Escaping Death: Individual Mobility and Female Mortality*

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Abstract

We document that access to individual mobility reduces female mortality using random variation from motorcycle credit lotteries involving about one million individuals. The strongest determinant of reduced female mortality is fewer fatal assaults in public spaces, suggesting mobility enables women to avoid dangerous environments. Access to individual mobility also reduces fatal domestic violence exposure and facilitates transitions from high-mortality risk occupations. For men, motorcycle access yields no net mortality effect; health improvements are offset by increased motorcycle accident fatalities. Back-of-the-envelope calculations suggest that the benefits of reduced mortality offset the cost of investing in a motorcycle for women.

JEL Codes: D14, G23, J16, J62, J12, I10, K42, O12.
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1 Introduction

It has long been recognized that women face barriers to opportunity for cultural, institutional, and other reasons. In fact, in many societies, women face existential challenges, exemplified by the "missing women" phenomenon, the lack of women in a population compared with levels predicted by natural birth and mortality rates (Sen, 1990; Duflo, 2012). Beyond the direct negative effects on women, such discrimination also has cascading adverse short-, medium-, and long-term effects for their children and households' economic, physical, and mental well-being, imposing high costs on society (Carlson, 2000; Huth-Bocks, Levendosky, and Semel, 2001; Campbell, 2002; Koenen et al., 2003; Aizer, 2011; Devries et al., 2013; Carrell and Hoekstra, 2010). All of this makes addressing the sources of these injustices and inefficiencies a high priority for society.

The main finding in our paper is that access to individual mobility significantly reduces mortality rates for women. Specifically, we find that female mortality declines by 16 percent after women obtain access to a motorcycle. Examining the channels contributing to lower female mortality, we identify three main channels. First, we find that access to individual mobility reduces female mortality from violent assaults in public in the evening hours. Second, we find that access to individual mobility reduces female mortality from domestic violence. Third, we find that access to individual mobility reduces female mortality as a result of better health (fewer deaths from infectious and respiratory diseases). For men, we find that access to a motorcycle has no net effect on mortality. While men exhibit slightly better health outcomes, they are more likely to die in accidents while riding a motorcycle.

One advantage of studying mortality is that it aggregates effects from multiple benefits into one important outcome measure. Understanding how socioeconomic factors influence mortality is challenging in most applications. Since mortality is a rare event, a large sample and comprehensive death records are required to engage in causal inference. In addition, exploring the underlying channels requires detailed information about the nature of deaths, including how, why, when, and where a person died. Detailed administrative data on death records in a sample of about one million individuals in Brazil allows us to overcome these challenges.

Causally identifying how access to individual mobility affects mortality is challenging. It results from endogenous decisions, which depend on characteristics that may also correlate with mortality. For example, unobservable characteristics such as economic opportunities, cognitive skills, or physical and mental health may jointly determine access to individual mobility and mortality. To overcome these challenges, we exploit data on participants in a group-lending mechanism in Brazil, Consorcio, which generates random time-series variation in access to a motorcycle. Specifically, the timing of access to individual mobility in a

consorcio group is determined by credit lotteries. The outcome of these lotteries is random and, therefore, uncorrelated with individuals' characteristics conditional on being in the same group.

Consorcios are a widespread group-lending mechanism to finance durable goods in Brazil, with more than 6.7m participants in a given year. We focus on motorcycle groups, which typically comprise credit-constrained individuals seeking to invest in individual mobility.[1] Every month, participants in a consorcio group make identical contributions, which are then allocated to a subset of participants as credit designated for motorcycle purchase. When allocating credit through lotteries, consorcios use a contractually specified algorithm to translate the outcome of the national lottery (*Loteria Federal*) into ticket numbers that have been assigned to all participants, and ex ante everybody has the same probability of winning a lottery at a given point in time. All participants continue their contributions until everybody has been awarded credit.

In a sample of about one million participants, we exploit the random timing of access to credit dedicated to motorcycle purchase to compare outcomes for participants who receive credit through a lottery with participants who have not yet received credit within the same group. This staggered difference-in-differences design controls for selection by and into a particular group. Moreover, the fact that participants in a consorcio group do not share social ties and do not live in geographic proximity mitigates concerns about multiplier or other general equilibrium effects that may differentially affect treated and untreated individuals (Cai and Szeidl, 2024; Breza and Kinnan, 2021).

Most groups allocate credit through lotteries and auctions. The choice to participate in auctions could be related to other variables that affect mortality. To resolve potential endogeneity concerns related to auctions, we implement an instrumental variable strategy introduced in Doornik et al. (2024). The contractual design of consorcios, combined with our data, allows us to simulate all groups *as if* all credit were allocated through lotteries. Specifically, since we know the algorithm a group employs to translate the national lottery number into the winning ticket number, we can identify who would have obtained credit through a lottery if the group held no auctions. We use these simulated lottery winners as an instrument to predict the actual lottery winners. Since the instrument is based on the outcomes of random lotteries, it is orthogonal to other characteristics and satisfies the exclusion restriction (see Section 4.2 for details).

We start by examining how access to individual mobility affects mortality rates. In the full sample in which two-thirds of participants are male, and one third of participants are female, we observe a decrease in mortality by 0.58 deaths per 1,000 people (3.6 percent

[1] One-third of motorcycles in Brazil are sold through consorcios (ABAC, 2017).

relative to the mean) for individuals who obtained a motorcycle through a credit lottery compared to those that have not yet obtained a motorcycle in the same group.[2] When we split the analysis by gender, we find that the effect is exclusively driven by women. Specifically, we find that women are 16 percent less likely to die after obtaining access to a motorcycle. We observe no effect for men. Consistent with the random nature in variation of access to individual mobility from credit lotteries, we observe no pre-treatment trends in mortality before winning a credit lottery for either gender.

Half of the decline in female mortality occurs right after obtaining a motorcycle (within 1-2 years), with an additional decline in the long run from four or more years after obtaining a motorcycle. This suggests that access to individual mobility mitigates acute mortality risk factors as well as factors that affect mortality in the medium or longer run.

We also observe a pattern in hospitalizations that are not directly linked to mortality that mirrors the mortality patterns documented above. While we do not observe a change in hospitalization rates for men after they gain access to a motorcycle, women show a 23% decline in hospitalization rates. These findings independently validate our mortality evidence using a different outcome variable from a different data source. Additionally, the decline in hospitalizations for women suggests that the mortality effects we find are likely to be the most extreme manifestation of broader benefits of individual mobility accruing to women.

Detailed administrative data on the cause, location, and time of death allows us to identify the most important channels contributing to lower female mortality after gaining access to mortality. We find that the decline in female mortality after obtaining access to individual mobility is driven by external and internal factors. While Table A1 provides a detailed description of the different causes of death and their classification, an intuitive way of thinking about external versus internal causes is that external causes relate to causes from external factors, such as violence or accidents, whereas internal causes relate to internal factors mostly related to an individual's health. In relative terms, the effect of external factors is stronger compared with internal factors, explaining about 60% of the reduction in mortality.

The strongest effect is reduced fatal assaults in public spaces in the evening hours. The decline in fatal assaults against women in public spaces is consistent with access to a motorcycle allowing women to avoid dangerous public spaces. Violence against women is prevalent

[2]We check the robustness of our estimates to heterogeneous treatment effects across individuals over time, as suggested by recent work in econometrics (Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; Borusyak, Jaravel, and Spiess, 2024; de Chaisemartin and D'Haultfoeuille, 2020; Goldsmith-Pinkham, Hull, and Kolesar, 2022). Applying the estimation in Sun and Abraham (2021), which is robust to heterogeneity in treatment effects across units over time, we find that the estimates are almost identical to the baseline estimates. This implies that our estimates are not subject to heterogeneous treatment effects across units over time.

in many societies. Globally, one in three women has experienced violence during their lifetime (World Health Organization, 2021), reaching up to 76% in Ethiopia and Peru (Garcia-Moreno et al., 2005). In Brazil, every 14 seconds, a women falls victim to physical violence (Fórum Brasileiro de Segurança Pública, 2023b) and about 40% of women have experienced physical violence against them in their lifetime (Garcia-Moreno et al., 2005). 46.7% of women have experienced sexual assault and 28.9% report being psychologically abused (Fórum Brasileiro de Segurança Pública, 2023b). According to data from the World Health Organization (WHO),[3] in 2019, Brazil was ranked 25th out of 183 countries for the number of women killed per population, with 5.8 homicides against women per 100,000 people. For comparison, the U.S. ranked 86th with 2.2 homicides against women per 100,000 people. Women are particularly vulnerable to fatal violent assaults in public spaces. Public transportation exposes women to elevated risk of robbery and assault in Brazil (Moreira and Ceccato, 2021; U.S. Department of State, 2024). Access to individual mobility allows women to avoid using public transportation. Similarly, even if a woman continues to be exposed to the same public space, such as a dangerous road or neighborhood, assault risk may be lower as a motorcycle rider than as a cyclist or pedestrian.

We also observe that access to individual mobility reduces female mortality as a result of domestic violence, albeit on a smaller scale. The decline in female mortality from a domestic violence channel could be related to a relaxation of households' budget constraint due to higher income (Buller et al., 2018) or female empowerment within households when women provide a larger share of household income (Manser and Brown, 1980; Pollak, 2005). Consistent with these theories, we find that women's formal labor income increases by 9.13 percent after obtaining access to a motorcycle. In addition, access to individual mobility may allow women to escape from a situation of acute conflict more easily.

Finally, women die less from infectious and respiratory diseases after obtaining access to individual mobility. The reduction in mortality through an improved health channel may result from multiple effects. As described above, individuals' labor income increases after obtaining access to individual mobility. This could have positive general health effects associated with higher income, such as access to better health care or better nutrition.[4] Moreover, access to a motorcycle may allow individuals to avoid crowded spaces such as public transit, where respiratory and infectious diseases are common to be transmitted (Xu, Connell McCluskey, and Cressman, 2013; Guo et al., 2023). Finally, further exploring the health-relevant labor market effects of access to a motorcycle, we observe a job-sorting effect for women. As documented in Doornik et al. (2024), access to individual mobility expands

[3] `https://apps.who.int/gho/data/view.main.VIOLENCEHOMICIDEv`

[4] The fact that women also become less likely to be hospitalized after gaining access to a motorcycle suggests that easier access to healthcare alone cannot explain our findings.

the scale and scope of employment opportunities by allowing individuals to engage in a geographically broader job search. We find that women, but not men, transition into jobs with lower exposure to mortality risk after gaining access to individual mobility, measured by observed mortality rates across different professions.

