Driving While Hungry
The Effect of Fasting on Traffic Accidents

Ahmet Gulek∗

Abstract

I study the impact of hunger on traffic accidents by exploiting the fasting that is religiously mandated during the month of Ramadan. Identification comes from working hours not being adjusted during Ramadan in Turkey. I find that driving while fasting at rush hour is associated with a significant increase in road traffic accidents. Using existing survey evidence on fasting rates in Turkey, I conclude that hunger induced by fasting increases the probability of an accident by 25%, which is smaller than the effect of driving while intoxicated, but larger than the effect of mild sleep deprivation.

JEL Classification: I18, R41, Z12.

Keywords: Hunger; traffic accidents; fasting; Ramadan; religion

∗Gulek: PhD student in Economics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA (e-mail: agulek@mit.edu). I am grateful to Oguzhan Celebi, Cem Çakmakli, Edward Davenport, Cem Demiroglu, Amy Finkelstein, Jon Gruber, Umit Gurun, Adam Solomon, Uluc Sengil, Advik Shreekumar, Insan Tunali, Sevcan Yesiltas, Kamil Yilmaz, Mehmet Yorukoglu, participants in the MIT Public Finance lunch, and seminar participants at Koç University for helpful comments.
1 Introduction

Traffic accidents are the leading cause of death among those between five and twenty-nine years old globally (World Health Organization, 2018). The last half-century has witnessed an abundance of research on the dangers of driving impaired, leading to numerous policy changes. A famous example is the literature on alcohol-related accidents that caused changes in the minimum legal drinking age and blood alcohol concentration (BAC) limits. Despite this significant progress, both the magnitude and persistence of traffic accidents keep the research on impaired driving active and policy-relevant.

One understudied factor of impaired driving is hunger, which can reduce cognitive and physical performance (Gailliot et al., 2007; Benton, 1990; Pollitt et al., 1998). There are many reasons why people drive while hungry, including food insecurity, religious practice, and lifestyle choices. These causes are widespread. According to the UN, more than 700 million people were “exposed to severe levels of food insecurity” in 2018 (FAO et al., 2019). A substantial amount of hungry driving occurs by choice through fasting in various religions.\footnote{Examples include Ramadan in Islam; Lent in Christianity; Yom Kippur, Tisha B’av, Fast of Esther, Tzom Gedalia, the Seventeenth of Tamuz, and the Tenth of Tevet in Judaism.} Intermittent fasting was the most popular diet in 2018 in a survey by the International Food Information Council (Food Insight, 2018). Driving while hungry is prevalent, yet to the best of my knowledge, no paper has determined a causal link between driving ability and hunger. The primary contribution of this paper is to provide the first causal evidence that prolonged hunger increases a driver’s probability of having an accident conditional on driving.

To isolate an exogenous variation in hunger, I study the impact of Ramadan fasting on traffic accidents in Turkey.\footnote{Ramadan fasting is arguably the most prevalent voluntary case of hungry driving in the world. A vast majority of the 1.6 billion Muslims fast during the Ramadan month by abstaining from food and drinks from sunrise until sunset. According to a survey by the Pew Research Center, 93% of adult Muslims state that they fast during Ramadan (Pew research Center, 2012).} The primary challenge in determining fasting’s effect on driving ability is that fasting affects traffic accidents in two
opposing ways. On the one hand, malnutrition caused by fasting may lower the attention span, reflexes, physical and cognitive abilities of the drivers (which I denote as lowering driving ability), increasing the number of crashes. On the other hand, fatigue induced by fasting can make people less likely to drive, which can lower traffic density and the number of accidents. Inference on hunger’s causal effect on driving ability from observational data on accidents requires closing this second channel.

To surmount this challenge, I leverage the institutional feature that, in Turkey, working hours are not adjusted during Ramadan. This is key for identification as it turns rush hour into a quasi-experiment. People leaving work constitute the majority of the traffic during rush hour. The same people leave work at the same time during and outside of Ramadan, with the only change being that some are fasting. Consequently, any effect of fasting on the driving decision should not apply during the rush hour of working days. In fact, I use administrative data on traffic density in Istanbul from 2012–2018 to show that Ramadan lowers traffic density throughout the day but does not affect it during the rush hour (3–6 pm) on working days. I thus focus on accidents between 3–6 pm on working days.

Once the empirical setting is such that fasting can affect traffic accidents by changing only driving ability and not driving frequency, what remains is fundamentally an IV problem. The Ramadan month is the instrument that initiates the fasting treatment. Turkey uses the Gregorian calendar in all matters except for religious events, including the Ramadan month, which are determined according to the Lunar calendar. The Gregorian and Lunar calendar differences cause the dates of Ramadan to shift by 11 days in the Gregorian calendar every year, which identifies the reduced form effect of Ramadan. I document that the traffic accidents during the rush hour increase on average by 21% during the day of Qadr, a religiously important day that arguably features the most fasting in the Turkish population.\(^3\) Traffic accidents increase

\(^3\)In Islamic belief Laylat al-Qadr, the Night of Decree, is the night when the Quran was first revealed to the prophet Muhammad. The worship done in this one night is worth more than the worship done in one thousand months in Islam. The exact date of Qadr is unclear, but Sunni Muslims in Turkey celebrate Qadr on the 27th night of Ramadan (Yusuf, 2009).
significantly during the other Ramadan days as well, albeit at lower rates as fewer people fast. Using existing survey evidence to approximate the ratio of fasting drivers, I obtain a Wald estimate of 25% for fasting’s effect on the accident probability conditional on driving.

I provide several additional analyses that support the conclusion that hunger induced by fasting causes the increase in accidents I document. First, I show that the additional increase in accidents during Qadr occurs only during working days (which isolate the impact of fasting) and not during vacations. This shows that potential Qadr-confounders (such as extra mosque attendance or social gatherings due to heightened religious atmosphere), which would be common to both vacations and working days, cannot explain the increase in accidents.

Second, I proxy for religiosity in each of the 81 provinces of Turkey using four different measures: the vote-share of the religious party AKP in the 2011 general elections, the vote share of the main secular opposition party CHP, the number of mosques per capita, and the percentage of alcohol-related accidents. All specifications point to the same conclusion: in more religious provinces where more people are likely fasting, there is an amplified reduced form effect of Ramadan.

Third, I show that a longer fast period amplifies the increase in accidents by exploiting an exogenous increase in the fasting period due to daylight saving time. Between 2000 and 2015, Turkey used two time zones: one for the summer and one for the winter. Clocks turned backward (forward) by one hour during the fall (spring) transition. In my sample, Ramadan overlapped with the fall transition twice, in 2004 and 2005, and never with the spring transition. As

---

4Turkey has a multi-party parliamentary system, where AKP and CHP are the two parties with the highest vote shares: 50% and 26% respectively.

5Alcohol consumption is prohibited in Islam, but not under Turkish law (Michalak and Trocki, 2006). Whereas religious Muslims in Turkey choose to abstain from alcoholic beverages, alcohol consumption is relatively common in Turkey (World Health Organization, 2019).

6The reason why I am using four different proxies is that none of them is an ideal predictor of fasting behavior. Each is a function of a number of variables, including religiosity. I explain these proxies in more detail in Section 6.1.
fasting periods are determined by the daylight and not by time zones, the fall transition causes an exogenous increase in the fasting period. For instance, on October 30, 2004, in Igdir (the easternmost province where the sun sets the earliest), Turkish citizens fasted from 4:59 am until 5:04 pm. On October 31, they fasted from 4:00 am until 4:02 pm. The total length of abstinence does not change, but the fasting time until the rush hour increases by one hour. Using days until/from the fall transition as the running variable, I employ a regression discontinuity design to show that the fall transition significantly increases the number of accidents between 2004 and 2005, when it coincides with Ramadan. Consistent with this increase being caused by the additional hour of abstinence from food and drinks, the fall transition has no impact on accidents between 2000–2003 and 2006–2015, when it does not coincide with Ramadan. Since the regression discontinuity design compares Ramadan observations before and after the time zone change, the observed discontinuity is independent of any potential Ramadan fixed effect that might otherwise cause bias. The only difference is attributable to an additional hour of fasting. Therefore, it provides strong evidence that fasting increases the probability of causing accidents.

Lastly, Ramadan fasting causes both hunger and dehydration. The generalizability of my results to other settings of hungry driving depends largely on how much dehydration affects driving ability. To test this channel, I use data on daily temperatures at the province level and show that the effect of Ramadan does not depend on the temperature. In other words, warmer weather, which arguably causes more dehydration during Ramadan, does not lead to more accidents. This evidence is also consistent with the medical literature, which shows that the levels of dehydration observed during Ramadan fasting are not associated with major changes in physical and cognitive functions (Maughan and Shirreffs, 2012). Therefore, I conclude that hunger is the main factor behind fasting’s causal effect on driving ability.

To determine the policy implications of my findings, I compare the 25% increase in crash probability due to fasting with other determinants of accidents that are regulated differently for commercial and noncommercial drivers,
mainly blood alcohol concentration and sleep deprivation. BAC is regulated for all drivers in almost all countries, but sleep is regulated only for commercial drivers in some countries (including the US). Voas et al. (2012) estimate that a BAC between 0.05 and 0.07 (which is legal in the US for noncommercial drivers, illegal in many European countries) increases the crash probability by a factor of 3 to 5 (similar estimates can be found in Levitt and Porter (2001)). Evidence for the causal effect of sleep deprivation on crash probability comes from the changing sleep duration due to daylight saving time. Using the American Time Use Survey, Barnes and Wagner (2009) find that Americans sleep 40 minutes less on average on the night of the spring transition to the daylight saving time. Smith (2016) finds a 5.6% increase in fatal crashes following the spring transition and employs tests to conclude that the sleep loss solely causes the increase. In comparison to the estimates in the literature, my findings suggest that fasting increases accident probability by far less than mild amounts of alcohol but more than mild sleep deprivation. Since the effect of sleep is seen to be significant enough to be regulated for commercial drivers, there seems to be some ground for regulation on the food intake of commercial drivers. However, whether this justifies public policy targeting is a normative question, which is beyond the scope of this paper.

This paper contributes to an extensive literature that investigates the determinants of traffic accidents. An important strand of this literature focuses on the effect of alcohol and alcohol-related policies on RTA (Moskowitz et al., 2000; Zador, 1991; Zador et al., 2000; Levitt and Porter, 2001; Voas et al., 2012). The 0.08 BAC limit in the United States has been shown to reduce traffic fatalities (Dee, 2001; Eisenberg, 2003). Another strand of the literature analyzes the impact of public policies on fatal traffic accidents. Examples of these policies include seatbelt laws (Cohen and Einav, 2003; Carpenter and Stehr, 2008), Graduated Licencing regulations (Dee et al., 2005), minimum legal drinking age (Dee, 1999; Dee and Evans, 2001; Lovenheim and Slemrod, 2010), zero-tolerance laws (Eisenberg, 2003; Carpenter, 2004), social host laws (Dills, 2010), and daylight saving time (Smith, 2016; Sood and Ghosh, 2007). I contribute to this literature by showing that hunger caused by fasting is a
significant determinant of traffic accidents. This is important for two reasons. First, fasting (and fasting drivers in particular) is already a topic of political discussion that lacked causal evidence (O’Grady, 2018). I answer both whether and by how much fasting impacts driving ability. My estimates can be used to guide policy discussions regarding fasting drivers. Second, Ramadan fasting is only a portion of aggregate hungry driving in the world. I provide empirical evidence that hunger is the main reason behind the increase in accidents I document. A testable out-of-sample prediction of my paper is that hunger induced by other religious/dietary fasting or food insecurity will increase the probability of causing accidents by similar amounts.

