

# **Biased Lung Cancer Risk Perceptions: Smokers are Misinformed**

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## **Abstract**

This paper empirically investigates biased beliefs about the risks of smoking. First, it confirms the established tendency of people to *overestimate* the lifetime risk of a smoker to contract lung cancer. In this paper's survey, almost half of all respondents overestimate this risk. However, 80% *underestimate* lung cancer deadliness. In reality, less than one in five patients survive five years after a lung cancer diagnosis. Due to the broad underestimation of the lung cancer deadliness, the lifetime risk of a smoker to die of lung cancer is underestimated by almost half of all respondents. Smokers who do not plan to quit are significantly more likely to underestimate this overall mortality risk.

**Keywords:** smoking, lung cancer risk, five-year survival rate, subjective beliefs, risk perceptions, over optimism bias

**JEL codes:** D81, D84, I12, L66

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## **1. Introduction**

One of the public policy success stories of the 20<sup>th</sup> century is the reduction in smoking rates in developed countries. As a result of tax increases, smoking bans, warnings and consumer information—as well as restrictions for the tobacco industry—smoking rates decreased sharply in industrialized countries during the second half of the 20<sup>th</sup> century (HHS 2014, OECD, 2014). For example, more than half of all US males smoked in the 1950s. This fraction has decreased to about 20% today (Office on Smoking and Health 1979; National Center for Health Statistics 2014). However, the European Union still has smoking rates around 30% (Gallup 2007).<sup>1</sup>

According to the American Lung Association (2017), 80% of all female and 90% of all male lung cancer cases can be traced back to smoking. Medical research is extremely clear when it comes to smoking and lung cancer: smoking leads to lung cancer, and lung cancer is one of the deadliest cancer types. This relationship makes smoking one of the leading causes of preventable deaths (Bach et al. 2003; Godtfredsen et. al. 2005; Couraud et al. 2012; Janssen et al. 2013; Hitchman et al. 2013; Fenelon and Preston 2012; American Cancer Society 2017; CDC 2017). Worldwide, 1.6 million people die every year from lung cancer (WHO, 2015).

This paper shows that the majority of people—in particular smokers and risk loving individuals—underestimate the deadliness of lung cancer despite the anti-smoking campaigns that have been in place for decades. This finding could provide new insights into why the decrease in smoking rates has leveled off in recent years, and why a significant share of the population still smokes.

Several questions to elicit lung cancer risk perceptions among smokers, non-smokers, and former smokers were included in a 2013 survey in Berlin. The survey asked about respondent characteristics, including intention to quit and a self-assessment of the likelihood of success in quitting.

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<sup>1</sup> The WHO indicates higher levels of the prevalence of tobacco use. For males above 15 years, the WHO (2015) reports a level of 33% for the US, similar to Germany (33%), Italy (33%), France (36%) or Spain (36%). They report even higher levels in Korea (49%), Turkey (47%) and Japan (42%).

As a first step, this paper's survey asks the same question as Viscusi (1990) did in his US study in 1985: "*Please estimate: Among 100 smokers, how many of them will develop lung cancer because they smoke.*" The question elicits lung cancer risk perceptions about a smoker's lifetime incidence. Second, using a similarly framed question, the survey goes a step further and elicits perceptions of the deadliness of lung cancer by asking respondents to estimate five-year lung cancer survival rates (cf. Ziebarth 2018). Advantages of eliciting survival rate perceptions is the concreteness of the question and the unambiguous medical evidence.

Research in economics, psychology, and epidemiology has empirically assessed risk perceptions among smokers and non-smokers (Leventhal et al. 1987; Viscusi 1990; Viscusi 1991; Viscusi 1992; Viscusi 1995; Schoenbaum 1997; Ayanian and Cleary 1999; Romer and Jamieson 2001; Slovic 2001; Viscusi 2002; Slovic et al. 2004; Khwaja et al. 2007a, b; Lundborg 2007; Dionne et al. 2007; Lundborg and Andersson 2008; Khwaja et al. 2009; Gerkin and Khaddaria 2012; Lin and Sloan 2015; Viscusi 2015; Ziebarth 2018). Most economic papers find that smokers are either accurate when predicting their smoking-related individual health risks, or even tend to overestimate their health risks.<sup>2</sup> Based on these findings, economic papers typically conclude that an underestimation of associated health risks is unlikely to be the main driving force behind the decision to either initiate or continue smoking. Kenkel (2000) provides an excellent discussion and summary of the economic literature on this topic.

Studies in cognitive psychology refute the economist's idea that "rational addiction" exists (Becker and Murphy 1988). These studies refer to the "experimental system" of humans that affects judgement and decision making (Slovic 2001; Romer and Jamieson 2001; Slovic et al. 2004). Research outside of the health sciences has consistently found that people underestimate personal risks (Weinstein 1982, 1989; Weinstein and Lyon 1999; Bracha and Brown 2012; Sloan et al. 2013), are bad at assessing small stake risks (Lichtenstein et al. 1978; Benjamin et al. 2001;

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<sup>2</sup> One exception is Schoenbaum (1997) who compares the subjective probabilities of white 1992/1993 HRS respondents between 50 and 62 years to reach the age of 75 to survival probabilities derived from life tables in the 1980s. While never, former, and current light smokers very accurately assess this probability, heavy smokers underestimate it.

Jones and Yeoman 2012) or probabilities in general (Binswanger and Salm 2017), and are overconfident about their ability to perform on the job (Malmendier and Tate 2005; Sandroni and Squintani 2013), which suggests that beliefs may be endogenously formed (Bénabou and Tirole 2002, Oster et al. 2013, Schwardmann, 2017).

Moreover, many smoking studies have focused on young people to study youth's decision to initiate smoking (Kenkel, 1991; DeCicca et al. 2002; Lundborg, 2007; Lungborg and Andersson 2008; DeCicca et al. 2008; Tekin et al. 2009; Lipkus and Shepperd 2009; Loureiro et al. 2010; Anger et al. 2011; Gerkin and Khaddaria 2012; Crost and Rees 2013; Lillard et al. 2013). This paper takes a different approach and focuses on all age groups to better understand who under- and overestimates lung cancer risks, and whether current smokers are particularly biased. While the focus on youth and initiation is arguably important due to the addiction component, it is also true that *(a)* many former smokers successfully manage to quit—in this paper's sample 27%, *(b)* almost half of all smokers believe that they will successfully quit sometime in the future, and *(c)* one of the clearest identified health risks of smoking, lung cancer, manifests itself in older ages with a mean age of 70. Furthermore, *(d)* the risk of contracting lung cancer increases significantly with the quantity of cigarettes smoked and decreases after successfully quitting (Bach et al. 2003; Godtfredsen et al. 2005; Couraud et al. 2012; American Cancer Society 2017). For all these reasons, risk perception biases (of smokers) could be a fruitful target for public policy initiatives to help smokers make informed choices.

This paper makes several contributions. First of all, it enriches and updates the literature on smoking-related risk perceptions. This paper's survey combines old and new methods to elicit individual-level subjective beliefs. It was conducted in the capital of Europe's most populous country, Berlin-Germany, in 2013. In light of the substantial change in smoking rates and norms, the focus on time and space is important. Most existing studies focus on the US and significantly older surveys.

