CAN PUBLIC TRANSPORTATION REDUCE ACCIDENTS? EVIDENCE FROM THE INTRODUCTION OF LATE-NIGHT BUSES IN ISRAELI CITIES

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Can Public Transportation Reduce Accidents? Evidence from the Introduction of Late-Night Buses in Israeli Cities

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Abstract

The notion that public transportation can mitigate accidents has been widely claimed but to-date empirical evidence that supports this relationship in a causal manner is scarce. We present results from difference-in-differences (DID) and triple differences (DDD) frameworks that exploit the introduction of late-night buses (night buses) into cities in Israel beginning in 2007. Our preferred DDD estimation utilizes spatial, temporal, and time-of-day variation in estimating the effect of night bus frequencies on accident outcomes. The results show a reduction in accidents involving young drivers in response to night buses, on the order of magnitude of 37% in the mean metropolitan area served by night buses. Injuries resulting from these accidents also decrease by 24%. Our results are robust to alternative DDD estimations, which utilize variation in the day of the week that night buses operate. Overall, the results suggest that public transportation - and in particular late-night public transportation - can entail substantial benefits in terms of road accident reductions.

JEL Classifications: R41, R42, R51, R58, I12, K42. **Keywords:** Public Transportation, Accidents, Risky Behavior, Drunk Driving

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1 Introduction

Can greater public transportation decrease the incidence of car accidents? Most people would answer this question positively, as public transportation should decrease traffic congestion and hence car accidents.[1] Indeed, in recent years numerous research reports and coverage by the media have advocated the expansion of public transportation networks, in light of the potential this would have in reducing vehicle accidents.[2] However, empirical evidence showing a causal relationship between public transportation infrastructure and accidents hardly exists.

This paper provides empirical evidence of the effect of public transportation services on road accidents by exploiting the gradual introduction of late-night buses (night buses) in Israeli cities beginning in 2007. Until the introduction of night buses, public transportation services in Israel ceased to operate around midnight and some bus lines even earlier. In 2007, the Israeli Ministry of Transportation (MOT) initiated night buses in Jerusalem and a few of its surrounding towns, intending to provide the adolescent and young adult population safe and low-cost access to nightlife centers within the city. The feedback from the night buses in Jerusalem was extremely positive in terms of their usage and public support for them, and in response, the service was expanded to other metropolitan areas throughout Israel. By 2012, the number of bus lines operating as night buses throughout Israel increased tenfold,[3] and according to the MOT, by 2014 night buses were serving over 700,000 passengers annually.[4] As all bus services in Israel, night bus services are provided by private companies under the supervision of the Israeli MOT.

The empirical strategy utilizes both difference-in-differences (DID) and triple differences (DDD) frameworks. Two separate DID estimations exploit variation across metropolitan areas and over time in the introduction and intensity of night buses. Two separate DDD estimations utilize two additional sources of variation - either across the time of day, as night buses should not affect accident outcomes during daytime, or across the days of the week, as night buses should not effect accident outcomes on days of the week that the night buses do not operate. The DDD is advantageous over the DID, as it allows us to control for trends unique to each metropolitan area in terms of accident outcomes. Under the DDD specifications, a threat to identification would have to differentially affect night accidents, as opposed to day accidents, or accidents on days of the week that night buses operate, as opposed to days of the week that they do not, within each metropolitan and be correlated with the intensity of night accidents. It would be difficult to

[1] According to Vickrey (1968), every driver poses an accident externality, even if they are not at fault because if they were not on the road, the accident would not have occurred. Thus, decreased road congestion would reduce accidents. However, Vickrey (1968) also states that reduced road congestion can increase drivers' risk-taking. Furthermore, one can argue that if public transportation is in the form of buses or above-ground rail systems, this can increase the incidence of accidents, due to interruptions these modes of transportation cause to the flow of traffic. Buses can also increase the incidence of more severe accidents involving heavier vehicles of the like of buses (See such arguments regarding trucks in Muehlenbachs et al. (2017)).

[2] See Litman (2016a,b); Duduta et al. (2013), as well as an article in the Guardian from 2013 (https://www.theguardian.com/global-development/poverty-matters/2013/sep/03/bus-public-transport-road-deaths). In particular, Litman (2016a) shows negative correlations between the intensity of the public transit services and traffic fatalities for U.S. urban regions and international cities. Duduta et al. (2013) provide case studies of cities in India and Latin America that introduced more efficient public transit systems and increased their road safety.

[3] Source: http://www.ynet.co.il/articles/0,7340,L-4326652,00.html (in Hebrew)

[4] Source: http://www.ynet.co.il/articles/0,7340,L-4531474,00.html (in Hebrew)

conceive of a compelling story supporting such an identification threat. Thus, our results are robust to two alternative DDD specifications - each utilizing a different source of variation to construct a control group within treated metro areas.

Our analysis is confined solely to inner-city night buses and their effect on areas within an urban continuity. This is due to limitations on relating specific inter-city highways with inter-city night buses. Due to this, we are limited to accidents occurring within relatively confined metropolitan areas, which are less severe accidents. We thus cannot estimate the effect of public transportation on important measures such as traffic fatalities or critical injuries. We are nevertheless able to encompass in our analysis the effect on overall accidents and on injuries resulting from road accidents. Because night buses served almost exclusively the adolescent and young adult population, we only examine accidents that involved individuals aged 15-29. Lastly, as night buses are intended to serve the adolescent and young adult populations on outings, we limit our analysis to the busiest nights in terms of night bus usage, which are the weekend nights. Our focus on the young driver population and an weekend nights is consistent with evidence from Israel and internationally that young drivers are much more likely to be involved in road accidents and these occur primarily on weekend nights (OECD (2006); Lotan and Grimberg (2011)).

Our results show a statistically significant decrease in accidents in response to night buses. We estimate that the average weekend night bus treatment within a metropolitan area resulted in a 37% reduction in the total weekend night accidents occurring among 15-29 year olds. The number of injured resulting from these accidents also decreased by 24%. Thus, our results support the common notion that public transportation can decrease the incidence of accidents.

Our paper provides an answer to a highly relevant policy question concerning urban infrastructure and planning and addresses an important public health concern internationally, with an annual death rate of 1.3 million persons.[5] The benefits of public transportation have been documented in terms of reductions in congestion (Anderson (2014); Bauernschuster et al. (2017)), pollution (Bauernschuster et al. (2017); Lalive et al. (2017)), increased job access and better matching (Holzer et al. (2003)), and healthcare access (Evans and Lien (2005)). However, findings concerning the causal effect of public transportation on traffic accidents, which this paper is now able to provide, are extremely limited. Past studies have examined various policy measures or traffic/road environments, without regard to public transportation networks, and their effects on accidents. There is some recent literature on the causal relationship between traffic congestion and the incidence of accidents. The exogenous variation in congestion is attributed to lower congestion due to London's congestion charge (Green et al. (2016)) or to the timing of the Jewish Sabbath in Israel, during which religious persons do not drive (Romem and Shurtz (2016)). Greenwood and Wattal (2017) present evidence that alternative transportation modes decrease fatal car accidents; however, the alternative transportation modes in their study are Uber driving services, rather than public transportation.

Most closely-related to our work are two papers examining changes in public transportation provision

[5] See http://www.who.int/features/factfiles/roadsafety/en/

and their effect on either drunk driving or car accidents. Jackson and Owens (2011) exploit changes in the Washington D.C. metropolitan area's late-night public transit availability and find that this reduced drunk driving but increased drunk-related arrests in areas with bars that were close to a metro station. The authors also examine the late-night public transportation effects on fatal car accidents but their estimates are imprecise and do not follow a systematic pattern in terms of the sign, so no conclusion is reached. Our paper extends and complements the findings of Jackson and Owens (2011), as here too late-night public transportation is evaluated, but the focus of the study is on accidents and injuries resulting from accidents. Our measure of total accidents allows us to reach conclusions regarding the effect of night buses on them, as we are not limited to just fatal road accidents, which may not produce sufficient statistical power in urban roadways. Bauernschuster et al. (2017) exploit one-day public transit strikes in German cities and evaluates their effect on traffic, accidents, pollution and health outcomes related to pollution. The authors find a 14% increase in vehicle accidents and a 20% increase in accident-related injuries in response to these strikes. Our paper complements the findings of Bauernschuster et al. (2017) by evaluating the *introduction* of public transportation, rather than just a one-day disruption in its services. Thus, our analysis allows us to evaluate the long-term effect of public transportation services on accidents, rather than just an immediate effect in response to brief changes.