Most closely related to my work, several papers in the medical literature have analyzed how the frequency of traffic accidents change during Ramadan (Bener et al., 1992; Langford et al., 1994; Shanks et al., 1994; Khammassh and Al-Shouha, 2006; Tahir et al., 2013; Mehmood et al., 2015; Kalafat et al., 2016). However, data and methodological limitations result in their estimates to remain observational, not causal. My main contribution to this literature is disentangling fasting’s impact on driving ability (which is of general interest) from its effect on driving propensity (which depends on local norms and laws regarding working hours). For example, I document an aggregate decline in accidents during Ramadan but show that hunger induced by fasting actually increases the probability of causing accidents by 25% conditional on driving. The latter is the key parameter that can generalize to other instances of driving while hungry. Examples include commercial drivers for whom driving propensity is constant and many commuters driving to/from work for whom public transport is not a close substitute.

I also contribute to a growing literature on the relationship between religion and economic outcomes (see Iyer (2016) for a review). In particular, the effects of Ramadan fasting have received special attention in the last decade. Campaete and Yanagizawa-Drott (2015) document that more prolonged Ramadan fasting has a negative effect on output growth. Their findings are consistent with the recent micro evidence that fasting reduces labor productivity (Hu and
Several studies investigate how fasting during early pregnancy affects the fetus’ prenatal development, educational outcomes, and economic success (Almond and Mazumder, 2011; Van Ewijk, 2011; Majid, 2015; Almond et al., 2015). They find that individuals whose mothers fasted while pregnant have shorter lives, worse health, less cognitive skills, lower grades at school, and weaker labor market performance.

The rest of this paper is organized as follows: Section 2 provides background on Ramadan fasting, Section 3 describes the data, Section 4 explains the identification strategy, Section 5 presents the main results, Section 6 shows supporting evidence, Section 7 discusses the policy implications of the findings, Section 8 comments on limitations, and Section 9 concludes.

2 Background

Ramadan is the ninth month of the Islamic lunar calendar, during which Muslims fast by abstaining from food and drinks (including water) from dawn to sunset for 29 or 30 days, depending on the length of the lunar month. Pre-pubescent children, pregnant women, menstruating women, women who are post-childbirth or breastfeeding, travelers on long journeys, and people with physical or mental illnesses are exempt from Ramadan fasting. The daily routine of Ramadan involves a pre-dawn breakfast (suhoor) and a meal at sunset (iftar).

There are no official statistics about the percentage of drivers who fast in Turkey, and the estimates regarding the fasting rate of the adult population vary across surveys. According to a survey conducted by the Pew Research Center in 2012, 84% of the Muslims in Turkey fast during Ramadan. The Religious Life Survey conducted in 2014 by the Turkish Statistical Institute

---

7Hu and Wang (2019) use high-frequency administrative data from a large retail chain in Indonesia to show that nutrition deficiency due to fasting lowers the productivity of salespersons by 30%. Demiroglu et al. (2021) demonstrate that small business loans originated during Ramadan have higher default rates conditional on the risk type. Consistent with fasting-induced judgement errors committed by individual loan officers, they do not find similar effects on personal loans, which are mostly automated, and large business loans where credit committees make the final decision.
(TUIK) on behalf of the Presidency of Religious Affairs found that 83.4% of the 37,624 households interviewed performed fasting. In 2018, the Lifestyle Survey of Konda, a local survey company, found that 65% of the surveyed population performed fasting. However, it is not clear whether households who stated that they fast during Ramadan fast for the entirety of the Ramadan month. There is anecdotal evidence that substantially more fasting occurs on special occasions like the the day of Qadr. I exploit this aspect as part of my identification strategy.

Avoiding traffic accidents often requires quick decision-making in complex environments and reflexes to perform those decisions instantly. Therefore, a driver’s cognitive, physical, and visuomotor skills are important determinants of crash probability. There are three ways by which Ramadan fasting can impair these attributes: malnutrition due to not eating, dehydration due to not drinking, and sleep deprivation due to changing mealtime. All three channels have been separately analyzed in the medical literature. Here, I summarize some of these findings.

Muslims abstain from food from sunrise to sunset during Ramadan. Consequently, Ramadan-fasting is associated with a decline in caloric intake (Husain et al., 1987; Mafauzy et al., 1990; Schofield, 2014). A meta-analysis documents that fasting during Ramadan results in significant weight loss in most Muslim countries (Sadeghirad et al., 2014). Besides the aggregate decline in caloric intake, abstinence during the day is also detrimental to physical performance (Waterhouse, 2010). Consistent with reduced caloric intake, Kul et al. (2014) document a decline in blood glucose levels during Ramadan. Blood glucose serves as a primary determinant of cognitive function (Alberts et al., 2014), so lessened blood glucose levels can impair cognitive performance (Gailliot et al., 2007; Benton, 1990; Pollitt et al., 1998).

Ramadan-fasting also requires abstinence from all drinks, including water, from sunrise until sunset. Several studies show that a loss of 2% or more of bodyweight due to water restriction, heat, and/or physical exertion can harm physical, visuomotor, psychomotor, and cognitive performance (see Grandjean and Grandjean (2007); Adan (2012) for reviews). However, in a review article
Leiper and Molla (2003) argue that “No detrimental effects on health have as yet been directly attributed to intermittent negative water balance at the levels that may be produced during Ramadan”. Therefore, it is unlikely that dehydration due to fasting (unless significant physical activity is undertaken) can impact the physical and cognitive functions of drivers.\footnote{I also provide empirical evidence that more dehydration does not lead to more accidents in Section 6.3.}

Ramadan also alters sleeping patterns due to changing eating habits (Roky et al., 2000, 2001), but there is not much evidence on how it affects the total amount slept. The limited evidence we have shows that people partially adapt by sleeping more during the day and less at night (Margolis and Reed, 2004; Bahammam, 2006). Moreover, changes in sleep patterns may depend on whether working hours are adjusted. To the best of my knowledge, there is not an extensive study of sleep patterns during Ramadan in a country where working hours are not adjusted.\footnote{Although I do not know the average amount of sleep lost during Ramadan in Turkey, the estimated effect of fasting on crash probability is significantly higher than existing estimates of the effects of sleep deprivation. I provide a more detailed explanation in section 7.}

Overall, the evidence from the medical literature suggests that the extent of dehydration and sleep loss associated with Ramadan fasting is highly unlikely to lead to major changes in driving ability. Consequently, the impact of fasting on driving ability can be interpreted as the causal effect of prolonged hunger.

## 3 Data

The main data for this study are provided by the Traffic Training and Research Department in Turkey. They provide daily records of traffic accidents that resulted in injury or death at the province level (81 provinces in total) for the period 2000–2018. During this period, there were 1,949,204 accidents that resulted in 3,279,067 injuries and 53,472 deaths. Table A.3 in the Appendix provides detailed summary statistics of the data.

I supplement this data with the records of Ramadan days in the Gregorian calendar; the timing of sunrise and sunset for each province-day observation.
in my dataset; and the maximum . To measure traffic patterns, I use density data for major roads in Istanbul. Istanbul Metropolitan Municipality started collecting this data in 2012, and provided me with an index that captures the overall traffic density at the beginning of each hour. This allows me to see how the traffic density changes throughout the day during Ramadan.

I supplement this data with the records of Ramadan days in the Gregorian calendar. I also include the timing of sunrise and sunset for each province-day observation in my dataset. To measure traffic patterns, I use density data for major roads in Istanbul. Istanbul Metropolitan Municipality started collecting this data in 2012, and provided me with an index that captures the overall traffic density at the beginning of each hour. This allows me to see how the traffic density changes throughout the day during Ramadan. I also acquired the daily maximum temperature in city centers from the Turkish State Meteorological Service (TSMS).

Exploiting Turkey’s constant working hours during Ramadan is a key part of my identification strategy, which requires determining the regular working days in a calendar year. A challenge in this regard is that the Ramadan month is followed by a nationwide “Ramadan holiday” that lasts for three and a half days. Sometimes the last few days of Ramadan stands in between a nine-day vacation. For instance, in 2015 the Ramadan vacation was set to occur from Tuesday afternoon until Friday. In such instances, sometimes the government declares the remaining one and half days a national holiday. Even if the government does not act, private companies often extend the holiday for their employees, or workers use their eligible vacation time. Consequently, the last two days of Ramadan may look like working days on paper, and be de facto a part of vacation during which more accidents occur because people are traveling to see their families. Not accounting for these instances would cause me to overestimate fasting’s effect. To avoid this bias, I define an “effective religious vacation” indicator that covers (1) the original dates of the religious vacations, (2) the dates when government extended the holidays, and (3) the

To the best of my knowledge, Istanbul is the only province that keeps records of traffic density data covering multiple years before 2018.
dates when similar conditions existed but the government did not extend the holidays. I then define a regular working day if it satisfies all of the following three criteria:

1. is a trading day according to the Central Bank of Turkey

2. is not a half-day working day

3. is not an effective religious vacation day

I provide more details in the Appendix section A.1.

4 Identification

An ideal experiment to investigate the effect of fasting on driving ability would be to select \( n \) people, randomly divide them into two groups, make one group fast, and make both the treatment and control groups drive similar distances in similar settings. The last part is the key since we want to focus solely on the effect on driving ability. For instance, if fasting causes people to change their driving frequency, then this would be a part of the fasting treatment that does not apply to commercial drivers for whom the amount of driving is not a choice variable, including bus and truck drivers.

My empirical setting is different from this experiment in two major ways. First, hunger induced by fasting can cause fatigue, which can discourage people from going out. If fewer trips occur during Ramadan, then there would be fewer accidents absent any affect on driving ability. The setting in Turkey allows me to overcome this obstacle, which is one of the main contributions of this paper. Second, traffic density may change during Ramadan for reasons other than fasting. For example, it is commonplace among Turks to dine together after sunset during Ramadan, even for people who do not fast. Since the dinner lasts longer to compensate for the lack of calories throughout the day, people spend a considerably longer time dining. Consequently, people who would have been driving absent Ramadan are dining instead. This can lower the traffic density, and the number of accidents, after sunset. Figure
1 shows the three mechanisms (including the effect on driving ability) that link Ramadan to traffic accidents. The reduced-form effect of Ramadan is a weighted average of these three channels, but I am only interested in the effect on driving ability. To isolate this channel, I employ empirical strategies to ensure that Ramadan does not affect the traffic density.

