	-0.052**	(0.007)
Worry	0.337*	(0.135)	1.030*	(0.453)
Summer	-0.076	(0.071)	-0.758+	(0.427)
Last Time Bad Asthma	-0.054	(0.059)	-0.395	(0.393)
Asthma Joint	0.233*	(0.105)	0.991	(0.703)
Asthma Seasonal	0.290*	(0.133)	1.722*	(0.757)
Asthma Present	0.132	(0.087)	0.507	(0.579)
Variable Cost	0.064*	(0.031)	0.199	(0.178)
Bid first	0.096*	(0.055)	0.586*	(0.260)
Intercept	0.365*	(0.206)	0.873	(1.192)
REVEALED PREFERENCE EQUATION				
Parent Asthma	-0.261+	(0.149)		
Cold Air	0.979*	(0.383)		
Pollen	0.319*	(0.151)		
Worry	0.743*	(0.292)		
Days Symptoms	1.272*	(0.598)		
Days Symptoms squared	-0.371*	(0.158)		
Intercept	4.119**	(0.616)		
EXPERIENCE OF ASTHMA EQUATION				
Physical Activity Rank	-0.236**	(0.057)		
Income	-0.130*	(0.055)		
Cold Air	-0.443**	(0.130)		
Days Symptoms High	0.204*	(0.080)		
Asthma Dangerous	0.182**	(0.053)		
Asthma Rank	0.253**	(0.056)		
Intercept	0.614**	(0.056)		
Mean WTP (Dec 2017 U.S dollar values)	***130.9***			
WTP std. dev.	***15.0***			

*Note: Standard deviations in parentheses. Contingent valuation equation is clustered by respondent. Dependent variable of Revealed Preference equation: Total Cost, Dependent variable of Contingent Valuation equation: WTP Answer, Dependent variable of Worry equation: Worry. + p=0.10 * p=0.05 ** p=0.010.*

A CV-only estimation using only the variables we incorporate in our model shows that *Variable Cost, Asthma Joint* and *Worry* are no longer significant. Thus, there is a gain in terms of incorporating the conditions on which the child and the parents experience and cope with asthma. Compared to Brandt et. al (2012), who look at the parental belief about the child's overall health status, our joint estimation incorporates different beliefs about the experience of asthma itself instead. We analyze different sides of the illness, such as the seasonality, the existence of comorbidities and the level of danger parents believe asthma poses. This allows us to explain how living and experiencing asthma is impacted by parental beliefs. In line with prior research, we find that the ranking parents give to asthma and the level of worry parents pose on the illness have a significant impact on WTP. We are also able to include different triggers, which has not been done so far, and to examine the impact of the cost of treating the illness and of families' income. We find that only income (and cost) is a significant socio explanatory variable, but not age or race, the number of siblings or parents' education. This is evidence towards the fact that the experience of asthma is unique. Thus, our results are robust and consistent with previous studies on children's asthma.

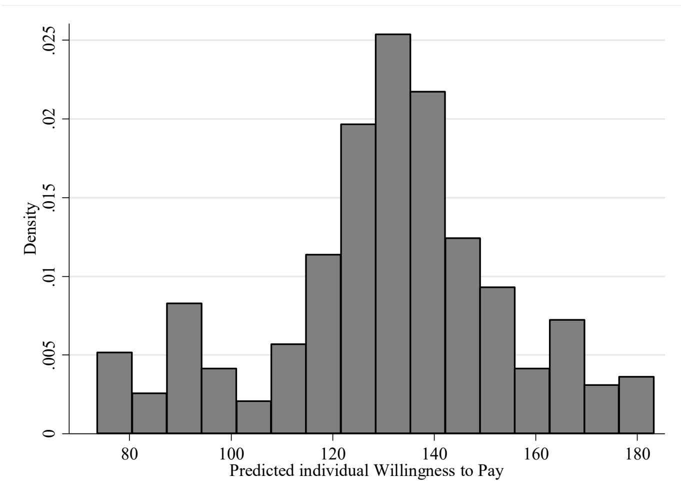
4.3.3. Willingness to pay

We calculated the mean parental WTP for the reduction in child's asthma symptoms at the corresponding sample averages of the independent variables (Figure 4.1). Dollar figures are reported in Dec 2017 U.S. dollars. As reported in Table 4.3, mean WTP is \$130.9 ± \$15.0 to reduce the child's asthma symptoms by 50%[18]. Specifications

[18] Standard deviations for the WTP were calculating the Krinsky-Robb (1986) method for WTP confidence interval construction. Haab and McConnell (2002) have a detailed, step-by-step explanation of the method,

of WTP with different parental responses about their beliefs on their child's asthma are presented on Table 4.3. WTP changes with the beliefs about the disease and the level of distress asthma causes to the parent. In particular, mean WTP if the parent worries about asthma, if asthma is believed to be seasonal and happens jointly with other illnesses is higher ($145.5, $163.8 and $154.4 respectively). If the parent does not worry about asthma, the mean WTP is much lower ($101.9). This is evidence towards the fact that although families can vary in their valuation of asthma, the beliefs about the illness as well as the experience of asthma on a daily basis is a key determinant of WTP.

Figure 4.1: Distribution of predicted individual willingness to pay



as well as Park et al. (1991). The confidence intervals were constructed using the wtpcikr command in stata (Jeanty 2007).

Table 4.3: Willingness to pay based on different parental beliefs (Dec. 2017 dollar values)

Mean WTP	**130.9**
If parent worries about asthma	145.5
If parent does not worry about asthma	101.9
If asthma is seasonal	163.8
If asthma is not seasonal	126.4
If asthma is joint with other illnesses	154.4
If asthma is not joint with other illnesses	124.2
Standard Deviation	*15.0*

Table 4.4 shows the average WTP per number of days of symptoms. There is an inverse relationship between mean WTP per day of symptom and the child's total days of asthma symptoms. For children with between no days and 4 days of asthma symptoms, mean WTP per day of symptoms is $63.4, while for children with over 28 days of asthma symptoms mean WTP per day is $4.9. Furthermore, there is not a linear relationship between parental WTP per days of symptoms and number of days with symptoms. Having a few days of symptoms or having symptoms every day of the month changes WTP drastically, as the experience of coping and living with asthma is very different. This happens to the point where going from bad asthma to worse asthma (say 20 days to 28 days of asthma symptoms) might not have a significant change in WTP to avoid part of the symptoms. Benchmarking is a relevant concept in the management of asthma, given that the experience of living with asthma changes the way asthma is perceived. If a person experiences symptoms frequently, they seem to be part of life and "normal", while when symptoms are experienced with less frequency the attacks seem to be out of the ordinary. In addition, the distribution for parental WTP per day of symptoms is not linear either, which is additional evidence towards the fact that experience and beliefs affect

WTP (Figure 4.2). The bulk of the individual WTP distribution per days of symptoms is between $0-$20, while there is another mode (albeit much smaller) around $60-$80 per day of symptoms. If we account for the minimum hourly wage of California[19], an adult working for 8 hours a day would earn $88 a day. This means that WTP could account from 4% to almost 90% of the daily minimum wage. For low income households, the costs of managing asthma for one of their children could put a significant strain on families' finances.

Table 4.4: Average WTP by days of symptoms (Dec. 2017 dollar values)

Days of Symptoms	Average WTP	WTP per day of symptoms	Number of children
0-4	126.7	63.4	30
4-12	128.2	12.9	45
12-20	134.9	8.4	59
20-28	123.4	5.2	10
28+	144.5	4.9	6
Average		**19.0**	

Note: Mean WTP was calculated as the mean of the individual WTP in each symptom day bracket. WTP per day was calculated as the mean WTP per symptom day bracket over the mid-point number of days in each bracket.

4.4. Discussion

Compared to the estimation using the CV-only approach, joint WTP estimates are much larger ($28.5 ± $20.2 in the CV-only model versus $130.9 ± $15 in the joint

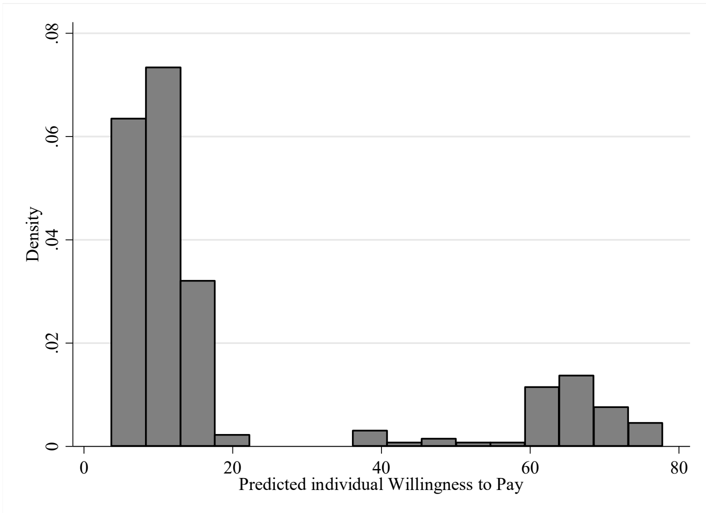
[19] The per hour minimum wage in California for January 1, 2018 is $11 an hour for employers with more than 26 employees (State of California Department of Industrial Relations, 2016). We use this wage to make it comparable with the accrued values of inflation in California including December 2017.

model). The CV-only specification only included the CV equation specification from the joint model. In addition, when it comes to the validity of the mean WTP estimate for the joint model, the Brandt et al. (2012) mean estimate is located within the individual WTP distribution in Figure 4.1 ($77.8 ± $4.42). In our joint estimation, we have parents who are still willing to pay over $77 for the hypothetical watch to control their child's blood oxygen level. Although there is no clear positive or negative effect in previous joint estimation literature in terms of how WTP changes with a joint estimation, we see that omitting the effects of the beliefs about and attitudes towards the illness biases the results downwards (as from our CV estimation results). Subjective measures about the severity of the illness that capture the experience of living with asthma on a daily basis are successful at improving WTP, while objective measures might fail to accurately measure the true cost of the illness. Given that households are impacted by the distress of each episode and between episodes as well as by the lack of control over the illness, it is important to incorporate these issues in to the analysis to understand how asthma affects quality of life.

As a check on our estimates, we compared them to those available in the literature. Our mean WTP estimates are similar to the values derived by Dickie and Messman (2004, $115.7 to $209.85 per symptom day avoided in 2017 dollars). Our mean WTP estimates are also consistent with the Rowe et al. (1986) CV-based estimates of a WTP for a 50% reduction in bad asthma days of $100.9-$197.1 (for very mild, moderate symptoms, original values of $43-$84). Our mean WTP estimates are in line with O'Conor and Blomquist (1997) CV-based estimates of average WTP of $47.8-$61.5 per symptom day avoided and $88.8-$119.5 per bad symptom day avoided (1995 values:

$28-$36, $52-$70). In particular, this is consistent for asthma episodes in children with a few days of symptoms per month (O'Conor and Blomquist 1997).

Figure 4.2: Distribution of predicted individual willingness to pay (per day of symptom)



Lastly, although we used the parental perspective to measure children's preferences (Dickie 2005, Gerking and Dickie 2013), which asks the people who have the best interests of the child at heart, and who are used to making decisions on their behalf, it still has the drawback of asking people and accounting for their own preferences over treatments and mitigating and averting behaviors (Alberini et al. 2010). Other approaches have been used to measure children's preferences which also have weaknesses. One of these approaches is the "societal perspective", which involves eliciting preferences from a representative sample of the population. However, it has the drawback that it might be affected by different types of altruism, which are difficult to separate from individual preferences (Alberini et al. 2010, Dockins et al. 2002). Another approach is the "adult-as-child" perspective, in which adults are required to think back to their childhood and assess the risks they faced or either asked to place themselves on the perspective of a child. This might be very demanding on the respondent, as there is a possibility that the adult does not fully accept or understand the question, thus responding as an adult and not as a child. We decided to take the parental approach. Parents, being in charge of the child's and their own health face choices on the different ways to reduce their children's and their own health risk. Therefore, parents should evaluate the tradeoffs they face between improving the child's health, their own health and the consumption of other goods by the household (Nastis and Crocker 2007).

4.5. Conclusion

In this study, we estimate parents' WTP for the reduction in the symptoms of their child's asthma. We use a joint estimation approach, which has been widely applied in the environmental economics literature, but less so to address health-related issues. By jointly estimating and exploiting the combination of averting behaviors and contingent valuation, we were able to address the effects of the endogeneity between parents' beliefs about the severity of their child's asthma symptoms and the decision for asthma treatments (averting behaviors). Compared to a joint estimation approach that considers RP, CV and beliefs about the illness, we find that a CV-only approach biases the results downward.

Our results show that asthma, and in particular, beliefs about asthma affect household decisions and consequently, WTP. We found that parents WTP is affected by their beliefs about different characteristics of asthma, such as its seasonality and whether it happens jointly with other illnesses. WTP is also affected by the stress created by uncertainty about the next attack. Thus, incorporating subjective perceptions and beliefs is essential in the case of a chronic illness, which is something that can be treated but not cured. Households are affected by both the discomfort of acute episodes and the ongoing burden of living with a chronic illness. The stress caused by lacking control over one's or a child's health can be profound and can have a detrimental effect on a broad range of outcomes. Therefore, to measure the true value of improved health, we have to understand the impact of disease on a household's quality of life, not just the frequency and severity of symptoms - even though the latter are far easier to measure. The design of the CV scenario considered all these issues, including the endogeneity between beliefs, behaviors and asthma symptoms, as well as the idea that any new product should incorporate minimal or no disruptions to the current way asthma was tackled in the family. We also accounted for the endogeneity between beliefs about the burden of asthma and decisions on asthma treatments by taking a novel estimation approach and jointly considering the RP and CV data.

We also find that there is not a linear relationship between asthma, days of symptoms and expenditures (WTP included). Having a few days of symptoms or having symptoms every day of the month changes the experience and the way of coping with asthma significantly, to the point that going from bad asthma to worse asthma might not have a significant change in WTP to avoid part of the symptoms. Asthma, as well as any other chronic illness affects all aspects of life, to the point where the experience of living with a chronic illness has a subjective aspect that depends on the characteristics of the illness, the numbers of days with symptoms and the ways the individual manages the illness.

As the experience of living with a chronic illness affects WTP, we could apply this joint approach to other chronic illnesses which can be managed but not cured, such as diabetes, chronic pain, arthritis or heart disease, among others. In addition, understanding perceptions and beliefs about the illness can also increase the effectiveness of public spending. Policy programs should take these beliefs and attitudes into consideration whenever possible. In the particular case of our analysis, the high degree of sensitivity of children with asthma makes them a population of special concern for environmental regulation.