Our paper also highlights the contribution of a policy measure that decreases drunk driving, in particularly following night outings. Changes in alcohol-related accidents have been examined primarily as unintended consequences resulting from various policy measures, such as smoking bans in bars (Adams and Cotti (2008)), extending bar hours (Green et al. (2014)), marijuana legalization (Mark Anderson et al. (2013)), and casino operation (Cotti and Walker (2010)). This paper examines the consequences of a policy measure directly intended to reduce alcohol-related accidents, among the numerous factors driving road accidents at night among the adolescent and young adult population.

The paper proceeds as follows: In Section 2, the introduction of night buses in Israel is described in detail. Section 3 describes the data used, its sources and its construction. We then proceed to describing the empirical strategy in Section 4, followed by the results (Section 5) and . Concluding remarks are provided in Section 7.

2 Late-Night Buses in Israel

While the number of deaths from car accidents per 100,000 residents in Israel is below the international average, Israel is above the international average when it comes to the number of deaths from car accidents per mileage traveled. The U.S. is above the international averages of both measures (Lahmi (2016); Litman (2016a)). The Ministry of Transportation (MOT) in Israel is responsible - among its many other responsibilities - for programs intended to reduce vehicle accidents. With drivers aged 15-34 involved in

50% of accidents occurring in Israel,[6] targeting this population seemed natural, and late-night buses was introduced for this purpose.

In 2007, the Israeli MOT, along with the Jerusalem municipality, established a new service of late-night buses ("night buses"). These buses were run by the same companies that operated bus lines during other hours of the day and the cost of a ride was equivalent to the cost of the same ride during the day time. The night buses provided public transportation services from residential areas in Jerusalem and its surrounding towns to night-life centers in the city, as well as between night-life centers within the city. There was also a night bus line that connected between Jerusalem and Tel Aviv. Until then, public transportation within Israel did not operate after midnight, and with the introduction of night buses, these bus lines were made available between midnight and 4 a.m. Prior to the introduction of night buses, individuals wishing to travel after midnight had to either use their own mode of transportation or a taxi. The night buses proved very popular and their supply gradually increased over the next years, both within Jerusalem and to other metropolitan areas throughout Israel. In the summer of 2011, a survey conducted by the MOT of night buses showed that during that summer weekly usage of night buses exceeded 52,000 persons (Ronen (2012)) with services in 9 metropolitan areas (this includes inter-city night bus usage as well). By 2014, the MOT reported that over 700,000 passengers were utilizing night buses annually.

The night buses have the highest frequencies and utilization rates during holidays and the summer months (July and August). All the night buses introduced do not operate on Friday night, which is the Jewish Sabbath, with the exception of night buses serving Northern towns in Israel (primarily in the Haifa area) and night buses serving Eilat. In the Haifa area, some of the night bus lines experience their busiest nights on Friday nights, which is a weekend night in Israel and one of the busiest nights in terms of outings.

In a Summer 2011 survey conducted by the MOT, 19% of night bus users stated that they use night buses so that they can consume alcohol "without worries". 46% of night bus users stated that they had the option of traveling to their destination with a private vehicle (Ronen (2012)). 79% of the passengers on the night buses during that summer were ages 15-24.[7]

A research paper produced by the Research and Information Department in Israel's Parliament compared the number of accidents within cities and a few intercity roads served by night buses before and after the introduction of night buses, as well as in comparison to the trends in all accidents within Israel (Ronen (2012)). The research paper concluded that night buses added an additional 6 percentage point to the drop in accidents within Israel, which is 40 percent of the mean drop in accidents during this period. Our study expands substantially upon the question how night buses affected car accidents by using DID and DDD frameworks, which enable us to control more precisely for accident trends through use of variation across metropolitan areas, over time and the type of accidents in terms of the time of day or day of the week within

[6]Source: http://www.nrg.co.il/online/1/ART2/273/323.html (in Hebrew)

[7]In Israel, until July 2013, the minimum age for a driver's license for a car was 17 years old, followed by 3 months of driving only while being accompanied by an adult. In July 2013, the minimum age changed to 16 years and 9 months followed by 6 months of driving only while being accompanied by an adult. For a light motorcycle (up to 125 cc), the minimum age for a license is 16. The lawful minimum drinking age in Israel is 18. However, this is not strictly enforced, and in practice it is quite easy for Israeli teenagers to obtain alcohol, even in bars serving the younger population. See https://news.walla.co.il/item/1048178 (in Hebrew).

each metropolitan area. We also examine an additional accident measure, injuries from car accidents.

3 Data

Our final data set is at the metropolitan (metro) area and year level for the DID analysis and at the metro area-year-time of day or at the metro area-year-day of the week level for the DDD analysis. The years covered are 2003-2015, thus our data begins 4 years prior to the first night buses in Israel. Our analysis of accident and night bus activity is confined to the months of July and August and Thursdays and Saturdays during the week. During July and August, night bus operation is substantially higher, which makes it easier to detect the effect of night bus activity on accidents. Furthermore, most historic documentation detailing night bus activity was only available for the months of July and August. Thursdays and Saturdays are the busiest weekend nights in terms of night bus activity in Israel. The weekend nights in Israel are Thursday through Saturday - Friday is not a work day for the vast majority of workplaces. While Friday is also a busy weekend night in terms of outings, night buses do not operate on Fridays in nearly all metro areas due to the Jewish Sabbath.

Because we need to associate geographic units to the operation of specific night buses and to accidents occurring within those units, we limit our analysis to geographic units with an urban continuity. Linking inter-city roads with inter-city night buses posed an unmet challenge as different inter-city roads and highways are served by many inter-city bus lines that cannot be grouped separately for treatment definition purposes, as is possible for city bus lines. We thus construct geographic units that we define as metro areas - a large city and surrounding smaller cities or towns that are all interlinked within an urban continuity. While the Israeli CBS has definitions of metropolitan areas, these are very broad and span very large geographic areas that cover many inter-city highways and could not serve our need for smaller geographic units with an urban continuity. We thus constructed our own metropolitan areas. We initially looked at the universe of all non-ultra-orthodox towns in Israel with a population exceeding 20,000 as of 2009 (the middle year in our data), and in which at least 50% of the population is Jewish[8] - 59 towns in total.[9] We then defined metro areas based on large cities and adjacent towns that were within 15 km from that city with a population exceeding 20,000. Limiting the distance between towns to 15 km served the purpose of creating geographic units in which large towns are interlinked with each other within an urban continuity. This resulted in the construction of 33 metro areas, out of which 25 were single-town metro areas - i.e. these metro areas were towns with a population exceeding 20,000 as of 2009 that were not within 15 km of another large town such that they could be combined into a multi-town metro area.

Within our newly-defined metro areas we constructed the accidents and night bus frequency associated to that area. For this purpose, we utilized two main sources. Night bus data was obtained from Adalya

[8]Night buses in Israel are not in ultra-orthodox or Arab towns. These populations do not utilize these services.

[9]We also added two slightly smaller towns - Giv'at Zeev and Azor - that were very obviously part of the Jerusalem and Tel Aviv metro areas, respectively. The results were not sensitive to this addition.