Figure 1: Mechanisms by which Ramadan affects RTAs

![Diagram showing the mechanisms by which Ramadan affects RTAs]

Note: (1) Malnutrition caused by fasting can lower driving ability. (2) Fatigue induced by fasting can discourage people from going out. (3) During Ramadan, traffic density declines substantially around sunset because of iftar (meal that opens fast after sunset).

The key to my identification strategy is the fact that Turkey is one of the few “Muslim” countries that do not adjust working hours during Ramadan. Because fasting workers still need to commute to and from their jobs, fatigue induced by fasting is less likely to affect traffic density in Turkey than in other Muslim countries.\(^\text{11}\) During rush hour, the same people are in traffic at the same time, regardless of Ramadan. To show that traffic density does not change during Ramadan, I use traffic density data from Istanbul.\(^\text{12}\) The local

\(^{11}\)In other words, fasting’s effect on crash probability can be identified in any country that does not change the working hours during Ramadan (e.g., all countries in the Americas and Europe). However, the noise in traffic accidents necessitates a strong first-stage for statistical power. Turkey provides an important balance as enough people fast to have sufficient power, and the effect of fasting on crash probability is identified since working hours are not adjusted.

\(^{12}\)Istanbul hosts 19% of Turkey’s population. To the best of my knowledge, Istanbul was the only province in Turkey that kept traffic density data going back more than one year.
government of Istanbul measures traffic density on major roads and creates an index that captures the average traffic density at the beginning of each hour. I run 24 separate regressions, one for each hour of the day, where I regress traffic density during hour \(h\) on an indicator of Ramadan and day of the week, month, year fixed effects. I run separate regressions for vacations and working days.\(^{13}\)

Figure 2 plots the 24 Ramadan coefficients that show the effect of Ramadan on traffic density throughout the day, during vacations and working days. Each blue error bar is the 95% confidence interval of the coefficient estimate of the Ramadan indicator. The rush hour between 3–6 pm is highlighted in green. The gray shaded area is the range of the timing of sunset in Istanbul during Ramadan since 2012. A few observations are striking. First, traffic density declines substantially during Ramadan, both during vacations and working days. This implies that some trips that would take place absent Ramadan disappear. Second, and most important for identification, Ramadan does not affect traffic density during the rush hours of working days. The observation that Ramadan significantly lowers traffic density between 3–6 pm during vacations but not during working-days is consistent with Turkey not changing the working hours during Ramadan. Since people are leaving work at similar times both during and outside of Ramadan, traffic density does not change between 3–6 pm.\(^{14}\) By focusing on the traffic accidents that occur between 3–6 pm I close the second channel: fasting no longer affects the driving frequency.

\(^{13}\)Vacations are the days that are not regular working days according to the criteria I introduced in the data section. Vacations include weekends, national holidays, effective religious holidays, and half-day working days. This is an important adjustment to ensure that Ramadan does not affect traffic density during working days. I provide more details in the Appendix Section A.

\(^{14}\)Interestingly, traffic density declines during the morning rush hour, even though work starts at the same time. I do not have a good explanation for this result. One potential reason is that people change their morning habits as they do not have breakfast. This can change the time people leave for work, or cause them to change their routes if they originally went to restaurants for a quick breakfast. Whatever the true reason for this phenomenon may be, it does not affect my estimates in the paper. Traffic density not changing during the afternoon rush hour is sufficient to isolate fasting's effect on driving ability through Ramadan observance.
Figure 2: Effect of Ramadan on traffic density in Istanbul between 2012-2018

(a) Working Days

(b) Vacations

Note: The error bars are the 95% confidence intervals of the 24 $\beta^h$ estimates of equation: $TI_d^h = \beta_0^h + \beta_1^h \text{Ramadan}_d + \beta_2^h \text{Day of the Week}_d + \beta_3^h \text{Month}_d + \beta_4^h \text{Year}_d + \delta^h \text{Religious Day}_d + \epsilon^h_d$, where $h$ is each hour-interval of the day, $TI_d^h$ denotes the traffic index on day $d$ and at hour $h$, and $\text{Religious Day}$ is an indicator for religious days outside of Ramadan. Data are from Istanbul since 2012. The left panel uses observations from working days only, and the right panel uses data from vacations only (vacations include all days that are not full working days). The rush hour between 3–6 pm are highlighted in green. The gray shaded area is the range of the timing of sunset in Istanbul during Ramadan since 2012. Traffic index ranges from 0 and 100. The decline in traffic around 8 pm occurs because of iftar (the meal at sunset that opens fasting), which takes place around 8 pm in Istanbul during summer time. This figure shows that during rush hour of working days, Ramadan does not impact the traffic density.

The last important observation from figure 2 is that traffic density declines substantially around sunset. This is the 3rd channel I introduced in figure 1. Even non-fasting people often alter their dining habits during Ramadan as dining at iftar is a cultural phenomenon. Since 2012, Ramadan has occurred mostly in the summer months when sunset is late. However, in the 2000s, Ramadan occurred during the Fall and Winter seasons when sunset happened as early as 3:45 pm. Figure 3 shows the range of sunset times during Ramadan across Turkey. Since 2009, sunset has always occurred after 6 pm. However, between 2000–2008 the timing of sunset can impact traffic accidents even during the rush hour. To avoid this bias, I restrict the sample to observations after 2009, during which sunset during Ramadan occurred always after 6 pm. In the Appendix section C, I show results using more conservative samples.
The results are very similar.

Figure 3: Range of sunset times during Ramadan across Turkey in different years

Note: Turkey has 81 provinces, and iftar (the meal at sunset that opens fasting) time is calculated in each province separately based on sunset. Each error bar shows the range of sunset timing (from earliest to latest) across Turkish provinces during the 30-day Ramadan period of that year.

Once I have isolated the causal link between Ramadan and traffic accidents where the only treatment is the hunger caused by fasting, the remaining problem is in spirit an IV problem: fasting is the treatment, and Ramadan is the instrument that initiates the treatment. Dividing the reduced form effect of Ramadan with an estimate of the first-stage, the ratio of fasting drivers, identifies the LATE of fasting on crash probability. The reduced form is identified by the differences between the Gregorian and Lunar calendars, which cause the dates of the Ramadan month to change by 11 days in the Gregorian calendar each year. Hence, an estimate of the fasting rate of drivers is sufficient for identification.

Despite the cultural importance of Ramadan in Turkey, we do not know much about the fasting practices of Turkish citizens, let alone commuters. There are surveys asking a representative sample of the population whether they fast during Ramadan, but they do not provide reliable data for two main
reasons. First, I am interested in the percentage of commuters who fast, who are a selected sample. Second, and more crucially, anecdotal evidence suggests that among people who perform fasting during Ramadan, many do not fast for the entire 30-day period. When asked an extensive-margin question about whether they fast during Ramadan, they are likely to say yes. This results in severe bias in the effective ratio of people who perform fasting on average. For example, if 100% of Turkish citizens fasted on average for 10 out of 30 days during Ramadan, the actual first-stage estimate would be 33%, whereas surveys would suggest a 100% fasting rate.

The intensive-margin adjustment to fasting, together with commuters being an unrepresentative sample of the population, makes it difficult to infer the ratio of fasting drivers on a regular Ramadan day from the existing survey evidence. To make progress on the first-stage, I make assumptions that, if anything, overestimate the actual fasting rate and therefore underestimate the effect of fasting. These assumptions are:

1. Anyone who fasts for at least one day during Ramadan would answer "yes" to an extensive margin question about fasting.

2. Anyone who fasts for at least one day during Ramadan fasts during the day of Qadr.

3. The fasting rate in the commuter population is the same as in the general public.

---

15 Car ownership is less common in Turkey than in the rest of the OECD countries. For instance, there were 14 cars per 100 people in Turkey in 2016, whereas the EU average was 51 (euronews, 2019).

16 This problem could be avoided if the empirical setting was a country where almost everyone fasted. However, these countries often adjust working hours during Ramadan, which prevents identification. Examples of these countries include United Arab Emirates, Saudi Arabia, Kuwait, Bahrain, Oman, Qatar, Indonesia, and Egypt (PwC, 2019; Egypt Today, 2011; Emerhub, 2019).

17 Even if such a survey on the commuters was conducted, people could over-report their actual fasting rates due to social desirability bias.

18 Since fasting’s effect on driving may have important political consequences as I argued in the introduction, I take extra caution not to provide a false positive result, or overstate the actual risk associated with fasting.
Assumption 1 allows me to interpret the 84% fasting rate found in the surveys as the percentage of people fasting for \textit{at least one day} during the 30-day Ramadan period. Considering the social desirability bias of fasting in Turkey, this may overstate the fasting rate. Assumption 2 relies on the observation that people choose the days they fast according to cultural and religious beliefs. Anecdotal evidence suggests that the day of Qadr initiates the most fasting in the Turkish population, which is why I employ this assumption. This is a conservative assumption that likely overestimates the first-stage. For example, a person who regularly fasts but happens to not fast during Qadr because of any reason (e.g., work, travel, sickness, etc.) is assumed to be fasting during Qadr. The third assumption is necessary to obtain a first-stage estimate in the commuter population. Given these assumptions, I deduce that 84% of drivers fast during Qadr and divide the reduced form effect by 0.84 to calculate the LATE.

Having set the identification strategy, I define the main regression equation as:

$$
\log(\mathbb{E}(RTA_{15:00-18:00})) = \beta_0 + \beta_1 \text{Ramadan}_d + \beta_2 \text{Qadr}_d + \Gamma W_d \\
\gamma_1 = (\exp(\beta_1) - 1) \times 100 \\
\gamma_2 = (\exp(\beta_1 + \beta_2) - 1) \times 100 \\
\text{LATE} = \frac{\gamma_2}{0.84}
$$

where $RTA_d$ is the number of crashes between 3–6 pm of day $d$, Ramadan$_d$ and Qadr$_d$ are indicators that equal to one if day $d$ is during Ramadan or Qadr, $\gamma_i, i \in \{1, 2\}$ is the transformed version of $\beta_i$ that allows for a percentage-wise interpretation, $W$ include day of the week, month, year, and religious day fixed effects. In this specification, since the only difference between Qadr and regular Ramadan days is that more people fast during Qadr, $\frac{\gamma_2}{\gamma_1}$ provides an estimate of how many times more drivers fast during Qadr than during regular Ramadan days.

In the main text I estimate this equation using Poisson regression. For the rest of the paper, I denote fasting’s effect on crash probability via changing
driving ability simply as *fasting’s effect*. When I refer to fasting’s effect on driving frequency, I write it explicitly.

5 Main Results

I estimate equation 1 using the number of accidents in Turkey between 3–6 pm, with the sample restricted to working days between 2009–2018, both with and without an indicator for Qadr. The results are shown in Figure 4. In the first column, I plot the increase during Ramadan without an indicator for Qadr. The number of accidents increases by around 4% during Ramadan in Turkey, and the effect is statistically significant. I then introduce an indicator for the day of Qadr and plot the estimates of $\gamma_1$ and $\gamma_2$ (the increase in accidents during Ramadan and Qadr) in the second and third columns of Figure 4. The results are striking. The number of accidents increases by around 3% during a regular Ramadan day, which is not much different from the average Ramadan effect. However, the number of crashes increases by 21% during the day of Qadr. Monte-Carlo estimates suggest that around 6 times more people fast during Qadr compared to a regular Ramadan-day (the 95% confidence interval cannot rule out around 2.4 times as many people fasting during Qadr). Assuming that the 84% of the driver population fasts during Qadr, which is almost surely an overestimate as I elaborated in the identification section, I conclude that fasting increases the crash probability by 25% conditional on driving.