Second, in addition to individual-level subjective beliefs about the health risks of smoking, this survey also elicits the level of risk aversion, discount rates, and health behaviors. It also asks whether smokers plan to quit and whether they believe that they would be successful in quitting. These measures help paint a more complete picture of the people with the most biased beliefs.

Third, the paper provides evidence that smokers have significantly lower lung cancer risk perceptions than non-smokers. They are more likely to underestimate the baseline risk of contracting lung cancer, while non-smokers are more likely to overestimate this risk.<sup>3</sup> If (especially heavy) smokers were properly educated, there could be a higher likelihood of cessation because of more informed choices (cf. Gollust et al. 2008). This paper finds that smokers who self-report that they do not plan to quit are significantly more likely to underestimate the lifetime risk of a smoker to contract lung cancer.

Finally, a majority of individuals underestimates the deadliness of lung cancer (Ziebarth 2018). Lung cancer remains one of the most aggressive and deadly cancers with less than one in five patients surviving five years after a diagnosis. Almost everyone in this paper's survey—but in particular heavy smokers and smokers who do not plan to quit—underestimates the deadliness of lung cancer. Because almost everyone underestimates the lung cancer deadliness, the (calculated) total lifetime risk of a smoker to die of lung cancer is underestimated more often than it is overestimated.

The next section provides details about the data, and Section 3 presents and discusses non-parametric as well as parametric results. Section 4 concludes.

## 2. Eliciting Perceived Lung Cancer Risks

Several survey questions measure the perceived lung cancer risks among smokers, former smokers, and non-smokers. Between July 23 and September 13, 2013, IPSOS MORI conducted the survey among their online panelists in Berlin. Henceforth, the survey is called Smoking Survey (SMOSU).<sup>4</sup>

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<sup>3</sup> It is, however, beyond the scope of this paper to show that smokers initiated smoking because of such biased beliefs. It could well be that smokers and non-smokers have adapted these beliefs over time to rationalize their habits.

<sup>4</sup> The survey was part of an independent international research project which carried out panels in Berlin, London, and Paris. Respondents participated annually in 2011, 2012 and 2013. This paper's questions were only asked in Berlin in 2013 among the 38% of respondents who had already participated in 2011.

Because the SMOSU is essentially a convenience sample, there are some differences between SMOSU respondents and respondents in the nationally representative German Socio-Economic Panel Study (SOEP) (cf. Wagner et al. 2007). The average age of SOEP respondents in Berlin is 51, whereas the SMOSU respondents have an average age of 45 (see Appendix). Comparing gender, marital status, employment status, and smoking status shows that the differences are rather small, but that the SMOSU sample is slightly younger, includes more females (54% vs. 57%), singles (24% vs. 28%), full-time employees (37% vs. 47%), but the same share of never smokers (37%). However, in the SOEP, the share of current smokers is slightly lower at 28% (vs. 36% in our survey). All respondents participated in a lottery with a €1,500 prize in order to maximize response rates. Disregarding respondents with missing data on variables of interest, the main sample consists of 1,860 Berliners.

## 2.1. Main Outcome Variables

**Perceived Lifetime Lung Cancer Risk of Smokers.** The first outcome variable is *Smoker Lifetime Lung Cancer Risk*. It measures the perceived lifetime risk of a smoker to contract lung cancer. Responses to the following question translate directly into the variable: “*Please estimate: Among 100 smokers, how many of them will develop lung cancer because they smoke?*” This is the exact same question that Viscusi (1990) asked. Viscusi’s (1990) seminal paper laid the foundation for a new economic subfield on smoking risks perceptions. As the Appendix shows, *Smoker Lifetime Lung Cancer Risk* varies between 1 and 100, with a mean of 31. This mean value is surprisingly close to several decades-old US surveys (cf. Viscusi 1992, 2002). According to medical research, the “true value” lies between 15 and 20% (Villeneuve and Mao 1994; Bach et al. 2003; WHO, 2014; American Lung Association, 2017; American Cancer Society, 2017).

Figure 1 shows the perceived *Smoker Lifetime Lung Cancer Risk* distributions by smoking status. The figure shows a long right tail. A significant share of respondents believes that the lifetime lung cancer risk for smokers lies above 50%, i.e., they substantially overestimate the true risk. The figure also shows that more smokers estimate that the risk is below 10%, i.e., they underestimate the true risk.

[Insert Figure 1 about here]

*Overestimation Lung Cancer Risk* has a value of one for people who estimate that a smoker's lung cancer risk is above 30%. *Underestimation Lung Cancer Risk* has a value of one for people who estimate that the risk is below 10%. As seen in the Appendix, 44% of all respondents overestimate the lifetime lung cancer risk, and 24% underestimate it.

**Perceived Lung Cancer Survival Rate.** The second main outcome variable is *5-Year Lung Cancer Survival Rate*, which is based on the question (cf. Ziebarth 2018): "*Please estimate: When diagnosed with lung cancer, how likely is it that a patient survives the next 5 years?*" Respondents could choose between ten answer categories that are provided in increments of ten percent, i.e., 0-10%, 10-20%, ..., 80-90%, 90-100%.<sup>5</sup> The summary statistic in the Appendix shows that the mean category chosen is a 4.5, i.e., assuming linearity this would imply a mean survival rate of 45%. Figure 2 shows the distribution of the categories, again separately for current smokers and non-smokers. The distribution for smokers is clearly rightward-shifted, implying that more smokers underestimate the deadliness of lung cancer.

#### [Insert Figure 2 about here]

The true 5 year lung cancer survival rate is up to 15% in North America and Central Europe, and even below 10% in the UK, i.e., between 5 and 15% overall (Butler et al. 2006; Coleman et al. 2011; Couraud et al. 2012; Hitchma/Fong 2011, WHO 2015; American Lung Association 2017). In recent years, it has increased slightly, but is still very low (Khakwani et al. 2013). Less than one in five smokers with a lung cancer diagnosis will survive the next five years.

Because it is essentially impossible to underestimate the very low survival rates of lung cancer patients, only *Overestimation Lung Cancer Survival* is generated; it is one if respondents indicate values above 20%. The Appendix shows that 80% of all respondents overestimate lung cancer

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<sup>5</sup> It has been shown that responses are surprisingly robust to the format in which risk beliefs are elicited, i.e., whether responses are open-ended, provided in categories, or have a different denominator than "100 smokers" in the question asked (Viscusi 1992, 2002; Khwaja et al. 2007b, 2009).

survival rates. Interestingly, the correlation between *Smoker Lifetime Lung Cancer Risk* and *5-Year Lung Cancer Survival Rate* is only 0.069.

**Calculated Total Smoker Risk to Die of Lung Cancer.** Lastly, one can calculate the estimated lifetime risk of a smoker to die of lung cancer using the two elicited risk measures. *Total Mortality Risk = Lung Cancer Risk\*(1-Survival Rate)* yields the estimate shown in Figure 3. Because the vast majority of respondents overestimates survival probabilities, the distribution of the (calculated) lifetime risk to die of lung cancer is clearly left-ward skewed. Because the true survival rates lie between 5 and 15%, the lifetime risk of a smoker to die of lung cancer nearly equals the probability of contracting lung cancer. The average estimated probability lies exactly within the true range of 10 to 20%, namely at 19% (Appendix). However, Figure 3 illustrates the wide left and right tails of the distribution with values ranging from 5% to 95%.