Consulting and Management, a consulting firm based in Tel Aviv, which provides consulting services to the public sector, including the Israeli MOT. City accident data was obtained from Israel's Central Bureau of Statistics (CBS) on their web site.[10]

Night bus data provided from Adalya was from 2007, when night buses were introduced in the first metro area, Jerusalem, and through 2015. The data documented each late-night bus line in Israel and its weekly frequency during the summer months (July and August). We also received a breakdown of night bus frequencies by the day of the week for most night buses operating during 2010, 2012 and 2015. Based on this, we either had a direct measure of the number night buses operating on Thursdays and Saturdays or we estimated this based on the fraction of the weekly activity that Thursdays and Saturdays generated in an adjacent year. For each bus line, data on both the town of origin and final destination town were provided. Bus lines were then looked up at the MOT website with details on all bus lines in Israel to outline the entire route of bus lines of interest and configure the other towns served by the bus line. This was done for the purpose of verifying that the bus line of interest was urban in its nature, serving solely a single metro area, and not an inter-city bus.

We combined all Thursday and Saturday frequencies of the relevant bus lines for each metro area and normalized this by the population of 15-29 year olds within the metro area. Thus, our main variable of interest within our regression analysis is the frequency of night buses within a metro area for each 1000 residents aged 15-29. Overall, 9 metro areas in our dataset experienced the introduction of night buses, 5 of which are single-town metro areas.

For accident data, the CBS provides on their web site data on all accidents that were investigated by the police from 2003 onwards. These are accidents that resulted in at least one injured individual (whether lightly injured, critically injured or dead) and the police determined the need for an investigation, due to either the severity of the accident or the potential for a traffic violation. Accidents investigated by the police represent roughly 25% of all accidents with at least one injured individual occurring in Israel each year. While the percent of police-investigated accidents occurring within city limits are only slightly smaller than non-police-investigated accidents occurring within the city, city accidents investigated by the police are much more likely to be at an intersection, as opposed to non-police-investigated city accidents. Furthermore, accidents investigated by the police are much more likely to occur at night than accidents not investigated by the police.[11] With regards to the accidents' geographic region, the number of individuals injured or involved in the accident, and type and age of vehicle, no significant differences were found between police-investigated accidents and non-police-investigated accidents.

From the CBS accident data, we document accidents that occurred during July and August on Thursday, Friday or Saturday, either at night or during the day, with either at least one of the injured or one of

[10]See http://teunot.cbs.gov.il/teunotm/

[11]According to a study from Israel's National Road Safety Authority examining accidents during 2015, 75.5% of police-investigated accidents were within city limits, while this was 81.7% for non-police-investigated accidents. However, 62.6% of city police-investigated accidents were at an intersection, while only 10.9% of city non-police-investigated accidents were at an intersection. Regarding the hour of the accident, 18.2% of police-investigated accidents occurred during the night, in comparison to 10.7% of non-police-investigated accidents (Lahmi (2016)).

the drivers aged 15-29, and that involved a private passenger vehicle or any type of motorcycle.[12]We constructed two accident measures for each metro area-year combination by examining the accidents occurring within the relevant towns we defined for each metro area: the total number of accidents and the total number of injured from these accidents. Our analysis is limited in its ability to detect any meaningful changes in the number of deaths or critical injuries resulting from accidents, given that we are confined to examining solely accidents within city limits, and the number of dead or critically-injured from these accidents is too small to provide sufficient statistical power. Our total accident and total injuries measures are normalized by the size of the population within the metro area for that year that is 15-29 years old. Thus, our total accident and total injuries measures are reported for each 1000 residents aged 15-29.

We also utilize the accident data to limit our sample of metro areas to those having at least 5 weekend accidents at night involving the population of 15-29 year olds during the sample period (2003-2015). With less than 5 weekend night accidents during the entire 13-year sample period, it is likely that the metro area is not a sufficiently vibrant destination in terms of its night-life. The variance in accidents for these metro areas is also extremely small, due to their very low levels of accidents. This restriction resulted in the omission of 16 single-town metro areas from the sample, mostly those covering a population very near the 20,000 threshold originally set. Our final sample includes 17 metro areas and covers 43 of the 59 towns in our original universe of towns selected based on population criteria. The total population covered by these towns is 4.8 million as of 2015, which represents roughly 57% of Israel's total population. The population of the metro areas covered as of 2015 ranges from 38,000 to 1.3 million in the Dan metro area, which encompasses the largest number of towns, and includes Tel Aviv. Table 1 below lists the metro areas in the sample, their region within Israel, the towns included in these metro areas, the year night buses were introduced, and their total population as of 2015.

Our final data set is a panel data set of 17 metro areas over 13 years, with the exception of the Ashdod, Ashkelon and Beer Sheva metro areas, which are excluded for 2014. During the summer of 2014, Israel was in the midst of Operation Protective Edge, a military operation in Gaza, and these three metro areas experienced each 80-154 rocket attacks between the beginning of July and end of August. Other areas in Israel as far North as the Haifa metropolitan area also experienced rocket attacks, although to a much lesser extent, such that a night life of some sort was still possible to maintain and annual fixed effects in our regression specifications should control for this shock throughout all of Israel.

We also downloaded from the CBS web site annual town-level characteristics. We use these statistics to construct metro area level characteristics using means that are weighted by each town's total population. The time-varying metro area level characteristics are used as control variables in our regression analysis.

[12]The definition of "night" in the CBS accident data is from sunset until sunrise. During July and August in Israel, sunset is between 6 and 7 p.m. and sunrise is between 4:30 and 5:30 a.m. "Day" in the accident data is all other hours of the day that are not "night". Our vehicle restriction excludes trucks, semi-trailers, buses, and other large vehicles, as well as bicycles and taxis. However, these vehicles can still be involved in our accident data if an additional vehicle that is either private or a motorcycle is also involved. Age definitions are only provided for either the injured or drivers involved in the accident and not for all involved in the accidents.

Table 1: Sample Metro Areas

Metro Area	Region	Towns	Introduction of Night Buses	Total Population as of 2015
Afula	Far North	Afula	-	44,900
Akko	North	Akko	-	47,700
Ashkelon	South	Ashkelon	-	220,200
Ashdod	South	Ashdod	2012	130,700
Beer Sheva	South	Beer Sheva	2010	203,600
Dan	Central	Azur, Bat Yam, Givataim, Givat Shmuel, Holon, Kiryat Ono, Or Yehuda, Petah Tiqva, Ramat Gan, Tel Aviv, Yehud	2009	1,332,300
Eilat	South	Eilat	2013	49,700
Hadera	North-Central	Hadera	-	88,800
Haifa	North	Haifa, Kiryat Ata, Kiryat Biyalik, Kiryat Motzkin, Kiryat Yam, Nesher, Tirat Karmel	2010	495,800
Jerusalem	Jerusalem	Givat Zeev, Jerusalem, Maale Adumim, Mevaseret Zion	2007	943,700
Nahariya	Far North	Nahariya	-	54,300
Netanya	North-Central	Netanya	2013	207,900
Pardes Hana-Karkur	North-Central	Pardes Hana-Karkur	-	38,000
Ramle-Lod	Central	Ramle, Lod	-	146,500
Rishon	Central	Nes Ziyona, Rehovot, Rishon Leziyon	2011	423,600
Sharon	Central	Herzerliya, Hod Hasharon, Kfar Saba, Raanana, Ramat Hasharon	2011	360,700
Tiberias	Far North	Tiberias	-	42,600

Notes: For an explanation of how the metro areas were constructed, see the Data section. Beer Sheva and Ashdod had the night buses canceled in 2015, two years after their introduction. Night buses referred to are inner-city or inner-metro-area night buses.

4 Empirical Strategy

We examine how night bus lines affected two measures of accidents occurring during the Summer weekends at night and involving 15-29 year olds: the total number of accidents per 1000 residents aged 15-29 in the metro area[13] and the total number of injured in accidents per 1000 residents aged 15-29 in the metro area. We exploit several sources of variation to assess the relationship between the frequency of night buses and measures of accidents within both a DID and DDD framework.