CHAPTER 5

RECONCILING HEALTH AND WEALTH BACKGROUND RISKS: AN ANALYSIS OF RISKY BEHAVIOR WHEN HIGHER-ORDER PREFERENCES ARE CONSIDERED

5.1. Introduction

Background risks, such as health status and income instability are pre-existing risks that cannot be avoided and are not under the control of an individual. These risks are also independent from other risks the individual faces (Eeckhoudt et al. 1996). Health status, job, food and environmental insecurity all have an element of risk that is both beyond the individual's full control. For background risks, there is no market for trading directly on this risk (Franke et al. 2018). In addition, individuals are in practice almost never faced with one single risk but usually face bundles of risk that might be correlated with each other. These bundles of risk could include the individual's health status, as well as and the impact health has on job and financial stability (Cardak and Wilkins 2009, Love and Smith 2010, Bressan et al. 2014, Edwards 2008, Pesko 2016). Fully understanding risk preferences requires accounting for background risks (Guiso and Paiella 2008, Berkowitz and Qiu 2006, Fan and Zhao 2009). In this paper, we focus on the intersection of two background risks: health and financial risks.

Prior work has shown that background risk affects economic decisions, both in theory (Gollier and Pratt 1996, Kimball 1993, Eeckhoudt et al. 1996, Pratt and Zeckhouser 1987) and in practice (Deck and Schlesinger 2010, 2014, Ebert and Wiesen 2011, 2014, Tarazona-Gomez 2004, Heinrich and Mayrhofer 2017, Noussair et al. 2014).

Recent studies have shown that health status could impact risky decisions and in particular, lead to less risky portfolio allocations (Rosen and Wu 2000, Edwards 2008, Coile and Milligan 2009, Bressan et al. 2014). Moreover, models that ignore background risk could generate biased estimates of individual risk preferences (Lusk and Coble 2008). We analyze how risky decisions change when individuals are exposed to increased financial background risk, while accounting for their health status.

Adding background risk usually reduces welfare, as more risk is usually viewed as worse for an individual (Pratt and Zeckhauser 1987, Kimball 1993, Eeckhoudt et al. 1996, Gollier and Pratt 1996). However, for some individuals (in particular those who have diminished sensitivity to risk) a small additional background risk could lead them to make more risky decisions. This means that individual preferences would be different for those individuals making more risky decisions and those making less risky decisions when more background risk is added (Quiggin and Chambers 1998). This is the principle of "psychological diminished sensitivity". Rather than being substitutes, risks could be complements for some types of preferences. In this paper, we want to understand if different types of small financial background risks have different effects in the level of individual riskiness when it comes to financial lottery decisions.

Lastly, the analysis of how risk impacts decisions typically focused on analyzing individual risk attitudes against a wide range of behavioral patterns and economic outcomes, such as trust, self-selection into payment schemes, financial investments and health outcomes (Bohnet and Zeckhauser 2004, Barsky et al. 1997, Riley and Chow 1992, Galizzi et al. 2012, Blais and Weber 2006, Lönnqvist et al. 2015). The analysis of risky decisions has mainly emphasized the measurement of risk aversion (second-order risk preferences). However, risk aversion is just one piece of an individual's risk-profile (Deck and Schlesinger 2014). An individual's risk profile is also composed of other higher-order risk aversion measures, such as prudence (third-order) and temperance (fourth-order). We analyze how higher-order preferences interact with risky decisions, depending on the health status of the individual.

As a summary, the focus of our analysis is tri-fold. We first want to examine whether the risky decisions of healthy individuals and individuals with chronic illnesses ("sick") differ. Second, we want to understand whether the introduction of different exogenous financial background risks makes individuals more or less prone to making more risky decisions. Third, we want to understand if the individual's risk profile, which includes higher-order preferences is a determinant of how risky decisions are affected once background risk increases.

We find that both health and higher-order risk preferences, when considered, explain changes in risky decisions once exogenous financial risks have been introduced. In particular, sick individuals (defined as individuals who report having at least one chronic illness) become make less risky decisions when exposed to potential exogenous losses. Higher-order preferences explain part of the changes in risky behaviors. However, they cannot be considered only on their own. Prudence is not enough to explain patterns of risky decisions, as prudent sick individuals make riskier decisions when exposed to exogenous risks, but sick, prudent and temperate individuals make less risky decisions when exposed to potential exogenous losses. Higher-order risk preferences and low income also have a positive impact in the number of risky choices, but in the case where individuals are exposed to a potential gain. Individuals react differently when exposed to exogenous gains, losses and mean-zero lotteries, which is evidence towards the existence of "cross-risk vulnerability", as one type of background risk, such as health status, could impact decisions on another type of foreground risk – financial decisions - (Malevergne and Ray 2009).

5.2. Previous literature

There are two main strands of literature relevant to our study. The first one is related to the empirical analysis of background risk, in particular in the case of health and financial decisions. The second one focuses on the experimental analysis of risk and higher-order risk preferences. We discuss both literatures below.

5.2.1. Empirical analysis of background risk: the case of health

Background risk has been found to affect patterns of individual savings, portfolio allocation decisions, entrance and permanence in the labor market (Heaton and Lucas 2000, Quiggin 2003, Hanaoka et al. 2015, Berkowitz and Qiu 2006). Prior literature on financial risks and portfolio allocation has shown that different background risks, such as income and credit constraints, health status, have an impact on financial-related decisions, which is the basis of our experimental setting (Guiso and Paiella 2008, Edwards 2008). In most cases, the presence of background risk has been shown to lead to less risky decisions (Bressan et al. 2014, Guiso et al. 1996, Quiggin 2003, Harrison et al. 2007).

For our analysis, we focus on two specific risks: financial decisions (as a foreground risk) when health status is considered (as a background risk). Financial and health risks are not independent, and health status could have an effect on financial decisions (Berkowitz and Qiu 2006). In the health domain, health status has both a direct and an indirect effect on risky decisions. Health shocks and the expectation of future health shocks represent a risk for large out of pocket expenses. It affects individual financial planning and planning horizons through its effect on life expectancy. Age (life expectancy) impacts health status by directly affecting survival risk (Love and Perozek 2007).

Individuals with worse health have been found to make less risky decisions and choose safer portfolio allocations (Rosen and Wu 2004, Edwards 2008). This happens particularly in countries where health care systems have less coverage, less protection or supplemental health care insurance (Atella et al. 2012, Bressan et al. 2014, Goldman and Maestas 2013). Poor health also has an impact on labor income risk, as poor health could lead to an individual reducing the hours of work or not working at all, which could have a negative effect on individual finances and income flows. Our focus is on how foreground financial risk, which could be diversified through individual choices, changes when health and financial background risks are considered. In our case, health is a pre-existing, endogenous background risk, as the individual could take measures to improve her health. However, financial background risk in our study is exogenous to the individual and added to the experimental setting.

Lastly, less risky financial decisions when health status is poor could have an additional direct effect by increasing precautionary savings to avoid financial shocks associated with health declines (Edwards 2008, Baptista 2008). The precautionary savings motive is usually associated with the concept of prudence, while making less risky financial choices could be associated with the concept of temperance. Prior studies of financial risky decisions when higher-order risk preferences are considered have heterogeneous results. While some studies find that income uncertainty leads to less risky decisions (Heaton and Lucas 2000, Guiso et al. 1996), some studies find the opposite (Arrondel et al. 1996) or no relationship at all (Alessie et al. 2002). We measure both prudence and temperance in our analysis and provide experimental evidence on the relationship between health and higher-order preferences on financial decisions.

5.2.2. Experimental analysis of higher-order risk preferences

Measures such as prudence and temperance have been recently used to construct an individual risk profile (Deck and Schlesinger 2014, Ebert and Wiesen 2011). Under the expected utility (EUT) approach, prudence (Kimball 1990) is the (positive) third derivative of the utility function and is equivalent to an aversion to increases in downside risk (Menezes et al. 1980). In a life cycle saving model, the uncertainty of future income only leads to an increase in savings when the individual exhibits prudence (Leland 1968, Noussair et al. 2014). Prudence can also be defined as an aversion to “increases in downside risk”, as it increases the negative skewness of a risky prospect (Deck and Schlesinger 2008, Menezes et al. 1980). Temperance (Kimball 1993, Menezes and Wang 2005) is defined as the (negative) fourth derivative of the utility function. A temperate individual facing an unavoidable risk would reduce exposure to another, independent risk. Temperate individuals dislike negative kurtosis. Temperance has mostly been linked to behavior under background risk (Gollier and Pratt 1996, Eeckhoudt et al. 1996). In particular, in the presence of future health and financial shocks, subjects who are prudent and temperate save more and invest more in safer assets than those individuals who are not (Leland 1968, Sandmo 1970, Kimball 1990, Gollier and Pratt 1996, Eeckhoudt and Schlesinger 2008, Noussair et al. 2014). To the best of our knowledge, only one paper has incorporated health status as a measure of background risk when examining the prevalence of higher-order risk preferences. Noussair et al. (2014) observes that the majority of individual decisions are consistent with risk aversion, prudence and temperance, and that higher income and better health negatively influence risk aversion. We include measures of prudence and temperance in our analysis and interact them with individual health.

In the EUT framework, most of the commonly utility functions imply not only risk aversion but also prudence and temperance. Tarazona-Gomez (2004) and Krieger and Mayrhofer (2012) have used approaches in line with EU theory to elicit higher-order risk preferences, finding some evidence for prudence. However, more recently, prudence and temperance have been defined in a non-parametric way (Heinrich and Mayrhofer 2017). This is the approach we take in our study. In this case, preferences are based on 50/50 lottery pairs (Eeckhoudt and Schlesinger 2006). Prudence is defined as a preference for disaggregating a zero-mean risk and a sure reduction in wealth across two equally likely states of nature, while temperance is a preference for disaggregating two independent zero-mean risks across two equally likely states of nature (Ebert and Wiesen 2014). This definition is appealing for experimental purposes and can be extended further than fourth-order risk preferences (Deck and Schlesinger 2014). Studies following the Eeckhoudt and Schlesinger (2006) approach have mostly found risk aversion and prudence, although temperate behaviors are not observed as often (Ebert and Wiesen 2011, 2014, Deck and Schlesinger 2010, 2012, Maier and Rüger 2012, Krieger and Mayrhofer, 2012, 2017, Noussair et al. 2014, Heinrich and Mayrhofer 2017). We follow the non-parametric approach proposed by Deck and Schlesinger (2008) to measure higher-order risk preferences. Specifically, we focus on measuring risk aversion, prudence and temperance through lottery choices.

5.3. Experimental design and procedures

The experimental design for each treatment consists of two main tasks and one exogenous background risk lottery. In the first task, individuals choose from a series of 16 risk apportionment lotteries to measure risk aversion, prudence and temperance ("Risk apportionment choices"). This set of tasks is repeated after an exogenous background risk lottery has been introduced. In the second task, individuals respond a series of questions related to the different background risks (health, income, job) that could be brought to the experimental session ("Individual background risk elicitation"). This is complemented with a socio-economic survey at the end of the experiment.

The order of each treatment is shown in Table 5.1. Individuals start with an endowment of 100 experimental dollars (E$), to avoid negative earnings. Instructions for the choice set tasks and the additional background risk lotteries were recorded as a video, which included examples. We included comprehension questions after the instructions for the first choice set and after the exogenous background risk was introduced. Subjects are paid at the end of the experiment. Participants only received feedback on the tasks paid, but not between experimental tasks.

Table 5.1: Experimental treatments

<table>
<tr><th rowspan="2">Treatment</th><th colspan="6">Stages</th></tr>
<tr><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th><th>(5)</th><th>(6)</th></tr>
<tr><td></td><td colspan="6">Background risks elicitation first</td></tr>
<tr><td>T1</td><td rowspan="4">Individual background risk elicitation</td><td rowspan="4">Risk apportionment choices</td><td>No BR</td><td rowspan="4">Risk apportionment choices</td><td rowspan="4"></td><td rowspan="4">Socio-economic survey</td></tr>
<tr><td>T2</td><td>Mean-zero BR</td></tr>
<tr><td>T3</td><td>Upside BR</td></tr>
<tr><td>T4</td><td>Downside BR</td></tr>
<tr><td></td><td colspan="6">Background risks elicitation last</td></tr>
<tr><td>T5</td><td rowspan="4"></td><td rowspan="4">Risk apportionment choices</td><td>No BR</td><td rowspan="4">Risk apportionment choices</td><td rowspan="4">Individual background risk elicitation</td><td rowspan="4">Socio-economic survey</td></tr>
<tr><td>T6</td><td>Mean-zero BR</td></tr>
<tr><td>T7</td><td>Upside BR</td></tr>
<tr><td>T8</td><td>Downside BR</td></tr>
</table>

5.3.1. Task 1: risk apportionment choices

Our elicitation method for higher-order risk preferences is based on the experimental risk apportionment approach developed by Eeckhoudt and Schlesinger (2006) and Eeckhoudt et al. (2009), while following the risk apportionment choice sets of Deck and Schlesinger (2008). The non-parametric concept of risk apportionment defines risk aversion, prudence and temperance over 50-50 lottery pairs (Eeckhoudt et al. 2009, Crainich et al. 2013).

Preferences for risk, prudence and temperance can be defined as follows. Consider an individual with wealth $W > 0$. In risk apportionment tasks, the individual faces a choice to aggregate or disaggregate two events, k and δ, which can be fixed monetary amounts or independent zero-mean lotteries. Following Deck and Schlesinger (2017) and using the notation $[O_1, O_2]$ to represent the lottery where the outcome is O_1 with 50 percent probability and O_2 with 50 percent probability, a risk averse person would prefer $[W + k, W + \delta]$ to $[W, W + k + \delta]$, where k and δ are fixed amounts. A risk averse individual prefers to "disaggregate the harms" (Eeckhoudt and Schlesinger 2006), with the "harms" being the losses of two fixed amounts of money. A risk loving individual would prefer to have both k and δ together. This also coincides under EU theory with a concave utility function ($u'' < 0$) and a dislike for mean-preserving spreads in the sense of Rothschild and Stiglitz (1971).

A prudent individual would prefer $[W + k, W + \delta]$ to $[W, W + k + \delta]$, where k is a fixed amount and δ is a zero-mean lottery. An imprudent individual would prefer the opposite. In an EU approach, this is consistent with a convex marginal utility ($u''' > 0$) or with a preference for decreases in downside risk (Menezes et al. 1990). Again, this is still a preference for "disaggregating the harms" (Deck and Schlesinger 2008).

Table 5.2: Higher-order risk preferences choice tasks

Decision	Preference type	Sure amount (W, E$)	First item (k, E$)	Second item (δ, E$)	Expected Payoff	Order of tasks Stage 1	Order of tasks Stage 2
1	Risk Aversion	10	[1/1]	[1/1]	**11**	3	15
2	Risk Aversion	10	[1/1]	[5/5]	**13**	6	9
3	Risk Aversion	10	[1/1]	[9/9]	**15**	8	12
4	Risk Aversion	10	[5/5]	[5/5]	**15**	11	14
5	Risk Aversion	6	[9/9]	[9/9]	**15**	13	10
6	Risk Aversion	50	[5/5]	[45/45]	**75**	14	4
7	Prudence	30	[25/-25]	[25/25]	**42.5**	1	3
8	Prudence	12.5	[9/9]	[5/-5]	**17**	4	11
9	Prudence	12.5	[5/-5]	[1/1]	**13**	7	7
10	Prudence	10.5	[9/9]	[1/-1]	**15**	10	8
11	Prudence	12.5	[5/5]	[5/-5]	**15**	15	6
12	Prudence	14.5	[9/-9]	[1/1]	**15**	16	16
13	Temperance	15	[5/-5]	[5/-5]	**15**	2	5
14	Temperance	15	[9/-9]	[1/-1]	**15**	5	1
15	Temperance	55	[25/-25]	[25/-25]	**55**	9	2
16	Temperance	55	[5/-5]	[45/-45]	**55**	12	13

Note: Tasks are shown in a different order in both choice stages. The order is specified in the last two columns of this table. +/- x denotes the lottery in which the subject can have a 50-50 chance of gaining or losing E$x.