We perform the same detailed mortality analysis for men and observe a slight reduction in mortality from respiratory diseases. However, we also find an increase in fatal motorcycle accidents after gaining access to a motorcycle for men. This increase in mortality from traffic accidents for men is consistent with motorcycles being a dangerous and vulnerable mode of transportation (Constant and Lagarde, 2010) and men taking more risk when riding a motorcycle than women. On net, the increase in fatal traffic accidents offsets the decline in mortality through an improved general health channel leading to a zero effect of access to a motorcycle on male mortality.

To better evaluate potential policies that enhance women's access to individual mobility, we conduct a cost-benefit analysis using standard mortality study methods. The reduction in female mortality translates into an expected value of statistical life (VSL) saving between USD 2,542 and USD 3,720 per capita (see Section 5.3 for details). The average cost of a motorcycle in our sample is USD 2,837. Thus, from a VSL perspective, the expected benefits from a reduction in mortality risk are about the same as the costs of a motorcycle for women. While our study exploits variation from an unsubsidized, market-based solution, our findings suggest that policies providing subsidized access to individual mobility could have an important additional effect on reducing female mortality.

Our work directly relates to the phenomenon of "missing women," where the actual number of women in a population is significantly lower than what would be expected based on natural birth and mortality rates (Sen, 1990; Duflo, 2012) and the broader literature on female empowerment, which explores ways to facilitate women's access to opportunity.[5] Prior work has explored the role of various interventions in affecting opportunity and outcomes for women. These include better access to resources, such as cash transfers (Fiszbein and Schady, 2009) and bicycles (Muralidharan and Prakash, 2017); access to education and healthcare, including vocational training and education (Deming et al., 2016; Kim et al., 2018; Bandiera et al., 2020; Field et al., 2016; Dhar, Jain, and Jayachandran, 2022), contraceptive pills (Goldin and Katz, 2002), health (Langer et al., 2015); and interventions to adapt cultural and workplace environments to better accommodate challenges facing women, such as improved employment practices (Goldin and Rouse, 2000), work flexibility (Goldin, 2014), parental leaves (Blau and Kahn, 2013), cultural norms (Field, Jayachandran, and Pande, 2010; Alesina, Giuliano, and Nunn, 2013), technological advancements (Goldin, 2006), fi-

[5]For excellent surveys and discussions, see Duflo (2012) and Kabeer (1999, 2005).

nancial inclusion (Field et al., 2021; Riley, 2024; Heath and Riley, 2024), and differences in preferences (Falk and Hermle, 2018). While some of these approaches have successfully improved outcomes in education, employment, and life expectancy for women, others have had mixed results. Identifying the primary frictions to narrow the gap in mortality and access to opportunity for women remains a key challenge (Chant, 2008; Chant and Sweetman, 2012). Our findings establish that access to individual mobility impacts women's safety, health, and mortality, helping to narrow gender disparities in death rates and opportunities.

Our analysis also connects to work in medicine, economics, and sociology, which examines the determinants of assaults and domestic violence against women (Anderson and Ray, 2010; Doepke, Tertilt, and Voena, 2012; Jayachandran, 2015, 2021).[6] This literature has explored a wide range of determinants of violence against women, for example the role of female bargaining power within a household (Aizer, 2010; Anderberg et al., 2015; Hidrobo, Peterman, and Heise, 2016; Haushofer et al., 2019); households' financial condition (Angelucci, 2008; Bobonis, González-Brenes, and Castro, 2013; Heath, Hidrobo, and Roy, 2020; Bhalotra et al., 2024); cost of incapacitation (Sanin, 2023); policing (Miller and Segal, 2019; Sukhtankar, Kruks-Wisner, and Mangla, 2022); emotional cues (Card and Dahl, 2011); extractive violence and male backlash (Bloch and Rao, 2002; Luke and Munshi, 2011; Heath, 2014); and violence against women at work (Adams-Prassl et al., 2023). We contribute to this literature by demonstrating that access to individual mobility is an important mechanism for reducing women's exposure to fatal violence in public spaces and domestic settings.

Our paper also relates to the literature on mobility and labor markets more broadly. The idea of spatial mismatch between where individuals live and labor market opportunities has been debated in urban economics for a long time (Kain, 1968; Ihlanfeldt and Sjoquist, 1998). Prior work mostly focuses on the relationship between geographic constraints and employment rates, labor income, and job match quality (e.g., Marinescu and Rathelot, 2018; Heise and Porzio, 2022; Doornik et al., 2024). Our analysis uncovers a novel dimension in which overcoming spatial mismatch by engaging in a broader geographical job search may improve labor market outcomes. Specifically, we find that female workers leverage increased mobility to access a wider set of employment opportunities, allowing them to reduce exposure to occupational health hazards. To the best of our knowledge, this type of labor market sorting behavior has not been documented before and may warrant further investigation in future research.

Finally, our study offers new insights into the literature on the effects of access to credit. Randomized-control trials across a diverse set of settings and countries document modest or no effects of extending credit to low-income households on various economic outcomes

[6]Survey papers include Heise, Garcia-Moreno et al. (2002), Jewkes (2002), Capaldi et al. (2012), Devries et al. (2013), Gibbs, Jacobson, and Kerr Wilson (2017), and Buller et al. (2018), among others.

(Karlan and Zinman, 2011; Angelucci, Karlan, and Zinman, 2015; Attanasio et al., 2015; Augsburg et al., 2015; Banerjee et al., 2015; Crepon et al., 2015; Tarozzi, Desai, and Johnson, 2015; Meager, 2019; Gertler, Green, and Wolfram, 2024; Bari et al., 2024), including intimate partner violence (Hashemi, Schuler, and Riley, 1996; Schuler et al., 1996; Hadi, 2000; Koenig et al., 2003; Ahmed, 2005; Pronyk et al., 2006; Bajracharya and Amin, 2013; Gibbs, Jacobson, and Kerr Wilson, 2017). While Pronyk et al. (2006) find that credit in combination with vocational and gender education leads to a decline in domestic violence, they cannot differentiate between the effect of education and credit. To the best of our knowledge, our paper provides the first direct evidence linking access to credit with lower female mortality. The fact that we only observe a decline in mortality rates for women resonates with the targeting of micro-credit towards women based on the view that they are more likely to face constraints in access to capital and, therefore, benefit more from facilitating access to credit than men (Kabeer, 2001; Pitt and Khandker, 1998).

2 Institutional Design

In this section, we describe consorcios, how they allocate credit and show descriptive statistics for motorcycle consorcios in Brazil.

2.1 Consorcios

This section provides a detailed description of consorcio groups and how they allocate credit designated for purchasing durable goods.

Basic Features

Consorcios are a financial product in which participants pool funds to save towards purchasing durable goods. Consorcio groups are typically administered by the finance division of a manufacturer who provides the good, a bank, or a specialty finance company. The administrator is in charge of marketing the consorcio, selecting participants, managing payments, and enforcing contracts. The administrator is compensated for these services through an administrative fee levied on all participants. Screening of applicants is virtually non-existent and it is easy for anyone with a social security number in Brazil to sign up and participate. Prospective participants are provided with several pieces of information when selecting a group. They know the identity of the administrator, the price of the good, the number of months for which the group will operate, and the target number of participants. All participants contribute identical pre-determined payments at regular intervals, typically monthly.

These payments are adjusted for inflation. The monthly payments also cover the administrative fee and establish a guarantee fund that covers losses from defaults of individual participants.[7] All participants are required to continue their monthly contributions, including those who have received credit from the group. The group continues until all participants have received credit. Due to the organization of the group through a central and independent administrator, personal connections between consorcio participants are uncommon, and participants in the same group are not known to each other. Enforcement relies on physical collateral generated by the durable good purchased through the group.

Credit Allocation

All participants start out as savers, making equal contributions to the group. Every month, some participants receive credit from the group. Which members receive credit in a given month is decided using two mechanisms: lotteries and auctions. The relative numbers of lotteries and auctions vary by group. By law, at least one good has to be allocated by lottery each period.

Lotteries are based on the national lottery (*Loteria Federal*) in Brazil, which is broadcast on TV. Each participant receives a ticket number at the start of the group. Based on an algorithm, which is contractually specific, the national lottery number is translated into a ticket number and the participant holding the respective ticket number is declared the winner of the lottery. Each algorithm is designed such that at the beginning of the group each participant has the same unconditional probability of winning the lottery at any point in time.

To illustrate, we describe in detail how one such algorithm works. Each week, five five-digit numbers are drawn in Brazil's national lottery. This algorithm uses the first of the five-digit numbers from the national lottery to determine the allocation of credit. The number is divided by the number of participants in the group, and then the remainder is multiplied by the number of participants. For example, if the number from the national lottery is 10084 and there are 250 participants in the group, the remainder from dividing 10084 by 250 is 0.336, which multiplied by 250 is 84. Thus, credit would be allocated to the participant with ticket number 84.[8]

If the individual with ticket number 84 has already been awarded credit in a previous round, the algorithm simply adds one to the initial result. In our example, this means that credit would be allocated to the holder of ticket number 85. If this participant has also been

[7] In most groups, a fraction of the payments is used to insure the good against damage to preserve its value as collateral.

[8] If the remainder is zero, credit goes to the highest ticket number.

awarded credit before, the algorithm subtracts one from the initial result, which in our case would imply that ticket number 83 is awarded credit. The algorithm continues to add and subtract two, then three, and so on, relative to the initial result, until a ticket number is selected that has not been awarded credit before.

In credit auctions, participants bid a fraction of the total value of the good. Rather than a higher aggregate payment, bids move payments forward, akin to making a higher down payment on the loan given by the group. Future contributions are adjusted accordingly. For example, if the value of a good is $5,000 with monthly contributions of $100 and a participant bids 40 percent, they would pay $2,000 immediately and would cease making monthly payments 20 months before the end of the group.

Defaults

After obtaining credit from either a lottery or an auction, the good is purchased and becomes the property of the group. The good serves as physical collateral and can be seized if payments are late.[9] Participants cannot sell the good to somebody else without the approval of the administrator to ensure that the good is not transferred to somebody who is a high credit risk to the group. If a participant defaults before receiving credit, their past payments are retained by the group until they win a lottery. Once they win a lottery, their funds are released instead of credit being allocated. However, defaulted participants receive only a fraction of their previous payments since default carries a contractually specified penalty of, on average, about 40 percent of the payments for motorcycle groups.[10]

Due to this contractual design, defaults of participants before receiving credit do not affect the required payments of other participants. However, defaults after receiving credit impose costs on the group if the collateral value of the good is not sufficient to recover the full amount of credit that is owed to the group. The resulting losses are first covered by the guarantee fund, which is designed to be sufficiently generous to make a collapse of the group highly unlikely. If losses exceed the capacity of the guarantee fund, administrators usually absorb the losses. In practice, losses from defaults virtually never exceed the capacity of the guarantee fund. At the termination date of the group, any remaining funds in the reserve fund are split equally and repaid to the participants.