4.1 Difference-in-Differences (DID) Specifications

For the basic DID specification, we exploit variation across metro areas and over time in the introduction and intensity of night buses. Our basic DID specification thus takes the following form:

$$Outcome_{my} = \alpha_0 + \alpha_1 BusFrequency_{my} + \alpha_2 X_{my} + \gamma_m + \delta_y + \eta_m y_y + \varepsilon_{my} \quad (1)$$

In equation (1), the dependent variable is one of our two measures for night accidents involving adolescents and young adults within the metro area, with m representing the metro area and with y representing

[13]In some parts of the papers this will be referred to simply as "accidents" so as not to burden the text with such a long description. In practice, all "accident" measures in the paper - unless specifically noted otherwise - are accidents that occurred during July and August, during weekend days of the week that night buses operate, at night, involving either private vehicles or motorcycles, and at least one of the injured or the drivers was 15-29 years old.

the year. X_{my} are time-varying metro area characteristics (sequentially added): mean wage for the employed population, percent of 18-year olds eligible for matriculation exam certification during that school year, vehicles per 1000 residents, unemployment benefits recipients per 1000 residents, gini coefficient for wages among employed residents, percent aged 0-14, percent aged 15-29, percent 65 and over, annual percent change in population, mean age of private cars in metro area, and percent of the population who are Jewish. Our regressions include metro area fixed effects (γ_m) and year fixed effects (δ_y) to control for non-time-varying metro area characteristics that are correlated with accident measures and for annual shocks in accidents for the entire state of Israel, respectively. To control for the fact that accidents in Israel were primarily on a downward trend during this period (Lahmi (2016)), we also add (sequentially) to equation (1) metro-area specific linear time trends ($\eta_m y_y$). All standard errors are clustered at the metro area level, to account for the possibility of within-metro-area correlation of the error term, ε_{my} (Bertrand et al. (2004)).

Our coefficient of interest is α_1, the coefficient on the measure for the weekend frequency of night buses for each 1000 residents aged 15-29 within that metro area. α_1 tells us how one additional weekend bus for every 1000 residents aged 15-29 in the metro area changes the dependent variable. If the dependent variable is the number of accidents occurring for each 1000 residents aged 15-29, then α_1 measures how one additional weekend bus for every 1000 residents aged 15-29 changed the number of nightly weekend accidents for each 1000 residents aged 15-29.

We estimate equation (1) using variation in the timing and intensity of night bus penetration using accident data from two different sets of days of the week. In the first estimation, we use accident data from Thursday and Saturday nights. These are the weekend nights in which night buses operate thoughout all of Israel following their introduction. We thus compare the effect of night bus penetration across the various metro areas that experienced night buses and we also examine the effect of night bus penetration in comparison to control metro areas to which night buses were not introduced. In the second estimation, we use accident data from Friday night only and the frequency of night buses is only that of Friday night. On Friday night buses only operate in the Haifa metro area, due to laws in Israel that do not permit the operation of public transportation during the Jewish Sabbath.[14] In this specification, we thus compare the effect of night buses on Friday between the Haifa metro area, which received treatment, and all other metro areas, which serve as controls, although on other days of the week some of the control metro areas also have night buses operating within them. This DID equation can provide a measure for the decrease in accidents or injuries if night buses were permitted to operate all throughout Israel (and not just Haifa) on Friday nights.

[14]The city of Eilat is also one of the few cities in Israel that officially has public transportation during the Jewish Sabbath; however, the operation of public transportation in Eilat during the Jewish Sabbath is much more sporadic in its nature during the Jewish Sabbath (there is mainly one bus line operating during Saturdays to the border with Egypt) and usage of its night buses during Friday nights was extremely low in a survey we received from 2015. For this reason, Eilat metro area was excluded from all Friday DID regressions.

4.2 Triple Differences (DDD) Specifications

The DID specification exploits variation across metro areas and over time. We wish to exploit two additional sources of variation that allow us to estimate the effect of night buses on accident measures in two different DDD frameworks. The first source of variation is the time of day of the accident. The frequency of night buses should only affect measures of night accidents, while day accidents should not be affected. This allows us to control for the general trends in adolescent and young adult accidents within a metro area through use of day accidents. The second source of variation is the day of the week of the accident. The frequency of night buses should only effect measures of night accidents on days of the week that night buses operate. Because night buses do not operate in nearly all metro areas on Friday nights, we take this sample of metro areas and measure the effect of night buses on accidents occurring on Thursday and Saturday nights, while controlling for the trends in adolescent and young adult night accidents within a metro area through use of Friday accidents. The sample for these regressions excludes the Haifa and Eilat metro areas, as Haifa has Friday night bus operation and Eilat officially has some late-night bus operation on Fridays but usage is extremely low.[15]

Taking into account our third source of variation, our data for the DDD documents accidents at the metro area-year level, along with time of day or day of the week variation. Our DDD specification thus takes the following form when examining night versus day accidents:

$$\begin{aligned} Outcome_{myt} &= \beta_0 + \beta_1 BusFrequency_{my} * Night_t + \beta_2 BusFrequency_{my} + \beta_3 Night_t \\ &+ \beta_4 X_{my} + \gamma_m + \delta_y + \eta_m y_y + \varepsilon_{myt} \end{aligned} \quad (2)$$

Our DDD specification when examining variation across days of the week is similar to equation 2 and takes the following form:

$$\begin{aligned} Outcome_{myt} &= \beta_0 + \beta_1 BusFrequency_{my} * NotFriday_t + \beta_2 BusFrequency_{my} + \beta_3 NotFriday_t \\ &+ \beta_4 X_{my} + \gamma_m + \delta_y + \eta_m y_y + \varepsilon_{myt} \end{aligned} \quad (3)$$

The dependent variable in equations (2) and (3) is now a measure of adolescent and young adult accidents in the metro area not just during the night and on days of the week that night buses operate. For the day vs. night specification, observations are either during the night or during the day, with the index t expressing this variation. For the Friday vs. non-Friday specification, observations are for accidents either on Thursdays and Saturdays or on Fridays, again with the index t expressing this variation. X_{my}, γ_m, δ_y,

[15] Another source of variation that theoretically can be used for an additional DDD specification is the age of those involved in the car accidents. However, a decrease in car accidents involving 15-29 year olds should also decrease the rate of car accidents involving individuals of other ages, as individuals from these other age groups can be involved in the accidents as well. Thus, if one wished to compare accidents between the two age groups, the only rough and imprecise way to do this would be to compare adolescents and young adult accidents to accidents not involving any adolescents or young adults. However, given the CBS search system and the details provided for accidents, it is not possible to construct this.

and $\eta_m y_y$ are as defined in equation (1).

β_2 is the coefficient on the variable $BusFrequency_{my}$, and as in equation (1), it tells us how our accident measure changes for each additional night bus per 1000 residents aged 15-29 during the week. However, it represents the effect of night bus frequency on accidents not only at night or on Thursdays and Saturdays but also on accidents occurring during day-time or on Fridays nights, accidents that should not be affected by night buses. If β_2 is not significantly different from zero, then this is a reassuring sign that night bus frequencies are not correlated with accidents in general within the metro area. To estimate the effect of night buses on night accidents occurring on Thursdays and Saturdays, one must examine the sum $\beta_1 + \beta_2$. β_1 is the differential effect that one additional night bus per 1000 residents aged 15-29 has on the Thursday and Saturday night accident measures, as opposed to the day or Friday night accident measures. Thus, our main coefficient of interest in equations (2) and (3) is β_1 - a negative and statistically significant estimate is evidence that night buses differentially reduced the accident measure dependent variable for the specific accidents that should have been affected by them, in comparison to those accidents that should not have been affected by them. The sum $\beta_1 + \beta_2$ resulting from the regression specification in equations (2) and (3) tells us how one additional night bus added to the weekly night bus frequency per 1000 residents aged 15-29 changes the number of night accidents involving individuals aged 15-29 for each 1000 residents aged 15-29.

As in the DID specification, in the DDD specification all standard errors are clustered at the metro area level.

4.3 Identification

The coefficient α_1 from equation (1) presents a causal relationship between the frequency of night buses and nightly accidents involving 15-29 year olds if the frequency of night buses is not correlated with other (time-varying) metro area characteristics that can affect accidents. Within the DDD framework, this assumption can be slightly relaxed, as the DDD specification controls for the general trends in accidents within the metro area during the time of day or day of the week that should not be affected by night buses. If the night bus frequency is not affecting accidents during the day-time or on Fridays, but it is affecting accidents during the night or on Thursday and Saturday, then the threat to identification is no longer differences in characteristics between treated and non-treated metro areas (whether time-varying or not) that may be correlated with accidents, but rather a correlation between the frequency of night buses and specifically night accidents or non-Friday accidents, besides of course the actual night bus frequency itself. It is much more difficult to imagine such a threat, in particular when using two different DDD specifications that address two separate threats.