**[Insert Figure 3 about here]**

According to this paper's definition, respondents whose (calculated) values for the lifetime risk of a smoker to die of lung cancer lie below 10% underestimate the true risk. Likewise, respondents whose values lie above 20% overestimate the risk. Accordingly, 45% underestimate and 23% overestimate the lifetime risk of a smoker to die of lung cancer (Appendix).

The finding that the overall lifetime risk of a smoker to die of lung cancer is underestimated by half of all respondents—particularly smokers as we will show below—is in contrast to US surveys (Viscusi 1992, 2002, 2015). Based on 206 respondents from a 1990/1991 survey in Durham (North Carolina), Viscusi (1992) reports an estimated mean “lung cancer fatality risk” of 0.38—recall that our mean rate is 0.18 (Appendix). Viscusi (2015) finds an almost identical rate of 0.41 in a nationally representative web-based panel. However, note that the question asked in Viscusi (1992) and Viscusi (2015) directly elicits a smoker's lifetime probability to die of lung cancer using an open-ended question.

## 2.2. Risk Bias Predictors

**Smoking Information.** The smoking status of an individual can potentially be an important predictor of biased beliefs. In addition, to the extent that smoker characteristics are predictive of biases, this information is crucial for the design of effective public health campaigns.

The Appendix shows that 36% of the sample are current smokers. This is very close to the overall share for Germany (Lampert et al. 2013). Almost 38% never smoked and 27% are ex-smokers, which also aligns with Germany's representative population statistics. The statistics illustrate that the population majority is or has been at significant risk of developing lung cancer or other smoking-related diseases.

Among all respondents, the average *#Cigarettes* smoked on the day prior to the interview is 5.2 and has a long right tail. Some respondents smoked three packs on the day prior to the interview. According to the definition of a *Heavy Smoker* ( $>15$  cigarettes), almost 20% of all respondents are heavy smokers.

SMOSU also elicits self-reported information on whether smokers (i) plan to quit and (ii) believe that they are (un)likely to quit (Appendix). Almost half of all current smokers *Plan to Quit* (conditional values not shown in Appendix). This is important information for policymakers because it indicates a large receptive target group for anti-smoking campaigns.

Second, self-assessing the likelihood of success at quitting shows that 39% of smokers believe that they are *Unlikely to Quit* (answer categories “less likely” and “unlikely”).

Third, combining this information, the variable *Addicted and Aware* is one for smokers who plan to quit but believe that they are *Unlikely to Quit* (in other words, smokers who have a 1 on *Plan to Quit AND Unlikely to Quit*).

**Other health behaviors.** Other health behaviors such as exercising, alcohol consumption, or overeating may provide additional insights into who has biased beliefs. The Appendix shows the summary statistics. *Daily Exercise* indicates that 18% of all respondents are very regularly physically active. *No Sports* indicates that 26% do not exercise at all. Like *#Cigarettes*, *#Drinks* has

a long right tail and values range from 0 to 27. The average *BMI* is 26.5, which is very close to the national average for Germany (Dragone and Ziebarth, 2017).

**Risk aversion and discount rates.** Using the standard Likert risk tolerance scale from 0 to 10 (Dohmen et al. 2011), respondents self-assess their risk tolerance with an average of 5. Collapsing this scale into binary measures and defining respondents between 0 and 4 as *Risk Averse*, one finds that 36% of respondents are *Risk Averse*. *Risk Loving* individuals are those between 7 and 10 on the risk tolerance scale, accounting for 27% of the sample. Research has shown that smokers are job risk takers (Viscusi and Hersch 2001), more risk loving (Pfeifer, 2012) and have worse credit scores (Adams et al. 2014).

Next, we exploit randomly assigned questions that ask “*If you had a choice of receiving €1,000 in one year’s time or (i) €1,100 (ii) €1,200 (iii) €1,300 in two years’ time, which would you choose?*” One can calculate discount rates from the answers to this question (e.g. Kang and Ikeda 2014). As seen in the Appendix, 62% of respondents have an annual discount rate of at least 10%.

**Socio-Demographic Sample Adjusters.** Other important socio-demographic covariates are *Age*, *Female*, *#Household Members*, *Full-Time Employed*, and *Master’s Degree* (Appendix).

### 3. Empirical Findings

The first three figures show the distributions of the perceived lung cancer risk for smokers (Figure 1), the perceived survival probabilities (Figure 2), and the (calculated) total risk of a smoker to die of lung cancer (Figure 3). Forty-four percent of the sample estimates that the lifetime risk for smokers to contract lung cancer lies above 30%, even though the true risk lies between 15 and 20%. In contrast, 24% underestimate the true lifetime cancer risk for smokers and believe that it lies below 10%. Eighty percent underestimate the deadliness of lung cancer. Combined, the perceived lifetime risk to contract and the perceived survival probability result in 45% of the sample underestimating the lifetime risk of a smoker to die of lung cancer.

#### 3.1 Perceived Lifetime Lung Cancer Risk of Smokers

**Non-parametric findings.** Figure 4 plots the perceived probability of smokers to contract lung cancer, by their *Risk Tolerance* (Figure 4a) and the *#Cigarettes* (Figure 4b). The intuition behind

these plots is simple: (a) An individual's *Risk Tolerance* may be related to how that individual perceives risk, here: the lung cancer risk. (b) The #Cigarettes smoked affects the lung cancer risk as well (Bach et al. 2003; Godtfredsen et al. 2005; Couraud et al. 2012). Light smokers may thus be more or less prone to biased risk perceptions. Another interpretation could be that, although the question refers to the *average* smoker, light smokers' reference group may be light smokers with a lower lung cancer risk.

**[Insert Figure 4 about here]**

Figure 4a shows, first, that the perceived lung cancer risk decreases with the risk tolerance level. Risk adverse people, on average, significantly overestimate the lung cancer risk for a smoker. They estimate it to lie around 35%. Risk loving people also overestimate the risk but their mean estimate of 30% is closer to the true value of 15 to 20%.

Second, Figure 4b shows that, for heavy smokers, the perceived lung cancer risk decreases with the #Cigarettes smoked from above 30% to below 20%. This is an important finding because it rejects the hypothesis above: namely, that light smokers implicitly think about a reference group of light smokers, and are thus more likely to underestimate the true risk. In fact, Figure 4b suggests the opposite. The more cigarettes smokers smoke, the less likely it is that they overestimate the true risk of a smoker to contract lung cancer. The finding implies that heavy smokers are more likely to underestimate the true lung cancer risk. Note that Figure 4b plots the *average* estimated risk; 24% actually underestimate the true risk (Appendix).

Hence, we next use the binary variable *Underestimation Lung Cancer Risk* and formally test for differences by smoker characteristics. Figure 5 plots the results as bar diagrams along with 95% confidence intervals. Figure 5a shows that smokers are almost twice as likely to underestimate the true lifetime risk of a smoker to contract lung cancer (34% vs. 19%, t-value: 7). Similarly, Figure 5b shows that smokers who do not plan to quit are significantly more likely to underestimate this risk (43% vs. 31%, t-value: 2.7). This finding suggests room for educating smokers in order to correct their biased beliefs. It is also in line with the notion that an underestimation of smoking-related health risks may prevent smokers from quitting.

However, there is no evidence that biased risk perceptions differ by *Addicted and Aware* or for respondents with high discount rates (Figures 5c and d).