[9] Consorcios register all collateral under the fiduciary lien (Alienação fiduciária) which allows for out of court settlement in the event of default. As a result, collateral can be recovered quickly.

[10] For details, see Doornik et al. (2023).

Aggregate Statistics

Consorcios are widespread in Brazil. In 2015, consorcios had 6,705,673 participants, and about half of them were in motorcycle consorcios. The 3,407,678 motorcycle consorcio participants are equivalent to 2.25 percent of the working-age population or 6.82 percent of formally employed individuals in Brazil. 444,636 individuals, or 0.29 percent of the working-age population, obtained a motorcycle through a consorcio group in 2015 alone.

The average motorcycle value across all groups is USD 2,837. Average monthly payments amount to about 3 percent of the value of the motorcycle. These payments cover the costs of the motorcycle, an average administrative fee of 16.84 percent of the value of the motorcycle, and a guarantee fund to cover losses. The average duration of a consorcio group is 48.4 months. The share of motorcycles allocated through lotteries is 36.71 percent, with the rest allocated through auctions. Consistent with consorcio groups not relying on social ties among participants, the average group comprises 284 participants from 153 different municipalities in 17 different states (out of 27). Thus, on average, fewer than two participants in the same group are from a given municipality.

3 Data

The data for this paper comes from two main sources. Data on consorcios is from the Sistema de Administração de Grupos/Cotas de Consorcio (SAG) database, which is maintained by the Banco Central do Brasil (BCB). Information on deaths is from the publicly available mortality information system (Sistema de Informações sobre Mortalidade) from the Ministry of Health.[11] Hospitalization data is from the publicly available hospital information system (Sistema de Informações Hospitalares do SUS)[12] also from the Ministry of Health. Data on labor market outcomes is from the Relação Anual de Informações Sociais (RAIS), an employer-employee matched database that includes employment information and wages for all formally employed workers in Brazil. The information on an individual's sex – male or female – comes from the population registry and refers to a biological characteristic defined at birth.

The database on consorcios provides information on the administrator, participants, the good being allocated, and the dates when credit is awarded to participants. The BCB has been collecting data on all consorcio groups since October 15, 2008, including consorcios that started earlier but were still ongoing. The earliest starting date of a consorcio group in our sample is January 2006 and the sample ends in December 2020. For our empirical analysis,

[11]The data can be downloaded at `https://opendatasus.saude.gov.br/dataset/sim`.

[12]The data can be downloaded at `https://datasus.saude.gov.br/transferencia-de-arquivos`.

information about the algorithms through which consorcio groups translate the national lottery draw into a number that matches the ticket number of a participant is required. This information is not readily available in the database. We hand-collect data from as many administrators as possible and verify the algorithms in the data.

The data for the causes of death provide detailed information on the nature of the death according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10).[13] The data provides detailed information for both internal and external causes. It also includes such information as the location of death, whether medical assistance was provided, whether an autopsy was performed, and who reported the death. We match the mortality data with the administrative population registry on the date of birth, the date of death, sex, and the deceased's municipality of residence. This results in about 87 percent unique matches. We omit the causes of death for the observations that do not result in a unique match. Consistent with the sample period for consorcios, we use data for the period from 2003 to 2020.

The data on hospitalization record information on hospital admissions. We match the hospitalization data with the administrative population registry on the date of birth, sex, and the patient's ZIP code. This results in about 74 percent unique matches. When analyzing this data, we omit the individuals who cannot be uniquely matched with this data. Consistent with the sample period for consorcios, we use data for the period from 2003 to 2020.

The final sample for our analysis comprises all groups for which we can collect the algorithm used to translate the national lottery number into a number that matches the ticket number of a participant, and our algorithm correctly predicts at least one lottery winner. Our sample comprises all lottery winners for each of these groups. Table 1 provides descriptive statistics for our sample. Panel A provides descriptive statistics for consorcio groups and Panel B for participants. The data contains 15,339 consorcio groups that allocate motorcycles through auctions and random lotteries between 2006 and 2020. The sample of members of these groups who win a lottery leaves us with an average group size of 62 participants, with a median of 50 participants. Thus, the total number of participants in our sample is 948,201. The average group lasts for 42 months, with a median of 36 months.

The average annual propensity to die across all participants in motorcycle consorcios is 0.08%. This compares to an average annual death rate of 0.06% in the working-age population. During the whole sample period, about 1.6% of consorcio participants die. About two-thirds of deaths are explained by internal causes and a third by external causes. The average annual propensity to die from external and internal causes are 0.04% and 0.03%, respectively. When split by sex, about 0.9 percent of female and 1.9 percent of male partici-

[13] `https://icd.who.int/browse10/2019/en`

pants die during the sample. The annual propensity for a female and male participant to die are 0.05% and 0.1%. Forty-four percent of participants have a formal job with an average monthly income of BRL 1,819. This compares to an average monthly salary of BRL 1,715 in the working-age population. A notable difference includes sex, with consorcio participants being about seventeen percentage points more likely to be male.

4 Empirical Analysis

This section presents our empirical analysis to assess the effects of access to individual mobility on mortality.

4.1 Consorcios

Exploiting time-series variation in credit allocation in consorcios implies the following specification to assess the relationship between access to individual mobility and mortality

$$Death_{it} = \alpha_i + \alpha_{gt} + \beta \cdot win_{it} + \epsilon_{it}, \quad (1)$$

where i denotes individuals, g denotes consorcio groups, and t denotes time. $Death_{it}$ is a dummy variable that takes the value of zero if an individual is alive and one in the year they die. The dummy variable win_{it} takes the value of one for individuals who obtain access to individual mobility by winning a credit lottery in year t or earlier and zero before winning a lottery. Individual fixed effects (α_i) ensure that we track changes for the same individual over time, eliminating concerns about differences in sample composition effects before and after treatment. Group-time fixed effects (α_{gt}) control for selection by and into a specific group.

As described in Section 2.1, groups allocate credit through a combination of auctions and lotteries. While we restrict the sample to participants who obtain credit through lotteries, the presence of auctions generates an endogeneity problem with respect to changes in the pool of lottery participants over time. Specifically, individuals who remain in the lottery pool have not obtained access to individual mobility through credit auctions, which may reflect characteristics correlated with mortality risk. As a result, endogenous selection into the lottery pool over time could bias the estimate of β in equation (1).

4.2 Instrument

To overcome the selection problem, we apply the instrumental variable approach developed in Doornik et al. (2024). Our data on participants' ticket numbers and historical national

lottery numbers enables us to simulate credit allocation as if there were no auctions. This allows us to identify which participants would have obtained access to individual mobility in a given month if a group allocated all credit through lotteries. For each group, we translate national lottery numbers into ticket numbers based on the group's algorithm. This way, we obtain the schedule of lottery winners unaffected by selection into the lottery pool over time. Due to the presence of auctions in real-world groups, the instrument is not perfectly correlated with winning a lottery. For example, an individual predicted to win the lottery may have replaced a previous auction winner in a different period.

We begin our analysis by documenting that the simulated lotteries are a strong predictor of winning a credit lottery by estimating the following first-stage

$$win_{it} \quad = \quad \alpha_i + \alpha_{gt} + \beta \cdot win\ sim_{it} + \epsilon_{it}, \tag{2}$$

where $win\ sim_{it}$ is a dummy variable that takes the value of one from the year an individual is predicted to obtain access to individual mobility based on the simulated lotteries and zero before. Since $win\ sim_{it}$ is based on the outcomes of random lotteries, it is orthogonal to ϵ_{it}, conditional on comparing participants in the same group.

We present the results in Table 2, Panel A. The results show that being predicted a winner in the simulated lottery is associated with a 14.34 percentage point higher probability of being the winner of an actual lottery. Since the simulated lotteries are based on the same lottery numbers and algorithms as the actual lotteries, the instrument is strong with a Cragg-Donald Wald F-statistic of 280,109.

Next, we estimate the reduced-form equation

$$Death_{it} \quad = \quad \alpha_i + \alpha_{gt} + \beta \cdot win\ sim_{it} + \epsilon_{it}, \tag{3}$$

where all variables are defined as before. The results are reported in Panel B. We estimate a reduction in mortality rates by 0.0083 percentage points. The reduced-form estimate can be interpreted as the mortality effects of winning a credit lottery with the probability given in the first stage.

To obtain estimates for mortality effects of access to individual mobility, we estimate equation (1) using a two-stage least square specification where win_{it} is instrumented with predicted lottery outcomes $win\ sim_{it}$. All variables are defined as before. The results are reported in Panel C. Since the estimation is just identified, the second stage estimate is equivalent to scaling the reduced-form estimate with the corresponding first-stage. Access to individual mobility reduces mortality by 0.0578 percentage points, equivalent to a 3.6 percent reduction in mortality. Separately estimating the effect of access to individual mobility on mortality for men and women, we find that the decline in mortality following access to

individual mobility is almost exclusively driven by women (column II). Specifically, female mortality declines by 0.1476 pp or 16 percent relative to the mean after obtaining access to individual mobility for women, whereas we do not find a statistically significant effect for men.

Exploiting information on the causes of death as categorized by the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), we split the causes of death into external and internal factors in columns III and IV.[14] Table A1 provides a detailed description of the different causes of death and their classification. An intuitive way of thinking about external versus internal causes is that external causes relate to causes from external factors, such as violence or accidents. In contrast, internal causes relate to internal factors primarily related to an individual's health.

We find that for women, mortality rates decline for deaths caused by external and internal factors by 0.0725 pp (57% relative to its mean) and 0.0494 pp (8% relative to its mean), respectively. These results suggest that access to individual mobility is more fundamental in reducing female mortality from external compared to internal factors. The reduction in female mortality is larger for external factors in absolute terms (0.00725 pp vs. 0.00494 pp) and even more so in relative terms (57 percent vs 8 percent relative to the mean). This is particularly important when we discuss policy implications. Specifically, access to individual mobility is a powerful first-order mechanism to reduce female mortality from external factors (explaining 57% of variation), whereas, while still important, it is relatively less effective for female mortality due to internal factors (explaining 8% of variation). The relative higher importantce of access to individual mobility for mortality from external factors is also consistent with the fact that for young individuals external factors contribute relatively more to mortality than for older individuals. The World Health Organization estimates that violent death is one of the top three causes of death for individuals between 15 and 60 years of age, explaining about 20 percent of deaths (World Health Organization, 2020).