In Table 2, summary statistics are presented, and these are broken down by treated and non-treated metro areas. As can be seen from the bottom panel, which summarizes annual metro areas' characteristics, treated metro areas are on average better off than non-treated metro areas, with higher mean wages, a greater percent of high school students eligible for the matriculation certificate, higher socioeconomic ranking, more vehicles per resident, and a lower age for the private vehicles held by the residents.

The last two columns of Table 2 present regression results that measure the correlation between the various metro-level characteristics and the frequency of Thursday and Saturday night buses per 1000 residents aged 15-29. The first of these two columns is a regression taking the $BusFrequency$ variable as of 2014 (when night bus frequencies were at their peak for the majority of metro areas in the sample) and regressing that on the metro area characteristic as of 2004, prior to the introduction of night buses. This regression tests whether metro area characteristic from 2004 can predict the 2014 night bus frequencies. The coefficient estimates from these regressions - from a separate regression for each characteristic - were not statistically significant, although it is not clear whether this is due to a true lack of correlation or the small sample size, as the number of observations for each regression is only 17 (the number of metro areas in the sample).

In the regressions in the last column, all metro-year observations from the sample are utilized (for a total of 218 observations), so it is more difficult to argue that null effects are due to lack of statistical power. In this last column, each cell presents the coefficient for $BusFrequency$ from a regression with the time-varying metro area characteristic as the dependent variable. These regressions also control for metro area and year fixed effects. Out of 11 time-varying metro area characteristics examined, the coefficient on $BusFrequency_{my}$ was statistically significant for just one metro area characteristic - more Thursday and Saturday night bus frequency per 1000 residents ages 15-29 predicts a lower percent within the population of 15-29 year olds. This statistically significant relationship may be by chance, but it may also be mechanical if metro areas with a more condensed population of 15-29 year olds receive fewer night buses for each resident aged 15-29, as the frequency of the buses may be inefficient beyond a certain threshold. These results are reassuring, in light of the differences observed in the summary statistics between treated and untreated metro areas in the first four columns of Table 2. According to the results in the last column of Table 2, these difference are not reflective of a correlation *over time* with the treatment variable.

Despite the reassurance of the regression results in the last column of Table 2 in establishing a causal interpretation for the coefficient estimate α_1 from the DID equation (1), our preferred specifications will utilize the DDD framework. The DDD framework is advantageous to the DID framework as it allows us to control for general trends in accidents within each metro area, by looking at accidents occurring during the time of day or day of the week that should not be affected by night buses. Thus, the main identification threat within the DDD framework is that night bus frequencies within metro areas are correlated with important observed or unobserved metro area characteristics that may affect accidents specifically at night and not during the day or on Thursday and Saturday and not during Friday. It is quite difficult to conceive of such a specific threat. For example, local campaigns for safer driving among adolescents and young adults that are correlated with the penetration of night buses (of which we are not aware), would not pose a threat to identification within the DDD framework, as we control for accidents among adolescents and young adults during times of the day or days of the week that should not be affect by night buses but should nevertheless be affected by anything like a local campaign affecting adolescent and young adult driving in general. Similarly, local improvements in road infrastructure that are correlated with night bus penetration (again, of which we are not aware) would not pose a threat within the DDD framework, as these improvements would affect all accidents within the locality and not just accidents occurring when night buses are operating.

If more police road enforcement is occurring specifically at night or on days of the week when night buses operate and this is correlated with night bus intensity, then this would be a threat to our identification. Nevertheless, we are not aware of greater police road enforcement at nights or on Thursday and Saturday nights and that is particularly correlated with night bus penetration - on the contrary, given the reduction in vehicles on the road due to night buses, then if anything, there should be less police presence on the roads at night or on Thursdays and Saturdays.

In Table 2, the first and second panels provide insights concerning the differences in accidents between treated and non-treated metro areas, as well as night-time vs. day-time and non-Friday vs. Friday accidents in the first panel. We see higher means for adolescent and young adult night accident measures among the control metro areas. This may be due to the criterion that metro areas included in the sample have at least 5 weekend night accidents involving 15-29 years olds during the sample period - because many of the control metro areas are single-town metro areas, then only those with a relatively high accident rate remained in the sample. Arguably, this may also be due to these towns having more of a night life, relative to their population size, which was initially the reason for the sample criterion. The third panel of Table 2 shows that treated metro areas actually experienced in 2004 more accidents among the entire population than control metro areas, but in terms of accidents involving 15-29 year olds, the reverse is true. Thus, our control metro areas may have a higher share of their overall accidents attributed to night accidents involving individuals aged 15-29.

5 Results

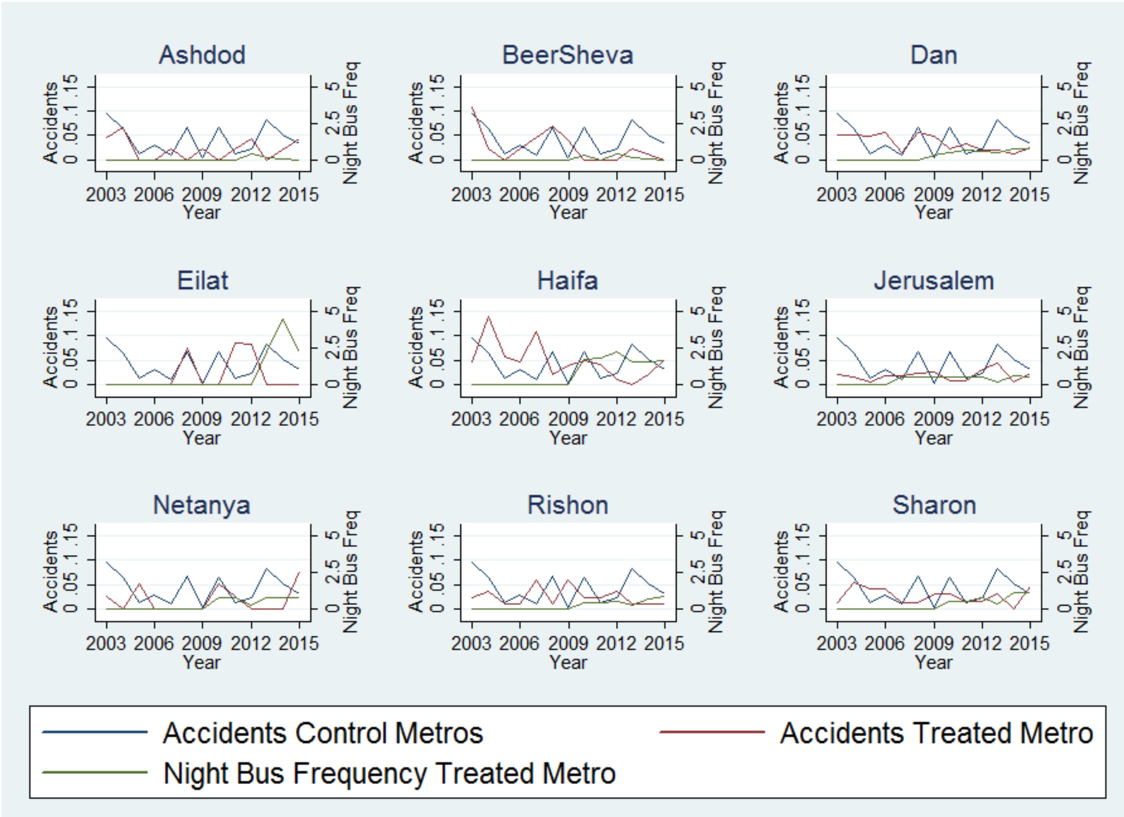
We begin by presenting the trends in night accidents among adolescents and young adults for each 1000 residents aged 15-29 and the injuries resulting from these accidents in each treated metro area (9 treated metro areas overall), in comparison to the average trend among the control metro areas, as well as in comparison to the frequency of night buses within the treated metro area for each 1000 residents aged 15-29. As can be seen in Figures 1 and 2, there are numerous negative correlations between the green line, representing night bus frequency (per 1000 residents aged 15-29) (right axis), and the red line, representing night accidents involving individuals aged 15-29 within the treated metro area (per 1000 residents aged 15-29) (left axis) - as the green line increases, we often see declines in the red line (especially relative to the blue line for control metro areas accidents), and as the green line decreases, we see relative increases in the red line. Thus, even in the raw data, we see evidence that a higher frequency of night buses is associated with a