**[Insert Figure 5 about here]**

**Parametric findings.** The next exercise parametrically adjusts the risk assessment biases and identifies predictors of such biases. The following regression is run by OLS:

$$\log(y_i) = \alpha + \beta S_i + \gamma B_i + X_i'\gamma + \varepsilon_i \quad (1)$$

where  $y_i$  is *Smoker Lifetime Lung Cancer Risk* and takes on values between 0 and 100. Figure 1 shows the raw distribution and equation (1) uses the logarithm, which allows the reader to interpret the coefficient estimates as (approximate) differences in percent.

$S_i$  is a vector of six smoker characteristics including *Smoker*, *#Cigarettes*, *Don't Plan to Quit*, or *Addicted and Aware*.  $B_i$  includes the other health behaviors *Daily Exercise*, *No Sports*, *# Drinks*, and *BMI*.  $X_i$  includes the two variables *Risk Tolerance* and *Discount Rate >10%* and the remaining control variables (see Appendix).  $\varepsilon_i$  is the error term.

**[Insert Table 1 about here]**

Table 1 shows results of four regressions where each column represents one model as in equation (1). The columns from left to right add the sets of covariates stepwise to test for the robustness of the identified predictors. The first set of predictors contains five smoker characteristics.

First, all five smoker characteristics are highly significant predictors of the perceived lifetime probability of a smoker to contract lung cancer.

Second, all five predictors are remarkably robust to considering (i) other health behaviors, (ii) risk aversion and time discount measures, and (iii) additional socio-demographics. On the one hand, this suggests that these smoking characteristics are not significantly correlated with the sets of covariates just listed. On the other hand, it makes it less likely that these smoking characteristics and the perceived lung cancer risk are associated via third unobservable factors.

Third, compared to *Former Smokers* (the omitted category), *Never Smokers* perceive the lung cancer risk to be a significant 26% higher (column (4)). For current smokers and in line with Figure 3b, each additional cigarette consumed decreases the perceived probability of contracting lung cancer by 1.2%. In line with Figure 5b, smokers who do not plan to quit have a 26% significantly lower perception of the lifetime lung cancer risk of a smoker—and underestimate it in many cases. When using the binary *Underestimate Cancer Risk* variable as an outcome and running the same regression as a linear probability model (LPM) (results not shown), one finds that being a *Smoker* and *Don't Plan to Quit* increases the likelihood of underestimating the lung cancer risk by 40% (also see Figure 5a).

Fourth, smokers who self-report that they are *Unlikely to Quit* in the future (either because they know that they are addicted or because they do not want to quit) have a 26% significantly lower risk perception. They are also 50% more likely to underestimate the lung cancer risk when running LMP models with *Underestimate Cancer Risk* as outcome (not shown). Interestingly, smokers who would like to quit but think that it is unlikely that they will, i.e., the *Addicted and Aware* category, have a perceived risk that lies (an imprecisely estimated) 26% *above* the average. This subgroup of smokers tends to overestimate the true lung cancer risk.

Fifth, none of the *Other Health Behavior* covariates such as exercising, overeating and drinking are significant predictors of biased risk perceptions. The other socio-demographics are also not very predictive of such biases, but there are three exceptions: (i) women have a 16% lower risk estimate, being less likely to overestimate the risk. The same holds for (ii) respondents with a master's degree (-11%) and (iii) more risk tolerant respondents (-2.6%).

### 3.2 Perceived Lung Cancer Survival Rates

**Non-parametric findings.** First, to re-emphasize and quantify what we see in Figure 2: A substantial 80% of respondents overestimate the *5-Year Lung Cancer Survival Rate* (cf. Ziebarth 2018). They believe that the survival rate would lie above 20% although it is 15% max. (Butler et al. 2006; Coleman et al. 2011; Couraud et al. 2012; WHO 2015; American Lung Association 2017).

Figure 6a plots the association between *Risk Tolerance* and perceived survival rates. Figure 6b plots the association between *#Cigarettes* and perceived survival rates. First, not surprisingly, the *Lung Cancer Survival Rate* is overestimated along the entire distributions of both variables. Second, the bias increases with the risk tolerance level. This means that risk loving people are also significantly more likely to underestimate the deadliness as compared to risk averse people. Third, we find a discontinuous sharp increase in the perceived survival rates for heavy smokers. Smokers who smoked more than 25 cigarettes on the day prior to the interview show a sharp increase in their perceived survival rate (but statistical uncertainty increases as well). This finding suggests that heavy smokers are particularly misinformed (or biased in their beliefs) about the risk of dying from lung cancer.

[Insert Figure 6 and 7 about here]

Similar to Figure 5 for *Smoker Lifetime Lung Cancer Risk*, Figure 7 plots bar diagrams along with confidence intervals to test whether the risk perception bias differs by certain characteristics, including *Smoker*, *Don't Plan to Quit*, *Addicted and Aware*, and *Discount Rate >10%*. As seen, because the bias is so widespread across the entire population it does not differ significantly by any of these stratifying variables.

**Parametric findings.** Lastly, we estimate a multivariate regression model similar to equation (1) and identify significant predictors of the *Lung Cancer Survival Rate*. Table 2 can be summarized as follows:

[Insert Table 2 about here]

First, very few characteristics are significant predictors of the size of *Lung Cancer Survival Rate*.

Second, one key significant predictor is *Don't Plan to Quit*. Smokers who are not planning to quit underestimate, on average, the deadliness of lung cancer by an additional 12%. When considering that the bias discontinuously increases for heavy smokers (Figure 6b), the results favor both broad public information campaigns and more targeted campaigns towards this particularly endangered group of smokers. Third, alcohol consumption seems to be a weakly significant predictor of the survival bias. Each additional drink increases the perceived *Lung*

*Cancer Survival Rate* by about 1%. Fourth, *Risk Tolerance* is also one of the few significant predictors. In line with Figure 6a, the bias almost linearly increases with the risk tolerance level. Each unit increase in the risk tolerance scale raises the perceived *Lung Cancer Survival Rate* by about 1%.

### **3.3 Total Lifetime Lung Cancer Mortality of Smokers**

As discussed, the total risk of a smoker to die of lung cancer is the product of the risk to contract lung cancer and the conditional mortality probability. In contrast to Viscusi (1992, 2002), this paper does not directly elicit this mortality risk via an open-ended question but rather calculates the overall mortality risk by multiplying the two separately elicited risks. This Figure 3 shows the (calculated) distribution of the total mortality risk.

Figure 8 shows that the perceived lifetime mortality risk appears to be surprisingly accurate, given that the true risk lies between 10 and 20%. *On average*, respondents do not seem to have biased risk perceptions, which is in line with the Rational Addiction Model (Becker and Murphy 1988). However, Figure 8 also shows very clear associations between the risk tolerance level and the total perceived mortality risk as well as the smoking intensity and the total perceived mortality risk. Very risk averse respondents tend to overestimate a smoker's lifetime mortality risk; the perceived risk then smoothly decreases with degree of risk aversion. Similarly, the perceived risk decreases with the number of cigarettes smoked, but the average smoker appears to have accurate beliefs.

The latter is not true, however, when investigating our binary *Underestimation Total Mortality Risk*. As the long left tail of the perceived mortality risk distribution shows (Figure 3), many respondents underestimate the true risk of a smoker to die of lung cancer. On the other hand, 24% overestimate it. Smokers in general are 17ppt more likely to underestimate the lifetime risk of a smoker to die of lung cancer (Figure 9a). Smokers who do not plan to quit are 7ppt more likely to underestimate the risk (Figure 9b).