In columns V and VI, we investigate effects on hospitalization. Our findings reveal that for women, motorcycle access decreases the hospital visits not directly linked to mortality by 0.53 percentage points (a 23% reduction relative to the mean for women) and reduces annual visit frequency by 0.0054 (a 21% decline relative to the mean for women). We detect no such effect for men. This suggests that the effects of access to individual mobility for womens' health extend beyond the reduction in mortality documented in this paper. Importantly, mortality results cannot be attributed simply to easier hospital access with no underlying health changes, as such a scenario would predict increased rather than decreased hospital utilization.

[14]For 13 percent of deaths, the cause of death is not available.

Before moving on to examining the underlying channels in more detail, we first tighten the interpretation of the results by conducting standard validation tests. First, we assess the presence of pre-treatment trends and examine the time-series evolution of changes in mortality around access to individual mobility by estimating a dynamic version of the reduced-form equation

$$Death_{it} = \alpha_i + \alpha_{gt} + \sum_{s=-5, s\neq -1}^{5} \beta_s \cdot win\ sim_{it}^{s} + \epsilon_{it}, \tag{4}$$

where the variables $win\ sim_{it}^{s}$ are dummy variables taking the value of one s years relative to when an individual is predicted to win a lottery. We omit the year before an individual is predicted to win a lottery, which is equivalent to normalizing to zero in the year before being predicted to win a lottery. We separately pool the years from 5 to 10 years before individuals are predicted to win a lottery, and the years from 5 to 10 years after individuals are predicted to win a lottery into one estimate, respectively. To separately assess the effect of obtaining access to individual mobility for men and women, we interact the independent variables in equation (4) with a factor variable, representing the sex – male or female – of a participant i.

The results are reported in Figure 1. The black solid line depicts the effect for the entire sample. We observe hardly any change in mortality after individuals obtain access to individual mobility for the entire sample. Mortality rates remain flat in the first years and start to somewhat decrease in the long run five or more years after individuals obtain access to individual mobility.

As expected, given the randomness of access to individual mobility through credit lotteries, we observe no pre-treatment trends in mortality before individuals obtain access to individual mobility. Following active recent literature in econometrics, we verify that our staggered difference-in-differences estimates are not biased as a result of variation in treatment effects across units over time. This literature argues that short-term effects may be overweighted when the treatment effect is not constant over time for the same unit (see, e.g., Goodman-Bacon 2021 and Borusyak, Jaravel, and Spiess 2024) or across units such that treatment effects vary with the timing of treatment (Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; Borusyak, Jaravel, and Spiess, 2024; de Chaisemartin and D'Haultfoeuille, 2020; Goldsmith-Pinkham, Hull, and Kolesar, 2022). In our setting, this would be problematic if treatment effects for earlier and later lottery winners in the same group would substantially vary. To assess whether this could cause a bias in our estimates, we apply the methodology developed in Sun and Abraham (2021) to our dynamic reduced-form estima-

tion, which is robust to heterogeneous treatment effects across units over time. We include these estimates in Figure 1 for comparison (dashed gray line). As is evident, the estimates with and without the application of the Sun and Abraham (2021) methodology are almost identical. This suggests that heterogeneous treatment effects across units over time do not meaningfully affect the estimates in our setting.

When estimating the dynamic effects by gender, we observe an immediate drop in mortality for women after obtaining access to individual mobility (red) and an additional decline in mortality in the long run. For men (blue), we observe no significant decline in mortality after obtaining access to individual mobility. If anything, male mortality rates become somewhat elevated, which also explains the near-zero effect for the entire sample, as men make up 68 percent of the whole sample. These results confirm the insights from the static estimation in Table 2 that the drop in mortality after obtaining access to individual mobility is exclusively driven by women.

To accurately quantify the effect of access to individual mobility on mortality, we estimate a two-stage least squares version of equation 4, where we use the simulated lotteries ($win\ sim_{it}^{s}$) as an instrument for the actual lottery results (win_{it}^{s}):

$$Death_{it} = \alpha_i + \alpha_{gt} + \sum_{s=-5, s\neq -1}^{5} \beta_s \cdot win_{it}^{s} + \epsilon_{it}, \tag{5}$$

where the variables win_{it}^{s} are dummy variables taking the value of one s years relative to when an individual wins a lottery. We omit the year before an individual wins a lottery, which is equivalent to normalizing to zero in the year before winning a lottery. We separately pool the years from 5 to 10 years before individuals win a lottery, and the years from 5 to 10 years after individuals win a lottery into one estimate, respectively. All other variables are defined as before.

The results are reported in Figure 2.[15] We find that female mortality declines by 0.0902 pp (10% relative to mean female mortality) in the first two years following access to individual mobility. After four years, the effect more than doubles to 0.20 pp (22% relative to the mean). Again, there is virtually no average effect of access to individual mobility on male mortality rates.

The fact that female mortality drops immediately in the first year after obtaining access to individual mobility suggests that access to individual mobility reduces mortality from

[15]Since the IV estimates are based on the same variation as the reduced-form estimates, the robustness of the reduced-form estimates to heterogeneity in treatment effects across units over time implies that the IV estimates are robust to the same type of heterogeneity.

immediate risk factors. The fact that there is a further drop in mortality rates for women in the longer run suggests that access to individual mobility also reduces mortality from slower moving medium- or long-term risk factors. We explore the exact channels through which access to individual mobility affects female mortality in more detail below.

5 Underlying Channels

We are fortunate that our administrative data not only allow us to obtain an accurate and reliable measure of mortality, but also provides us with detailed data on the causes of death, and the time and location when the deaths occurred. This enables us to narrow down the set of potential channels through which access to individual mobility affects mortality.

5.1 External Causes of Death

We first decompose changes in mortality from external causes after individuals obtain credit into the different causes of death in Table 3. We find that among external causes, the decline in mortality for women is predominantly a result of fewer fatal assaults (column I). We do not find any significant effects for suicide (column II), traffic and non-traffic accidents (columns III and IV), or other external causes (column V). For men, we, in fact, observe an increase in mortality from traffic accidents (column IV). These results suggest that the main channel through which access to individual mobility reduces female mortality from external causes is fatal assault.

Assault Channel Guided by the evidence that individual mobility reduces female mortality from fatal assaults, we further explore the nature of fatal assaults that access to individual mobility allows women to evade. To start, we decompose deaths from assault more granularly. Our administrative data provides information on the location and time of death. In Table 4, we examine the importance of the location of assaults related to access to individual mobility. We find that female mortality rates from assault decline in both domestic (column I) and public spaces (column II). The magnitude of the effect is substantially stronger for public spaces.

In terms of timing, we examine the time in which fatal assaults decline for each two-hour window throughout the day. The estimates are depicted in Figure 3. We find that the effect is strongly concentrated in the late afternoon and evening hours from 4 to 8 pm, with no detectable effects in other time windows. In particular, the time from 4 to 6 pm, which shows the strongest effect, is consistent with commuting hours, suggesting that access to a motorcycle allows women to avoid dangerous modes of transportation, such

as public transportation, or being on a dangerous road as a cyclist or pedestrian.[16] Public transportation exposes riders to elevated risk of robbery or assault in Brazil (U.S. Department of State, 2024), which is particularly problematic for women (Moreira and Ceccato, 2021). Furthermore, even if a woman continues to be exposed to the same public space, such as a dark alley, she may be less exposed to assault risk as a motorcycle rider compared with a cyclist or a pedestrian.

As a secondary part of the assault channel, we find that women's access to individual mobility reduces mortality from domestic assaults. While also statistically significant and economically meaningful, the magnitude of the effect is only about one-sixth of the magnitude of the impact of access to individual mobility on fatal assaults in public. There are many theories that provide plausible links between access to individual mobility and a decline in fatal domestic assaults against women. Since total household income or the relative income of household members play an important role in many of these theories, we also examine whether and how access to individual mobility affects labor market outcomes for women.[17] For example, higher household income may relax financial constraints, which has been found to reduce domestic conflict (Buller et al., 2018) or higher income may increase women's bargaining power in intra-household conflicts, leading to lower risk of experiencing domestic violence (Manser and Brown, 1980; Pollak, 2005).

Using data from the universe of administrative labor records (RAIS), in Table 5, we find that access to individual mobility increases female participation in formal labor markets by 9.13 percent (column I) and their formal income by 7.05 percent (column II) (the effects are 7.41 percent and 3.22 percent for men, respectively). Since these income results are consistent with both a relaxation of household budget constraints and an increase in women's bargaining power in domestic settings, we cannot further evaluate which of the two sets of theories described above plays a more important role in explaining the decrease in fatal domestic assaults. One theory that our results are less consistent with is exposure theories on domestic violence. According to this theory, individuals experience lower exposure to domestic violence after obtaining a job due to lower exposure to a violent assailant while being out for work (Dugan, Nagin, and Rosenfeld, 1999). However, since we find that fatal assault declines in the late afternoon and evening hours rather than during working hours, this theory is less likely to explain the results.

Finally, the fatal assault channel aligns with the findings presented in Figures 1 and 2, which demonstrate that female mortality decreases immediately following access to individual

[16]Note that we also observe somewhat of a decline in male mortality during commuting hours even though the effect is not statistically significant.

[17]Doornik et al. (2024) first documented that access to individual mobility has positive effects on individuals' income and formal labor market participation. However, their findings are not broken down by gender.

mobility. This immediate effect is consistent with the hypothesis that individual mobility enables women to promptly reduce their exposure to more dangerous forms of commuting and general movement. Furthermore, the reduction in non-fatal hospitalization reported in Table 2 is inconsistent with mobility providing access to hospitalization without reducing the underlying mortality risk.

To put the gender-specific effect on lower mortality from fatal assaults into a broader context, we provide a brief summary of evidence on physical violence against women in Brazil. In Brazil, every 14 seconds, a woman falls victim to physical violence (Fórum Brasileiro de Segurança Pública, 2023b) and about 40% women have experienced physical violence against them in their lifetime (Garcia-Moreno et al., 2005). In addition, 46.7% of women have ever experienced a sexual assault, and 28.9% report being psychologically abused (Fórum Brasileiro de Segurança Pública, 2023b). According to data from the World Health Organization (WHO),[18] in 2019, Brazil was ranked 25th by the number of women killed per population in a ranking of 183 countries. There are 5.8 homicides of women per 100,000 people. For comparison, the U.S. ranks 86th with 2.2 female homicides per 100,000 people. The homicide rate is higher for women aged 18 to 44 years (72%) and among non-white women with children (Fórum Brasileiro de Segurança Pública, 2023a).[19] 84% of female homicide victims knew their attacker with more than half of the killings carried out with the use of a bladed weapon (Fórum Brasileiro de Segurança Pública, 2023a).