Table 2: Summary Statistics and Correlations between Metro Characteristics and Night Bus Frequencies

	Treated		Not Treated		Min	Max	Non-Time Varying Regression	Time Varying DID
	Night	Day	Night	Day				
Annual Accident Variables								
Total accidents involving	2.843	3.139	0.544	0.359	0	18	-	-
residents ages 15-29 - Thurs. & Sat.	(3.501)	(4.138)	(0.711)	(0.575)				
Total accidents involving	1.574	1.861	0.214	0.262	0	14	-	-
residents ages 15-29 - Friday	(1.974)	(2.395)	(0.457)	(0.504)				
Total accidents per 1000	0.027	0.028	0.042	0.030	0	0.31	-	-
residents ages 15-29 - Thurs. & Sat.	(0.027)	(0.025)	(0.060)	(0.053)				
Total accidents per 1000	0.017	0.019	0.015	0.019	0	0.21	-	-
residents ages 15-29 - Friday	(0.024)	(0.023)	(0.034)	(0.039)				
Total injuries per 1000	0.051	0.053	0.099	0.080	0	0.91	-	-
residents ages 15-29 - Thurs. & Sat.	(0.060)	(0.052)	(0.170)	(0.167)				
Total injuries per 1000	0.031	0.040	0.024	0.033	0	0.59	-	-
residents ages 15-29 - Friday	(0.048)	(0.068)	(0.060)	(0.079)				
Annual Bus Frequency Variables								
Thurs & Sat frequency of night buses	34.33		0.00		0	217.71	-	-
	(55.76)							
Thurs & Sat frequency of night buses	0.362		0.00		0	4.45	-	-
per 1000 residents ages 15-29	(0.65)							
Thurs & Sat frequency of night buses	0.853		-		0.151	4.45	-	
per 1000 res. conditional on non-zero	(0.748)							
Constant Metro Area Chracteristics								
Total accidents per 1000	2.31		1.93		0	3.85	0.0251	-
residents in 2004	(0.82)		(0.96)				(0.0565)	
Total night accidents per 1000	0.043		0.064		0	0.15	-0.0016	-
residents ages 15-29 in 2004	(0.043)		(0.052)				(0.0030)	
Socioeconomic ranking	5.72		4.75		4.00	8.12	0.0642	-
	(1.21)		(0.71)				(0.0681)	
Annual Metro Area Characteristics								
Mean wage of employed	7271.12		6053.25		4270	12255.4	50.7505	1.398
	(1588.43)		(1189.65)				(67.2175)	(13.999)
Percent of high school students	60.83		54.99		33.79	84.02	0.5235	0.0091
eligible for matriculation certificate	(11.23)		(8.78)				(0.5175)	(0.2196)
Vehicles per 1,000 residents	327.04		303.40		188.38	501.04	36.2980	-0.2487
	(90.90)		(57.99)				(46.9837)	(0.7337)
Unemployment benefits recipients	9.33		11.52		2.98	16.58	-0.1478	0.0496
per 1000 residents	(2.61)		(1.80)				(0.1471)	(0.1285)
Gini coefficient for employed	0.44		0.40		0.35	0.50	0.0008	-0.0006
persons' wages	(0.03)		(0.02)				(0.0020)	(0.0004)
Percent ages 65 and over	12.52		11.89		3.70	18.83	-0.1898	0.0601
	(3.23)		(1.96)				(0.1628)	(0.0587)
Percent ages 0-14	23.75		24.13		18.22	34.36	-0.2263	-0.0002
	(4.27)		(2.02)				(0.2260)	(0.0789)
Percent ages 15-29	22.71		22.69		17.62	34.98	0.0415	-0.1920**
	(3.17)		(2.00)				(0.1296)	(0.0845)
Annual population change (perc)	1.28		1.13		-2.45	4.10	0.0641	0.0040
	(0.81)		(0.99)				(0.0582)	(0.0318)
Mean age of private cars	7.17		7.54		5.73	9.31	0.0450	-0.0194
	(0.89)		(0.64)				(0.0443)	(0.0231)
Percent of jews in population	88.16		86.01		61.80	97.36	0.1732	-0.0859
	(8.91)		(10.77)				(0.5814)	(0.0795)

Notes: All accident figures refer to accidents as they are defined in the Data Section, with the exception of "Total accidents per 1000 residents in 2004" (under Constant Metro Area Characteristics), which is all accidents per 1000 residents regardless of their age. "Thursday and Saturday frequency of night buses per 1000 res. condition on non-zero" refers to per 1000 residents ages 15-29, as defined in the Data section. In the first four columns, standard deviations are in parenthesis. The last two columns present results from regression analysis, as explained in Section 4.3. Each cell in the last two columns shows the coefficient estimate from a single regression, with the first column as the dependent variable and standard errors are in parenthesis. In the last column, these standard errors are clustered at the metro area level. Number of observations is 17 for regressions in the second-to-last column, and 218 for regressions in the last column. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Trends in Accidents and Bus Frequency for Each Treated Metro Area



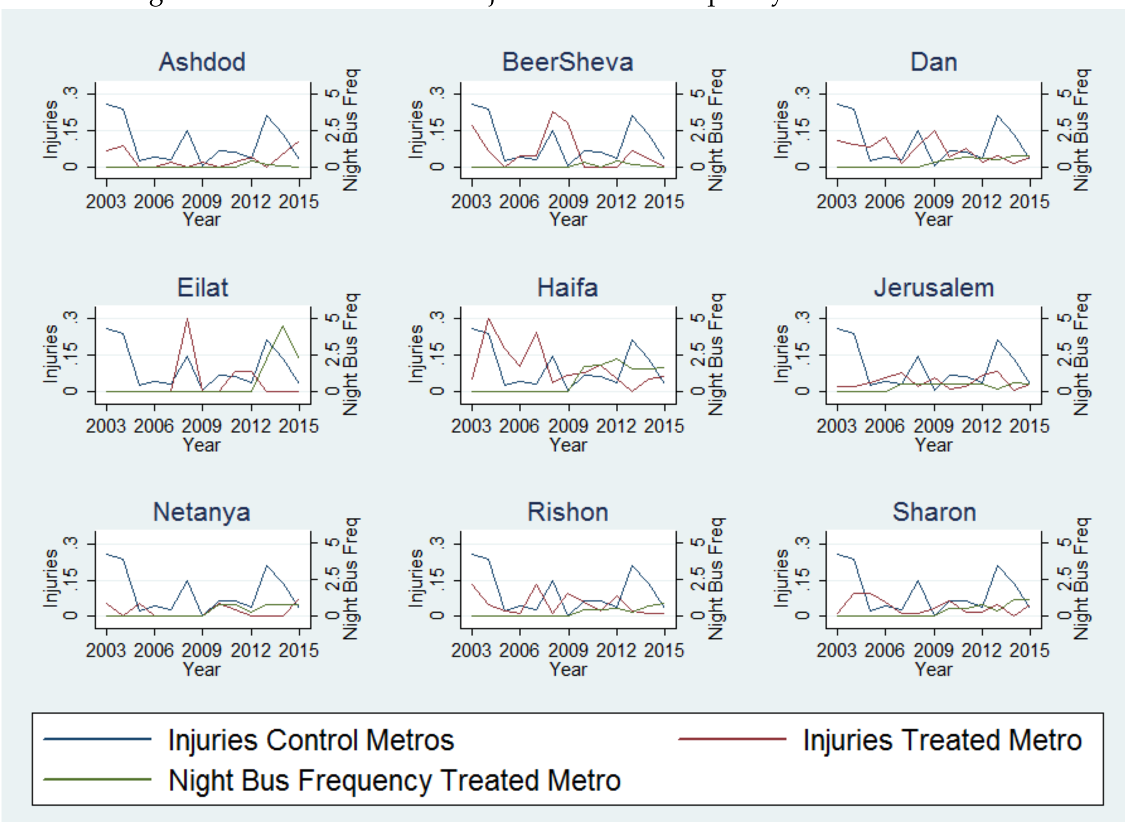
lower night accident rate among adolescents and young adults and a lower injury rate resulting from these accidents.