**[Insert Figure 8 and 9 about here]**

The latter finding also holds up in a multivariate regression framework as in equation (1) (not shown). The only two socio-demographic factors that are significantly associated with the likelihood to underestimate the total mortality risk are *Don't Plan to Quit* (12%) and *Risk Tolerance* (1.3%).

#### **4. Discussion and Conclusion**

A large share of the population has been in the focus of public policy anti-smoking campaigns: not only current smokers but also non-smokers who are at risk of initiating as well as former smokers who are at risk of relapsing. In our online survey, half of all smokers plan to quit entirely sometime. Moreover they believe that it is “very likely” or “likely” that they will quit.

The first section of this paper reinforces the established finding that parts of the population significantly overestimate the lifetime risk of a smoker to *contract* lung cancer. Although this perception bias may be desirable from a public health perspective, this paper also shows that a significant population share, 24% in this survey, underestimates this risk. In particular, smokers have a higher probability of underestimating the risk of contracting lung cancer. Moreover, smokers who self-report that they do not plan to quit are more likely to underestimate their risk of contracting lung cancer. It is beyond the scope of this paper to assess whether biased risk perceptions played a role in the initiation process. Rather, the objective of this paper is to show that such risk perception biases exist; and to identify who is particularly prone to under- and overestimating risks.

The second part of this paper demonstrates that the deadliness of lung cancer is widely underestimated. While lung cancer is one of the deadliest cancers with five-year survival rates that are at most 15%, a large majority of the population (80% of the sample) underestimates its deadliness (i.e. overestimates survival rates). The reasons for this substantial perception bias are unclear. In contrast with other cancer types, medical technology has not resulted in a substantial improvement of lung cancer survival rates over the past decades. The high five-year survival rates for other cancer types such as breast cancer (90%) or prostate cancer (100%) may be a reason why the perception in the population is so biased (NIH 2015). In any case, evidence for such substantial biases warrants further investigation and research.

Because the average respondent overestimates the lifetime risk of a smoker to contract lung cancer but underestimates its deadliness, the overall probability of a smoker to die of lung cancer is relatively accurately assessed. However, the tails of the distribution are wide: Many people either over- or underestimate the lifetime risk of a smoker to die of lung cancer.

While anti-smoking policies were incredibly successful in changing social norms and reducing smoking rates, risk perception biases related to smoking obviously still exist. The findings of this paper suggest significant potential to inform the population about the risks of contracting and dying of lung cancer. After all, due to its high mortality rates and tightly linked relationship to smoking, tobacco use is the leading preventable cause of death (CDC 2017).

A standard critique of how to elicit risk perceptions also applies to this paper: respondents are asked about the average smoker and they may perceive their *personal* risk as lower. Moreover, due to the advanced age at which smokers typically contract lung cancer, the available medical evidence mostly refers to smokers who initiated smoking generations ago. Therefore, the true lifetime cancer risks of younger smokers are unknown and extrapolated from the past. They may not hold up in the future. A final limitation of this research is the non-representativeness of the data, which could be overcome by future research on this topic.

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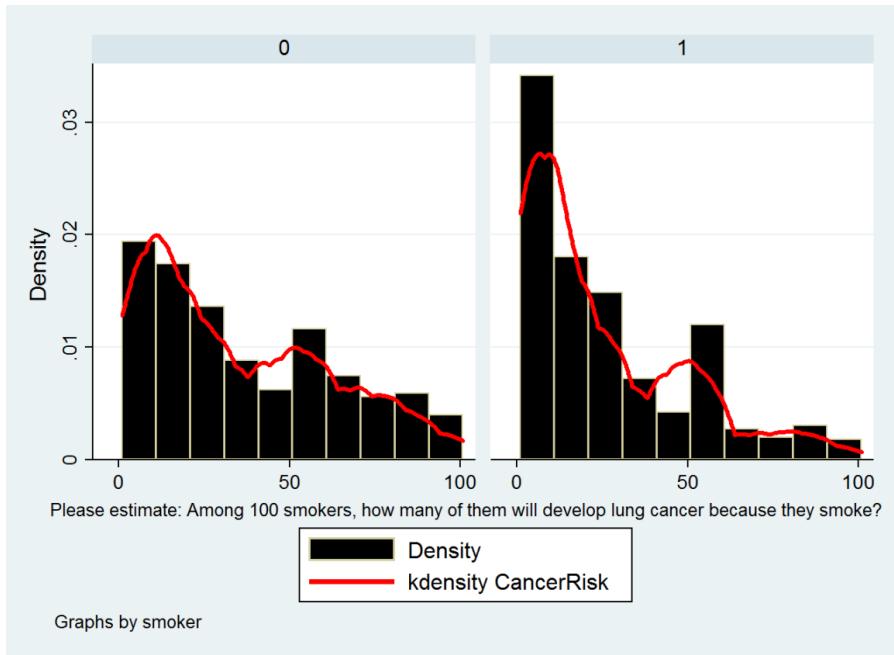
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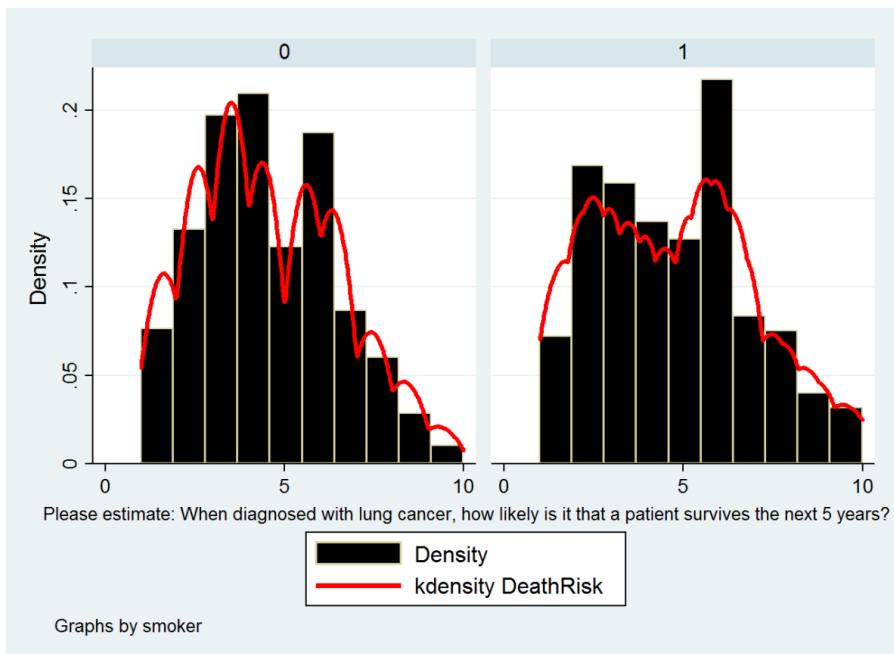
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## Figures and Tables