Traffic Accidents The second category of external causes of death that warrants further investigation is deaths from traffic accidents. While we find no significant effect on women, we do observe a significant increase in fatal traffic accidents for men after they obtain access to a motorcycle in Table 3, column III. In Table 6, we break down fatal traffic accidents by mode of transportation, specifically into whether the deceased was involved in the accident as a pedestrian, cyclist, motorcycle rider, driver of a car, or operator of other heavy transport. We find that the increase in mortality after obtaining access to a motorcycle among men is fully attributed to the rise in fatal accidents while operating a motorcycle (column III). The likelihood of dying in a motorcycle accident increases by 0.018 p.p. for men (18% relative to the mean). Consistent with the evidence in Table 3, there is no significant change in mortality associated with traffic accidents for any type of vehicle for women. These results are consistent with motorcycles being a risky and vulnerable mode of transportation (Constant and Lagarde, 2010) and men taking more risk when riding a motorcycle than women.

[18] https://apps.who.int/gho/data/view.main.VIOLENCEHOMICIDEv

[19] https://www.ipea.gov.br/atlasviolencia/arquivos/artigos/9350-223443riatlasdaviolencia2023-final.pdf

5.2 Internal Causes of Death

Next, we explore the underlying factors leading to lower mortality from internal causes after individuals obtain access to individual mobility. To start with, it is important to note that it can be challenging to analyze the causes of death from internal causes. It is inherently difficult to distinguish between underlying slow-moving and the immediate causes of death. This ambiguity arises when deciding whether to attribute a death to the final failure (for example, a cardiac arrest) or to the initial condition that caused the problems leading to a fatal outcome (for example, infection with influenza). This complexity is further amplified in cases involving multiple contributing factors. As a result, the officially recorded main cause of death oversimplifies a complex web of underlying conditions and events, making it challenging to identify specific determinants that affect mortality from internal causes through various channels and ultimate outcomes. With this in mind, in the main analysis, we focus on all recorded contributing factors rather than narrowly relying on the main recorded factor when analyzing the causes of internal deaths.[20]

Health Channel In Table 7, columns I to V, we separately estimate the effect of access to individual mobility on mortality for the five most prevalent categories of mortality from internal causes in Brazil. We follow the standard definitions of the International Statistical Classification of Diseases and Related Health Problems (ICD). According to these statistics, the five most prevalent categories of mortality from internal causes in Brazil comprise infectious and parasitic diseases (ICD 01), accounting for 5% of deaths from internal causes, benign and malignant neoplasms (ICD 02), accounting for 18% of deaths from internal causes, diseases of the circulatory system (ICD 09), accounting for 32% of deaths from internal causes, diseases of the respiratory system (ICD 10), accounting for 13% of deaths from internal causes, and deaths related to symptoms from internal causes not classified elsewhere (ICD 18), which account for 8% of deaths from internal causes. In column VI, we add estimates for mortality from all remaining internal causes, which collectively account for approximately 24% of deaths from internal causes in Brazil.[21]

The results suggest that the decline in mortality from internal causes after gaining access to individual mobility is predominantly driven by two factors commonly associated with highly contagious and fast-spreading diseases such as influenza. First, women experience a 0.0345 p.p. reduction (17% relative to mean) in deaths from diseases linked to the respiratory system (column IV). Second, females experience a 0.019 p.p. reduction (13% relative to

[20]We also provide the results when we replicate the analysis using only the main contributing factor in Table A2.

[21]The results cannot be explained by better access to hospital care alone given that we also observe a decline in hospilizations for women.

mean) in deaths from infectious/parasitic diseases, column I. Interestingly, we find that for these internal causes, the results are not gender-specific. Men also experience a 0.0162 and 0.0281 reduction (7% and 10% relative to means) in mortality associated with infectious and parasitic diseases and diseases linked to the respiratory system, respectively, after gaining access to a motorcycle.

The absence of substantial gender differences in mortality from diseases following access to individual mobility is perhaps unsurprising when considering the most plausible mechanisms linking transportation access to disease outcomes. Respiratory and infectious diseases spread most easily in crowded spaces (Xu, Connell McCluskey, and Cressman, 2013; Guo et al., 2023). Access to individual mobility allows individuals to avoid crowded public spaces such as public transit. This benefit should be available and equally important for both women and men.

The positive employment and income effects we document in Table 5 surely may also contribute to general health effects reducing mortality from internal factors due to a higher ability to invest in an individual's health. For example, higher income may positively affect health outcomes through better nutrition, improved access to information, or greater access to (higher quality) health care. Again, this effect, in principle, applies to both women and men. However, given that we find stronger labor market effects for women and that women may be the residual claimants on financial resources in a household (or more likely to use additional resources for investment in better health), it could explain why the benefits from access to individual mobility on mortality from internal causes are stronger for women.

Inspired by the results in Doornik et al. (2024), who document that access to individual mobility allows individuals to engage in a geographically broader job search, we examine whether individuals may not only exploit broader geographic access to increase labor income but also systematically transition to jobs with lower exposure to mortality risk. To do so, we construct occupation-specific health mortality rates based on the Brazilian Occupational Classification (Classificação Brasileira de Ocupações) at the 3-digit level. Specifically, for each combination of occupations and cause of death categories (ICD), we compute the mortality rates by measuring the number of deaths within a five-year period per 1,000 employees who were working in 2015.

Table 8 lists the occupations with the highest realized mortality risk for different categories. Overall, the occupations line up well with the overall occupational risk rankings in the United States (U.S. Bureau of Labor Statistics, 2023), although Brazil's occupational classification system is more granular and detailed. High-risk occupations in both the U.S. and Brazil include fishing, construction, and air transportation. Necropsy technicians and taxidermists represent the occupation with the highest mortality risk in Brazil.

With respect to internal factors, necropsy technicians and taxidermists experience the highest mortality risk (20 deaths per 1,000 workers over a five-year period) and appear consistently across multiple disease categories. Public interest organization directors and administrators also face significant mortality risk (12.6 deaths per 1,000 workers), with circulatory system diseases being a primary factor (4.0 deaths per 1,000 workers), potentially related to stress factors. The other top five high-risk occupations with respect to internal factors are technicians in air, maritime, and river navigation, mineral extraction and construction, and workers in protection and security services. For external factors, construction assistants show the highest mortality rate (6.9 deaths per 1,000 workers), followed by service workers, fishermen and hunters, and artisans in the steel and building materials industry (all 5.3 deaths per 1,000 workers), as well as workers of rail maneuvers and load handling (5.2 deaths per 1,000 workers).

Breaking down the data by disease-specific mortality patterns, we find that fishermen and hunters experience the highest mortality from infectious diseases (1.4 deaths per 1,000 workers), electromechanical professionals have the highest neoplasm-related mortality risk (5.1 deaths per 1,000 workers), and necropsy technicians show the highest circulatory system mortality risk (5.3 deaths per 1,000 workers). Air, maritime, and river navigation technicians appear vulnerable across multiple mortality categories, indicating they face diverse occupational health risks, possibly due to health effects related to frequent air travel and time zone changes.

The results from our analysis are shown in Table 9. The dependent variable is the occupational mortality risk for an individual's job. First, when splitting up exposure to mortality risk from external and internal causes in columns I and II, we do not find any evidence that workers sort into jobs with lower external hazards (column I), but we find strong evidence that women move out of occupations that expose them to health risks associated with internal factors (column II). In columns III to VIII, we split up the result by exposure to different internal mortality risk factors. With the exception of infectious and parasitic diseases (column III), we find that women move away from jobs associated with higher mortality risk for all other categories. In terms of economic magnitudes, the dominant risk categories that women seem to avoid are exposure to conditions leading to more neoplasms (cancer) and circulatory system problems (for example, stress). In contrast, for men, we do not observe any such re-optimization of job preferences with respect to mortality risk. While we can only speculate, the differences in sensitivity to exposure to mortality risk from internal factors across occupations for men and women may reflect differences in risk preferences, risk awareness, and demand functions when men and women evaluate employment choices.[22]

[22]These gender-specific effects provide an intriguing puzzle that warrants further investigation in future research.

The findings in Table 9 further align with the larger decline in mortality from internal causes observed for women in Table 2. There is, however, a slight disconnect linking job sorting and death from internal factors results in Tables 9 and 7, respectively. Our findings show that reduced female mortality is concentrated in infectious, parasitic, and respiratory diseases. However, women decrease their exposure to occupation-specific mortality risks across most internal factors. This apparent disconnect may be explained by timing: some exposures, such as those leading to neoplasms, might only result in fatalities over a longer timeframe than our study's duration allows us to observe after motorcycle access is obtained. For infectious and parasitic diseases specifically, access to individual mobility via motorcycles may enable women to avoid crowded spaces, reducing exposure to pathogens. This mechanism would explain our observation of substantial mortality reductions despite more modest effects on occupational sorting.

5.3 Discussion

To conclude our empirical analysis, we provide a brief discussion of the main policy implications of our findings, clarify the interpretation of the results, and discuss the limitations of the empirical setting.

Policy Implications The most direct insight from our paper is that facilitating women's access to individual mobility has important implications for reducing female mortality. In addition, our results suggest two main channels through which access to individual mobility reduces female mortality – women become less likely to be victims of fatal assaults and are less likely to die from infectious diseases and respiratory system problems. When considering the importance of the different channels in order to compare their effectiveness relative to alternative policies targeting the causes of female mortality, the fatal assault channel is clearly the most important one. Access to individual mobility reduces female mortality from fatal assaults by 57 percent relative to the mean. This suggests that facilitating access to individual mobility is a powerful policy tool to reduce fatal assaults against women. While in terms of absolute magnitudes, the health channel is similarly large, in relative terms, it reduces female mortality from internal health factors by only 8 percent relative to the mean. Thus, while also having an important impact, access to individual mobility may not be the most effective way for targeting female mortality from internal factors compared to alternative policy options.

There are many possible policy choices to facilitate access to individual mobility for women. In the setting we exploit, women obtain access to individual mobility through credit. There may be certain advantages of facilitating access to individual mobility for

women through credit. While facilitating access to individual mobility for women sidestepping the credit mechanism may yield comparable benefits, it has been documented in other settings that facilitating access to financial resources through credit yields higher benefits as selection into credit programs helps to reach the relevant population that benefits most. For example, Beaman et al. (2023) document that selecting individuals based on their willingness to access financial resources through credit can be a vital determinant of the success of policy interventions. Of course, based on our results, we cannot tell whether facilitating access to individual mobility through credit or other means, such as cash grants or direct provision of good, would yield different or the same benefits, but it is a distinction that is important to be aware of.

Our results are also interesting with respect to recent findings and discussions related to targeting women versus men when allocating credit in mid- or low-income countries. While targeting women used to be common practice for micro-credit, there is some evidence suggesting that such gender-specific targeting might be counterproductive with respect to fostering successful entrepreneurship (Karlan and Zinman, 2011). Our results suggest that when it comes to reducing mortality through access to individual mobility, targeting women may indeed be the right choice.