Figures 1 and 2 also exhibit large variation in the frequency of night buses per 1000 residents aged 15-29 across treated metro areas. Eilat has relatively high night bus frequencies for the size of its 15-29 year-old population. We suspect that this is because Eilat is a tourist destination and the size of its population is not reflective of the true numbers served by the night buses. Haifa metro area also has high rates of night bus frequency relative to its population.

5.1 DID Analysis

We proceed to examine the results of our DID regressions, as specified in equation (1). Table 3 presents results from both DID specifications discussed in Section 4. The top panel is the DID specification with Thursday and Saturday night accidents, using variation in the frequency of night buses across treated metros and between treated and control metros. The bottom panel is the DID specificaiton with Friday only accidents, and it exploits variation in night bus operation on Friday night between the Haifa metro area

Figure 2: Trends in Accident Injuries and Bus Frequency for Each Treated Metro Area



Notes: The left axis measures the number of injuries from Thursday and Saturday night accidents involving 15-29 year olds per 1000 residents aged 15-29 (blue and red line for the control metro areas and treated metro areas, respectively). The right axis measures the frequency of Thursday and Saturday night buses per 1000 residents in the treated metro area examined (green line). The blue line represents the average injuries measure among all 8 control metro areas.

Table 3: Difference-in-Differences Analysis

	Accidents per 1000 Residents Ages 15-29			Injuries per 1000 Residents Ages 15-29		
Thursdays and Saturdays Regressions						
Thurs. & Sat. Night Bus Frequency	-0.0108	-0.0218***	-0.0181**	-0.0158	-0.0313**	-0.0285*
per 1000 Residents Ages 15-29	(0.0066)	(0.0056)	(0.0066)	(0.0127)	(0.0133)	(0.0148)
Number of Observations	218	218	218	218	218	218
R-squared	0.21	0.30	0.36	0.25	0.32	0.36
Mean of Dependent Variable	0.0342	0.0342	0.0342	0.0737	0.0737	0.0737
Friday Only Regressions						
Friday Night Bus Frequency	-0.0017	-0.0084	-0.0278**	0.0092	-0.0044	-0.0101
per 1000 Residents Ages 15-29	(0.0040)	(0.0081)	(0.0120)	(0.0068)	(0.0139)	(0.0245)
Number of Observations	205	205	205	205	205	205
R-squared	0.15	0.23	0.32	0.18	0.25	0.32
Mean of Dependent Variable	0.0149	0.0149	0.0149	0.0258	0.0258	0.0258
Metro Fixed Effects	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Controls		✓	✓		✓	✓
Linear Time Trends			✓			✓

Notes: Each column in each panel presents results from a separate regression. For the exact definition of the dependent and independent variables, see the Data Section. Control variables are the following: mean wage for the employed population, percent of 18-year olds eligible for matriculation exam certification during that school year, vehicles per 1000 residents, unemployment benefits recipients per 1000 residents, gini coefficient for wages among employed residents, percent aged 0-14, percent aged 15-29, percent 65 and over, annual percent change in population, mean age of private cars in metro area, and percent of the population who are Jewish. Regressions utilizing Friday only accident data exclude Eilat metro area. Standard errors clustered at the metro area level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

and all other metro areas, which serve as the control group. For each dependent variable, initial regressions with just year and metro area fixed effects are presented, followed by regressions that also include metro area time-varying characteristics, and lastly adding to the regression specification metro-area-specific linear time trends.

One thing that is noticeable in Table 3's results is that the coefficient estimates vary substantially as metro area characteristics are added to the specification. This is suggestive of the treatment variable - the frequency of Thursday and Saturday night buses per 1000 residents aged 15-29 - being correlated with unobserved metro area characteristics that may affect accidents, which is of concern when interpreting the coefficient as causal, as discussed in Section 4.3. For this reason, our discussion of Table 3's results is with this caveat in mind and we will more strongly rely on the results from the DDD specifications - as will be demonstrated below, the DDD results do not exhibit evidence of this identification threat.

The results from the first three columns of Table 3 suggest that accidents decreased in response to higher night bus frequencies. The results using Thursday and Saturday accident data (top panel) suggest that for each additional night bus per 1000 residents aged 15-29, the number of night accidents involving 15-29 years olds per 1000 residents aged 15-29 decreased by 0.018. When night buses are active, the mean Thursday and Saturday frequency per 1000 residents aged 15-29 is 0.853 (see Table 2, second panel). Thus, the average treated metro area experienced an annual decrease of 0.015 in the number of Thursday and Saturday night accidents involving 15-29 year olds per 1000 residents aged 15-29. Given a mean of 0.034 in the number of Thursday and Saturday night accidents per 1000 residents aged 15-29, this attributes a 45% decrease in night accidents for the adolescent and young adult population to night buses.

Given the decrease in accidents attributed to a greater frequency of night buses, we proceed to examine the effect of more night buses on the number of injuries resulting from car accidents. The coefficient estimate in the last column of Table 3 suggests that the number of injured persons aged 15-29 in Thursday and Saturday night accidents decreased by 0.0285. When multiplying this by 0.853, the mean Thursdya and Saturday frequency of night buses per 1000 residents aged 15-29, we observe a mean decrease of 0.024, which is a 33% decrease from the mean injuries measured.

The bottom panel of Table 3 presents results when examining only Friday night measures of accidents and night bus frequencies. According to this, the 0.0278 decrease in Friday night accidents occurring in Haifa due to the operation of night buses represents too large. This decrease, as a percent decline, calculated based on the mean frequencies of night buses in the Haifa metro area and the mean of the accident measure for Haifa, is greater than 100%.[16] When analyzing the effect of Friday night buses on injuries resulting from Friday night accidents involving 15-29 year olds, the estimate was not statistically significant. Thus, the DID analysis using only Friday night bus frequencies and accident measures produces less concrete results than the DID analysis using Thursday and Saturday night accidents. This may be due to the fact that the Friday night DID anlaysis relies on just a single treatment unit (Haifa metro area), and as such the variation in treatment may not suffice to produce precise estimates of the effect of Friday night buses on Friday night accidents. This assertion is slightly corroborated by the large standard errors for the point estimates in the final Friday night regressions with linear time trends, as opposed to the standard errors for the point estimates in the Thursday and Saturday night regressions. Nevertheless, the negative and statistically significant estimate for the effect that Friday night buses have on Friday night accidents in the Haifa metro area is still informative and indicative of a substantial decrease in accidents in the Haifa metro area in response to Friday night buses.

5.2 DDD Analysis

As explained above, the DDD analysis is our preferred analysis, as it controls for trends in adolescent and young adult accidents within the metro area, by adding metro-year units with accidents involving adolescents and young adults during the day-time or on Friday nights, and these should not be affected by

[16]In particular, the mean number Friday night buses in Haifa per 1000 residents aged 15-29 was 1.11, while the mean number of Friday night accidents per 1000 residents aged 15-29 was 0.0273. Thus, the overall effect of Friday night buses was 0.031, which exceeds the Haifa mean of Friday night accidents.