Temperance could also be defined as a preference for $[W + k, W + \delta]$ over $[W, W + k + \delta]$, where k and δ are independent zero-mean lotteries. Kimball (1993) defines the two harms as "mutually aggravating", as a temperate individual would prefer to receive only one of these harms (or risks). An intemperate individual would prefer to have both lotteries together. In an EU approach, this is equivalent to $u^{iv} < 0$ or to a preference for decreases in outer risk (Menezes and Wang 2005).

Based on the definitions of risk apportioning tasks above, subjects start with a fixed amount of money (W) in each task. Subjects know that one of two possible states would occur, which is determined by a coin toss flip at the end of the experiment. We denote these states *Heads* and *Tails.* The subject decides for each choice task if she wishes to receive the first additional item (k) when the coin flip lands on *Heads* or *Tails* and the second additional item (δ) on the *Same* or *Different* outcome of the coin toss as the first item. There is only one coin toss and the subject decides if she wants the two additional items combined (by choosing *Same* so that she receives both or neither items) or if she wants them separated (by choosing *Different* so that she receives one item or the other). We can measure the individual's preferences for aggregating or disaggregating k and δ by examining their choices in each task. In terms of presentation, when items are fixed dollar amounts, they are presented to the experimental subject as $[x\ /\ x]$. When items are for zero-mean lotteries, they are presented as $[x\ /\quad x]$, where x is the amount that can be won or lost.

In our experimental setup, we present lotteries in a compound format, as this makes the choice whether to aggregate or disaggregate harmful events explicit (Noussair et al. 2014). The way the choice tasks in Table 5.2 are presented follows the design of Deck and Schlesinger (2010) for prudence and temperance. Risk aversion tasks are defined to be comparable to Deck and Schlesinger (2010) in terms of amounts used and expected values. We defined six risk aversion tasks, six prudence tasks and four temperance tasks. Amounts are defined in terms of experimental dollars (E$) and translated to dollars ($) at a specific exchange rate. An example of the risk aversion task is below (task 2 in Table 5.2):

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[5 / 5] if the coin lands on *Same* or *Different* outcome.

In the risk aversion task above, the subject starts with a fixed amount of E$10 and has to identify their preferences regarding receiving two additional fixed amounts, defined as [1 / 1] and [5 / 5]. A risk averse person would prefer having the two items separated, so as to “disaggregate the harms”. For the purposes of measuring higher-order risk preferences, the relevant decision is whether the subject chooses between getting the two items in the *Same* outcome of the coin toss or to get one or the other when choosing *Different*. Following Deck and Schlesinger (2010), although the answer to the first additional item is not directly relevant for measuring higher-order risk preferences, the answer is designed to give the subject flexibility and to ensure that the experiment is not rigged.

An example of a prudence choice task is below (task 9 in Table 5.2):

You will receive E$10.50 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[1 / -1] if the coin lands on *Same* or *Different* outcome.

In the example prudence task, the subject starts with a fixed amount of E$10.50 and has to identify their preferences regarding receiving a fixed amount of E$9, defined as [9 / 9] and a zero-mean lottery, where she can win or lose E$5, defined as [5 / -5]. Each zero-mean lottery is a 50/50 lottery which allows the subjects to gain or lose an amount of money. Whether it is a gain or a loss depends on the outcome of a die roll. A prudent person would choose *Different* in the second additional item, as she would prefer to have the fixed amount and the lottery separated.

Lastly, an example of a temperance choice task is (task 14 in Table 5.2):

You will receive E$15 +

[9 / -9] if the coin lands on *Heads* or *Tails* and

[1 / -1] if the coin lands on *Same* or *Different* outcome.

In the temperance task above, the subject starts with a fixed amount of E$10 and has to identify their preferences regarding receiving two mean-zero lotteries. In the first lottery, she can win or lose E$9, so it is defined as [9 / 9]. In the second lottery, she can win or lose E$5, so it is defined as [5 / -5]. A temperate individual would choose to get one lottery or the other, so as to "disaggregate the harms". Thus, she would choose *Different* in the second additional item.

Each treatment has two choice sets of 16 risk apportionment tasks, in which subjects revealed their preferred combination of fixed dollar amounts and zero-mean random variables (the "two additional items"). The first choice set takes place before the background risk lottery is introduced, while the second choice set takes place afterwards. Each choice set has the same 16 tasks but is presented in two different orders (see Table 5.2).

The choice tasks were selected to allow for a variety of comparisons. For the risk aversion tasks, tasks number 1, 2 and 3 have the same initial sure amount, same first fixed and varying second fixed amount. Tasks 3, 4 and 5 have the same expected value. Task 6 has 5 times the amounts as task 3, to account for a stakes effect. Task 4 has 5 times the amount of the additional items as task 1, to account for a stakes effect. For the prudence tasks, tasks 8, 9 and 11 have the same initial sure amount but different zero-mean lotteries and fixed additional items. Tasks 10, 11 and 12 have equal expected payoff. Tasks 8 and 10 and tasks 9 and 12 have the same fixed amount and different zero-mean lottery. To examine a stakes effect, task 11 has 5 times the amount in the additional items compared to task 7, as well as a larger initial sure amount. The temperance tasks 13 and 14 allow for a relative lottery size comparison, while task 16 has a larger lottery size compared to task 15 to examine a stakes effect.

5.3.2. Task 2: Individual background risk elicitation

Our questionnaire elicits the different background risks the individual might come to the experiment with. This is independent from the addition of financial background risk in our treatments through the lotteries and the focus of the study on health. For health, our background risk questionnaire incorporates the main categories suggested by Cardak and Wilkins (2009) and Noussair et al. (2014): health risk, labor income risk, committed expenditure risk, liquidity and credit constraints, investment substitutes, mandatory retirement savings, preferences and other factors.

For health risk, we included self-reported measures of health status, number and type of chronic illnesses, private medical insurance, as well as medical coverage of household and family members. For labor income risk, we elicited the subjects' employment status and employment type, perception of job security in the short and mid-term. For committed expenditure risk, we asked the individual if she has mortgages or pays rent. In the case of liquidity and credit constraints, we measured the liquidity to face financial emergencies, number of credit cards and credit card debt and income. For investment substitutes, we included a question on house ownership. In the case of mandatory retirement savings, we elicit the subjects' affiliation to a pension plan. Lastly, for preferences, we include a self-reported measure of risk preferences, a self-reported question on investment behavior as well as questions that help us understand what the individual would do with her spare cash (pay debt, spend, save).

To elicit other factors, we included a short socioeconomic survey at the end of each study that included age, gender, race and ethnicity, State of residence, religion, marital status, educational level, number of children, a self-reported happiness question and a self-reported risk aversion question. The full questionnaire and short survey can be found in Appendix G.

5.3.3. Exogenous background risk lottery

As background risks should be pre-existing and uninsurable for individuals, we set up four treatments to reflect these three characteristics. Three of the treatments involve a lottery which differs on its expected value. The background risk lottery is introduced between the two sets of risk apportionment lotteries. The subject knows that the lottery will affect her payoff but she will not make any decisions regarding the lottery. Hence, this risk is uninsurable and also pre-existing before the second set of choices. Although the lotteries introduced are financial background risks, this background risk lottery is independent from other background risks the individual might have. The background risk lottery is also introduced exogenously, being explicitly imposed to the individual. The outcome of the lottery is realized after the end of the experiment.

The four treatments are: no lottery (*No BR* treatment), a mean-zero lottery (*mean-zero BR* treatment), a negative expected value lottery (*downside BR* treatment) and a positive expected lottery (*upside BR* treatment). The *No BR* treatment involves no lottery and the subject makes the two sets of choices back to back. The mean-zero and downside background risk treatments follow the logic of Lusk and Coble (2008) as a point of comparison for changes in risky decisions. However, we changed the value of the positive and negative outcomes of the lotteries to match our choice set payments. The mean-zero lottery has a 50 percent chance of winning E$50 and a 50 percent chance of losing E$50. The downside risk lottery has a 50 percent chance of winning E$0 and 50 percent chance of losing E$50. The upside risk lottery has a 50 percent chance of winning E$50 and 50 percent chance of losing E$0. In the *Mean-zero* and *downside* treatments, the risk is pre-existing, uninsurable and also undesirable, as it could lead to losses.

A distinction should be made between the zero-mean lotteries which are part of the choice set decisions and the additional background risks introduced in our treatments. Examining preferences for disaggregating sure losses and zero-mean lotteries (prudence) and preferences for disaggregating two independent zero-mean lotteries (temperance) in our choice sets could help us explain reductions in exposures to background risks (Mayrhofer 2017). These zero-mean lotteries could be thought of in these choice sets as background risks. The background risks in our choice sets are avoidable (based on the choices the individual makes) and are not pre-existing. However, our additional (treatment) background risks are unavoidable, uninsurable and pre-existing in the case of our second set of choices. Subjects are not allowed to make choices on the additional background risk lotteries, while they could avoid unfair or zero-mean lotteries of the choice sets based on their own decisions. Both types of background risks in our experiment are independent from each other, which allows us to examine the impact of one type of background risk on the other and vice versa.

5.3.4. Implementation and payment

Our experiment is computerized and run online in Amazon Mechanical Turk (MTurk) with an adult population. This allows us to have as much variability in pre-existing risks as possible, which could be more difficult with a population of undergraduate students. Each individual experimental session lasts around 30 minutes. Based on the way the MTurk platform works, individuals work on their experiment independently, once they agree to take part of our experiment and sign off on the consent page. The experiment is run in Qualtrics, which allows for an easy assignment of the treatments to each person. Each treatment is assigned 80 subjects, for a total of 640 individuals participating in our experiment.

Total payment includes a base fee of $0.5 for participation in the experiment. Bonus payment consists in one of the choice task decisions and the outcome of the background risk lottery. This is done at an exchange rate of E$80:$1. From the choice tasks, one decision will be selected to be paid as bonus, by drawing a random number from 1 to 32 (corresponding to the 32 higher-order risk preference choice tasks the individual makes). Regardless of whether it is a risk, prudence or temperance task, for the task chosen for payment the subject always gets the initial sure amount in the risk apportionment lottery. In addition, if based on the subject choices and the outcome of the coin toss the subject gets the first additional item, we roll a red six-sided die to determine the payoff from this lottery. If the first additional item is a fixed amount, the subject receives the amount regardless of the die roll (whether it is an odd or an even number). If the first additional item is a zero-mean lottery, the payoff of this lottery depends on the die roll. If the die roll is odd, the subject receives the first outcome of the lottery and gains the amount specified. If the die roll is even, the subject receives the second outcome of the lottery and loses the amount specified. If the subject gets the second additional item, we roll a blue six-sided die to determine the payoff from this lottery. The payoffs for the second additional item work the same way as for the first additional item. If based on the choices and the outcome of the coin toss the subject does not get an additional item, she gets E$0 for that item.

The outcome of the background risk lottery in the treatments where additional background risk is introduced is determined by rolling a purple six-sided die. If the die roll is odd, the subject receives the first outcome of the lottery, which could be positive, negative or zero. If the die roll is even, the subject receives the second outcome of the lottery, which could be positive, negative or zero.

5.4. Results

For the following analysis, we define individuals as sick if they reported that they had at least one chronic illness. Healthy individuals are those who reported that they had no chronic illnesses. We first examine differences in overall risky behavior between sick and healthy subjects. Second, we focus on the impact of the different treatments on risky behavior, accounting for individual health. Third, we introduce higher-order preferences to the analysis, specifically prudence and temperance. Treatments yield the same results regardless of the position of the background risk elicitation survey so we pool them together. Table 5.3 presents the number of subjects per treatment and health status.

Table 5.3: Number of subjects by treatment and self-reported health status

	Sick	Healthy	Total
No BR	175	98	*273*
Mean-zero BR	175	99	*274*
Upside BR	170	110	*280*
Downside BR	158	116	*274*
Total	***678***	***423***	***1101***

5.4.1. Aggregate behavior: sick versus healthy

First, we measure the overall incidence of riskiness in our sample as well as for sick and healthy individuals. The use of the count of the number of binary decisions consistent with risk aversion, prudence and temperance as measures of the strength of these attitudes has been used by Deck and Schlesinger (2010, 2014), Ebert and Wiesen (2011) and Noussair et al. (2014). We initially focus on the number of risk averse choices (that is the number of times individuals choose to disaggregate the harms and choose to receive both additional items separately).

We expect sick individuals to be less risky in their choices when compared to healthy subjects, both pre- and post-treatment. What we find is that pre-treatment, sick subjects make on average the same number of risk averse choices compared to healthy subjects ($p<0.001$). The distribution of the number of risk averse choices pre-treatment is also the same for sick and healthy individuals (Kolmogorov-Smirnov test $p=0.75$, Figure 5.1). But post-treatment, sick subjects make a significantly higher number of risk averse choices than healthy subjects ($p<0.001$).

In our experiment, sick and healthy individuals seem to react differently when exposed to the treatments, which is in line with the prior discussion. When taking all subjects in our sample, the average number of risk averse choices pre- and post-treatments is the same (2.85 choices p=0.03). However, this hides two different behaviors. Sick individuals overall make more risk averse choices when comparing pre- and post-treatments (2.90 versus 3.02 choices, p=0.03) while healthy individuals overall make a lower number of risk averse choices (2.77 versus 2.58 choices, p=0.01). When we compare sick and healthy individuals post-treatment, the distribution of the number of risk averse choices is different from each other (Kolmogorov-Smirnov test p=0.002). This means that there is a change in the distribution of the number of risk averse choices and that sick and healthy behave differently after treatment. The shifts in the distributions can be clearly seen in Figure 5.1 when distributions are split by health status.