In order to compare the costs and benefits of providing women with access to individual mobility relative to other policy options, it may also be helpful to run a cost-benefit analysis. This is common in the health literature when evaluating the relative effectiveness of different interventions. For our setting, a cost-benefit analysis should compare the costs of investment in a motorcycle against the benefits of reducing mortality risk. Estimating the value of a life is complex and can be controversial. We simply follow the standard methodology used in the literature and estimate the Value of Statistical Life (VSL) in Brazil. Specifically, we follow Viscusi and Aldy (2003) by adjusting the US VSL of USD 6 million using a GDP per capita elasticity of 0.6. Given Brazil's GDP per capita of USD 11.2 thousand compared to the US's USD 48.6 thousand in 2010, we calculate Brazil's VSL at USD 2.48 million. Alternative methods provide a more conservative measure of VSL in Brazil (USD 1.695 million) (Viscusi and Masterman, 2017). Both measures provide us with a range of VSLs that we can compare to the costs of a motorcycle. Most VSL calculations tend to focus on individuals aged 35-40, which aligns with the average age of individuals in our sample fairly well.

We find that for our sample female mortality decreases by 0.15 percentage points after gaining access to a motorcycle (Table 2, column II). This reduction in mortality translates into an expected VSL saving between USD 2,542 and USD 3,720 per woman based on the VSL estimates described above. The average motorcycle cost in our sample is USD 2,837. Thus, purely from a VSL perspective, one can conclude that the expected benefits from a reduction in mortality risk are about the same as the costs of a motorcycle for women. While

our study examines an unsubsidized, self-sustaining, and market-based credit product that facilitates access to individual mobility, our findings and the insights from the cost-benefit analysis suggest that policies providing subsidized access to individual mobility might be an effective and cost-efficient public policy option.

Interpretation and Limitations As for all empirical evidence, our results are obtained by exploiting a specific institutional setting, which comes with costs and benefits. Consorcio participants in Brazil are a selected group of individuals. By revealed preferences, they believe that obtaining credit for investment in individual mobility will be beneficial for them, but are unable to invest in individual mobility because they are credit-constrained. Our estimates apply to this selected group, and the effects of providing access to individual mobility may differ for the general population. It is not clear whether this is necessarily a vice since individuals selecting into consorcio groups to purchase a motorcycle may be exactly the individuals a policy intervention would like to target if mortality benefits are greatest for them. The high participation rate in motorcycle consorcios in Brazil suggests that the combination of seeking to invest in individual mobility and credit constraints applies to a significant share of the population. In addition, in our setting, individuals obtain access to a motorcycle. Mortality effects may differ for other modes of individual transportation, such as bicycles or cars.[23] For example, we see an increase in fatalities from motorcycle accidents for men that offset other benefits. With a car, we may also see a net positive effect on mortality for men. These factors are important to consider when designing policy interventions.

We are fortunate that we have access to very detailed data on deaths, the causes, timing, and location, which allows us to identify the main channels through which access to individual mobility affects mortality. Nevertheless, some of our results are consistent with more than one channel, most notably the mortality from fatal domestic assaults channel. Detailed data on household dynamics and relative incomes would be helpful to understand the relative importance of the overall relaxation of household budget constraints or compared with improved intra-household bargaining power for women. Our data also does not provide information on the motives behind violent assaults or the relationship between the perpetrator and the victim. While somewhat beyond the scope of our analysis, more information about the nature of the assaults could further inform policy design, enabling interventions that address the root causes of fatal violence against women more effectively and prevent such incidents at their source.

[23]Unfortunately, the market for car consorcios is smaller than for motorcycles, as a result of which we are not able to run the same analysis for a rare event outcome such as mortality. In addition, a car is often not the first mode of transportation that provides individuals with access to individual mobility, but rather an upgrade.

While we view lower mortality from access to individual mobility through a health channel as less central compared with the fatal assault channel, it would still be valuable to better understand how exactly individual mobility affects health outcomes. Is avoiding infection risk in crowded spaces more important, or is the main effect a general health effect allowing for more investment in health? More detailed knowledge about health characteristics could reveal interesting interactions of the benefits of access to individual mobility and mortality from internal factors. For example, individuals with more vulnerable respiratory systems, who are more prone to serious complications from exposure to respiratory diseases, may benefit more from access to individual mobility.

6 Conclusion

In this paper, we document that access to individual mobility reduces female mortality by 16 percent through three channels. Specifically, access to individual mobility reduces female mortality from violent assaults in public, from fatal domestic violence, and through positive health effects (fewer deaths from infectious and respiratory diseases). The fact that we also observe lower hospitalization rates for women after gaining access to individual mobility suggests that the mortality results we report in this paper are only the most extreme manifestation of broader benefits to women's physical wellbeing as a result of access to individual mobility. For men, we find that access to a motorcycle has no net effect on mortality or hospitalizations. The reason is that while men exhibit slightly better health outcomes, they are more likely to die in accidents while riding a motorcycle. The assault channel is the most important one for women. The reduction in female mortality is larger for external factors in absolute terms (0.00725 pp vs. 0.00494 pp) and even more so in relative terms (57 percent vs 8 percent relative to the mean). Thus, the primary first-order channel through which access to mobility reduces female mortality is by reducing fatal assaults against women, in particular in public spaces in the evening hours.

These findings have important policy implications. The World Health Organization estimates that violent death is one of the top three causes of death for individuals between 15 and 60 years of age, explaining about 20 percent of deaths (World Health Organization, 2020). Globally, one in three women has experienced violence during their lifetime (World Health Organization, 2021), reaching up to 76% in Ethiopia and Peru (Garcia-Moreno et al., 2005). Violence against women has significant short-, medium- and long-term effects on the physical and mental well-being of women, children, and families, and serious social and economic consequences for society (Carlson, 2000; Huth-Bocks, Levendosky, and Semel, 2001; Campbell, 2002; Koenen et al., 2003; Aizer, 2011; Devries et al., 2013; Carrell and Hoekstra, 2010). Various policies, such as extra policing and better education, have been implemented

to address the issue (Ellsberg et al., 2015; Jewkes, Flood, and Lang, 2015; Michau et al., 2015), but we still lack understanding of the underlying social and economic determinants of violent deaths of women (García-Moreno et al., 2015; Angelucci and Heath, 2020; Blair and Jassal, 2022). Our findings suggest that facilitating access to individual mobility should be seriously considered as an important mechanism to protect women against violent and fatal assault.

While not the main focus of our study, we are intrigued by the gender-specific occupation sorting with respect to mortality risk after individuals obtain access to individual mobility. While women systematically move to occupations that expose them to lower mortality risk from internal factors (health risks), we do not observe any such behavior in men. We can only speculate whether this may be driven by different preferences in terms of job characteristics (risk vs. income) and different awareness of mortality risks across professions or other channels. This may be an interesting question to be examined in future research.

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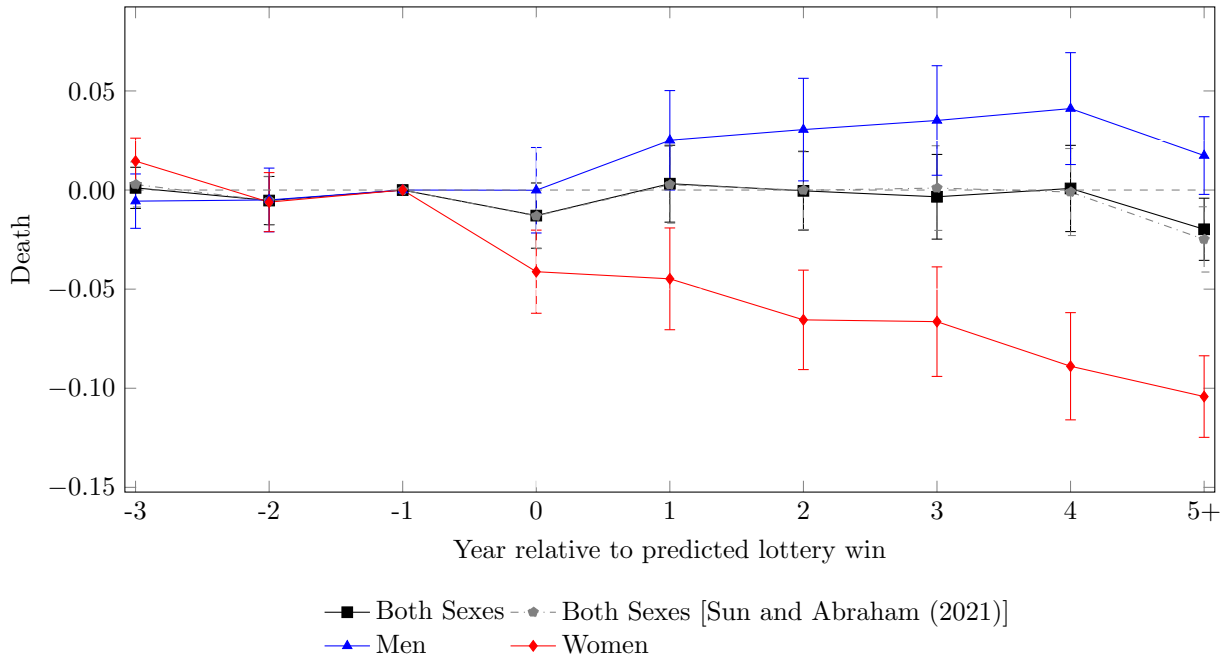
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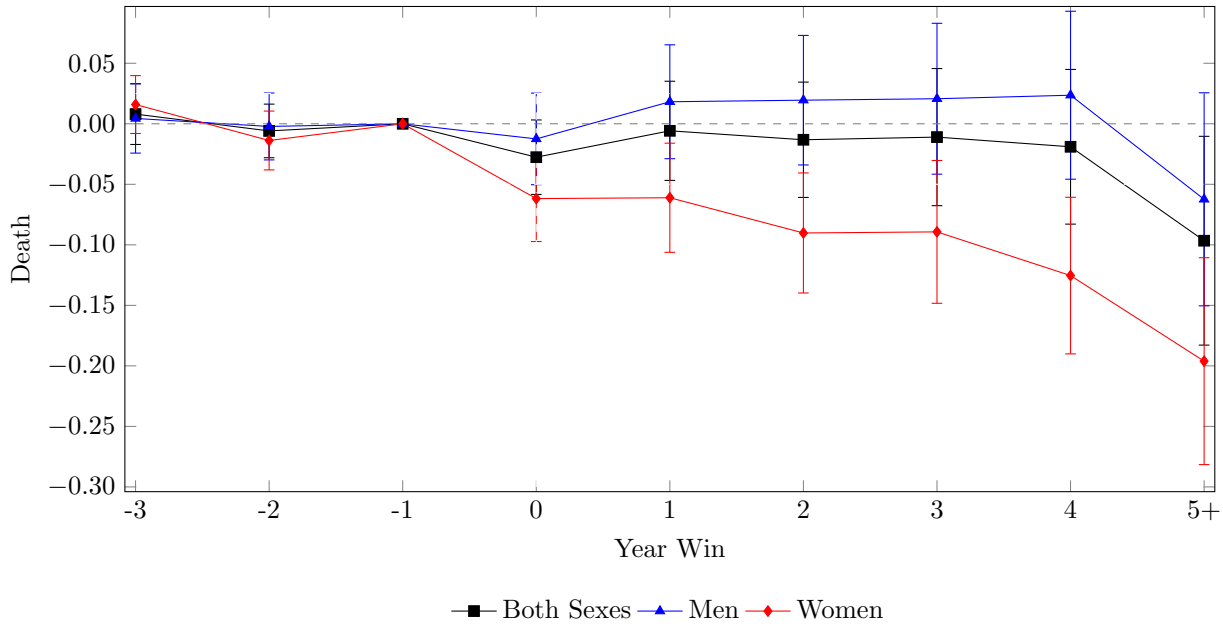
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Figure 1: **Access to Mobility and Mortality - Reduced-form Estimates**