I perform several robustness checks to ensure that the increase in accidents during Qadr is caused by more people fasting and not by other confounders. First, I showed Ramadan’s null effect on traffic density only in Istanbul, but used the reduced form evidence from Turkey. This is to improve the external validity of my results, as evidence from one province may not generalize as easily as evidence from a country. Nonetheless, I provide the results using accidents from Istanbul in Figure C.2 in the Appendix. In Istanbul, RTAs increase by 10% during a regular Ramadan day, and by more than 40% during Qadr. The estimates from Istanbul have larger confidence intervals than the
Figure 4: Reduced-form effect of Ramadan on crashes

Note: In the first column, the regression model is: $\log(\mathbb{E}(RTA_{h}^{d})) = \beta_{0}^{h} + \beta_{1}^{h}\text{Ramadan}_{d} + \Gamma^{h}W_{d}$, where $\mathbb{E}(RTA_{h}^{d})$ is the expected number of accidents in Turkey on day $d$ and hour interval 3–6 pm. $W$ includes day of the week, month, year fixed effects, and religious-day indicators that control for religious occasions other than Ramadan (more details available in the Appendix Section A). Sample is restricted to working days. The equation is estimated using Poisson regression. The 95% confidence interval of $\gamma = (exp(\beta_{1}) - 1) \times 100$ estimate is plotted, where the standard errors are calculated by the Delta method.

In the second and third columns, the regression equation is: $\log(\mathbb{E}(RTA_{h}^{d})) = \beta_{0}^{h} + \beta_{1}^{h}\text{Ramadan}_{d} + \beta_{2}^{h}\text{Qadr}_{d} + \Gamma^{h}W_{d}$, where Qadr$_{d}$ is an indicator that equals to one if day $d$ is the day of the Qadr night. $\gamma_{1} = exp(\beta_{1} - 1) \times 100$, $\gamma_{2} = (exp(\beta_{1} + \beta_{2}) - 1) \times 100$ estimates are plotted, where the standard errors are calculated by the Delta method.

estimates from Turkey, but all are statistically significant.

Second, one could be concerned that Qadr captures an accumulated fatigue effect as it takes later in the Ramadan month. To test this hypothesis, I include the first lead of Qadr to the regression equation, and plot the results in Figure C.3 in the Appendix. Both in Istanbul and in Turkey, there is not a significant change in accidents on the the day before Qadr. The additional effect starts on the day of Qadr. Therefore it is not an accumulated fatigue effect.

Third, as in many IV strategies, one potential concern is the exclusion restriction. Both Ramadan and Qadr are assumed to affect accidents only through initiating fasting. This assumption would be false if a Ramadan and/or Qadr fixed effect (e.g., increased social gatherings, mosque attendance
etc.) could also be a determinant of accidents. However, there are several empirical facts in the data that strongly suggest that the exclusion restriction holds. First, if the increase in social gatherings was causing the increase in accidents, then it would also increase the traffic density. Yet, as I showed in Figure 2, it does not. Second, the evidence on Qadr actually suggests that a Ramadan fixed effect cannot explain the results, as the most of the increase in accidents occurs during Qadr when more fasting occurs.

The only remaining concern is a Qadr fixed effect, that is some change in people’s behavior (only during Qadr) that causes the observed increase in accidents. For instance, it can be argued that the heightened spiritual environment during Qadr also increases social gatherings, which can lead to more accidents. To test this channel, I repeat the same analysis with sample restricted to vacations instead of working days. The idea is that, any fasting-unrelated Qadr fixed effect that creates accidents would also exist in vacations (e.g., if people go out to celebrate Qadr during working days, they would also go out to celebrate during vacations). In contrast, if more fasting is the main reason behind the increase in crashes during Qadr in working days, then this effect could disappear in vacations as fasting decreases people’s propensity of driving. In other words, under the null that a Qadr fixed effect is driving the increase in accidents, we would expect similar increases in accidents during working days and vacations.

I show the results in table 1. Column 1 shows the same results as Figure 4: when sample is restricted to working days there is a 2.9% increase in accidents during regular Ramadan days, and a 21.3% increase in accidents during Qadr. This additional increase in Qadr disappears when sample is restricted to vacations, as shown in column 2. There is a statistically significant 5% increase in accidents during regular Ramadan days. However, there is no significant change during Qadr. In fact, the estimated increase during Qadr is 2.7%, which is both statistically indistinguishable from zero, and much less than the 21.3% increase I document during working days. This evidence is also apparent in Istanbul. There is a statistically significant 47% increase in accidents during Qadr on working days, and an insignificant 0.07% increase
during vacations. This evidence clearly shows that cultural changes during Qadr (such as increased social gatherings) cannot explain the increase in accidents I document. Hence, I conclude that fasting increases the probability of causing accidents by 25%.
Table 1: The effect of Ramadan and Qadr during work-days and vacations

<table>
<thead>
<tr>
<th></th>
<th>Turkey Work-Day</th>
<th>Turkey Vacation</th>
<th>Istanbul Work-Day</th>
<th>Istanbul Vacation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramadan</td>
<td>2.94 (1.17)</td>
<td>5.37 (1.94)</td>
<td>8.21 (3.22)</td>
<td>3.26 (4.00)</td>
</tr>
<tr>
<td>Qadr</td>
<td>21.32 (3.70)</td>
<td>2.68 (8.27)</td>
<td>46.71 (11.98)</td>
<td>0.07 (17.47)</td>
</tr>
</tbody>
</table>

Note: The regression model is: \( \log(\mathbb{E}(RTA_{h,d})) = \beta_0 + \beta_1 \text{Ramadan}_d + \beta_2 \text{Qadr}_d + \Gamma_h W_d \), where \( \mathbb{E}(RTA_{h,d}) \) is the expected number of accidents in Turkey on day \( d \) and hour interval 3–6 pm. \( W \) includes day of the week, month, year fixed effects, and religious-day indicators that control for religious occasions other than Ramadan (more details available in the Appendix Section A). The equation is estimated using Poisson regression. In columns 1–2, all accidents in Turkey are counted; and in columns 3–4, all accidents in Istanbul are counted. In columns 1 and 3, the sample is restricted to working days between 2009–2018 as in the main text. In columns 2 and 4, sample is restricted to vacations. Since the Qadr observations during vacations are limited, I extend the sample to 2000–2018. This increases the Qadr observations during vacations from 3 to 5.

6 Supporting Evidence

6.1 Provincial heterogeneity in the treatment effect

There are 81 provinces in Turkey located in 7 regions. There is considerable heterogeneity among these provinces in terms of purchasing power, population, living standards, religiosity, etc. If the increase in RTAs during Ramadan was caused by fasting, then we would expect a higher increase in provinces where a higher percentage of people are fasting. Ideally, I would interact Ramadan indicator with the fasting rate in each province, but I do not have data on
fasting rates at the provincial level. Instead, I rely on proxies. I use two proxies that are positively correlated with the religiosity of provinces (which I denote as religiosity proxies), and two proxies that are negatively correlated with average religiosity (which I denote as secularism proxies). The religiosity proxies are the number of mosques per capita and the vote-share of the current ruling party AKP in the 2011 general elections. The secularism proxies are the vote share of the secular opposition party CHP, and the ratio of alcohol-related accidents.\footnote{All four proxies are noisy predictors of fasting rates. Political party vote shares depend on various factors, not only on the religious discourse. The number of mosques per capita is also a function of socio-economic status of the locals and geographical factors. Road conditions and police enforcement likely vary across provinces and are also determinants of alcohol-related accidents. However noisy, each proxy is directly related to religiosity. The strong Islamic rhetoric of AKP, and the secular origins of CHP make their vote shares correlated with religiosity. In more religious provinces the demand for mosques should be higher on average. Fewer alcohol consumption in religious provinces should lead to a lower ratio of alcohol-related accidents.} Given these four proxies, I estimate the following equation:

\[ \log(\mathbb{E}(RTA^{3-6pm}_{d,p})) = \beta_0 + \beta_1 \text{Ramadan}_d + \beta_2 \text{Ramadan}_d \ast \text{Proxy}_p + \Gamma W_{d,p} \] (2)

where \( p \) denotes the province, and \( W_{d,p} \) additionally includes province fixed effects. I use the standardized versions of each proxy for comparability across specifications. I rely on Ramadan observance instead of Qadr for statistical power. I plot the 95% confidence interval of \( \gamma_i = (\exp(\beta_i) - 1) \ast 100, i \in \{1, 2\} \) estimates using different proxies in Figure 5. Even though the proxies are likely capturing different aspects of religiosity/secularism, their coefficient estimates are very similar. The main takeaway is clear: in provinces where more people are likely fasting, we observe a higher increase in RTAs during Ramadan. Using my preferred specification (AKP vote share), we see that one standard deviation increase in the AKP vote share results in an 8% increase in the number of crashes during Ramadan between 3–6 pm. The effect is statistically significant at the 5% significance level.

The provincial heterogeneity in fasting rates also allows me to investigate how the marginal effect of a fasting driver changes with the aggregate fasting rate. This is especially important for the generalizability of my results. For
Figure 5: Differential effects of Ramadan

(a) Religiousness Proxies

(b) Secularism Proxies

Note: The regression equation is \( \log(\mathbb{E}(RTA_{d,p}^{3-6pm})) = \beta_0 + \beta_1 \text{Ramadan}_d + \beta_2 \text{Ramadan}_d \ast \text{Proxy}_p + \Gamma W_{d,p} \), where \( \log(\mathbb{E}(RTA_{d,p}^{3-6pm})) \) is the natural logarithm of the expected number of accidents on day \( d \) and province \( p \), and hour-interval 3-6 pm. 4 Proxy variables are used in separate regressions: AKP and CHP vote-shares in the 2011 elections, number of mosques per capita and the ratio of alcohol-related accidents. All proxies are standardized, so the \( \beta_2 \) coefficients are comparable across specifications. The equation is estimated using fixed effects Poisson regression. Standard errors are clustered at the province level. The 95% confidence interval of \( \gamma_i = (\exp(\beta_i) - 1) \ast 100, i \in \{1, 2\} \) estimates are plotted, where the standard errors are calculated by the Delta method. Sample restricted to working days between 2009–2018.

instance, if a certain level of hungry driving has to take place for hunger to make the the marginal driver more likely to cause accidents, then the estimates from Turkey where a large number of people fast during Ramadan would not be applicable to a country like US where hungry driving (due to religious, dietary and financial reasons) is less common. Definitive answers require more work in different settings. However, I can provide a framework for some extrapolation about fasting’s effect on the marginal driver by adding more structure to the relationship between different types of traffic accidents and fasting.