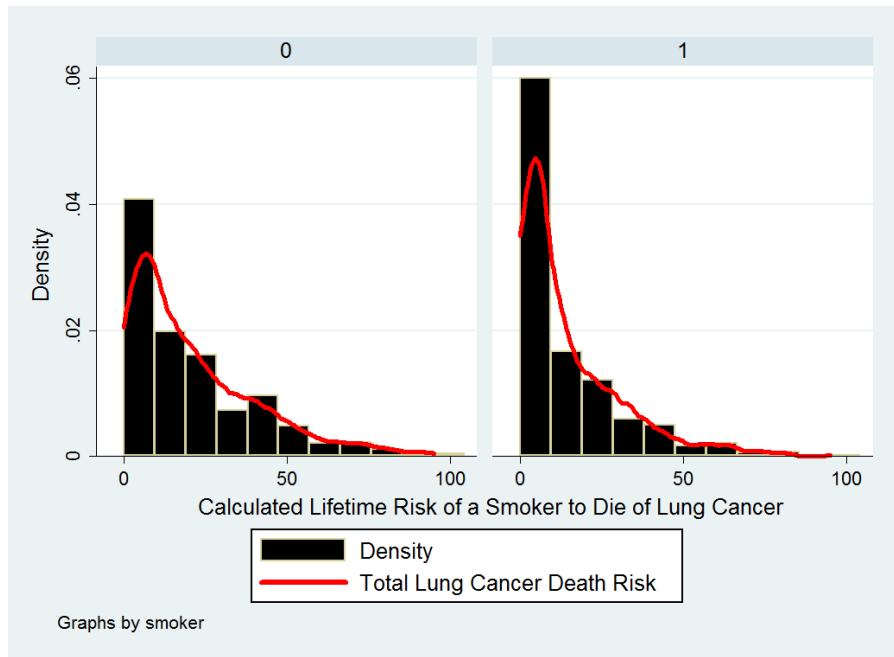
**Figure 1:** Perceived Lifetime Lung Cancer Risk for Smokers, by Smoking Status (True: 15-20%)



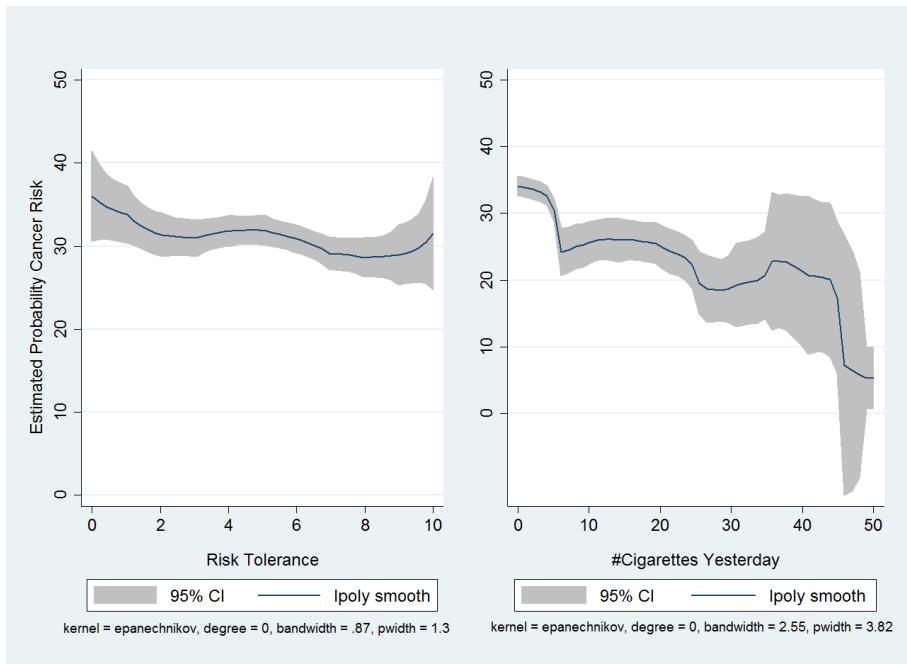
**Figure 2:** Perceived Five-Year Lung Cancer Survival Probability, by Smoking Status (True: 5-15%)



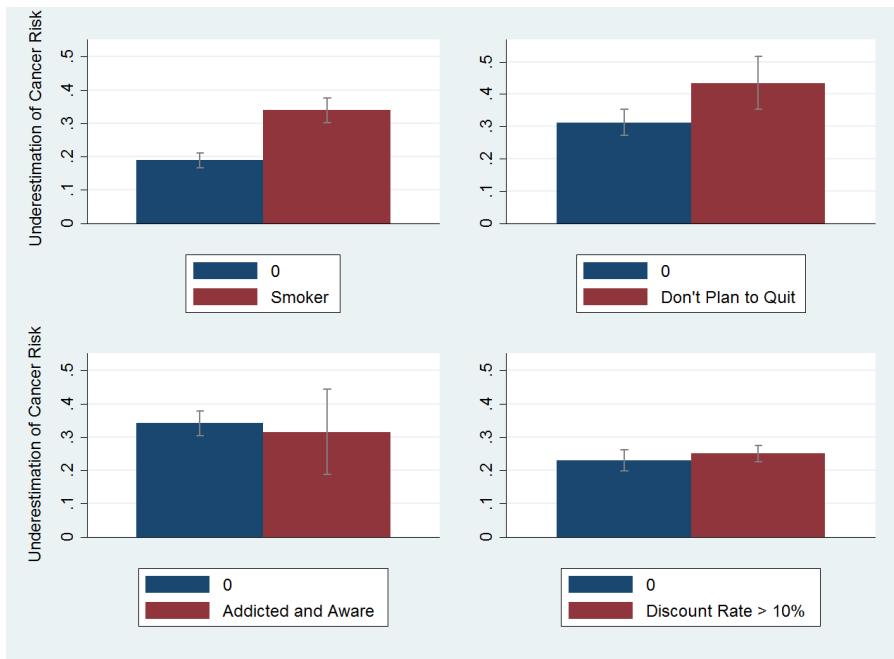
**Figure 3:** Lifetime Lung Cancer Mortality Risk for Smokers, by Smoking Status (True: 10-20%)



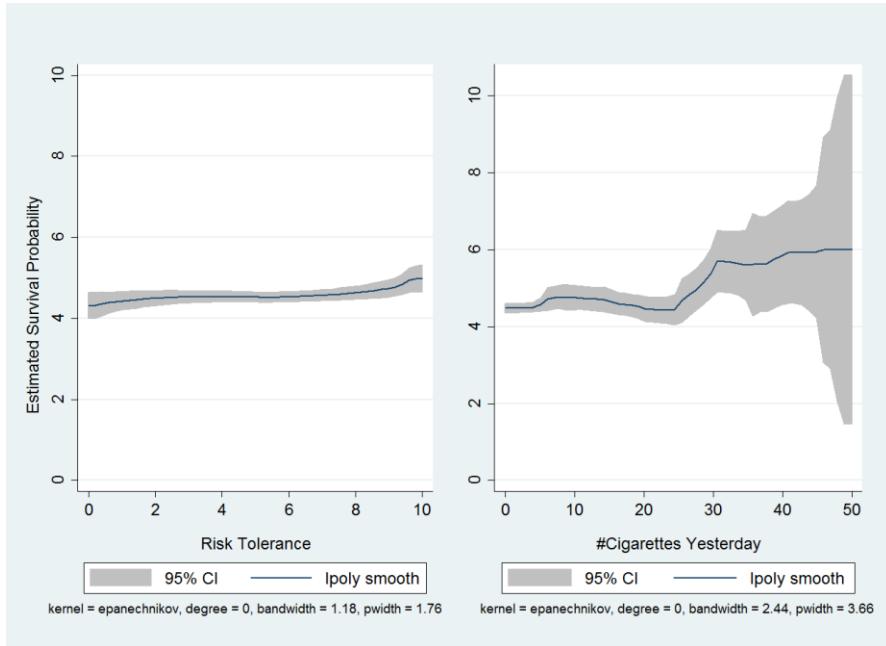
**Figure 4:** Lung Cancer Risk by (a) Risk Tolerance and (b) #Cigarettes Smoked