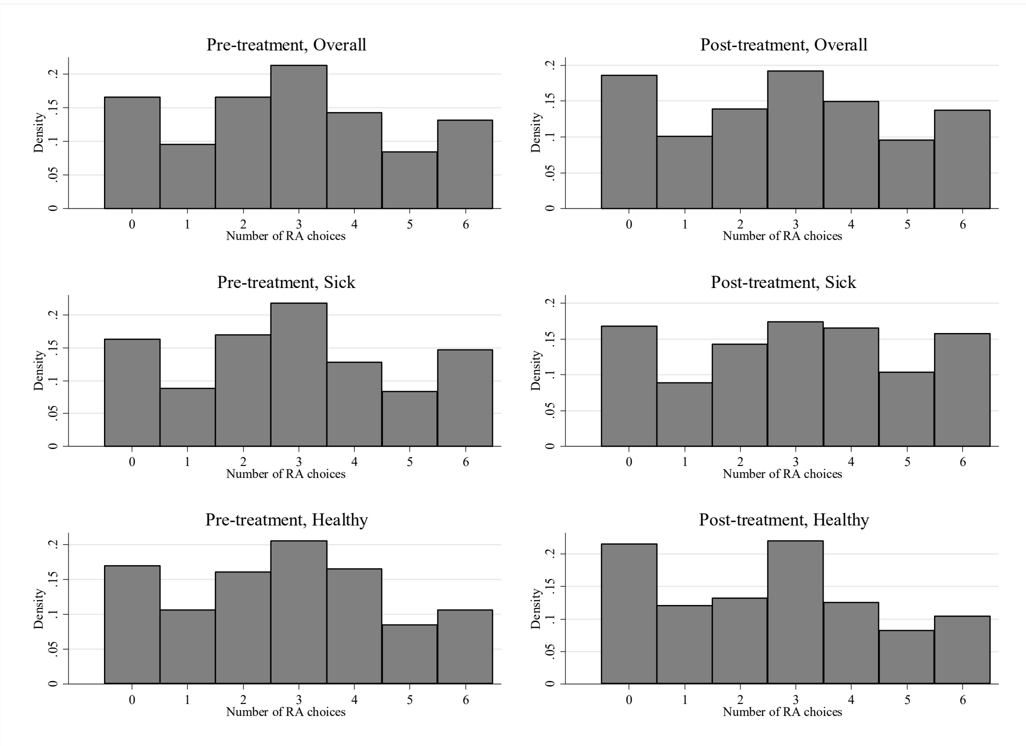
5.4.2. Impact of treatment and health status

In this section we examine the risky behavior of our experimental subjects by treatment from a within-individual perspective. We split the sample into those who change their behavior (CB) pre- and post-treatment and those who do not change their behavior in terms of the number of risk averse choices (DCB). Those individuals who CB are the ones who have a different number of risk averse choices pre- and the post-treatment, regardless of whether they make more risky decisions post-treatment or not. Those who DCB have the same number of risk averse choices in the pre- and post-treatment. We focus our analysis on those individuals who CB and initially compare the three treatments with background risk lotteries against the treatment with no additional background risk.

In addition to the number of risk averse choices, we also define three categories to place individuals in terms of the number of choices they make. Individuals have a low degree of riskiness (LR) if they made four, five or six risk averse choices. Individuals are classified as having a mild degree of riskiness (MR) if they made three risk averse choices and as having a high degree of riskiness (HR) if they made two or less risk averse choices.

As a check against the results of the prior literature, we analyze the number of risk averse choices pre-treatment. The results are in Appendix H.

Figure 5.1: Distributions of the number of risk averse choices, overall and by health status, pre and post treatment



5.2.1. *Downside BR* treatment (only potential losses)

Theoretically, the anticipated effect of background risk outcomes on individual riskiness is not completely clear, as most of the literature focuses on negative outcomes or losses. For the case of a negative outcome (a financial loss) if the individual is "risk vulnerable", adding background risk to wealth would decrease the level of individual riskiness to other independent risks (Eeckhoudt et al. 1996, Guiso and Paiella 2008). In addition, Quiggin (2003) argues that if the individual has diminished sensitivity to risk, adding extra risk would make her behave in a riskier manner.

In practice, most of findings show some degree of risk vulnerability, but there is evidence of the opposite behavior as well. For example, Lusk and Coble (2008) analyze individuals' choices over a series of lottery choices in a laboratory setting in the presence and absence of uncorrelated (financial) background risk. They find that adding an unfair background risk lottery similar to our *Downside BR* treatment reduces individual riskiness, although the effect is not quantitatively large. Cameron and Shah (2015) find that after experiencing a natural disaster (additional exogenous background risk), individuals exhibit a lower degree of riskiness. However, Eckel et al. (2009) and Page et al. (2014) find the opposite result, which would be in line with Quiggin's (2003) and with prospect theory predictions, particularly regarding a higher degree of riskiness after a loss. In the financial realm, Heaton and Lucas (2000) find that higher levels of background risk are associated with a lower degree of riskiness in individual financial portfolios.

Table 5.4: percentages of individuals with different degrees of riskiness

Low Riskiness				
	Sick		Healthy	
Treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
No BR	32.2	41.5	36.8	29.2
Upside BR	30.4	33.3	47.7	38.5
Mean-zero BR	29.2	40.6+	42.2	34.4
Downside BR	33.7	52.5**	40.0	34.3
Mid Riskiness				
	Sick		Healthy	
Treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
No BR	23.7	16.9	24.5	22.8
Upside BR	29.4	28.4	13.9	23.1
Mean-zero BR	27.4	25.5	23.4	20.3
Downside BR	32.7	13.9**	21.4	25.7
High Riskiness				
	Sick		Healthy	
Treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
No BR	44.1	41.5	38.6	47.4
Upside BR	40.2	38.2	38.5	38.5
Mean-zero BR	43.4	33.9	34.8	45.3
Downside BR	33.7	33.7	38.5	40.0

*Notes: +p=0.10 * p=0.05 ** p=0.010 for test of difference between percentage of individuals pre- and post-treatment in each category*

In our experiment, we find that only individuals who are sick respond to exogenous potential losses. This is in line with the health literature on risky financial decisions and on background risk addition (Heaton and Lucas 2000, Lusk and Coble 2008). On average, when sick individuals are exposed to the *Downside BR* lottery, the number of risk averse choices significantly increases (from an average of 2.96 choices to

3.35. p=0.035). There is no significant change in the number of risk averse choices for healthy individuals. In addition, not only average choices change but the distribution of the number of risk averse choices as well. Comparing the pre-treatment choices of sick subjects exposed to the *Downside BR* treatment, there is a shift of the distribution post-treatment to the right (towards less riskiness) in the number of risk averse decisions (Kolmogorov-Smirnov test p=0.04, Figure 5.2). The from Table 5.4, the shift in the *Downside BR* treatment can be attributed to MR individuals who become LR. This means that on average, individuals could be defined as risk vulnerable, as adding exogenous risk with the potential for losses reduces the level of riskiness (the number of risk averse choices made).

For mixed gains and losses, Lusk and Coble (2008) find that when a mean-zero background risk lottery is introduced, subjects' riskiness is reduced. From the Lusk and Coble (2008) findings, we would expect that when exogenous potential losses are involved, subjects make less risky choices. However, in our case, adding a zero-mean background risk lottery does not have any significant average effects in terms of the number of risk averse choices, regardless of the health of the individual (Sick: average 2.84 risk averse choices pre-treatment versus to 2.91 post-treatment, p=0.17, Healthy: average 3.29 risk averse choices pre-treatment versus to 2.94 post-treatment, p=0.12, see Table 5.4). Although there is a marginally significant increase in the percentage of individuals who are LR, there are no major changes in the distribution of the number of risk averse choices pre- and post-treatment (Kolmogorov-Smirnov test for sick p=0.44, for healthy p=0.34). One reason why the mean-zero treatment might not be significant is that our stakes are small compared to the decisions subjects make outside the laboratory

(Maier and Rüger 2012). Higher stakes outside the laboratory could lead to more speculative behavior, particularly to cover for potential losses, where subjects' might aggregate different risks to have one positive outcome.

Table 5.5: Average number of risk averse choices pre- and post-treatment, by health status and treatment

Treatment	Sick		Healthy	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
No BR	2.85	2.94	3.04	2.45
	(1.55)	(1.65)	(1.68)	(1.61)
Upside BR	2.82	3.03	3.11	2.79[c]
	(1.56)	(1.75)	(1.50)	(1.79)
Mean-zero BR	2.84	2.91	3.29	2.94
	(1.56)	(1.52)	(1.60)	(1.66)
Downside BR	2.96	3.35[b]	2.97	2.93
	(1.53)	(1.70)	(1.67)	(1.99)

Notes: Standard deviation between parentheses. b=significant at 5% for increase in the number of risk averse choices. c=significant at 5% for decrease in the number of risk averse choices.

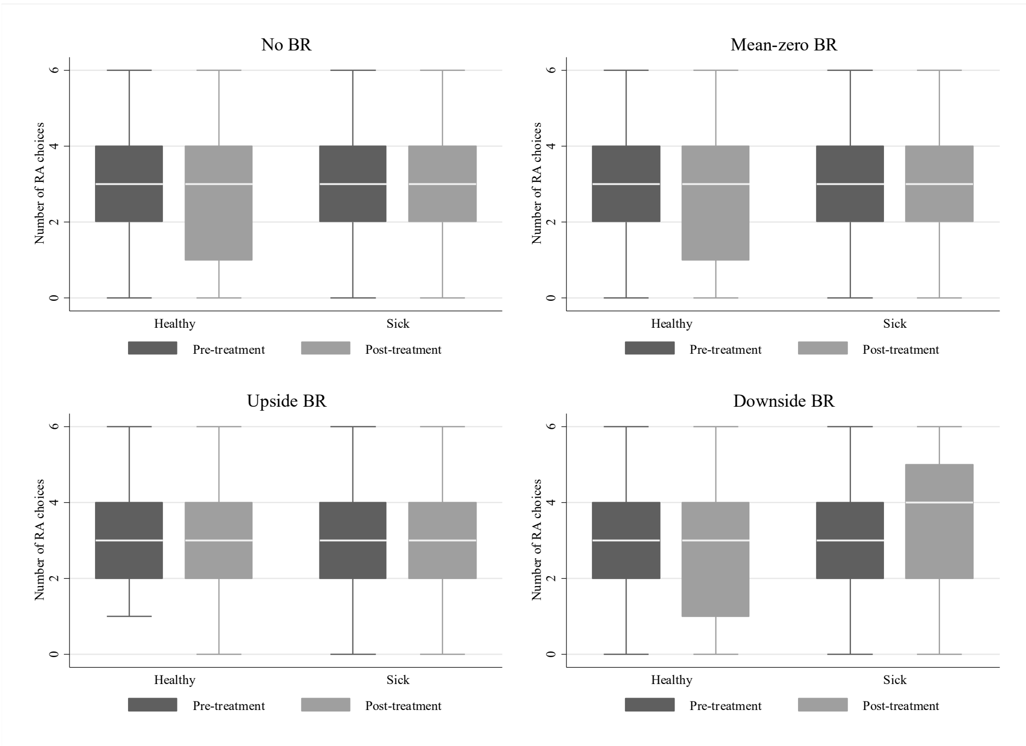
As a summary, we find that individuals respond differently depending on their health status and the treatment they are exposed to. The degree of individual riskiness changes following potential exogenous gains and losses, but it does not change when a mixed prospect is exogenously introduced. These changes also depend on health: sick subjects reduce their riskiness when exposed to exogenous losses (Rosen and Wu 2004, Edwards 2008, Fan and Zhao 2009), while healthy subjects increase their riskiness following the introduction of exogenous gains. Individuals with health issues have been usually found to be less risky than healthy subjects, particularly when it comes to financial decisions (Bressan et al. 2014).

One potential explanation for the difference found between sick and healthy subjects could be related to reference-dependence. Prospect theory predicts that individuals' risk attitudes may be reference-dependent, in that individuals are riskier when considering losses to a reference point and less risky when considering gains (Kahneman and Tversky 1979, Thaler and Johnson 1990, Kahneman 2003). We find the opposite result. Individuals who are sick (self-report at least one chronic illness) become less risky when exposed to exogenous potential financial losses, while healthy subjects become riskier when exposed to exogenous potential financial gains. In our study, individuals who are chronically sick might be more sensitive to potential losses, as poor health affects both current and future income and health-related expenditures. Thus, chronically sick subjects might be averse to losses (Kőszegi and Rabin 2006). Being prudent and temperate in financial decisions could be another explanation why sick individuals make a higher number of risk averse choices when facing potential losses. We explore this next.

5.4.3. Higher order preferences and health

A risk is not the only part of an individual’s risk profile, we explore whether higher-order preferences play a role in risky decisions when exogenous risk is added. One of the reasons why analyzing higher-order risk preferences in this context is relevant is related to the impact on health on future risks. In particular, future health shocks can trigger out-of-pocket expenditures, which absorbs financial wealth and raises its marginal utility (Edwards 2008). So being exposed to risks not only affects individual riskiness but their behavior in terms of risky decisions and tolerance to risks. The precautionary saving motive, or "prudence" (Kimball 1990), prompts individuals to acquire more wealth to offset the background risk. Any risk that leads to precautionary savings should also lower the demand for risky assets, which results in "temperance" (Kimball 1992). When faced with potential income losses and increased risks, prudent and temperate individuals aim at saving more in less risky investments.

Figure 5.2: Box and whisker plots of number of risk averse choices, by treatment, health status, pre- and post-treatment



We can first examine this relationship by looking at the correlation between the number of risk averse, prudent and temperate choices by health status and treatment (Table 5.6). On the aggregate, we observe a positive relationship between the number of risk averse choices pre- and post-treatment with the initial number of prudent and temperate choices, which is the typical pattern found in the literature (Ebert and Wiesen 2011, Noussair et al. 2014, Maier and Rüger 2012)[20] [21]. This correlation holds regardless of the health status and treatment. Additional analysis of the average individual risk profile can be found on Appendix I.

Although we do not directly measure health expenditures after a health shock, we do have a financial shock with potential losses in the *Downside BR* treatment and a mean-zero lottery with potential losses in the *Mean-zero BR* treatment. In our experiment, we cannot measure the precautionary savings motive directly, but following the prior literature, we would expect that individuals who are at least temperate and sick should behave in a less risky manner when exposed to a background risk lottery that involves potential financial losses (Heaton and Lucas 2000).

To analyze the average number of risk averse choices by degrees of prudence and temperance, we define a high degree of prudence if the subject made 4 prudent choices or more and a low degree if the subject made 2 prudent choices or less. For the case of temperance, an individual has a high degree of temperance if she made 3 temperate

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[20] We focus on the higher-order risk preferences pre-treatment, as our focus is not on the change in higher-order preferences but to look at the individual risk profile itself and analyze how individual riskiness changes.

[21] The correlation values are in line with Ebert and Wiesen's (2014) experimental results for the three measures and the results of Deck and Schlesinger (2017) for risk aversion and temperance. Our overall correlations are 0.48, 0.29 and 0.52 for our pre-treatment measures and our 0.42 and 0.26 for the risk aversion correlations with prudence and temperance in the post-treatment. In addition, the correlation between risk aversion and prudence is higher than between risk aversion and temperance.

choices or more, and a low degree of temperance if she made one or no temperate choices. Table 5.7 presents the average number of risk averse choices by health status, treatment and the different degrees of higher order preferences. We find that for sick individuals, in the case of additional exogenous financial lotteries, the degree of prudence (or precautionary savings) does not matter, while the degree of temperance (or avoidance of other risks) does, as expected. Subjects with a high degree of temperance increase their average number of risk averse choices after being exposed to a background risk lottery with potential losses (*Downside BR* treatment). This could be explained as a strategy to reduce their exposure to risks and compensate for potential future losses coming from the background risk lottery. Those subjects who are sick and exhibit a low degree of temperance show the same behavior when exposed to treatments that include a gain, although this effect is marginally significant. This increase in the number of risk averse choices can be explained as a way to increase potential gains instead of hedging risks, compared to their high temperate counterparts. For the case of healthy subjects, those who show a low degree of prudence significantly reduce their average number of risk averse choices after exposed to the treatments, as we would expect (*Upside BR* treatment is marginally significant). Less prudent subjects care less about precautionary income, hedging risks or avoiding losses (or no gains at all) and are therefore riskier in their choices.