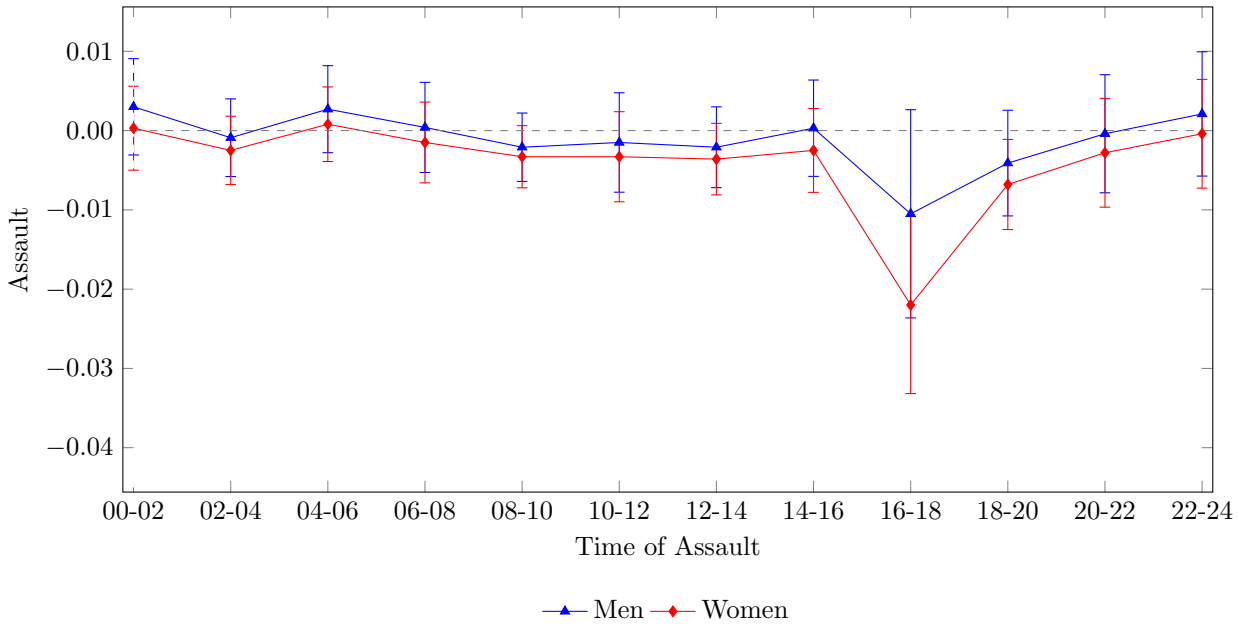
This figure depicts the estimates of the dynamic treatment effect from the reduced-form equation (4) with 95 percent confidence bounds. The values on the y axis are multiplied by 100. $Death_{it}$ is a dummy variable that equals one if individual i dies in year t and zero if individual i is alive. The black line depicts the estimates for both sexes, the gray line depicts the estimates for both sexes with the Sun and Abraham (2021) methodology, the blue and red lines depict the estimates for men and women, respectively.

Figure 2: **Access to Mobility and Mortality - IV Estimates**



This figure depicts the estimates of the dynamic treatment effect from the IV equation (5) with 95 percent confidence bounds. The values on the y axis are multiplied by 100. $Death_{it}$ is a dummy variable that equals one if individual i dies in year t and zero if individual i is alive. The black line depicts the estimates for both sexes, the blue and red lines depict the estimates for men and women, respectively.

Figure 3: **Timing of Assaults**



This figure depicts the estimates of the probability of assault by time from the IV equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$, with 95 percent confidence bounds. The values on the y axis are multiplied by 100. $Assault_{it}$ is a dummy variable that equals one if individual i dies in year t during the two-hour time intervals depicted on x axis and zero if individual i is alive. The blue and red lines depict the estimates for men and women, respectively.

Table 1: **Descriptive Statistics**

Panel A: Consorcios	Mean	Median	Std.	
Groups	15,339			
Members per group	61.82	50.00	39.09	
Duration (months)	41.84	36.00	17.80	
Number of individuals	948,201			
Panel B: Individual Characteristics (means)	**Overall**	**Male**	**Female**	**Working-Age**
Formal Employment Share	0.44	0.46	0.41	0.37
Salary	1,819	1,956	1,503	1,715
Age	35.94	36.03	35.76	36.59
Male	0.68			0.51
Death rate (per 1,000 ppl)	15.84	19.15	8.97	12.46
External cause	5.12	6.99	1.26	4.86
Internal cause	7.68	8.53	5.91	6.13

Panel A provides descriptive statistics on the number of consorcio groups, the number of members per group, the duration of the groups, and the number of individuals. Panel B depicts descriptive statistics for consorcio participants and the working-age population in Brazil.

Table 2: **Access to Mobility and Mortality**

	I	II	III	IV	V	VI
	Mortality Data				Hospitalization Data	
Dep. Var.:	$Death_{it}$		$External_{it}$	$Internal_{it}$	$Hospital_{it}$	$\#Visits_{it}$
Mean:	1.58%		0.51%	0.76%	1.37%	0.016
Panel A: First Stage win_{it}						
$win\ sim_{it}$	0.1434***					
	(0.0008)					
Panel B: Reduced-form						
$win\ sim_{it}$	-0.0083*					
	(0.0046)					
R^2	0.088					
Panel C: IV						
win_{it}	-0.0578*					
	(0.0317)					
$win_{it} * male_i$		-0.0250	0.0042	-0.0236	0.0189	0.0007
		(0.0324)	(0.0191)	(0.0227)	(0.1232)	(0.0019)
$win_{it} * female_i$		-0.1476***	-0.0725***	-0.0494**	-0.5254***	-0.0054***
		(0.0307)	(0.0169)	(0.0225)	(0.1401)	(0.0020)
R^2	0.088	0.088	0.093	0.087	0.122	0.124
F-stat		280,109			202,671	
Observations	17,952,710	17,952,710	17,952,710	17,952,710	13,226,727	13,226,727
Group-Time FE	yes	yes	yes	yes	yes	yes
Individual FE	yes	yes	yes	yes	yes	yes
Clustered SE	group	group	group	group	group	group

This table depicts the results from the first-stage estimation in equation (2) in Panel A, the reduced-form estimation in equation (3) in Panel B, and the IV estimates from equation (1) in Panel C. The dependent variable is a dummy variable that equals one if individual i dies (columns I and II), dies from an external cause (column III) or an internal cause (column IV) in year t and zero if individual i is alive. In columns V and VI, the dependent variables equal one if a person is admitted to a hospital and the number of hospital visits in year t and zero otherwise, respectively. The estimates, except column VI, are multiplied by 100. The variable win_{it} ($win\ sim_{it}$) takes the value of one from the year an individual wins (is predicted to win) a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: **External Causes of Death**

	I	II	III	IV	V
Dep. Var.:	Assault	Suicide	Accidents		Other External
			Traffic	Non-Traffic	Causes
Mean:	0.22%	0.03%	0.22%	0.02%	0.02%
$win_{it} * male_i$	-0.0141	-0.0021	0.0243*	-0.0015	-0.0024
	(0.0123)	(0.0046)	(0.0132)	(0.0027)	(0.0036)
$win_{it} * female_i$	-0.0488***	-0.0052	-0.0120	-0.0032	-0.0033
	(0.0108)	(0.0044)	(0.0115)	(0.0023)	(0.0035)
R^2	0.093	0.089	0.095	0.090	0.088
Observations	17,952,710	17,952,710	17,952,710	17,952,710	17,952,710
Group-Time FE	yes	yes	yes	yes	yes
Individual FE	yes	yes	yes	yes	yes
Clustered SE	group	group	group	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable is a dummy variable that equals one if individual i dies from an assault (column I), suicide (column II), traffic and non-traffic related accidents (columns III and IV), or another external cause (column IV) in year t and zero if individual i is alive. The estimates are multiplied by 100. The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: **Location of Fatal Assaults**

	I	II
	Location	
Dep. Var.:	Home	Public
Mean:	0.03%	0.20%
$win_{it} * male_i$	-0.0039	-0.0102
	(0.0038)	(0.0117)
$win_{it} * female_i$	-0.0070**	-0.0418***
	(0.0034)	(0.0103)
R^2	0.089	0.093
Observations	17,952,022	17,952,022
Group-Time FE	yes	yes
Individual FE	yes	yes
Clustered SE	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable is a dummy variable that equals one if individual i dies from an assault at home (column I) or in a public space (column II) in year t and zero if individual i is alive. The estimates are multiplied by 100. The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: **Labor Market Effects**

	I	II
Dep. Var.:	Employment	Earnings
Mean:	44%	1,819 BRL
$win_{it} * male_i$	0.0741***	0.0322***
	(0.0064)	(0.0075)
$win_{it} * female_i$	0.0913***	0.0705***
	(0.0065)	(0.0077)
R^2	0.567	0.883
Observations	17,952,710	7,527,933
Group-Time FE	yes	yes
Individual FE	yes	yes
Clustered SE	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable is a dummy variable that equals one if individual i is formally employed in year t and zero otherwise (column I) and log earnings from formal job in year t. The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6: **Traffic Accidents**