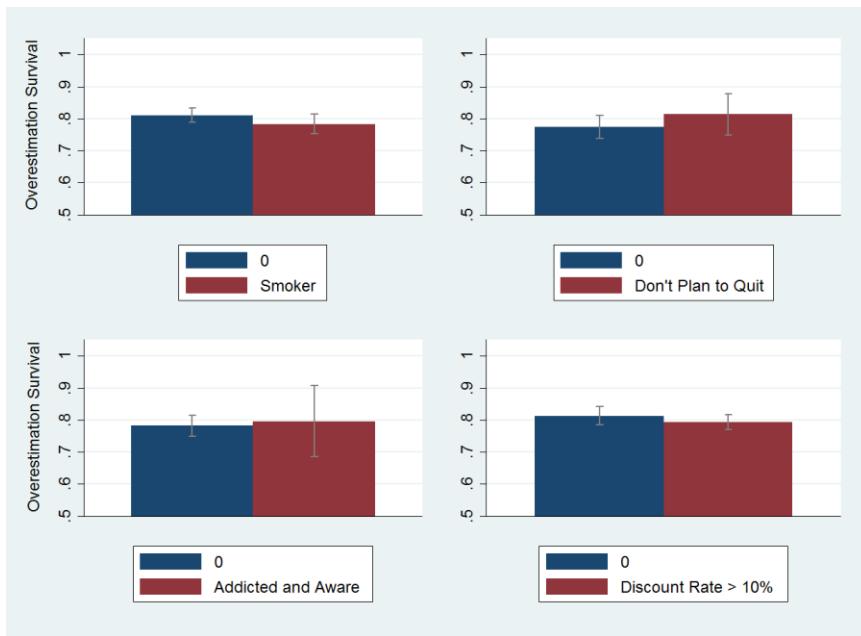
**Figure 5:** Underestimation of Lung Cancer Risk by Smoker Characteristics



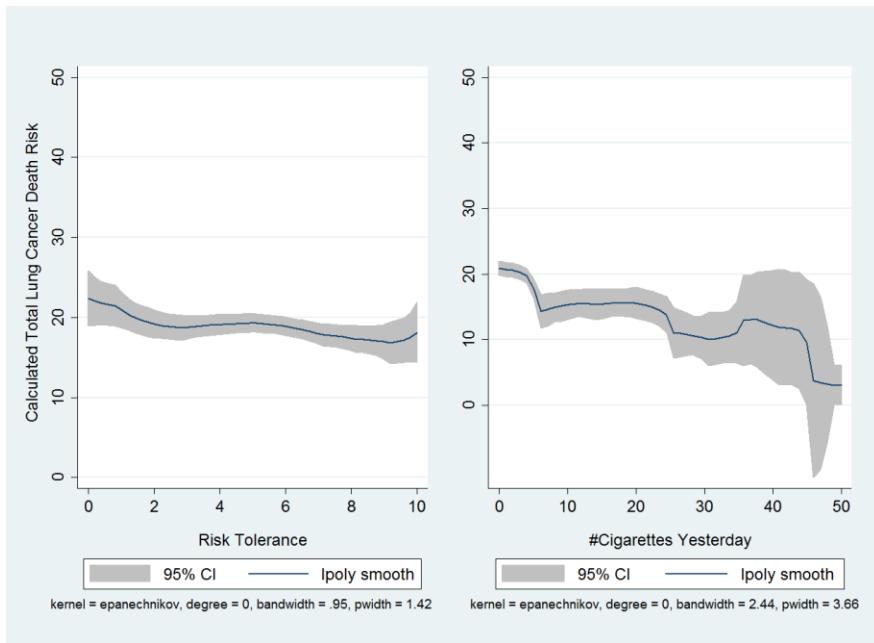
**Figure 6:** 5-Year Lung Cancer Survival Probability by (a) Risk Tolerance, (b) # Cigarettes



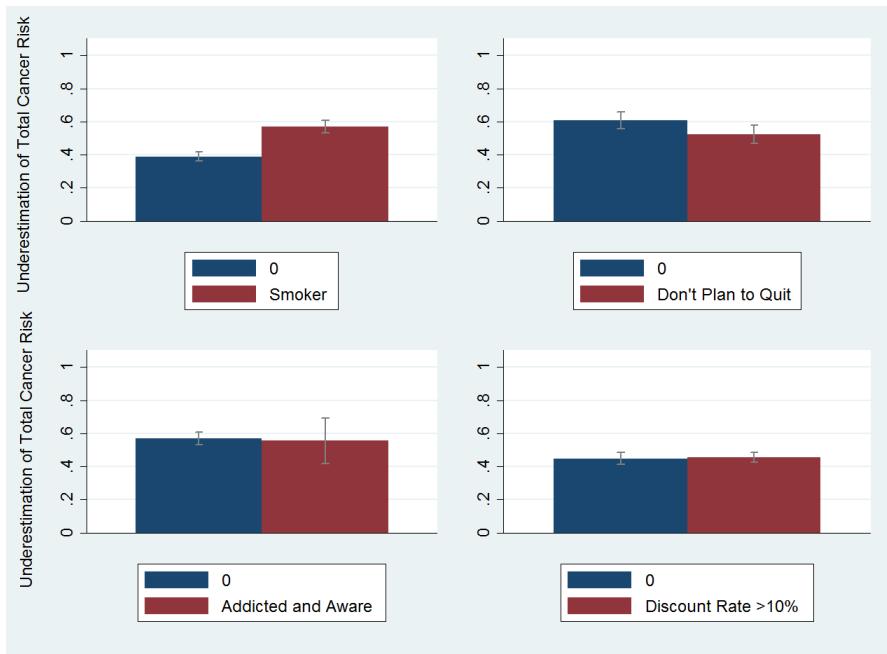
**Figure 7:** Overestimation of Cancer Survival Probability by Smoker Characteristics