Therefore, behavior towards risky choices and exogenous background risks does not only depend on the degree of individual riskiness but also on the level of higher-order risk preferences of the individual. An individual risk profile should incorporate not only riskiness, but also prudence and temperance (and other higher-order risk preferences if available, Deck and Schlesinger 2014). Risk also comes in many forms, not only financial, and we can argue that prior background risks, such as health, also play a part in the individual's risk profile, as sick and healthy individuals with the same degree of prudence and temperance behave differently when it comes to their riskiness.

5.4.4. Between-subject analysis: exposure to background risk

To explain individual changes in the number of risk averse choices when exposed to the background risk lotteries compared to the *No BR* treatment, we run ordered logit models for each sub-sample. In each specification, the dependent variable is the number of risk averse choices made post-treatment. The dependent variable ranges from 0 choices for an individual who made no risk averse choices to 6 choices for an individual who made 6 risk averse choices. Table 5.8 presents the results of the ordered logit specifications. The relevant variables in the model are related to the health of the individual, gender, income and higher-order risk preferences (and their interactions).

Subjects with poor health have been found to be less risky in their decisions and choose safer financial portfolio allocations to avoid potential declines in wealth (Rosen and Wu 2008, Baptista 2008). Therefore, compared to healthy individuals, we expect sick subjects to make more risk averse choices when exposed to losses. In line with our aggregate analysis (section 4.1.), subjects who self-reported having at least a chronic illness (*Sick*) make an average of 1.5 more risk averse choices after being treated. This is in comparison to subjects who do not report having chronic illnesses and were not exposed to additional background risk lotteries. The effect is (marginally) significant when potential losses are introduced in the exogenous background risk lottery (*Mean-zero BR* and *Downside BR*). In the case of subjects with health risks, the higher number of risk averse choices after being treated could be a strategy to counteract the potential losses from the exogenous background risk, since the *Downside BR* and the *Mean-zero BR* treatments both have loss scenarios. This is also evidence towards cross-risk vulnerability (Malevergne and Rey 2009). Economic decisions take place in the context of multiple and correlated risks, and decisions about endogenous risks, such as our choice tasks are usually taken while facing exogenous background risks, such as our background risk lotteries or the individual's health status. Our finding agrees with the literature that finds that health risks and poor health prompts less risky financial decisions (Edwards 2008, Heaton and Lucas 2000, Rosen and Wu 2004, Cardak and Wilkins 2009) but takes into consideration that both health and financial risks are related. Edwards (2008) argues that similar findings in the context of expected utility theory (EUT) coincides with a negative cross partial derivative for health and consumption, with sick individuals demanding more funds to make up for the lost non-market production of essential goods and services. In our case, this would be translated in a higher number of risk averse choices.

Figure 5.3 shows the distribution of the number of risk averse choices, where we can compare healthy subjects exposed to *No BR* and sick subjects post-treatment (*No BR, Mean-zero BR, Upside BR, Downside BR).* Compared to healthy subjects not exposed to additional background risk, the sick *Mean-zero BR* and the sick *Downside BR* seem to have a difference when behaviors are low risk (5 and 6 risk averse decisions). This is what the regression shows at the individual level. At the aggregate level, the comparison of the whole distributions of the number of risk averse choices from the healthy *No BR* treatment and sick subjects is only marginally significant for the *Downside BR* treatment (Kolmogorov-Smirnov test p=0.096).

A similar effect, albeit smaller is found for the *Number of prudent choices*. A prudent agent is one who increases his savings when uncertainty affects her future income (Tarazona-Gomez 2004). In our case, prudent subjects could be insuring themselves against the uncertainty coming from the potential losses of the exogenous background risk lottery, when compared to imprudent subjects who are not exposed to extra exogenous risk. We find that subjects who are more prudent and who are exposed to potential exogenous losses (*Downside BR* or *Mean-zero BR* treatments) make more risk averse choices compared to subjects not exposed to additional background risk. The effect is smaller compared to the impact of health status and marginally significant. This behavior is relevant when individuals try to offset the potential loss of the background risk lottery (Kimball 1990, Carroll 1994, Merrigan and Normandin 1996, Dynan 1993). In addition, for the case of an exogenous mean-zero risk, this is evidence towards the concept of "risk vulnerability", in which additional background risk could induce less risky behavior towards any other risk (Gollier and Pratt 1996, Edwards 2008). There is no significant effect of prudence when subjects are exposed to an exogenous background risk with potential gains only (*Upside BR*).

Table 5.6: Correlations between risk (pre- and post-treatment) and baseline (pre-treatment) higher-order preferences

	Pre-treatment number of risk averse choices, pre-treatment higher order risk measures								
	Overall	No BR		Mean-Zero BR		Upside BR		Downside BR	
		Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy
Number of risk averse choices - Number of prudent choices	0.48**	0.48**	0.63**	0.60**	0.36**	0.54**	0.30**	0.34**	0.45**
Number of risk averse choices - Number of temperate choices	0.29**	0.35**	0.47**	0.49**	0.14	0.26**	0.13	0.10	0.30**
Number of prudent choices - Number of temperate choices	0.52**	0.46**	0.58**	0.59**	0.51**	0.55**	0.49**	0.40**	0.59**
	Post-treatment number of risk averse choices, pre-treatment higher order risk measures								
	Overall	No BR		Mean-Zero BR		Upside BR		Downside BR	
		Sick	Healthy	Sick	Healthy	Sick	Healthy	Sick	Healthy
Number of risk averse choices - Number of prudent choices	0.42**	0.46**	0.44**	0.43**	0.39**	0.46**	0.43**	0.28**	0.47**
Number of risk averse choices - Number of temperate choices	0.26**	0.33**	0.32**	0.31**	0.15	0.28**	0.22*	0.13+	0.24**

*Notes: $^{+}$p=0.10 * p=0.05 ** p=0.010 for a Spearman correlation test.*

Table 5.7: Average number of risk averse choices, by degree of prudence and temperance, health status and treatment

Treatment	Sick		Healthy		Sick		Healthy	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
	High degree of prudence				Low degree of prudence			
No BR	3.20	3.24	3.36	2.40*	2.59	2.76	2.66	2.5
Upside BR	3.10	2.92	3.33	3.26	2.84	2.87	2.61	1.94+
Mean-zero BR	3.06	2.87	3.00	3.15	2.36	2.77	3.52	2.35**
Downside BR	3.16	3.50	3.07	3.33	3.00	2.86	3.76	3.04*
	High degree of temperance				Low degree of temperance			
No BR	3.00	3.21	3.28	2.09*	2.44	3.13*	3.33	2.55*
Upside BR	2.85	2.94	3.42	3.57	2.52	3.04+	3.44	2.92
Mean-zero BR	3.18	2.84	2.65	2.40	2.61	3.31+	2.96	2.33
Downside BR	3.03	3.75*	3.18	2.77	2.93	3.20	3.04	2.64

However, we find the opposite effect on subjects who are sick and more prudent than their healthy, imprudent counterparts (*Sick * Number of prudent choices*). These individuals make a smaller number of risk averse choices when exposed to the exogenous lotteries, regardless of whether the background risk lottery contains gains, losses or is a mixed gamble. The effect is small and marginally significant for skewed background lotteries (*Upside BR* and *Downside BR)* and significant when an exogenous mean-zero lottery is introduced (*Mean-zero BR*). Quiggin (2003) argues that although adding an independent risk reduces welfare, some individuals could have diminished sensitivity to risk, which might not make them particularly concerned with the addition of a small risk. This might be the case for this subsample of sick, prudent subjects, who although display prudent behavior, having additional background risk added to their risk pool might make them behave in a riskier manner. These are individuals who, according to Quiggin (2003) might display constant risk aversion with linear utility functions (risk neutral individuals) and whose premium for risk could be reduced by the presence of an independent background risk. Following Edwards (2008), this result could also be evidence that our sample has individuals who have a positive cross partial between health and consumption in the EUT framework.

In line with the results in our within-subject analysis, there is a positive relationship between health status, riskiness, prudence and temperance. When subjects are sick and make more prudent and temperate choices (*Sick * Prudence * Temperance*) they make more risk averse choices when exposed to potential exogenous losses (*Downside BR,* compared to healthy subjects with low degrees of prudence and temperance). In our case, the effect of the introduction of exogenous background risk affects subjects with a high degree of temperance in an indirect manner. Nevertheless, the effect is in line with the literature stating that background risks should lower the demand for risky assets (Kimball 1993, Elmendorf and Kimball 2000). This also is the effect we find between the pre- and post-treatment number of risk averse choices when sick individuals who are temperate are exposed to an unfair exogenous background risk. In particular, sick individuals who are temperate might be less risky in their choices as they have stronger preference to disaggregate two (in our case, independent) background risks. So intuitively, an individual facing an unavoidable background risk (potential negative health shocks) will seek to reduce exposure to another background risk (our exogenous unfair lottery, Mayrhofer 2017). The differential impact of sick (prudent and temperate) subjects when exposed to potential exogenous losses could also be evidence towards loss aversion as these subjects make less risky decisions when facing potential exogenous losses (Kahneman and Tversky 1979).

An indirect way health status can impact the degree of individual risk aversion is through the subject's wealth. Poorer health status negatively impacts individual finances, so we would expect that subjects who are exposed to high levels of background risk (in terms of income instability) and have a higher degree of prudence make more risk averse choices than those with higher levels of wealth (Cardak and Wilkins 2009, Edwards 2008). In our case we focus on one of the possible measures of wealth, the subject's income. We find that low income[22], prudent subjects (*Low Income * Number of prudent choices*) become significantly more risk averse when exposed to potential exogenous gains. Guiso and Paiella (2008) and Noussair et al. (2014) find that lower wealth subjects

[22] Low income subjects are defined as those subjects who earn $35.000 or less per year. Mid income subjects earn between $35.000 and $75.000 per year and high income subjects earn over $75.000 a year.

are more risk averse only. However, Noussair et al. (2014) finds that lower income has a negative impact on prudence. Our result pools these two findings together. The increase in risk aversion for low income and prudent subjects could be associated with the concept of precautionary savings. When faced with a potential exogenous gain, low income, prudent individuals would tend to make more risk averse choices to potentially increase their income.

As a check of the individual findings, we also find that at the aggregate level the distribution of the number of risk averse choices between low and higher income subjects who are prudent are significantly different only for those subjects exposed to the Upside BR treatment (Wilcoxon rank sum test p = 0.01). In particular, low prudent subjects seem to be make more risk averse choices (mean test for the number of risk averse choices, low versus mid-high income p-value=0.006).

5.5. Discussion

From the aggregate correlation analysis of risky behaviors of different orders, we cannot discard the possibility that some of our subjects fit under common EUT specifications. There are overall similar patterns of riskiness, prudence and temperance among the four treatments for sick and healthy individuals. In addition, there is evidence that some of our subjects (those who are prudent) could be risk vulnerable, which fits the EUT setup. However, when it comes to individual characteristics, sick, prudent and low income individuals seem to react differently when exposed to exogenous gains and losses. Low income and low degrees of riskiness are positively related, in our case for prudent individuals (Guiso and Paiella 2008). The positive correlation between a low level of riskiness, prudence and temperance would discard constant absolute risk aversion for these individuals (CARA) as well as constant absolute risk aversion (CRRA) but not for those who are sick, prudent and temperate. Other studies have also discarded other EUT specifications as well (Trautmann and van de Kuilen 2018, Deck and Schlesinger 2008, Guiso and Paiella 2008).

The different behavior of individuals when facing exogenous gains, losses and mean-zero lotteries could be evidence towards the existence of a reference point or loss aversion (PT - Kahneman and Tversky 1979). The heterogeneous behavior in these risky choice tasks could be evidence towards the idea of a mixture-model as well, where some individuals fall under EUT and some under PT, depending on the domain the subjects are exposed to (exogenous gains, losses or mean-zero, Harrison and Rutström 2009). Imposing a single functional form on the utility function would not properly explain the changes we see in individual behavior during this experiment.

Analysing the links between health and risky choices is an extension of the literature on portfolio choice in the presence of background risk (Edwards 2008). We can think of health as a background risk with the potential for a loss (either a decline in health, an increase in health expenditures or just aging, which increases the risk of health complications). Adding an independent exogenous (financial) risk with the potential of a loss seems to reduce the risky behavior of sick individuals depending on the type of risk introduced, which would imply a state dependent utility function (Finkelstein et al. 2013). In particular, there is an increase in number of risk averse choices for sick individuals who are prudent and temperate when facing the potential of a loss instead of a mixed-gamble. This means that prudent behavior alone (and precautionary savings-related behavior) is not enough to ensure the reduction in risk averse choices. The patterns in the data reveal that the impact of being prudent on the number of risk averse choices depends on whether subjects have a prior health-related background risk.

Therefore, incorporating higher order preferences is relevant for the analysis of risky decisions (Ebert and Wiesen 2011). Temperance appears to be less pervasive than prudence, (Trautmann and van de Kuilen 2018, Eeckhoudt and Schlesinger 2006, Crainich et al. 2013) as it but has a significant impact for sick individuals when exposed to a potential exogenous loss. Although it has been already shown that undesirable risks increase the level of individual riskiness (Lusk and Coble 2008), our results show that undesirable risks change the level of individual riskiness depending on the individual's higher-order preferences profile and individual characteristics. Thus, the analysis of risk and higher-order preferences should take into account individual characteristics and the case of health is one of many examples: there is no one-size-fits-all approach to examine risky decisions.

5.6. Conclusion

In this study, we set up an online experiment with the aim of understanding how health and financial background risks, risk aversion and higher-order preferences are related. Given that in practice individuals face bundles of risk that might be correlated, we focus on the interaction of two background risks: health and financial (Malevergne and Ray 2009). We incorporate exogenous background risks with potential gains, losses and a mixed-gamble and measure changes in risky decisions through a risk apportionment choice set (Eeckhoudt and Schlesinger 2006). We aim to examine the degree of riskiness of subjects who reported having chronic illnesses (have health background risks), including the interaction with the degrees of prudence and temperance. Our experiment allows us to focus on the number of risk averse choices individuals make after being exposed to the exogenous background risks, as they cannot be avoided or insured against. We also measure the potential determinants of the number of risk averse choices before background risks are introduced, as a measure of behavior before the increase of financial risk.