	I	II	III	IV	V
Dep. Var.:	Pedestrian	Bicycle	Motorcycle	Car	Heavy Transport
Mean:	0.01%	0.01%	0.10%	0.01%	0.01%
$win_{it} * male_i$	0.0015	0.0022	0.0180**	0.0027	0.0007
	(0.0034)	(0.0016)	(0.0091)	(0.0032)	(0.0022)
$win_{it} * female_i$	-0.0002	0.0012	0.0009	0.0007	0.0004
	(0.0031)	(0.0014)	(0.0078)	(0.0029)	(0.0022)
R^2	0.097	0.096	0.094	0.092	0.092
Observations	17,952,710	17,952,710	17,952,710	17,952,710	17,952,710
Group-Time FE	yes	yes	yes	yes	yes
Individual FE	yes	yes	yes	yes	yes
Clustered SE	group	group	group	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable is a dummy variable that equals one if individual i dies in a traffic accident as a pedestrian (column I), on a bicycle (column II), a motorcycle (column III), in a car (column IV), or another heavy transport such as a truck or a bus (column V) in year t and zero if individual i is alive. The estimates are multiplied by 100. The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7: **Internal Causes of Death**

	I	II	III	IV	V	VI
Dep. Var.:	Infectious and Parasitic Diseases	Neoplasms (incl. cancer)	Circulatory System	Respiratory System	Symptoms not elsewhere	Other Internal Causes
Mean:	0.19%	0.22%	0.34%	0.25%	0.28%	0.32%
$win_{it} * male_i$	-0.0162	-0.0144	0.0078	-0.0281**	-0.0030	-0.0047
	(0.0112)	(0.0121)	(0.0153)	(0.0122)	(0.0137)	(0.0146)
$win_{it} * female_i$	-0.0190*	-0.0080	-0.0163	-0.0345***	-0.0143	-0.0197
	(0.0112)	(0.0125)	(0.0147)	(0.0060)	(0.0135)	(0.0142)
R^2	0.087	0.086	0.086	0.088	0.086	0.087
Observations	17,952,710	17,952,710	17,952,710	17,952,710	17,952,710	17,952,710
Group-Time FE	yes	yes	yes	yes	yes	yes
Individual FE	yes	yes	yes	yes	yes	yes
Clustered SE	group	group	group	group	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable is a dummy variable that equals one if individual i dies in year t and zero if individual i is alive. The cause of death is listed at the top of the respective column, defined as any of the factors contributing to the death from internal causes: column I – infectious and parasitic diseases (ICD 01), column II – neoplasms benign (not cancer) and malignant (cancer) (ICD 02), column III – diseases of circulatory system (ICD 09), column IV – diseases of respiratory system (ICD 10), column V – symptoms not classified elsewhere (ICD 18), column VI – all other categories. The estimates are multiplied by 100. The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 8: **Occupational Mortality Rates**

Rank	Occupation (incl. 3-digit code)	Rate
Any death		
1	328 Necropsy technicians and taxidermists	23.1
2	341 Technicians in air, maritime and river navigation	16.2
3	631 Fishermen and hunters	15.5
4	717 Construction assistants	14.0
5	715 Construction and public works workers	14.0
External factors		
1	717 Construction assistants	6.9
2	519 Other workers in miscellaneous services	5.3
3	631 Fishermen and hunters	5.3
4	828 Artisan workers in the steel and building materials industry	5.3
5	783 Workers of rail maneuvers and load handling	5.2
Internal factors		
1	328 Necropsy technicians and taxidermists	20.0
2	114 Directors and administrators of public interest organizations	12.6
3	341 Technicians in air, maritime and river navigation	10.4
4	710 Mineral extraction and construction supervisors	10.0
5	517 Workers in protection and security services	8.6
Infectious and Parasitic Diseases (ICD 01)		
1	328 Necropsy technicians and taxidermists	3.2
2	631 Fishermen and hunters	1.4
3	777 Carpentry workers vehicle	0.9
4	830 Supervisors in the manufacture of pulp and paper	0.9
5	341 Technicians in air, maritime and river navigation	0.7
Neoplasms (ICD 02)		
1	202 Electromechanical professionals	5.1
2	328 Necropsy technicians and taxidermists	4.2
3	204 Criminal investigation professionals	3.8
4	271 Professionals in gastronomy and food services	3.6
5	791 Urban and rural artisan workers	3.6
Circulatory System (ICD 09)		
1	328 Necropsy technicians and taxidermists	5.3
2	114 Directors and administrators of public interest organizations	4.0
3	710 Mineral extraction and construction supervisors	3.7
4	271 Professionals in gastronomy and food services	3.0
5	517 Workers in protection and security services	3.0
Respiratory System (ICD 10)		
1	750 Supervisors in jewellery, glassware, ceramics and related products	1.6
2	341 Technicians in air, maritime and river navigation	1.1
3	631 Fishermen and hunters	1.0
4	777 Vehicular carpentry workers	0.9
5	822 Operators of facilities and equipment for the production of metals	0.7

This table presents occupational mortality rates based on the Classificação Brasileira de Ocupações (Brazilian Occupational Classification) at the 3-digit level. Mortality rates are calculated by measuring the number of deaths within a five-year period per 1,000 employees who were working in 2015.

Table 9: **Occupation Choices and Mortality Risk**

	I	II	III	IV	V	VI	VII	VIII
			Internal Factors					
Dep. Var.:	External	Internal	Infectious and Parasitic Diseases ICD 01	Neoplasms (incl. cancer) ICD 02	Circulatory System ICD 09	Respiratory System ICD 10	Symptoms not elsewhere ICD 18	Other Internal Causes
Mean: deaths per 1,000 ppl	2.36	5.02	0.39	1.44	1.51	0.37	0.32	2.49
$win_{it} * male_i$	-0.0064	0.0140	0.0011	-0.0046	0.0204	-0.0019	0.0007	0.0186
	(0.0185)	(0.0333)	(0.0030)	(0.0099)	(0.0126)	(0.0036)	(0.0029)	(0.0189)
$win_{it} * female_i$	-0.0066	-0.1136***	-0.0006	-0.0333***	-0.0477***	-0.0098***	-0.0045*	-0.0654***
	(0.0169)	(0.0324)	(0.0029)	(0.0098)	(0.0121)	(0.0035)	(0.0027)	(0.0183)
R^2	0.80	0.75	0.69	0.69	0.74	0.68	0.74	0.75
Observations	7,398,329	7,398,329	7,398,329	7,398,329	7,398,329	7,398,329	7,398,329	7,398,329
Group-Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Individual FE	yes	yes	yes	yes	yes	yes	yes	yes
Clustered SE	group	group	group	group	group	group	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable measures the mortality risk – deaths per 1,000 people – of the occupation where individual i in year t is formally employed. The occupation risk measures the deaths per 1,000 workers in an occupation where the cause of death relates to external (column I), internal (column II), infectious and parasitic diseases (column III), neoplasms benign (not cancer) and malignant (cancer) (column IV), diseases of circulatory system (column V), diseases of respiratory system (column VI), symptoms not classified elsewhere (column VII), all other internal categories (column VIII). The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Online Appendix for

Escaping Death: Individual Mobility and Female Mortality

Bernardus van Doornik, David Schoenherr, Jānis Skrastiņš

Table A1: **Variable Definitions**

Variable	Definition
Death	Indicator variable of whether a person dies.
External	External cause of death: ICD chapters 19 to 22.
Assault	External cause of death, ICD Chapters 19 and 20, X85-Y09.
Suicide	External cause of death, ICD Chapter 20, X60-X84.
Traffic Accidents	External cause of death, ICD Chapter 20, V01-V99.
Pedestrian	External cause of death, ICD Chapter 20, V00-V09.
Bicycle	External cause of death, ICD Chapter 20, V10-V19.
Motorcycle	External cause of death, ICD Chapter 20, V20-V39.
Cars	External cause of death, ICD Chapter 20, V40-V49.
Heavy Transport	External cause of death, ICD Chapter 20, V50-V79.
Non-traffic Accidents	External cause of death, ICD Chapter 20, W00-X59.
Other External Causes	External causes not listed above.
Internal	Internal cause of death: ICD chapters 1 to 18.
Infectious and Parasitic Diseases	Internal cause of death, ICD Chapter 1.
Neoplasms	Internal cause of death, ICD Chapter 2.
Respiratory System	Internal cause of death, ICD Chapter 10.
Circulatory System	Internal cause of death, ICD Chapter 9.
Symptoms not Classified Elsewhere	Internal cause of death, ICD Chapter 18.
Other Internal Causes	Internal causes not listed above.

Variable definitions are based on International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), also available at `https://icd.who.int/browse10/2019/en`.

Table A2: **Internal Causes of Death: Main Cause**

	I	II	III	IV	V	VI
Dep. Var.:	Infectious and Parasitic Diseases	Neoplasms (incl. cancer)	Circulatory System	Respiratory System	Symptoms not elsewhere	Other Internal Causes
Mean:	0.05%	0.21%	0.26%	0.06%	0.05%	0.16%
$win_{it} * male_i$	-0.0028	-0.0120	0.0010	-0.0045	-0.0092	0.0039
	(0.0059)	(0.0121)	(0.0136)	(0.0062)	(0.0056)	(0.0114)
$win_{it} * female_i$	-0.0048	-0.0067	-0.0184	-0.0069	-0.0134**	0.0009
	(0.0058)	(0.0124)	(0.0131)	(0.0060)	(0.0052)	(0.0112)
R^2	0.087	0.086	0.086	0.088	0.086	0.086
Observations	17,952,710	17,952,710	17,952,710	17,952,710	17,952,710	17,952,710
Group-Time FE	yes	yes	yes	yes	yes	yes
Individual FE	yes	yes	yes	yes	yes	yes
Clustered SE	group	group	group	group	group	group

This table depicts the results from IV estimation in equation (1), where actual lottery outcomes win_{it} are instrumented with predicted lottery outcomes $win\ sim_{it}$. The Cragg-Donald Wald F-stat is 280,190. The dependent variable is a dummy variable that equals one if individual i dies in year t and zero if individual i is alive. The cause of death is listed at the top of the respective column, defined as the *main* factor contributing to the death from internal causes: column I – infectious and parasitic diseases (ICD 01), column II – neoplasms benign (not cancer) and malignant (cancer) (ICD 02), column III – diseases of circulatory system (ICD 09), column IV – diseases of respiratory system (ICD 10), column V – symptoms not classified elsewhere (ICD 18), column VI – all other categories. The estimates are multiplied by 100. The variable win_{it} takes the value of one from the year an individual wins a credit lottery and zero before. The variables $male_i$ and $female_i$ represent individual's sex. Standard errors are reported in parentheses. The bottom of the table provides information on fixed effects and the clustering of standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.