Intuitively, in accidents involving one vehicle, the only relevant parameter is a driver’s own probability of causing an accident. Hence, fasting’s effect on the probability of causing a one-vehicle accident should not depend on whether other drivers also fast. This creates a linear relationship between the aggregate effect of Ramadan (on one-vehicle accidents) and the fasting rate. However, in two-vehicle accidents, the probability that one driver is involved in such a crash
depends on the ability of other drivers. If one driver’s mistake is sufficient to cause a two-vehicle accident (which is an assumption used by Levitt and Porter (2001)), an additional fasting driver’s aggregate effect would be decreasing in the driver population’s fasting rate. To see this, let two drivers interact while driving. The probability of one driver causing an accident matters only in the state when the other driver does not make a mistake. As the fasting ratio in the population increases, the probability of other drivers making mistakes increase, hence the aggregate effect of the marginal driver who decides to fast declines. This would create a concave relationship between the increase in accidents during Ramadan and the fasting rate in the population. In Appendix Section B, I formalize this intuition in a simple model.20

To test this intuition, I count the number of one-vehicle accidents and two-vehicle accidents between 3–6 pm. Then, I estimate the following equation:

\[
\log(\mathbb{E}(RTA_{d,p}^{k,3-6 \text{pm}})) = \beta_0^k + \beta_1^k \text{Ramadan}_d + \beta_2^k \text{Ramadan}_d \ast \text{Proxy}_p + \beta_3^k \text{Ramadan}_d \ast \text{Proxy}_p^2 + \Gamma W_{d,p} (3)
\]

where \( k \) denotes one-vehicle and two-vehicle accidents. In other words, I estimate equation 2 for one-vehicle and two-vehicle accidents separately, while also adding a squared proxy interaction. \( \gamma_i = (\exp(\beta_i) - 1) \ast 100 \) are plotted in Figure 6. I use AKP vote share as the preferred proxy. As predicted, Ramadan’s effect is linear in the AKP vote-share in one-vehicle accidents. The coefficient of the squared term is indistinguishable from zero. In contrast, the coefficient of the squared term in two-vehicle accidents is negative and statistically significant, implying a concave relationship between Ramadan’s reduced-form effect and the fasting rate.

This finding serves two purposes. First, it functions as an additional robustness check. The fact that Ramadan’s coefficient moves in ways consistent with the modeled effect of fasting supports my identification strategy. Second, from a policy perspective, it implies that a fasting driver’s marginal effect may

---

20I put the model in the Appendix because I think the intuition is straight-forward, and hence the marginal contribution of the model does not justify the space in the main text that I need to introduce the parameters.
Note: The regression equation is $\log(\mathbb{E}(RTA_{d,p}^{k,3−6pm})) = \beta_{0}^{k} + \beta_{1}^{k}\text{Ramadan}_{d} + \beta_{2}^{k}\text{Ramadan}_{d} \ast \text{Proxy}_{p} + \beta_{3}^{k}\text{Ramadan}_{d} \ast \text{Proxy}_{p}^{2} + \Gamma_{d,p}$, where $\log(\mathbb{E}(RTA_{d,p}^{k,3−6pm}))$ is the natural logarithm of the expected number of one-vehicle ($k=1$) or two-vehicle ($k=2$) accidents on day $d$ and province $p$, during the hour-interval 3–6 pm. The standardized AKP vote shares in the 2011 elections are used as a proxy for fasting rates. The equation is estimated using fixed effects Poisson regression. Standard errors are clustered at the province level. The 95% confidence interval of $\gamma_{i} = (\exp(\beta_{i}) − 1) \ast 100$, $i \in \{1, 2, 3\}$ estimates are plotted, where the standard errors are calculated by the Delta method. Sample is restricted to working days between 2009–2018.

be higher in countries with lower fasting rates.

### 6.2 Longer fast period causes more accidents

If hunger is causing a decline in driving ability due to fasting, then we would expect to see a larger increase in RTAs when the fasting period is longer. In this section, I exploit an exogenous increase in the fasting period caused by the change in time zones due to daylight saving time to investigate this effect. Between 2000–2015, Turkey used Eastern European Time during winter (UTC+02:00) and Easter European Summer Time (UTC+03:00) during summer.\(^{21}\) Clocks are turned backward (forward) by one hour during the

\(^{21}\)Turkey ended this practice in September 2016. It now uses only one time zone: UTC+03:00
fall (spring) transition. Between 2000–2018, Ramadan overlapped with the fall transition twice (in 2004 and 2005), and never with the spring transition. Since fasting periods are determined by the location of the Sun and not by time zones, the fall transition causes an exogenous increase in the fasting period. On October 30, 2004, in Igdir (the easternmost province where the sun sets earliest), people fasted from 4:59 am until 5:04 pm. On October 31, they fasted from 4:00 am until 4:02 pm. The total length of abstinence does not change, but fasting time until the rush hour increases. This is shown in Figure 7. In 2004, sunset occurred as early as 3:45 pm after the transition. To avoid bias from the effect of sunset, I focus on the time interval 14:30–15:30.

Figure 7: Time zone change and fasting period in Igdir, 2004

Note: The blue and red lines show the beginning and the end of the fasting period during Ramadan in 2004 in Igdir, the easternmost province of Turkey, where the fast ends the earliest. The fall transition from summer time zone into winter time zone on October 31st results in an increase in the length of fast until the rush hour begins. Since sunset occurs as early as 3:45 pm, I use the accidents between 14:30-15:30, which is shaded in green in the figure, as the dependent variable instead of the usual 3–6 pm definition I used throughout the paper.

To the best of my knowledge, the fall transition is not associated with

\footnote{It is worth emphasizing that this additional hour of abstinence lasts more than one day, unlike potential changes in sleep schedule.}
an increase in the number of crashes in other studies (Smith, 2016). However, even if the fall transition had a separate effect on accidents, the effect of an additional hour of fasting is still identified by the difference of the discontinuities between the fall transitions during 2004–2005, and during other times (e.g. 2000–2003, or 2006–2015). To investigate this effect, I utilize the following regression discontinuity design:

$$\ln RTA_{d,h}^s = \beta_0^s + \beta_1^s \text{FallT}_{d} + f^s(DaysTo\text{FallT}_{d})$$

$$+ f^s(DaysTo\text{FallT} \times \text{FallT}_{d}) + \epsilon_{d,h}^s \quad (4)$$

where I first demean RTAs with day of the week, month and year fixed effects to eliminate persistent seasonalities and time trends. DaysToFallT_{d} is the running variable; FallT_{d} is an indicator equal to one if day d falls after the fall transition. I estimate equation 4 using local-linear regressions and a triangular kernel, with 3 different time spans: 2000–2003, 2004–2005, and 2006–2015. Since the fall transition occurred during Ramadan only in 2004 and 2005, we would expect to find no effect between 2000-2003 and 2006-2015. I display my results in Figure 8. The fall transition has no effect on traffic accidents between 2000–2003 and 2006-2015, when the transition did not occur during Ramadan. In contrast, between 2004–2005 there is a substantial increase in RTAs due to the fall transition. The effect is significant at the conventional levels.23 The fact that the fall transition has a significant effect only when it coincides with Ramadan provides strong evidence that it is the extra hour of abstinence from food and drinks that is causing the increase in RTAs between 2004–2005. Since the RD design compares Ramadan observations before and after the time zone change, the observed effect is independent of any unknown confounders that may have driven the results in

23It is worth emphasizing that the test is under-powered as there are only two years where DST coincided with Ramadan, which is why the confidence interval is very large. Given this uncertainty, I would advise against taking the coefficient estimate of 0.3 at face value. Instead, I focus on the way RD estimates are practically zero both before (2000–2003) and after (2006-2015) the treated two-year period. It is only during the years 2004–2005 where DST affects RTAs, and this is exactly when it coincided with Ramadan and increased the length of abstinence.
the previous sections.

Figure 8: Effect of an additional hour of abstinence

Note: The regression equation is

$$\ln RTA_{d,h} = \beta_0 + \beta_1 \text{FallTran}_d + f(DaysToFallTran_d) + f(DaysToFallTran \times \text{FallTran}_d) + \epsilon_{d,h},$$

where I first demean RTAs with day of the week, month and year fixed effects. $DaysToFallTran_d$ is the running variable of the RD design, $\text{FallTran}_d$ is an indicator that equals to one if day $d$ falls after the fall transition. I estimate this equation using local-linear regressions and a triangular kernel, with three different time spans: 2000–2003, 2004–2005 (when the fall transition occurred during Ramadan), and 2006–2015. The 95% confidence interval of $\gamma = (exp(\beta_1) - 1) \times 100$ estimates using each sample period are plotted. The figure shows that the fall transition increases traffic accidents only when it coincides with Ramadan, during which it causes an increase in the fasting period.

6.3 Hunger is the main factor

Ramadan fasting involves abstinence from food and drinks. Since hunger and dehydration are joint treatments, the results thus far do not signal which treatment is the main factor of Ramadan fasting’s impact. This is important because various forms of hungry driving (e.g., voluntary fasting for other religious or dietary reasons) do not include abstinence from water. Hence, the generalizability of my results depends largely on how much dehydration impacts the causal effect of Ramadan fasting on driving ability.

In the background section, I explained that the medical literature points
to hunger as the most likely culprit. For instance, it is shown that decline in caloric intake and blood glucose from deprivation from food while fasting can impair cognitive function (Waterhouse, 2010; Iraki et al., 1997). In contrast, levels of dehydration found in Ramadan fasting are “unlikely to have a major adverse effect on any aspect of physical or cognitive performance” (Maughan and Shirreffs, 2012). Therefore, one can conclude that hunger induced by fasting is causing the increase in accidents I document.

This hypothesis is also empirically testable in my data. Levels of dehydration depend on the weather temperature. In warmer weathers, we would expect people to lose more water that they cannot replenish while fasting. Hence, if dehydration caused the increase in accidents, then we would expect to see an amplified Ramadan effect when the weather is warmer.

To test this hypothesis, I interact the Ramadan treatment with the maximum temperature observed in each province-day observation. The regression equation is:

$$
\log(1 + RTA_{d,p}^{3-6pm}) = \beta_0 + \beta_1 (\text{Ramadan}_d \ast \text{Temperature}_{p,d}) + \beta_2 \text{Temperature}_{p,d} + \theta (\text{Ramadan}_d \ast \text{Province}_p) + \Gamma W_{d,p} + \epsilon_{d,p}
$$

(5)

where $\text{Temperature}_{p,d}$ is the maximum temperature on day $d$ and in province $p$. $(\text{Ramadan}_d \ast \text{Province}_p)$ captures the average Ramadan effect in each province. This variable is added because fasting rates and temperature may be correlated across provinces. $\beta_1$ is the target parameter, which captures the impact of temperature on the reduced-form effect of Ramadan. The estimate of $\beta_1$ can be found in column 1 of Table 2. The coefficient estimate is -0.0011 (standard error 0.0009), which implies that a 1°C increase in the temperature decreases Ramadan’s impact by 0.1%. This effect is also statistically insignificant. Notice that the standard errors are small, so the null impact does not come from lack of power. I repeat the same analysis using data from Istanbul as a robustness check. The results (from log-linear OLS and Poisson specifications) can be found in columns 2–3. The coefficient estimates remain negative and
insignificant, although the confidence intervals become larger as the sample size decreases.