On the aggregate level, we find that sick subjects react differently to additional background risk compared to healthy subjects and make a lower number of risk averse decisions. This is in line with the health and financial risks literature, which states that subjects with poorer health tend to be less risky when it comes to financial decisions and portfolio allocations (Edwards 2008, Cardak and Wilkins 2009, Bressan et al. 2014). This is also evidence towards the existence of “cross-risk vulnerability” (Malevergne and Rey 2009), which incorporates risk vulnerability (Gollier and Pratt 1996) into a multivariate background risk setting and shows that having one type of background risk can reduce the level of riskiness of other risky individual decisions. However, not all treatments have the same impact on the level of individual riskiness. we find when sick individuals are exposed to a background risk lottery with potential losses, the number of risk averse choices significantly increases compared to healthy subjects (Rosen and Wu 2004, Edwards 2008, Fan and Zhao 2009). However, healthy subjects increase their riskiness following the introduction of exogenous gains (Bressan et al. 2014). Extensions of this work include examining how adding health risk impacts financial risk, which is the other side of “cross-risk vulnerability” proposed by Malavergne and Rey (2009). In addition, analyzing the changes in higher order risk preferences when financial risk is introduced is another avenue of research, which would be an extension of the experimental work by Deck and Schlesinger (2010, 2014) and Noussair et al. (2014).

Our findings indicate that the empirical relationship between health and financial risks is not a linear one. At the individual level, subjects behave differently depending on the exogenous background risk introduced. Sick individuals become make a higher number of risk averse choices when exposed to potential exogenous losses. However, changes in individual riskiness are also partly explained by higher-order risk preferences once the background risk lotteries have been introduced. Nevertheless, higher-order risk preferences cannot be considered only on their own. Prudence is not enough to explain risky decisions, as prudent sick individuals make riskier decisions when exposed to exogenous risks. As expected, sick, prudent and temperate individuals behave in a less risky manner when exposed to potential exogenous losses. Our results also suggest that low income has a positive impact on the degree of individual riskiness, but only in the case where individuals are exposed to a potential gain. This could be an indirect measure of health risks, as declining health increases the probability of health expenditures and of substituting labor (lower income) for time caring for an illness. Although the effect is not direct, more analysis is needed in order to clarify the impact of health shocks through changes individual wealth (out-of-pocket medical expenses) in the case exogenous financial background risk is added.

Table 5.8: Ordered logit models for post-treatment risk aversion, by treatment

D.V.: Number of risk averse choices (post-treatment)	No BR	Mean-zero BR	Upside BR	Downside BR
Number of risk averse choices (pre-treatment)	0.079	0.166+	0.117	0.051
	(0.091)	(0.095)	(0.093)	(0.096)
Health survey first	0.147	0.281	-0.025	0.113
	(0.287)	(0.280)	(0.284)	(0.289)
Sick	-0.578	1.510+	1.107	1.478+
	(0.844)	(0.790)	(0.790)	(0.816)
Female	-0.378	-0.297	0.066	0.192
	(0.430)	(0.413)	(0.410)	(0.451)
Number of prudent choices	-0.005	0.326+	0.102	0.312+
	(0.213)	(0.188)	(0.172)	(0.160)
Number of temperate choices	-0.321	-0.276	-0.044	-0.067
	(0.269)	(0.231)	(0.244)	(0.221)
Sick * Number of prudent choices	0.119	-0.636*	-0.376+	-0.471+
	(0.239)	(0.276)	(0.226)	(0.274)
Sick * Number of temperate choices	0.319	0.067	-0.266	0.382
	(0.318)	(0.341)	(0.348)	(0.326)
Prudence * Sick * Female	0.092	0.246	0.143	-0.014
	(0.182)	(0.231)	(0.223)	(0.222)
Temperance * Sick * Female	0.034	0.029	0.151	-0.422
	(0.248)	(0.318)	(0.307)	(0.299)
Prudence * Temperance * Sick	0.684	0.663	0.550	1.444*
	(0.660)	(0.689)	(0.677)	(0.697)
Low Income	0.240	0.512	-1.082	-0.346
	(0.750)	(0.684)	(0.720)	(0.753)
Low Income * Number of prudent choices	-0.022	-0.080	0.502*	0.022
	(0.189)	(0.208)	(0.198)	(0.192)
Low Income * Number of temperate choices	0.224	-0.064	0.248	-0.003
	(0.250)	(0.257)	(0.250)	(0.263)
cut1	-2.209*	-0.983	-1.633+	-1.089+
	(0.870)	(0.846)	(0.862)	(0.637)
cut2	-0.890	0.120	-0.558	-0.339
	(0.844)	(0.839)	(0.835)	(0.625)
cut3	-0.089	0.763	0.484	0.593
	(0.845)	(0.841)	(0.833)	(0.627)
cut4	0.713	1.781*	1.706*	1.422*
	(0.850)	(0.847)	(0.843)	(0.635)
cut5	2.007*	2.582**	2.777**	2.371**
	(0.864)	(0.854)	(0.863)	(0.656)
cut6	3.463**	3.872**	4.653**	3.230**
	(0.911)	(0.886)	(0.960)	(0.682)
N	*175*	*170*	*167*	*171*

APPENDICES

APPENDIX A

POSTERS FOR BASELINE, SELF AND OTHERS TREATMENTS

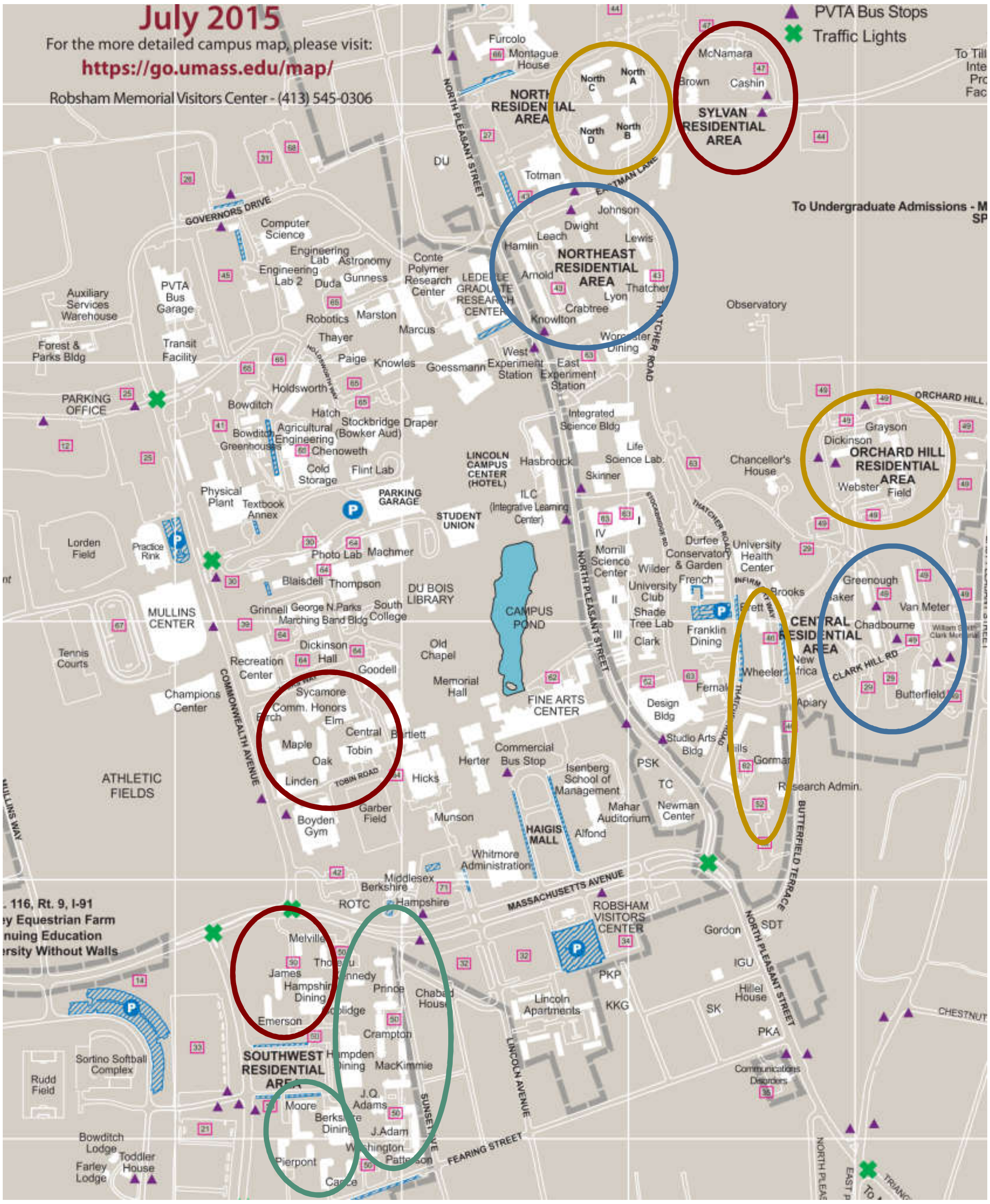
Baseline

Self

Others

APPENDIX B

DISTRIBUTION OF TREATMENTS AMONG RESIDENTIAL HALLS ON CAMPUS



Baseline
Self
Others
Both

APPENDIX C

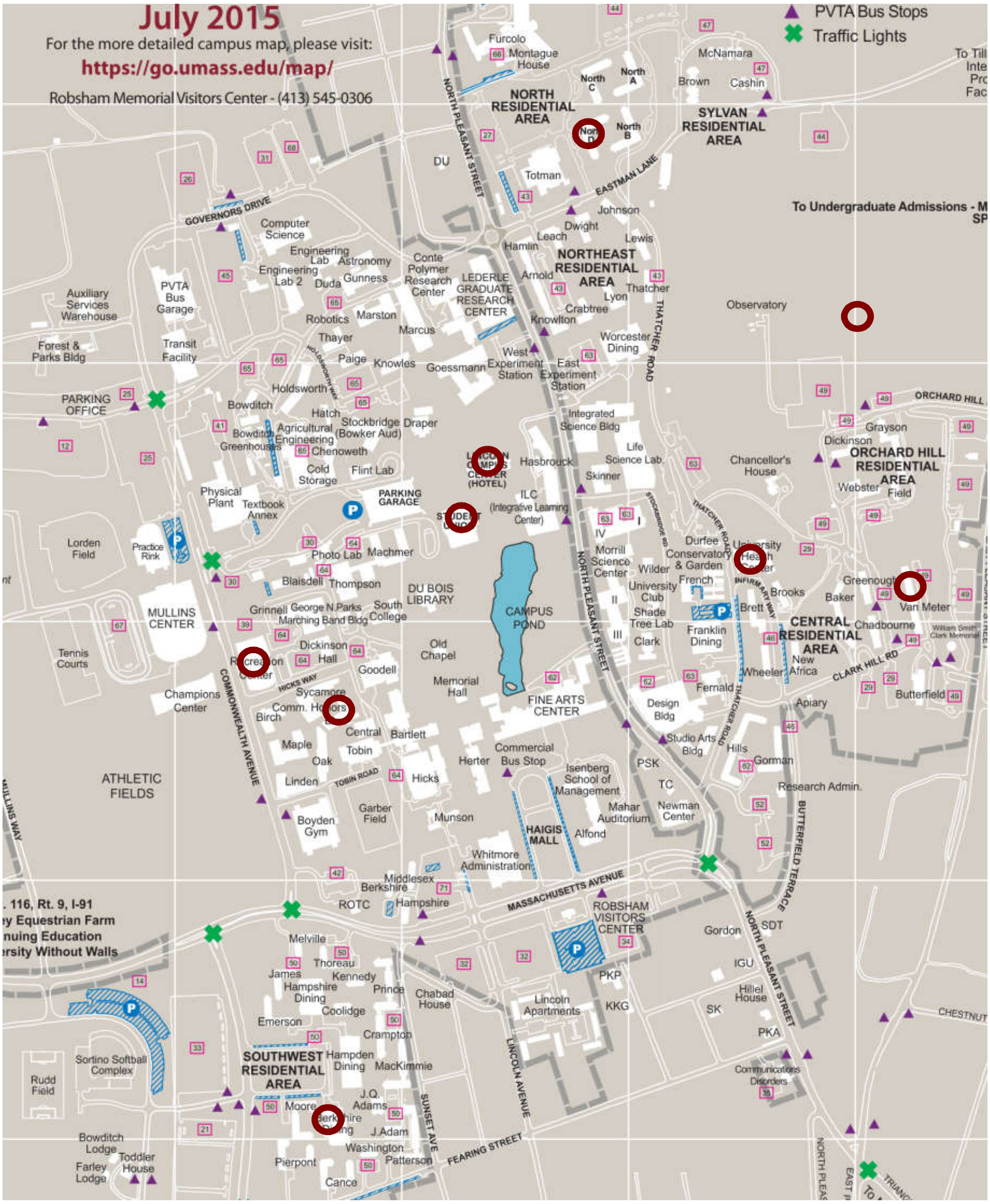
TIMELINE OF EVENTS: DISTRIBUTION OF CONDITIONS/TREATMENTS AND FLU DRIVES DURING FALL 2016

Month	Day	Action
September	23	Poster distribution
	26	Targeted Drive
	27	Targeted Drive
	28	Email reminder to University population
	29	Non-targeted Drive*
	30	Targeted Drive
October	6	Targeted Drive + Non-targeted Drive*
	7	Non-targeted Drive**
	13	Non-targeted Drive*
	14	Non-targeted Drive†
	20	Non-targeted Drive*
	21	Non-targeted Drive*
	27	Non-targeted Drive*
	28	Non-targeted Drive**
	31	Targeted Drive
November	8	Targeted Drive
	10	Non-targeted Drive*
	17	Non-targeted Drive*
	18	Non-targeted Drive**
December	2	Non-targeted Drive**
	8	Non-targeted Drive**

*Note: ** = Drive at University Health Services, * = Drive at Residential Area location, † = Drive at graduate student family housing*

APPENDIX D

LOCATION OF FLU DRIVES AROUND CAMPUS DURING FALL 2016



APPENDIX E

COMPARISON OF VACCINATED AND NON-VACCINATED SUB-POPULATIONS

On average, vaccinated and non-vaccinated students are similar in terms of gender (means test, $p=0.83$) and age (means test, $p=0.09$). However, the vaccinated sample is slightly more diversified in terms of race (almost 70 percent of white non-Hispanic in the vaccinated versus 77 in the non-vaccinated). Students who decided to receive the vaccine self-report overall better health status (means test, $p<0.001$). Also, almost 60 percent of students who received the vaccine self-report having no illnesses, while only 18 percent of those who did not receive the vaccine do so. This means that in our sample, many of those at risk for complications from the flu do not get the vaccine. The most prevalent self-declared illnesses in our study were asthma, migraines and depression (see Table 3).

APPENDIX F

COMPARISON OF GENDER TURNOUT

Compared to the *Baseline*, all messaging treatments seem to be getting a higher proportion of female students who live on campus coming to the flu drives (Proportion tests: *Baseline* = *Self*, p<0.001; *Baseline* = *Others*, p=0.001; *Baseline* = *Both*, p<0.001). In the case of male undergraduate students living on campus, compared to the *Baseline*, the proportion of students getting vaccinated in the *Self* treatment is not significantly different, while the proportion in the *Others* treatment is marginally significant and in the *Both* treatment is significant (Proportion tests: *Baseline* = *Self*, p=0.433; *Baseline* = *Others*, p=0.095; *Baseline* = *Both*, p<0.001).