**Figure 8:** Total Lung Cancer Mortality Risk by (a) Risk Tolerance and (b) #Cigarettes



**Figure 9:** Underestimation of Total Lung Cancer Mortality Risk by Smoker Characteristics



**Table 1: Perceived Lung Cancer Lifetime Risk**

	<i>Lung Cancer Risk</i>			
	(1)	(2)	(3)	-4
<b>A. Smoking Characteristics</b>				
Never Smoker	0.2352*** (0.0607)	0.2360*** (0.0609)	0.2355*** (0.0609)	0.2575*** (0.0618)
#Cigarettes Smoked	-0.0118*** (0.0038)	-0.0123*** (0.0039)	-0.0123*** (0.0039)	-0.0126*** (0.0040)
Don't Plan to Quit	-0.2546** (0.1106)	-0.2623** (0.1108)	-0.2616** (0.1107)	-0.2586** (0.1107)
Unlikely to Quit	-0.2708*** (0.1012)	-0.2754*** (0.1016)	-0.2761*** (0.1016)	-0.2616** (0.1015)
Addicted and Aware	0.2963* (0.1778)	0.2884 (0.1781)	0.2814 (0.1782)	0.2697 (0.1783)
<b>B. Other Health Behavior</b>				
Daily Exercise		-0.0087 (0.0707)	-0.0059 (0.0710)	0.0014 (0.0712)
No Sports		0.0876 (0.0630)	0.0771 (0.0632)	0.0646 (0.0639)
#Drinks Yesterday		0.0027 (0.0133)	0.0035 (0.0133)	-0.0005 (0.0136)
BMI		-0.0003 (0.0045)	-0.0008 (0.0046)	-0.0025 (0.0047)
<b>C. Risk Aversion and Discount Rates</b>				
Risk Tolerance			-0.0201* (0.0122)	-0.0262** (0.0126)
Discount Rate>10%			0.0408 (0.0545)	0.0547 (0.0554)
<b>D. Socio-Demographics</b>				
Female				-0.1592*** (0.0561)
Age				0.0007 (0.0023)
Married				0.0744 (0.0650)
Annual Household Income				-0.0010 (0.0102)
#HH Members				0.0301 (0.0291)
Full-Time Employed				0.0216 (0.0563)
8 Years of Schooling				-0.0144

				(0.1009)
Master's Degree				-0.1139*
				(0.0593)
Life Satisfaction				0.0083
				(0.0140)
Constant	2.9520***	2.9408***	3.0302***	3.0430***
	(0.0435)	(0.1311)	(0.1477)	(0.2184)
Observations	1860	1860	1860	1860
R-squared	0.0552	0.0564	0.0580	0.0666

**Source:** Data collection by IPSOS MORI through an online survey among Berlin residents between August 9 and September 30, 2013. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01; standard errors are in parentheses. Each column stands for one OLS regression model. The dependent variable is the logarithm of *Lung Cancer Risk*. See main text and Appendix for more details.

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**Table 2: Perceived Lung Cancer Survival Rate**

	5-Year Lung Cancer Survival Rate			
	(1)	(2)	(3)	-4
<b>A. Smoking Characteristics</b>				
Never Smoker	0.0330 (0.0308)	0.0338 (0.0309)	0.0344 (0.0309)	0.0285 (0.0313)
#Cigarettes Smoked	0.0024 (0.0019)	0.0018 (0.0020)	0.0017 (0.0020)	0.0017 (0.0020)
Don't Plan to Quit	0.1155** (0.0561)	0.1183** (0.0562)	0.1177** (0.0561)	0.1159** (0.0562)
Unlikely to Quit	-0.0381 (0.0514)	-0.0324 (0.0515)	-0.0319 (0.0515)	-0.0329 (0.0515)
Addicted and Aware	-0.0669 (0.0903)	-0.0618 (0.0904)	-0.0566 (0.0903)	-0.0549 (0.0905)
<b>B. Other Health Behavior</b>				
Daily Exercise		-0.0263 (0.0359)	-0.0289 (0.0360)	-0.0244 (0.0361)
No Sports		-0.0429 (0.0320)	-0.0344 (0.0320)	-0.0300 (0.0324)
#Drinks Yesterday		0.0121* (0.0067)	0.0115* (0.0067)	0.0112 (0.0069)
BMI		0.0008 (0.0023)	0.0012 (0.0023)	0.0021 (0.0024)
<b>C. Risk Aversion and Discount Rates</b>				
Risk Tolerance			0.0163*** (0.0062)	0.0126** (0.0064)
Discount Rate>10%			-0.0299 (0.0276)	-0.0191 (0.0281)
<b>D. Socio-Demographics</b>				
Female				-0.0291 (0.0285)
Age				-0.0019 (0.0012)
Annual Household Income				-0.0397 (0.0330)
Married				-0.0060 (0.0052)
#HH Members				0.0135 (0.0148)
Full-Time Employed				-0.0006 (0.0286)
8 Years of Schooling				0.0104 (0.0512)

Master's Degree			0.0012	
			(0.0301)	
Life Satisfaction			0.0143**	
			(0.0071)	
Constant	1.3472*** (0.0221)	1.3328*** (0.0665)	1.2590*** (0.0748)	1.2749*** (0.1108)
Observations	1860	1860	1860	1860
R-squared	0.0046	0.0074	0.0116	0.0179

Source: Data collection by IPSOS MORI through an online survey among Berlin residents between August 9 and September 30, 2013. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01; standard errors are in parentheses. Each column stands for one OLS regression model. The dependent variable is the logarithm of 5-Year *Lung Cancer Survival Rate*. See main text and Appendix for more details.

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## Appendix: Descriptive Statistics

	Mean	Std. Dev.	Min.	Max.	N
<b>A. Perceived Cancer Risks</b>					
Smoker Lifetime Lung Cancer Risk	31.0505	26.3858	1	100	1860
Overestimation Lung Cancer Risk	0.4361	0.4962	0	1	1860
Underestimation Lung Cancer Risk	0.2424	0.4287	0	1	1860
5-Year Lung Cancer Survival Rate	4.5478	2.1847	1	10	1860
Overestimation Survival	0.8011	0.3993	0	1	1860
Calculated Smoker Total Mortality Risk	0.1888	0.1875	0.05	0.95	1860
Overestimation Total Mortality Risk	0.4527	0.4979	0	1	1860
Underestimation Total Mortality Risk	0.2306	0.4214	0	1	1860
<b>B. Smoking information</b>					
Smoker	0.3553	0.4787	0	1	1860
Never Smoker	0.3769	0.4847	0	1	1860
Ex Smoker	0.2677	0.4429	0	1	1860
#Cigarettes Smoked Yesterday	5.2301	8.8637	0	60	1860
Heavy Smoker (>15 cigarettes)	0.1978	0.3984	0	1	1860
Don't Plan to Quit	0.0779	0.2682	0	1	1860
Plan to Quit	0.1656	0.3718	0	1	1860
Unlikely to Quit	0.1403	0.3474	0	1	1860
Addicted	0.0290	0.1679	0	1	1860
<b>C. Other health behavior</b>					
Daily Exercise	0.1823	0.3862	0	1	1860
No Sports	0.2629	0.4403	0	1	1860
#Drinks Yesterday	0.8946	2.0332	0	27	1860
BMI	26.5481	5.8487	13	70	1860
<b>D. Risk aversion and discount rates</b>					
Risk Tolerance	5.0145	2.1596	0	10	1860
Risk Averse	0.3645	0.4814	0	10	1860
Risk Loving	0.2715	0.4448	0	10	1860
Discount Rate min. 10%	0.2274	0.4193	0	1	1860
Discount Rate min. 20%	0.2102	0.4046	0	1	1860
Discount Rate min. 30%	0.1860	0.3892	0	1	1860
Discount Rate>10%	0.6237	0.4846	0	1	1860
<b>C. Socio-demographics</b>					
Female	0.5731	0.4948	0	1	1860
Age	45.09	13.59	18	86	1860
Married	0.3645	0.4814	0	1	1860
Annual Gross Household Income	6.4435	2.8871	1	11	1860
#HH Members	2.1435	1.0771	1	13	1860
Full-Time Employed	0.4747	0.4995	0	1	1860
8 Years of Schooling	0.0790	0.2699	0	1	1860
Master's Degree	0.3274	0.4693	0	1	1860
Life Satisfaction	6.6484	1.9854	0	10	1860