The data strongly suggest that heat does not play a sizable role in Ramadan’s effect. Therefore, I conclude that dehydration is not a major determinant of fasting’s impact on driving ability. In other words, hunger induced by fasting is causing the increase in accidents during Ramadan.

Table 2: Effect of temperature on Ramadan’s reduced-form impact

<table>
<thead>
<tr>
<th>Sample</th>
<th>Turkey</th>
<th>Istanbul</th>
<th>Istanbul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td>log(1+RTA)</td>
<td>log(1+RTA)</td>
<td>RTA</td>
</tr>
<tr>
<td>Estimation Method</td>
<td>OLS</td>
<td>OLS</td>
<td>Poisson</td>
</tr>
<tr>
<td>Ramadan*temperature</td>
<td>-0.0011</td>
<td>-0.0070</td>
<td>-0.0089</td>
</tr>
<tr>
<td></td>
<td>(0.0009)</td>
<td>(0.0092)</td>
<td>(0.0096)</td>
</tr>
<tr>
<td>N</td>
<td>200369</td>
<td>2484</td>
<td>2484</td>
</tr>
</tbody>
</table>

Note: In the first column, the regression equation is: \( \log(1 + RTA_{3-6pm}^{d,p}) = \beta_0 + \beta_1 (\text{Ramadan}_{d} \ast \text{Temperature}_{p,d}) + \beta_2 \text{Temperature}_{p,d} + \theta (\text{Ramadan}_{d} \ast \text{Province}_p) + \Gamma W_{d,p} + \epsilon_{d,p} \), where \( RTA_{3-6pm}^{d,p} \) is the number of accidents between 3–6 pm in province \( p \) and on day \( d \), Temperature\(_{p,d}\) is the maximum temperature (in Celsius) on day \( d \) and in province \( p \), (Ramadan\(_{d} \ast \text{Province}_p\)) captures the Ramadan effect in each province. This variable is added because fasting rates and temperature may be correlated across provinces. \( W \) includes day of the week, month, year, province fixed effects, and religious-day indicators that control for religious occasions other than Ramadan (more details available in the Appendix Section A). The dependent variable is in \( \log(1+y) \) format (unlike the Poisson regression used in the main text) because of convergence issues with many covariates. Standard errors are clustered at the province level.

In the second and third columns, sample is restricted to Istanbul. In the second column, the regression equation is: \( \log(1 + RTA_{3-6pm}^{d}) = \beta_0 + \beta_1 (\text{Ramadan}_{d} \ast \text{Temperature}_{d}) + \beta_2 \text{Temperature}_{d} + \theta \text{Ramadan}_{d} + \Gamma W_{d} + \epsilon_{d} \), where \( W \) includes the usual controls. The dependent variable is in \( \log(1+y) \) format, and the regression equation is estimated using OLS. Robust standard errors are in parenthesis. In the third column, the dependent variable is the count of accidents, and the equation is estimated using Poisson regression.
7 Public Policy Implications

This section lays the groundwork for future policy discussions by comparing the results of this paper with other determinants of traffic accidents that are subject to regulation. In particular, I contrast the effect of fasting with the effects of alcohol and sleep deprivation. These are good starting points because (1) they are known causes of accidents and (2) they are regulated differently. Drunk driving is a major cause of accidents and is regulated in almost all countries via blood alcohol concentration (BAC) limits. In contrast, there are no official sleep requirements for non-commercial drivers. However, there are regulations for commercial drivers to ensure that drivers get enough time to sleep and rest. For instance, truck drivers in the United States are allowed a period of 14 consecutive hours of driving up to 11 hours after being off duty for 10 or more consecutive hours (Federal Motor Carrier Safety Administration, 2011). There are specific rules about how long, in total and consecutively, drivers can work for in a week; and when and how much they should rest.\[24\]

Where does hunger stand compared to alcohol and sleep deprivation? There is plenty of evidence about alcohol’s effect on crash probability. Levitt and Porter (2001) estimate that drivers with nonzero BAC are 7 times more likely than sober drivers to cause an RTA, and legally drunk drivers 13 times more likely. Similar estimates can be found in Voas et al. (2012), where the authors find that having a BAC between 0.05–0.07 (legal BAC limit is 0.05 in most western European countries, 0.08 in the US) increases the crash probability by 3 to 5 times. Evidence for the effect of sleep deprivation on crash probability comes from Smith (2016) who finds a 5.6% increase in fatal crashes following the spring transition to daylight saving time. Smith (2016) employs further tests to conclude that the sleep loss solely causes the increase. Using Barnes and Wagner (2009)’s estimate that Americans sleep 40 minutes less on the night of the spring transition, a back of the envelope calculation shows that a one-hour decline in sleep is associated with an 8.4% increase in the likelihood

\[24\]Interested readers can visit the website of the Federal Motor Carrier Safety Administration, https://www.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations
of causing accidents. In contrast, I estimate that hunger induced by fasting increases the crash probability by 25%.

My estimates, combined with other results found in the literature, suggest that driving while hungry from fasting is far less dangerous than driving with moderate amounts of alcohol, around three times as dangerous as driving with one hour of less sleep, and probably as dangerous as driving with a substantial lack of sleep. Given these comparisons, there seems to be (1) no ground for universal regulation, and (2) some ground for regulation on commercial drivers. As the source of impaired driving is the decline in blood glucose induced by not eating, an optimal policy should target the food intake of drivers. However, the optimal form of this regulation depends on the social planner’s objective function, which is beyond the scope of this paper.

The length of deprivation from food during fasting (around 16 hours in my sample) is not necessarily longer than the length of deprivation from food poorer populations face in their daily lives. This paper adds little to the dangers of hunger in much of the developing world: worsened driving ability is not a first-order issue for the very poor. However, deprivation from food occurs also in the developed countries where feasible policies can make a difference. In the US it is well documented that SNAP households experience deprivation at the end of their benefit cycles (Carlson et al., 2019). For instance, Hamrick and Andrews (2016) document that SNAP participants become increasingly more likely to report a day with no eating over the benefit cycle. Taken at face value, my results indicate that such periods of deprivation can make these households significantly more likely to cause accidents. A policy recommendation from this paper would be to increase the frequency by which aid is provided, which could reduce the time spent in deprivation.

Lastly, from a religious perspective, Ramadan fasting is not mandatory for people who can be hurt by fasting, including the pregnant, the ill, and travelers. Taking into account the new evidence that fasting can cause significant injuries and deaths via traffic accidents, future research in religious studies may also

\[\text{25I am thankful to an anonymous referee for pointing this fact.}\]
\[\text{26I leave this as a testable prediction for future research.}\]
investigate the grounds for exemption for drivers. Commenting on the religious status of fasting drivers is beyond the scope of this paper.

8 Limitations

I estimate the effect of fasting on crash probability from essentially two steps: (1) focusing on the rush hour of working days to keep traffic density constant, and (2) relying on Qadr for a more reliable first-stage. Both steps rely on assumptions, which results in certain limitations. In this section, I discuss some of these limitations.

In the data, there is low take-up on non-Qadr Ramadan days that surveys cannot capture. This results in an upward-biased first-stage estimate from surveys, and hence in an underestimate of LATE. To circumvent this problem, I rely on the day of Qadr that generates the most fasting in the Turkish population. There is only one Qadr day a year, and hence the confidence interval of my estimates is larger. Moreover, reliance on a particular day generates concerns about unobserved confounders, i.e., channels other than fasting by which Qadr causes accidents. Whereas I provide falsification tests to show that such confounders are unlikely (e.g., Qadr has no effect on accidents during holidays), it still adds uncertainty that should be mentioned.

Working hours not changing during Ramadan is the core institutional detail behind my analysis. However, this rule primarily impacts the formal sector. Working hours may be adjusted in the informal sector, which can cause traffic density to decline in some regions in Turkey. This would lead to fewer accidents during Ramadan, and hence cause me to underestimate fasting’s effect. For instance, this can be why I find a higher increase (around 60% during Qadr) in Istanbul, where informal employment is lower, than in Turkey (around 22% during Qadr) where informal employment is higher.

Considering the possible biases, it is worth noting that, if anything, I am underestimating fasting’s effect, which is already larger than some factors that are regulated for commercial drivers, such as sleep deprivation.

One may be concerned about the specificity of the Turkish road structure
and how much it matters for the impact of fasting on accidents. Traffic accidents are complex, and modeling how road structure interacts with driving ability is beyond the scope of this paper. However, to address this issue, I provided some figures in Appendix Section D that show how Turkey compares to other OECD countries in terms of road density, traffic, and the number of road fatalities per vehicle, vehicle-km, and inhabitant. Turkey is similar to other OECD countries, with slightly more fatalities than the average. This shows that the specificity of road structure in Turkey should not be a concern for external validity.

9 Conclusion

Many people drive while hungry, but not much is known about its effects. This paper provides causal evidence, for the first time, that hunger induced by Ramadan fasting increases the probability of causing traffic accidents. Inference on fasting’s effect on driving ability is complicated because (1) fasting affects traffic accidents also through changing driving frequency, and (2) the Ramadan month, which initiates fasting, impacts traffic accidents also through changing traffic density. This creates three separate channels that link Ramadan observance to traffic accidents, and only the channel via changing driving ability is relevant for inference on hungry driving.

I propose several identification strategies to isolate the variation in RTAs that comes solely from fasting’s effect on driving ability. Key to the identification is the fact that Turkey does not adjust working hours during Ramadan. This turns the rush hour into a quasi-experiment because the same people leave work at the same time during and outside of Ramadan, with the only difference being that some are fasting. I estimate that fasting increases the crash probability by 25% conditional on driving. The effect is robust to various specifications. Ramadan has a stronger reduced-form effect (1) in provinces where more people are likely fasting and (2) when there is an exogenously longer fasting period due to daylight saving time. I also show that Ramadan’s effect does not depend on the outside temperature, which suggests that de-
hydration is not an important factor behind fasting’s causal effect on driving ability. This implies that hunger induced by fasting causes accidents.

To understand my findings’ policy implications, I compare fasting with drunk driving, which is regulated for all drivers, and with sleep deprivation, which is regulated only for commercial drivers. I find that driving while hungry is substantially less dangerous than drunk driving but more dangerous than driving with mild sleep deprivation. Consequently, it can be argued that commercial drivers’ blood glucose levels should be regulated.