Overall, in terms of gender, a higher percentage of females intent to treat are getting vaccinated than men (6.4% of the intent to treat females vs. 4.3% of the intent to treat males). In the *Baseline*, the same percentage of intent to treat females and males get vaccinated (3% of the intent to treat females and 3% of the intent to treat males). However, in every treatment, a higher percentage of the intent to treat females get vaccinated compared to the intent to treat males (see Table 2). When focusing on the total number of intent to treat students, women also constitute a higher proportion of the vaccinated students in the *Both* treatment, while Self and *Others* bring a similar number of females from the total intent to treat population (Proportion tests for females: *Self* = *Others*, p=0.13; *Others* = *Both*, p<0.001). The same could be argued for males (Proportion tests for males: *Self* = *Others*, p=0.38; *Others* = *Both*, p=0.007). However, the percentage of females is higher than males for all treatments (Proportion tests: Self, p<0.001; *Others*, p=0.021; *Both*, p<0.001).

APPENDIX G

WRITTEN INSTRUCTIONS AND QUESTIONNAIRES

General Instructions

Welcome to this study in decision making.

By signing the consent form in the previous screen you agreed to participate in this study. Remember, your participation is completely voluntary. If you choose to leave before finishing the study, you will forfeit any amount you may have earned. You must be at least 18 to participate in this study.

The study will take about 30 minutes during which you will make a series of decisions and answer a series of questions. All your answers will remain confidential. You will be paid according to the instructions, which will be explained in a moment. You will receive the HIT payment after you complete the study. Any bonuses you receive will be paid in the next 48 hours. Please complete the tasks on your own.

During this study, we will talk about all decisions using Experimental Tokens (E$). You will start with an endowment of E$100.

Your payoffs will be calculated in terms of Experimental Tokens and then translated at the end of the experiment into dollars at the following rate:

80 E$ = 1 U.S. Dollar

Instructions

[This is the script of the instructions video. Video can be seen here*]*

On the following screens, there will be a series of tasks. Once you have completed all the tasks in the experiment, the program will randomly choose one task for payment. Since we do not know which task will be chosen for payment, you should make each decision as if it will determine how much you will earn. Please note that you cannot lose your own money.

This is an example of what one of the tasks looks like:

"You will receive E$10 +

[10 / -10] if the coin lands on *Heads* or *Tails* and [5 / -5] if the coin lands on *Same* or *Different* outcome."

Each task starts with you receiving a fixed amount of cash (*show only first part of task*), and the ability to make choices about two additional items that could alter your payment (*show the two parts of the task*). The two additional items are lotteries. As an example, [10 / -10] in the first lottery represents the lottery in which you could have E$10.00 added to or subtracted from your payoff, depending on the outcome of the die roll. I will explain how the lottery outcomes are determined soon.

In each task, we will decide what lotteries you end up getting by tossing a coin. For each task, you first will have to decide if you prefer to receive the first additional lottery when the coin toss lands on *Heads* or *Tails*. You will also determine if you prefer to receive the second lottery on the *Same* or *Different* outcome of the coin toss as the first item. There is only one coin toss and you are deciding if you want the two lotteries combined (so that you receive both or neither) or if you want the two lotteries separated (so that you receive one or the other). If you do not get a lottery, that means that you get E$0 for that lottery.

Suppose you choose to receive the first lottery of the example task when the coin lands on Tails. You also choose to receive the second lottery on the Same outcome of the coin toss. This means that if the coin lands on tails, you get the first lottery and because you chose the same outcome, you also get the second lottery. If the coin lands on Heads, given your choices, you would get neither of the lotteries, because you chose to get the first lottery on Tails and the second lottery on the same outcome.

Suppose you now choose to receive the first lottery of the example task when the coin lands on Tails. You also choose to receive the second lottery on the Different outcome of the coin toss. In this case, you would get one lottery or the other based on the coin toss. If the coin lands on Tails, you get the first lottery but not the second one, as you chose to get the second lottery on the Different outcome. If the coin landed on Heads, you would not get the first lottery because you chose Tails, but you would get the second lottery, because you chose to receive it in a different outcome.

As a summary, choosing Same means that you will get both lotteries if the coin toss matches what you chose. If the coin toss does not match your choice, you do not get any of the lotteries. Choosing Different means that you will get one of the lotteries depending on the coin toss outcome. If your choice matches the coin toss and you chose Different in the second lottery, you only get the first lottery. If your choice does not match the coin toss and you chose Different, you only get the second lottery but not the first one. Remember that lotteries you do not get mean that you get E$0 from that lottery.

The outcomes of the lotteries you receive based on your decision will be determined as follows. For lotteries you receive in the *Heads/Tails* decision, we will roll a red six-sided die. For lotteries you receive in the *Same/Different* decision, we will roll a blue six-sided die. In our example, if you get the first lottery and the red die roll is odd (1, 3, 5), the first outcome of the lottery will occur and E$10 will be added to your payoff. If the red die roll is even (2, 4, 6), the second outcome of the lottery will occur and E$10 will be subtracted from your payoff. Following the example, our second lottery is [5 /-5]. If you get the second lottery and the blue die roll is odd (1, 3, 5), the first outcome of the lottery will occur and E$5 will be added to your payoff. If the blue die roll is even (2, 4, 6), the second outcome of the lottery will occur and E$5 will be subtracted from your payoff. Some of your tasks have a [5 / 5] instead of a [5 / - 5]. This means that instead of the lottery adding or subtracting money from your payoff, the lottery adds E$5 regardless of the outcome of your die roll.

To summarize, first you will choose the outcome of your coin toss for your first lottery, either Heads or Tails. You will then choose whether you want to receive your second lottery on the same or different outcome as your coin toss choice. We will toss a coin and determine which lotteries you will receive. Remember, based on your choices and the coin toss, you could receive the first lottery, the second lottery, both or neither of the lotteries. If you do not get a lottery, you receive E$0 from that lottery. If you get the first lottery, we will roll a red die to determine the outcome. If you get the second lottery, we will roll a blue die to determine the outcome. After this, we will calculate your payoffs, which consist of the sure amount and the outcomes of the lotteries, if you received any.

Let's go through some examples to calculate the final payoffs and to explain how you will make your choices in each of the tasks. In the first example,

You will receive E$10 +

[10 / -10] if the coin lands on *Heads* or ***Tails*** and [5 / -5] if the coin lands on ***Same*** or *Different* outcome.

Suppose you made the following responses. You clicked on and chose Tails and Same. This means you choose to receive both lotteries if the coin lands on tails or neither if it comes up heads. If your coin toss landed on *Heads*, your total payoff will be E$10, the sure amount. If your coin toss landed on *Tails,* that means that you get both lotteries. If the red die roll lands odd you get E$10 added to your payoff from the first lottery. If the blue die roll lands odd, you get E$5 added to your payoff from the second lottery. That means that your final payoff will consist of E$10 from the sure amount plus E$10 from the first lottery plus E$5 from the second lottery, for a total payoff of E$25.

If your coin toss landed on *Tails,* that means that you get both lotteries. If the red die roll lands even, you get E$10 subtracted from your payoff from the first lottery. If the blue die roll lands odd, you get E$5 added to your payoff from the second lottery. That means that your final payoff will consist of E$10 from the sure amount, minus E$10 from the first lottery plus E$5 from the second lottery, for a total payoff of E$5

Following the example,

You will receive E$10 +

[10 / -10] if the coin lands on ***Heads*** or *Tails* and [5 / -5] if the coin lands on *Same* or ***Different*** outcome.

Suppose you made the following responses. You clicked on and chose Heads and Different. This means you choose the receive the first lottery if the coin toss comes up heads, and the second lottery if the coin toss comes up tails. If your coin toss landed on *Heads*, you get the first lottery but not the second. If the red die roll lands odd you get E$10 added to your payoff from the first lottery. You get E$0 from the second lottery. That means that your final payoff will consist of E$10 from the sure amount plus E$10 from the first lottery for a total payoff of E$20.

If your coin toss landed on *Tails,* that means that you get the second lottery but not the first one. If the blue die roll lands odd you get E$5 added to your payoff from the second lottery. You get E$0 from the first lottery. That means that your final payoff will consist of E$10 from the sure amount plus E$5 from the second lottery for a total payoff of E$15.

Please click next to go through some comprehension questions. These will not impact your payoff in any way.

Comprehension questions

The comprehension questions will not impact your payoff in any way.

You will receive E$10 +

[10 / -10] if the coin lands on ***Heads*** or *Tails* and [5 / -5] if the coin lands on *Same* or ***Different*** outcome.

Suppose you made the responses marked in red.

If your coin toss landed on *Heads* and the red die lands in 3, your total payoff will be E$_____ ***(answer: E$10 (sure amount) = E$10 (from Heads) + E$0 (from Different outcome) = E$20)***

If your coin toss landed on *Tails* and the blue die lands in 6, your total payoff will be: E$ ______ ***(answer: E$10 (sure amount) + E$0 (from Heads) - E$5 (from Different outcome) = E$5)***

Please click next to continue and make your choices.

Your choices

<u>Remember</u>: You will have to make **two choices**. Your first choice is whether you want the first lottery when the coin lands on *Heads* or *Tails.* Your second choice is whether you want the second lottery in the *Same* or *Different* outcome as the result of the coin toss.

Please click on your choices.

If you want to review the instructions, you can do so here.

Choice #1.

You will receive E$30 +

[25 / -25] if the coin lands on *Heads* or *Tails* and

[25 / 25] if the coin lands on *Same* or *Different* outcome.

Choice #2.

You will receive E$15 +

[5 / -5] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.

Choice #3.

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[1 / 1] if the coin lands on *Same* or *Different* outcome.

Choice #4.

You will receive E$12.50 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.

Choice #5.

You will receive E$15 +

[9 / -9] if the coin lands on *Heads* or *Tails* and

[1 / -1] if the coin lands on *Same* or *Different* outcome.

Choice #6.

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[5 / 5] if the coin lands on *Same* or *Different* outcome.

Choice #7.

You will receive E$12.50 +

[5 / -5] if the coin lands on *Heads* or *Tails* and

[1 / 1] if the coin lands on *Same* or *Different* outcome.

Choice #8.

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[9 / 9] if the coin lands on *Same* or *Different* outcome.

Choice #9.

You will receive E$55 +

[25 / -25] if the coin lands on *Heads* or *Tails* and

[25 / -25] if the coin lands on *Same* or *Different* outcome.

Choice #10.

You will receive E$10.50 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[1 / -1] if the coin lands on *Same* or *Different* outcome.

Choice #11.

You will receive E$10 +

[5 / 5] if the coin lands on *Heads* or *Tails* and

[5 / 5] if the coin lands on *Same* or *Different* outcome.

Choice #12.

You will receive E$55 +

[5 / -5] if the coin lands on *Heads* or *Tails* and

[45 / -45] if the coin lands on *Same* or *Different* outcome.

Choice #13.

You will receive E$6 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[9 / 9] if the coin lands on *Same* or *Different* outcome.

Choice #14.

You will receive E$50 +

[5 / 5] if the coin lands on *Heads* or *Tails* and

[45 / 45] if the coin lands on *Same* or *Different* outcome.

Choice #15.

You will receive E$12.50 +

[5 / 5] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.

Choice #16.

You will receive E$14.50 +

[9 / -9] if the coin lands on *Heads* or *Tails* and

[1 / 1] if the coin lands on *Same* or *Different* outcome.

Please click next to continue.

Additional earnings

[This is the script of the additional earnings video. Videos can be seen here for Mean Zero*,* Upside *and* Downside*]*

Please make sure you carefully follow and understand the instructions for this stage.

Independent from the decisions you make throughout the experiment, you will participate in a lottery in which you could have the chance to get additional earnings. The outcome of the lottery will be revealed when your bonus is paid and it can impact your final payoff. You do not have to make any decisions in this stage but we ask you to pay close attention to how the lottery you will participate in might affect your final payoff.

[Mean-zero risk] In the lottery you will participate in today, you will have a 50% chance of winning E$50 and a 50% chance of losing E$50.

[Upside risk] In the lottery you will participate in today, you will have a 50% chance of winning E$50 and a 50% chance of losing E$0.

[Downside risk] In the lottery you will participate in today, you will have a 50% chance of winning E$0 and a 50% chance of losing E$50.

The outcome of the lottery is determined by a six-sided die at the end of study. If the die roll is odd, your outcome is the first one. If the die roll is even, your outcome is the second one. The outcome of the lottery will be added to your final payoff. Remember you cannot lose your own money.

[Mean-zero risk] As an illustration, if the die roll is 1, this means that you would win E$50, the first outcome of the lottery. If the die roll is 6, you would lose E$50, the second outcome of the lottery.

[Upside risk] As an illustration, if the die roll is 1, this means that you would win E$50, the first outcome of the lottery. If the die roll is 6, you would lose E$0, the second outcome of the lottery.

[Downside risk] As an illustration, if the die roll is 5, this means that you would win E$0, the first outcome of the lottery. If the die roll is 6, you would lose E$50, the second outcome of the lottery.

Remember:

[Mean-zero risk] In the lottery you will participate in today, you have a 50% chance of winning E$50 and a 50% chance of losing E$50.

[Upside risk] In the lottery you will participate in today, you have a 50% chance of winning E$50 and a 50% chance of losing E$0.

[Downside risk] In the lottery you will participate in today, you have a 50% chance of winning E$0 and a 50% chance of losing E$50.

Please answer the following comprehension questions to continue:

1. When will the outcome of this lottery be revealed?

Now/At the end of the study

2. What will we draw to determine your lottery outcome?

A 6-sided die / A 10-sided die / A 20-sided die

3. If your die roll is 4 you get the:

First outcome of the lottery / Second outcome of the lottery lottery

4. Although you will not have to make any choices in this lottery, will this lottery impact your payoffs?

Yes / No

Instructions

In this task, you will be asked again to make a new series of choices. The instructions are the same as before. You can go over the instructions again as well as the examples by watching the video if you want to do so.

[Video goes here. Video can be seen <u>here</u>*]*

Please remember that you cannot lose your own money.

Please click next to continue and make your choices.

Your choices

<u>Remember</u>: You will have to make **two choices**. Your first choice is whether you want the first lottery when the coin lands on *Heads* or *Tails.* Your second choice is whether you want the second lottery in the *Same* or *Different* outcome as the result of the coin toss.

Please click on your choices.

If you want to review the instructions, you can do so here.

Choice #1.

You will receive E$30 +

[25 / -25] if the coin lands on *Heads* or *Tails* and

[25 / 25] if the coin lands on *Same* or *Different* outcome.

Choice #2.

You will receive E$15 +

[5 / -5] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.

Choice #3.

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[1 / 1] if the coin lands on *Same* or *Different* outcome.

Choice #4.

You will receive E$12.50 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.

Choice #5.

You will receive E$15 +

[9 / -9] if the coin lands on *Heads* or *Tails* and

[1 / -1] if the coin lands on *Same* or *Different* outcome.

Choice #6.