Lastly, it is worth noting that there are already policies that target the month of Ramadan in many Muslim countries. Working hours are reduced during Ramadan in countries including United Arab Emirates, Saudi Arabia, Kuwait, Bahrain, Oman, Qatar, Indonesia, and Egypt (PwC, 2019; Egypt Today, 2011; Emerhub, 2019). Assuming that these policies are designed to address problems caused by the hunger induced by fasting, it is natural to ask what can or should be done about the problems caused by fasting (for religious or dietary reasons) in other countries where significant numbers of people fast.
References


41


A Data Appendix

A.1 Effective Religious Holidays

Ramadan month is followed by a nationwide Ramadan holiday that lasts for 3 days in general, with the last day of Ramadan month, arefe, being a half-day working day. Sometimes, this 3.5 day vacation occurs during the middle of the week (e.g. in 2015 the Ramadan vacation was set to occur from Tuesday afternoon to Friday). Since only a few working days remain in the way of a nine-day vacation, government sometimes declares the rest of the week an official holiday. This happened for the Ramadan holiday in 2008, and 2016. In 2003, similar conditions were present, but the vacation was not officially extended. However, it is possible that people take voluntary leave from their work to go on vacations, which would violate the assumption that the time people leave work does not change during Ramadan. To eliminate the bias that comes from people extending their holidays, I use an extended definition of religious vacations. The official dates of the Ramadan vacations, and my definition of the first and last effective days of these vacations, are given in Table A.1. The yellow color indicates the vacations that are officially extended by the government. The blue color indicates the extra extensions that I defined in my analysis to shield away from potential bias coming from people extending their holidays. It is worth noting that, absent this adjustment, I would overestimate fasting’s effect on crash probability because traffic accidents increase substantially during these long vacations.

I also make this adjustment for the Kurban holiday, as can be seen in Table A.2. The reason is that, the dates of Ramadan and Kurban holidays are determined according to the lunar calendar. Consequently, there is a deterministic relationship between the Ramadan dates and the Kurban holiday, during which there are substantially more accidents because more people are driving across the country to visit their families. By dropping the effective vacations due to the Kurban holiday, I eliminate this correlation and ensure that Ramadan dates are as if randomly assigned in the sample.

Figure A.5 shows how the control variables are selected, and their respective
effects on the relationship between Ramadan and traffic density. Dropping
vacations is the first step for identification since the rush hour of working
days provides the relevant quasi-experimental setting. The day of the week,
month and year fixed effects control for the seasonality in the traffic accidents
data. The reason why it substantially changes the estimates is that Ramadan
occurred mostly during the summer months since 2009. On average, during
the rush hour of summer months, the traffic density in Istanbul was lower.
The indicators for the day before the religious vacation starts, and for the two
days after the religious vacation ends control for potential irregularities caused
by the national vacations (e.g., increased traffic due to vacation preparations).

To show the empirical importance of restricting the analysis to the rush
hour, I estimate the reduced-form effect of Ramadan using different models,
and plot the estimates in Figure A.6. Counting all accidents during a day
and using the relevant control variables, we see that the number of accidents
declines by 10% during Ramadan. This is because the amount of driving
declines substantially during Ramadan. Only by focusing on the rush hour of
working days can we see the increase in accidents during Ramadan, which is
the result of fasting’s impact on driving ability.
Table A.1: Ramadan Vacations

<table>
<thead>
<tr>
<th>Arefe</th>
<th>first official</th>
<th>last official</th>
<th>effective first</th>
<th>effective last</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuesday, December 26, 2000</td>
<td>Wednesday, December 27, 2000</td>
<td>Friday, December 29, 2000</td>
<td>Saturday, December 23, 2000</td>
<td>Monday, January 1, 2001</td>
</tr>
<tr>
<td>Saturday, December 15, 2001</td>
<td>Wednesday, December 16, 2001</td>
<td>Tuesday, December 18, 2001</td>
<td>Saturday, December 15, 2001</td>
<td>Tuesday, December 18, 2001</td>
</tr>
<tr>
<td>Wednesday, December 4, 2002</td>
<td>Thursday, December 5, 2002</td>
<td>Saturday, December 7, 2002</td>
<td>Wednesday, December 4, 2002</td>
<td>Sunday, December 8, 2002</td>
</tr>
<tr>
<td>Saturday, November 13, 2004</td>
<td>Tuesday, November 14, 2004</td>
<td>Thursday, November 16, 2004</td>
<td>Saturday, November 13, 2004</td>
<td>Tuesday, November 16, 2004</td>
</tr>
<tr>
<td>Wednesday, November 2, 2005</td>
<td>Tuesday, November 3, 2005</td>
<td>Saturday, November 5, 2005</td>
<td>Saturday, October 29, 2005</td>
<td>Sunday, November 6, 2005</td>
</tr>
<tr>
<td>Sunday, October 22, 2006</td>
<td>Monday, October 23, 2006</td>
<td>Wednesday, October 25, 2006</td>
<td>Saturday, October 21, 2006</td>
<td>Wednesday, October 25, 2006</td>
</tr>
<tr>
<td>Thursday, October 11, 2007</td>
<td>Friday, October 12, 2007</td>
<td>Sunday, October 14, 2007</td>
<td>Thursday, October 11, 2007</td>
<td>Sunday, October 14, 2007</td>
</tr>
<tr>
<td>Monday, September 29, 2008</td>
<td>Tuesday, September 30, 2008</td>
<td>Thursday, October 2, 2008</td>
<td>Saturday, September 27, 2008</td>
<td>Sunday, October 5, 2008</td>
</tr>
<tr>
<td>Saturday, September 19, 2009</td>
<td>Tuesday, September 20, 2009</td>
<td>Tuesday, September 22, 2009</td>
<td>Saturday, September 19, 2009</td>
<td>Tuesday, September 22, 2009</td>
</tr>
<tr>
<td>Wednesday, September 8, 2010</td>
<td>Thursday, September 9, 2010</td>
<td>Saturday, September 11, 2010</td>
<td>Wednesday, September 8, 2010</td>
<td>Sunday, September 12, 2010</td>
</tr>
<tr>
<td>Saturday, August 18, 2012</td>
<td>Sunday, August 19, 2012</td>
<td>Tuesday, August 21, 2012</td>
<td>Saturday, August 18, 2012</td>
<td>Tuesday, August 21, 2012</td>
</tr>
<tr>
<td>Wednesday, August 7, 2013</td>
<td>Thursday, August 8, 2013</td>
<td>Saturday, August 10, 2013</td>
<td>Wednesday, August 7, 2013</td>
<td>Sunday, August 11, 2013</td>
</tr>
<tr>
<td>Saturday, June 24, 2017</td>
<td>Sunday, June 25, 2017</td>
<td>Tuesday, June 27, 2017</td>
<td>Saturday, June 24, 2017</td>
<td>Tuesday, June 27, 2017</td>
</tr>
<tr>
<td>Thursday, June 14, 2018</td>
<td>Friday, June 15, 2018</td>
<td>Sunday, June 17, 2018</td>
<td>Thursday, June 14, 2018</td>
<td>Sunday, June 17, 2018</td>
</tr>
</tbody>
</table>

Note 1: “Arefe” is the day before the religious vacation starts and is usually a half working day. Since half-working days violate the identifying assumption (no reason for traffic density to remain constant between 3–6 pm), I consider them as vacations. “First official” and “Last official” denotes the first and last days of the Ramadan holiday. Ramadan holiday lasts for 3.5 days in general, but is extended to cover the entire week by the government in certain years. Such extensions occurred in 2008 and 2016. If similar conditions existed in other years but the government did not extend the holiday, I still counted those dates as vacations as workers likely use their vacation time. Such extensions occurred in 2000, 2003, 2005, and 2011. “Effective first” and “Effective last” are the first and last days of the religious vacations under my definition. In the main text, I drop all observations that are between these two dates.

Note 2: It is worthwhile noting the additional dates I count as vacation have higher accident counts because people are more likely traveling more due to being on vacation. Not dropping such dates would cause me to overestimate fasting’s effect on crash probability.
Table A.2: Kurban Vacations

<table>
<thead>
<tr>
<th>Arefe</th>
<th>first</th>
<th>last</th>
<th>first-eff</th>
<th>last-eff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday, January 9, 2006</td>
<td>Tuesday, January 10, 2006</td>
<td>Friday, January 13, 2006</td>
<td>Saturday, January 7, 2006</td>
<td>Sunday, January 15, 2006</td>
</tr>
<tr>
<td>Thursday, November 26, 2009</td>
<td>Friday, November 27, 2009</td>
<td>Monday, November 30, 2009</td>
<td>Thursday, November 26, 2009</td>
<td>Monday, November 30, 2009</td>
</tr>
<tr>
<td>Monday, November 15, 2010</td>
<td>Tuesday, November 16, 2010</td>
<td>Friday, November 19, 2010</td>
<td>Saturday, November 13, 2010</td>
<td>Sunday, November 21, 2010</td>
</tr>
<tr>
<td>Saturday, November 5, 2011</td>
<td>Sunday, November 6, 2011</td>
<td>Wednesday, November 9, 2011</td>
<td>Saturday, November 5, 2011</td>
<td>Wednesday, November 9, 2011</td>
</tr>
<tr>
<td>Monday, October 14, 2013</td>
<td>Tuesday, October 15, 2013</td>
<td>Friday, October 18, 2013</td>
<td>Saturday, October 12, 2013</td>
<td>Sunday, October 20, 2013</td>
</tr>
<tr>
<td>Friday, October 3, 2014</td>
<td>Saturday, October 4, 2014</td>
<td>Tuesday, October 7, 2014</td>
<td>Friday, October 4, 2014</td>
<td>Tuesday, October 7, 2014</td>
</tr>
<tr>
<td>Tuesday, September 22, 2015</td>
<td>Wednesday, September 23, 2015</td>
<td>Saturday, September 26, 2015</td>
<td>Saturday, September 19, 2015</td>
<td>Sunday, September 27, 2015</td>
</tr>
<tr>
<td>Sunday, September 11, 2016</td>
<td>Monday, September 12, 2016</td>
<td>Thursday, September 15, 2016</td>
<td>Saturday, September 10, 2016</td>
<td>Sunday, September 18, 2016</td>
</tr>
<tr>
<td>Thursday, August 31, 2017</td>
<td>Friday, September 1, 2017</td>
<td>Monday, September 4, 2017</td>
<td>Saturday, August 26, 2017</td>
<td>Monday, September 4, 2017</td>
</tr>
<tr>
<td>Monday, August 20, 2018</td>
<td>Tuesday, August 21, 2018</td>
<td>Friday, August 24, 2018</td>
<td>Saturday, August 18, 2018</td>
<td>Sunday, August 26, 2018</td>
</tr>
</tbody>
</table>

Note 1: "Arefe" is the day before the religious vacation starts and is usually a half working day. Since half-working days violate the identifying assumption (no reason for traffic density to remain constant between 3-6 pm), I consider them as vacations. "First official" and "Last official" denotes the first and last days of the Kurban holiday. Kurban holiday lasts 4.5 days in general, but is sometimes extended to cover the entire week by the government. These extensions occurred in 2006, 2015, 2016, and 2017. If similar conditions existed in other years but the government did not extend the holiday, I still counted those dates as vacations as workers likely use their vacation time. This extension occurred in 2001. "Effective first" and "Effective last" are the first and last days of the religious vacations under my definition. In the main text, I drop all observations that are between these two dates.
Table A.3: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vacation</td>
<td>Work-Day</td>
</tr>
<tr>
<td></td>
<td>non-Ramadan</td>
<td>Ramadan</td>
</tr>
<tr>
<td>15:00-16:00</td>
<td>12.04</td>
<td>15.61</td>
</tr>
<tr>
<td>16:00-17:00</td>
<td>12.14</td>
<td>16.18</td>
</tr>
<tr>
<td>17:00-18:00</td>
<td>12.86</td>
<td>12.77</td>
</tr>
<tr>
<td>15:00-18:00</td>
<td>37.03</td>
<td>44.56</td>
</tr>
</tbody>
</table>

n | 953  | 87   | 2    | 2064 | 174  | 8    | 1064 | 89  | 3    | 2293 | 196   | 7    |

Note: The vacations include weekends, national and religious holidays, half working days, and certain days between the weekend before a religious holiday starts during which people are likely to use vacations to extend the holidays. Such dates are specified in figures A.1 and A.2.
Figure A.1: AKP vote percentage in 2011 elections (Standardized)

Figure A.2: CHP vote percentage in 2011 elections (Standardized)
Figure A.3: Percentage of Alcohol-related Accidents (standardized)

Figure A.4: Number of Mosques per capita (standardized)
Figure A.5: Effect of Ramadan on Traffic density with different controls

Note: The error bars are the 95% confidence intervals of the coefficient estimate of Ramadan. This figure shows how the model selection (sample selection and control variable selection) impacts the reduced-form effect of Ramadan on traffic density. Given the right set of controls and sample, Ramadan does not impact traffic density.
Figure A.6: Ramadan’s effect with different models

Note: The error bars are the 95% confidence intervals of the coefficient estimate of Ramadan. Sample is restricted to accidents between 2009 and 2018. The first three columns plot Ramadan’s effect in this equation: $RTA_d = \beta_0 + \beta_1 \text{Ramadan}_d + \theta W + \epsilon_d$, where $RTA_d$ is the number of all accidents on day $d$. In the first column simple OLS is run without any controls. In the second column indicators for the day of the week, month, year, religious vacations are added. The reason why coefficient changes sign is that since 2009, Ramadan occurred mostly during the summer months that have relatively more accidents due to seasonality. Controlling for seasonality via month fixed effects eliminates this bias, therefore the estimate in the second column can be read as the aggregate reduced-form effect of Ramadan. In the third column all vacations are dropped: i.e., sample is restricted to the working days. In the fourth column, $RTA_d$ (the number of accidents on day $d$) is replaced by $RTA_{d,15:00-18:00}$, the number of accidents on day $d$ between 3-6 pm. Consequently, the estimate in the fourth column is the first column of Figure 4 in the main text.
B Model

In this section, I introduce a simple model of traffic accidents and show that the marginal impact of a fasting driver can be stronger in places with lower fasting rates. At the heart of the model is a distinction between accidents involving only one vehicle and those involving two vehicles. Assuming that one driver’s fault is sufficient for a two-vehicle accident, the joint probability of both drivers making a mistake creates a nonlinearity between the number of accidents and the ratio of fasting drivers.

Denote by $\theta_1$ the probability of causing a one-vehicle accident, and by $\theta_2$ the probability of causing a two-vehicle accident without fasting. For simplicity, I abstract away from driving distance, fasting’s effect on the propensity to drive, and the fact that a driver cannot cause both a one-car accident and a two-vehicle accident. Moreover, I assume that fasting has the same effect on both probabilities in percentage terms, which I denote by $\gamma$. Thus, the probability of a driver $i$ causing a one-vehicle or two-vehicle accident is given by:

$$\theta_{ki} = \theta_k(1 + 1 \{R_i = 1\} \gamma), \quad k \in \{1, 2\},$$

where $R_i = 1$ if driver $i$ fasts.

First, consider one-vehicle accidents. Assume there are $N$ drivers, and $x$ ratio of drivers are fasting, $x \in [0, 1]$. The number of one-vehicle accidents is the sum of 2 binomial distributions with parameters $N(1-x), \theta_1$ and $Nx, \theta_1(1+\gamma)$. The expected number of one-vehicle accidents is given by

$$N(1-x)\theta_1 + Nx\theta_1(1 + \gamma) = N\theta_1(1 + x\gamma)$$

which is linear in $x$, the ratio of fasting drivers.

The two-vehicle accidents are slightly more complex as the mistake of either driver is assumed to be sufficient for an accident. Denote an interaction between two vehicles by $I$. Here, interaction can be interpreted as an opportunity for a two-vehicle accident. Given an interaction between drivers $i, j$,
the probability of an accident occurring is given by:

\[
Pr(A = 1|I, i, j) = \theta_{2i} + \theta_{2j} - \theta_{2i}\theta_{2j} \\
= 2\theta_2 + \theta_2\gamma(1\{R_i = 1\} + 1\{R_j = 1\}) \\
+ \theta^2_2(1 + \gamma(1\{R_i = 1\} + 1\{R_j = 1\}) + \gamma^2 1\{R_i = 1\}1\{R_j = 1\})
\]

Assuming that \(x\) ratio of drivers are fasting, and that fasting drivers and non-fasting drivers are equally mixed (i.e., they have the same relative likelihood of interacting with each other), the expected probability of an accident is given by:

\[
E(Pr(A = 1|I, i, j)) = \theta_2(2 - \theta_2) + 2\theta_2\gamma(1 - \theta_2)x - \theta^2_2\gamma^2x^2
\]

which is concave in \(x\). As two drivers interact, the probability of the former driver causing an accident matters only in the state when the other driver does not make a mistake. As the fasting ratio increases, the probability of other drivers making mistakes increases; hence the overall impact of the marginal driver who decides to fast declines.
C Additional Robustness Checks
Figure C.1: Reduced-form effect of Ramadan on crashes in different samples

Note 1: In the first column, the regression model is: $\log(\mathbb{E}(RTA_{d}^{h})) = \beta_{0}^{h} + \beta_{1}^{h}\text{Ramadan}_{d} + \Gamma^{h}W_{d}$, where $\mathbb{E}(RTA_{d}^{h})$ is the expected number of accidents in Turkey on day $d$ and hour interval 3–6 pm. $W$ includes day of the week, month, year fixed effects, and religious-day indicators that control for religious occasions other than Ramadan (more details available in the appendix). Sample is always restricted to working days. The equation is estimated using Poisson regression. The 95% confidence interval of $\gamma = (\exp(\beta_{1}) - 1) \times 100$ estimate is plotted, where the standard errors are calculated by the Delta method. In the second and third columns, the regression equation is: $\log(\mathbb{E}(RTA_{d}^{h})) = \beta_{0}^{h} + \beta_{1}^{h}\text{Ramadan}_{d} + \beta_{2}^{h}\text{Qadr}_{d} + \Gamma^{h}W_{d}$, where Qadr$_{d}$ is an indicator that equals to one if day $d$ is the day of the Qadr night. $\gamma_{1} = \exp(\beta_{1} - 1) \times 100$, $\gamma_{2} = (\exp(\beta_{1} + \beta_{2}) - 1) \times 100$ estimates are plotted, where the standard errors are calculated by the Delta method. Unlike in figure 4 of the main text, I use six different samples as shown in the legend. Timeseries and Panel denote whether I count the accidents in Turkey as a whole, or in each province separately. The estimates do not change in either method.

Note 2: In Istanbul the increase during Ramadan and Qadr is higher than the increase in Turkey, albeit less precise. This evidence would be consistent with the claim that in more rural provinces of Turkey with a less developed economy, working hours may adjust (for example in the informal sector), lowering traffic density and hence the accidents during Ramadan. This would imply that I underestimate fasting’s effect on crash probability.
Figure C.2: Reduced-form effect of Ramadan on crashes in Istanbul

Note: In the first column, the regression model is: $\log(\mathbb{E}(RTA^h_d)) = \beta_0^h + \beta_1^h \text{Ramadan}_d + \Gamma^h W_d$, where $\mathbb{E}(RTA^h_d)$ is the expected number of accidents in Turkey on day $d$ and hour interval 3–6 pm. $W$ includes day of the week, month, year fixed effects, and religious-day indicators that control for religious occasions other than Ramadan (more details available in the Appendix Section A). Sample is restricted to working days. The equation is estimated using Poisson regression. The 95% confidence interval of $\gamma = (exp(\beta_1) - 1) \cdot 100$ estimate is plotted, where the standard errors are calculated by the Delta method.

In the second and third columns, the regression equation is: $\log(\mathbb{E}(RTA^h_d)) = \beta_0^h + \beta_1^h \text{Ramadan}_d + \beta_2^h \text{Qadr}_d + \Gamma^h W_d$, where $\text{Qadr}_d$ is an indicator that equals to one if day $d$ is the day of the Qadr night. $\gamma_1 = exp(\beta_1 - 1) \cdot 100$, $\gamma_2 = (exp(\beta_1 + \beta_2) - 1) \cdot 100$ estimates are plotted, where the standard errors are calculated by the Delta method.
Figure C.3: Effects of regular Ramadan, the day before and of Qadr

(a) Turkey

(b) Istanbul

Note: The regression model is: $\log(E(RTA_{td})) = \beta_0 + \beta_1^{\text{Ramadan}} + \beta_2^{\text{L.Qadr}} + \beta_3^{\text{Qadr}} + \Gamma^W_d$, where $E(RTA_{td})$ is the expected number of accidents in Turkey on day $d$ and hour interval 3–6 pm. $L.$ is the lead operator ($L.$Qadr is the day before Qadr). $W$ includes day of the week, month, year fixed effects, and religious-day indicators that control for religious occasions other than Ramadan (more details available in the Appendix Section A). Sample is restricted to working days. The equation is estimated using Poisson regression. The 95% confidence interval of $\gamma_1 = \exp(\beta_1 - 1) \times 100$, $\gamma_i = (\exp(\beta_1 + \beta_i) - 1) \times 100$, $i \in \{2, 3\}$ estimates are plotted, where the standard errors are calculated by the Delta method.
D  Road Structure of Turkey

Figure D.1: Density of road

Note: Density of road, km per one hundred sq. km, 2017 values. Malta is left out of the graph as an outlier. If 2017 values were not present, the value from the most recent year was used. Source: OECD Stats/Transport/Performance Indicators/Indicators/Transport infrastructure/ Density of road

Figure D.2: Road traffic per road motor vehicle

Source: OECD Stats/Transport/Performance Indicators/Indicators/Traffic/Road traffic in thousand vehicle-km per road motor
Figure D.3: Road fatalities per one million vehicle-km

Source: OECD Stats/Transport/Performance Indicators/Indicators/Safety/Road fatalities per one million vehicle-km

Figure D.4: Road fatalities per one million vehicles

Source: OECD Stats/Transport/Performance Indicators/Indicators/Safety/Road fatalities per one million vehicles

Figure D.5: Road fatalities per one million inhabitants

Source: OECD Stats/Transport/Performance Indicators/Indicators/Safety/Road fatalities per one million inhabitants