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[5 / 5] if the coin lands on *Same* or *Different* outcome.

Choice #7.

You will receive E$12.50 +

[5 / -5] if the coin lands on *Heads* or *Tails* and

[1 / 1] if the coin lands on *Same* or *Different* outcome.

Choice #8.

You will receive E$10 +

[1 / 1] if the coin lands on *Heads* or *Tails* and

[9 / 9] if the coin lands on *Same* or *Different* outcome.

Choice #9.

You will receive E$55 +

[25 / -25] if the coin lands on *Heads* or *Tails* and

[25 / -25] if the coin lands on *Same* or *Different* outcome.

Choice #10.

You will receive E$10.50 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[1 / -1] if the coin lands on *Same* or *Different* outcome.

Choice #11.

You will receive E$10 +

[5 / 5] if the coin lands on *Heads* or *Tails* and

[5 / 5] if the coin lands on *Same* or *Different* outcome.

Choice #12.

You will receive E$55 +

[5 / -5] if the coin lands on *Heads* or *Tails* and

[45 / -45] if the coin lands on *Same* or *Different* outcome.

Choice #13.

You will receive E$6 +

[9 / 9] if the coin lands on *Heads* or *Tails* and

[9 / 9] if the coin lands on *Same* or *Different* outcome.

Choice #14.

You will receive E$50 +

[5 / 5] if the coin lands on *Heads* or *Tails* and

[45 / 45] if the coin lands on *Same* or *Different* outcome.

Choice #15.

You will receive E$12.50 +

[5 / 5] if the coin lands on *Heads* or *Tails* and

[5 / -5] if the coin lands on *Same* or *Different* outcome.

Choice #16.

You will receive E$14.50 +

[9 / -9] if the coin lands on *Heads* or *Tails* and

[1 / 1] if the coin lands on *Same* or *Different* outcome.

Please click next to continue.

Questionnaire

Please answer the following questions:

1. How would you describe your current health? Very good/good/satisfactory/poor/bad

2. Compared to one year ago, how would you rate your health in general now? Much better now than a year ago / Somewhat better now than a year ago / About the same as one year ago / Somewhat worse now than one year ago / Much worse now than one year ago

3. Do you have any long-term health conditions, impairments or disabilities that restricts you in your everyday activities, and has lasted or is likely to last, for 6 months or more? Yes / No

4. Do(es) your condition(s) limit the type of work or the amount of work you can do? Yes/No

5. Has a doctor ever diagnosed you to have one or more of the following conditions? Sleep disorder / Diabetes / Asthma / Cardiac disease (cardiac insufficiency, weak heart) / Cancer / Stroke / Migraine / High blood pressure / Depression / Anxiety / Joint diseases (including arthritis, rheumatism) / Chronic back trouble / Other illness (please specify) / No illness diagnosed

6. Are you currently covered by private health insurance? Yes/No

7. Do you take regular medication? Yes/No

8. If you take regular medication, is it covered by your health plan or do you pay for it out of pocket? Yes, it is covered fully / Yes, it is covered partially/ No, it is not covered and I pay for the medication fully

9. How TRUE or FALSE is each of the following statements for you?

	Definitely True	*Mostly True*	*Don't know*	*Mostly False*	*Definitely False*
a. I seem to get sick a little easier than other people b. I am as healthy as anybody I know c. I expect my health to get worse d. My health is excellent					

10. Do you have any household members who are currently suffering from a long-term disability or chronic illness? Yes, my wife (husband) / Yes, one of my children / Yes, another family member I have to take care of / No

11. If yes, are the expenses related to taking care of the sick household member(s) covered by your health plan or do you pay for it out of pocket? Yes, it is covered fully / Yes, it is covered partially / No, it is not covered and I pay for the expenses fully

12. Given your current needs and financial responsibilities, would you say that you and your family are ... Prosperous / Very comfortable / Reasonably comfortable / Just getting along / Poor / Very poor

13. Are you the chief wage earner in your household? Yes / No

14. If No, is the chief wage earner of your household employed now? Yes/ No

15. If Yes, which of the following categories best describes your employment status? Employed, working 1-20 hours per week / Employed, working 21-39 hours per week / Employed working 40 or more hours per week / Not employed, looking for work / Not employed, not looking for work / Retired / Student / Disabled, not able to work / Homemaker / Unpaid family worker

16. If you are employed, are you self-employed? Yes / No

17. The organization you work for is in which of the following: Public sector (e.g. government) / Private sector (e.g. most businesses and individuals) / Not-for-profit sector / Other

18. What is the total number of people employed in your household? 0/ 1/ 2/ more than 2

19. How much money did you personally earn last year? This includes money from jobs, net income from business, farm or rent, dividends or interest, social security payments or any other income received by any household member over 18 years old. Please report the total amount earned. Do not subtract taxes or deductions listed on your tax return

Less than $10,000

$10,000 to $19,999

$20,000 to $29,999

$30,000 to $39,999

$40,000 to $49,999

$50,000 to $59,999

$60,000 to $69,999

$70,000 to $79,999

$80,000 to $89,999

$90,000 to $99,999

$100,000 to $149,999

$150,000 or more

20. How much money did all members of your household earn last year? This includes money from jobs, net income from business, farm or rent, dividends or interest, social security payments or any other income received by any household member over 18 years old. Please report the total amount earned. Do not subtract taxes or deductions listed on your tax return.

Less than $10,000

$10,000 to $19,999

$20,000 to $29,999

$30,000 to $39,999

$40,000 to $49,999

$50,000 to $59,999

$60,000 to $69,999

$70,000 to $79,999

$80,000 to $89,999

$90,000 to $99,999

$100,000 to $149,999

$150,000 or more

21. If you are employed or self-employed, how much do you agree or disagree with the following statements:

	Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a. I have a secure future in my job b. I worry about the future of my job c. The company/business I work for (I own) will still be in business 5 years from now					

22. Are you currently enrolled in a pension plan (401 K)? Yes / No

23. Do you own a credit card? (Do not include debit cards) Yes / No

24. How many credit cards do you own? (Do not include debit cards) 1, 2, 3, more than 3

25. How often is the entire balance on all of your credit cards paid off each month? Hardly ever or never / Not very often / About half of the time / Most months / Always or almost always

26. Suppose you had only one week to raise $2000 for an emergency. Which of the following best describes how hard it would be for you to get that money? I could easily raise the money / I could raise the money, but it would involve some sacrifices (e.g., reduced spending, selling a possession) / I would have to do something drastic to raise the money (e.g., selling an important possession) / I don't think I could raise the money

27. Imagine you unexpectedly receive $1000. How much of it would you save, how much would you spend, and how much of it would you use to pay off debt (for example, on a mortgage, other loans or credit cards)? Spending amount / Saving amount / Paying off debt amount (in whole $)

28. What if this amount was $10,000? Spending amount / Saving amount / Paying off debt amount (in whole $)

29. Do you own the home you are living now? Yes / No, but I own other properties / No, I do not own any properties

30. If Yes, did you (or other members of your household) take out mortgages or home loans from a bank, (credit union, or some other financial institution) to help pay for your home or the properties you own? Yes / No

31. Has your household paid off the loan(s) completely now? Yes / No

32. In what year do you expect the loan(s) to be fully paid off?

33. If No, do you pay rent for the property you live in now? Yes / No

34. Which of the following statements comes closest to describing the amount of financial risk that you are willing to take with your spare cash? That is, cash used for savings or investment. I take substantial financial risks expecting to earn substantial returns / I take above-average financial risks expecting to earn above-average returns / I take average financial risks expecting to earn average returns / I am not willing to take any financial risks / I never have any spare cash

Survey

Please answer the following questions:

1. What sex were you assigned at birth, on your original birth certificate: Male / Female / Other / Prefer not to answer

2. Your age: [] years

3. Which U.S. State do you live in?

5. Select the racial category that best describes you: White / Black or African American / American Indian or Alaska Native / Asian / Hawaiian/Pacific Islander / Other

6. What is your ethnicity? Hispanic or Latino / Not Hispanic nor Latino

7. Are you currently: Married / Living together as married / Divorced / Separated / Widowed / Single, never married

8. Do you have children? If so, how many?

9. What is the highest educational level that you have completed? Less than high school degree / High school degree or equivalent (e.g., GED) / Some college but no degree / Associate's degree / Bachelor's degree / Master's degree / Doctorate degree / Professional degree beyond a bachelor's degree / Other

10. Do you belong to a religion or religious denomination? If yes, which one? Roman Catholi / Protestant / Orthodox / Jewish / Muslim / Hindu / Bhuddist / Other / No, I do not belong to any denomination

11. Apart from weddings and funerals, about how often do you attend religious services these days? Never / Less than once a year / About once or twice a year / Several times a year / 2-3 times a month / Nearly every week / Every week / Several times a week / Don't know

12. How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please choose a value on the scale, where the value 1 means 'not at all willing to take risks' and the value 10 means 'very willing to take risks'.

13. Taking all things together, would you say you are: Very happy / Rather happy / Not very happy / Not at all happy

Please click next to continue.

APPENDIX H

PRE-TREATMENT BEHAVIOR

In this section, we analyze the determinants of the number of risk averse choices pre-treatment as a way of checking the influence of different variables in risky behavior. Table 5.9 presents ordered logit regressions for the number of risk averse choices in the pre-treatment with our relevant variables (gender, health status and higher order preferences) as explanatory factors. Females are always less risky than men (Eckel and Grossman 2008, Croson and Gneezy 2009) and this result has been found in the non-parametric higher-order risk apportionment literature (Ebert and Wiesen 2014, Noussair et al. 2014). In this case, females make a higher number of risk averse choices pre-treatment. Individuals who make more prudent choices are always less risky (make a higher number of risk averse choices). However, there is no effect of temperance on the number of risk averse choices, which is in line with prior studies which show that temperance is less prevalent than prudence (Deck and Schlesinger 2008, Baillon et al 2017, Bleichrodt and van Bruggen 2018). Lastly, subjects who CB and are sick initially have a higher degree of riskiness, which is opposite to the usual findings in prior studies (Cardak and Wilkins 2009, Edwards 2008). A reason for this finding could be related to the fact that health changes might matter for the (static) analysis of riskiness, but the effect of health on risky decisions might not be contemporaneous with changes in health itself (Love and Smith 2010). In particular, individuals who reported having a chronic illness might have adjusted their level of riskiness in the past, once they learned of their expected health outcomes. Thus, playing with house money would incentivize making less risk averse choices (a higher level of riskiness), even for those who are expected to be riskier. We find no effect of health on the number of risk averse choices pre-treatment for those who DCB.

Table **5.9: Ordered logit models for pre-treatment levels of risk aversion, by behavior**

D.V: Number of RA choices (pre-treatment)	Change Behavior	Do not change behavior
Female	0.963*	0.816*
	(0.38)	(0.35)
Number of prudent choices	0.708**	0.181*
	(0.12)	(0.09)
Number of temperate choices	0.247	0.015
	(0.16)	(0.12)
Female*Number of prudent choices	-0.073	-0.048
	(0.13)	(0.10)
Female*Number of temperate choices	-0.113	-0.168
	(0.18)	(0.12)
Sick	0.066	-0.965**
	(0.39)	(0.36)
Sick*Number of prudent choices	0.159	0.122
	(0.13)	(0.10)
Sick*Number of temperate choices	-0.091	0.167
	(0.18)	(0.13)
cut1	1.760**	-2.213**
	(0.36)	(0.36)
cut2	2.132**	-0.956**
	(0.36)	(0.34)
cut3	2.721**	0.127
	(0.37)	(0.34)
cut4	3.633**	1.201**
	(0.39)	(0.34)
cut5	4.312**	2.163**
	(0.40)	(0.34)
cut6	4.715**	3.307**
	(0.42)	(0.37)
N	***418***	***683***

APPENDIX I

ADDITIONAL ANALYSIS OF HIGHER-ORDER RISK PREFERENCES

Table 5.10 shows the number of prudent and temperate choices by number of risk averse choices, pre- and post-treatment. On average, the subjects who make the highest number of risk averse choices also make the highest number of prudent and temperate choices (Noussair et al. 2014, Maier and Rüger 2012). Subjects who are HR make the highest number of imprudent and intemperate choices. The positive correlation holds when comparing HR subjects pre- and post-treatment with their baseline numbers of prudent and temperate choices, but it mostly happens at the extremes. This happens regardless of the health status of the subject. Average increases in the number of prudent and temperate choices mostly happen when comparing extreme riskiness levels with MR subjects. From Table 5.4, moderately HR and LR individuals do not behave differently from MR individuals in terms of higher-order preferences. These MR subjects are moderately prudent and moderately temperate in terms of their number of choices compared to the extreme HR and LR subjects.

Table 5.10: Prudence and temperance by number of risk-averse choices, pre- and post-treatment.

Pre-treatment number of risk averse choices					
SICK			HEALTHY		
Number of risk averse choices (pre-treatment)	Number of prudent choices (pre-treatment)	Number of temperate choices (pre-treatment)	Number of risk averse choices (pre-treatment)	Number of prudent choices (pre-treatment)	Number of temperate choices (pre-treatment)
0 (n=111, HR)	1.32**	1.32**	0 (n=72, HR)	0.56**[a]	0.69**[a]
1 (n=60, HR)	2.83	2.07[a]	1 (n=45, HR)	3.33	2.25*[a]
2 (n=115, HR)	2.97	1.93	2 (n=68, HR)	3.12	2.35
3 (n=148, MR)	2.72*[a]	1.82+	3 (n=87, MR)	3.18[a]	1.86
4 (n=87, LR)	3.08	1.93	4 (n=70, LR)	2.92	1.33**[a]
5 (n=57, LR)	3.04	2.09	5 (n=36, LR)	3.83	2.50[a]
6 (n=100, LR)	5.07**[a]	3.10**[a]	6 (n=45, LR)	5.46**[a]	3.69**[a]
Post-treatment number of risk averse choices					
SICK			HEALTHY		
Number of risk averse choices (post-treatment)	Number of prudent choices (pre-treatment)	Number of temperate choices (pre-treatment)	Number of risk averse choices (post-treatment)	Number of prudent choices (pre-treatment)	Number of temperate choices (pre-treatment)
0 (n=114, HR)	1.56**	1.46**	0 (n=91, HR)	1.60**	1.37**
1 (n=60, HR)	3.08[a]	1.85[a]	1 (n=51, HR)	2.84[a]	2.24[a]
2 (n=97, HR)	2.78	1.91	2 (n=56, HR)	2.57*	1.88
3 (n=118, MR)	2.89	1.89	3 (n=93, MR)	2.96	1.85
4 (n=112, LR)	2.87	1.99	4 (n=53, LR)	3.08	1.72+
5 (n=70, LR)	3.30[a]	1.99	5 (n=35, LR)	3.63+	2.03
6 (n=107, LR)	4.51**[a]	2.91**[a]	6 (n=44, LR)	4.64**[a]	2.98**[a]

*Notes: +p=0.10 * p=0.05 ** p=0.010 for test against random behavior (3 choices for prudence, 2 choices for temperance). a=category value is different from the prior category level value at 10% significance or less (Mann-Whitney test).*

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