Table 4: Correlation between Night Bus Frequencies and Accidents during the Day or on Friday Nights

	Accidents per 1000 Residents Ages 15-29				Injuries per 1000 Residents Ages 15-29			
	Daytime Accidents		Friday Night Accidents		Daytime Accidents		Friday Night Accidents	
Thurs. & Sat. Night Bus Freq.	0.0005	0.0078	0.0029	-0.0132	-0.0013	0.0184	0.0021	-0.0348
per 1000 Residents Ages 15-29	(0.007)	(0.007)	(0.011)	(0.011)	(0.026)	(0.019)	(0.024)	(0.029)
	218	218	192	192	218	218	192	192
	0.27	0.32	0.23	0.32	0.18	0.28	0.24	0.32
Metro Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Linear Time Trends		✓		✓		✓		✓

Notes: Each column presents results from a separate regression. For the exact definition of the dependent and independent variables, see the Data Section. Control variables are the following: mean wage for the employed population, percent of 18-year olds eligible for matriculation exam certification during that school year, vehicles per 1000 residents, unemployment benefits recipients per 1000 residents, gini coefficient for wages among employed residents, percent aged 0-14, percent aged 15-29, percent 65 and over, annual percent change in population, mean age of private cars in metro area, and percent of the population who are Jewish. Standard errors clustered at the metro area level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

night buses.

Before presenting the DDD results, we show that accidents involving adolescents or young adults occurring during the day on on Friday nights were indeed not affected by the frequency of night buses. In Table 4, the same DID specification as in Table 3 is presented with either only metro area characteristics or also the addition of metro area linear time trends (in addition to year and metro area fixed effects). When examining the correlation between the frequency of night buses on Thursdays and Saturdays and accidents measures during the day time or on Friday nights (in metro areas not served by night buses on Friday night) with metro-area-specific linear time trends, the coefficient estimates are far from statistically significant. When adding to these specifications linear time trends, the p-values decrease; however, none of the p-values are less than 0.24. Thus, Table 4 demonstrates that day-time or Friday night accidents can serve as good controls for the general trends in accidents within each metro area.

Table 5 presents our preferred results for examining the relationship between night accidents involving adolescents and young adults and the frequency of night buses within the DDD framework. As discussed in Section 4, two different DDD specifications are examined: in the top panel, we present results for the DDD specification utilizing day-time accidents to control for accident trends within each metro area (equation (2)); in the bottom panel, we present results for the DDD specification utilizing Friday night accidents to control for accident trends within each metro area (equation (3)).

The first thing that is noticeably different in the DDD results in Table 5 from the DID results in Table 3 is that the coefficient estimates are remarkably stable as time-varying metro area characteristics and metro area linear time trends are sequentially added to the regression specification. There is no longer concern that our coefficient of interest - the estimate on the interaction between the frequency of night buses per 1000 residents aged 15-29 and an indicator for whether the metro area-year observation is for night or non-

Friday accidents (in the top and bottom panel, respectively) - is correlated with unobservable metro area characteristics that are affecting accidents.

The results in the top panel of Table 5 show a differential effect of -0.017 for night accidents involving 15-29 year olds for every 1000 residents ages 15-29 in response to each additional night bus per 1000 residents ages 15-29 during Thursday and Saturday. This differential effect is highly statistically significant, and the overall effect of one additional night bus on Thursday and Saturday is statistically significant at below the 1% level and is -0.0136 (the sum $\beta_1 + \beta_2$). Thus, each additional night bus on the weekend for each 100 residents aged 15-29 decreases the number of accidents per 1000 residents aged 15-29 by 0.014. The mean number of night buses during Thursday and Saturday for metro areas with night buses is 0.853. Thus, the mean decrease in accidents is 0.012, which is 37% of the mean accident rate on Thursdays and Saturdays for each 1000 residents aged 15-29. Similar calculations for the statistically significant differential effect and overall effect for injuries resulting from accidents on Thursays and Saturdays from Table 5's top panel suggest that night buses during the weekend decreased injuries resulting from car accidents by 24%.

On the bottom panel of Table 5, Friday night accidents control for trends within each metro area, and the sample is limited to metro areas that do not have night buses operating on Friday nights. The coefficient estimate for the differential effect of Thursday and Saturday night buses on accidents is not statistically significant at conventional levels, but the p-value is 0.145. The overall effect of Thurday and Saturday night buses is -0.0086 and is not statistically significant, but it suggests a drop that is 20.2% of the mean accident rate for the sample.[17] For injuries resulting from accidents, the differential effect estimated in the bottom panel of Table 5 for Non-Friday vs. Friday accidents is statistically significant and the p-value for the overall effect is less than 0.2. These results suggest that night buses reduced the injuries arising from accidents involving individuals 15-29 years old by 44%.

Overall, both DDD specifications present evidence that night buses decreased weekend accidents involving 15-29 year olds and the injured from these accidents. The fact that this decrease is robust to two alternative DDD specifications involving different control groups provides reassurance that the decrease observed is indeed driven by night buses rather than other confounding factors. The results for the DDD specification involving day accidents as the control group are more concrete, with greater statistical significance, and this specification also utilizes the entire sample of metro areas.

6 Robustness Checks

We verify that our results are not being driven by a single metro area or a group of metro areas. For this purpose, we run the same regressions as those in Table 5, each time excluding metro areas from one of six regions within Israel. Table 6 presents the results of these regressions for each of our dependent variables. For each dependent variable, the first column is the day versus night accidents DDD specification

[17] The mean non-zero frequency for the Friday vs. non-Friday sample is 0.572 rather than 0.853, as the sample excludes Eilat and Haifa metro areas.

Table 5: Triple Differences Analysis

	Accidents per 1000 Residents Ages 15-29			Injuries per 1000 Residents Ages 15-29		
Day vs. Night Accidents						
Thurs. & Sat. Night Bus Frequency per 1000 Res Ages 15-29 * Night	-0.0170***	-0.0170***	-0.0170***	-0.0297***	-0.0297***	-0.0297***
	(0.0045)	(0.0046)	(0.0047)	(0.0087)	(0.0088)	(0.0090)
Thurs. & Sat. Night Bus Frequency per 1000 Res Ages 15-29	0.0035	-0.0022	0.0034	0.0077	-0.0014	0.0098
	(0.0060)	(0.0057)	(0.0061)	(0.0127)	(0.0153)	(0.0122)
Night	0.0084*	0.0084*	0.0084*	0.0125	0.0125	0.0136
	(0.0044)	(0.0045)	(0.0046)	(0.0095)	(0.0097)	(0.0101)
Number of Observations	436	436	436	436	436	436
R-squared	0.14	0.17	0.20	0.14	0.17	0.21
Mean of Dependent Variable	0.0317	0.0317	0.0317	0.0697	0.0697	0.0697
P-Value for Test of Joint Significance	0.0057	0.0045	0.0413	0.0624	0.0523	0.102
Friday vs. Non-Friday Accidents						
Thurs. & Sat. Night Bus Frequency per 1000 Res Ages 15-29 * Not Friday	-0.0159	-0.0159	-0.0159	-0.0607**	-0.0607**	-0.0607**
	(0.0099)	(0.0101)	(0.0103)	(0.0244)	(0.0248)	(0.0253)
Thurs. & Sat. Night Bus Frequency per 1000 Res Ages 15-29	-0.0007	0.0029	0.0073	0.0395*	0.0203	0.0226
	(0.0141)	(0.0065)	(0.0117)	(0.0189)	(0.0308)	(0.0296)
Not Friday	0.0217***	0.0217***	0.0218***	0.0574***	0.0574***	0.0574***
	(0.0044)	(0.0045)	(0.0049)	(0.0145)	(0.0147)	(0.0150)
Number of Observations	384	384	384	384	384	384
R-squared	0.19	0.24	0.28	0.20	0.25	0.28
Mean of Dependent Variable	0.0244	0.0244	0.0244	0.0491	0.0491	0.0491
P-Value for Test of Joint Significance	0.595	0.279	0.463	0.336	0.227	0.197
Metro Fixed Effects	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Controls		✓	✓		✓	✓
Linear Time Trends			✓			✓

Notes: Each column within each panel presents results from a separate regression. For the exact definition of the dependent and independent variables, see the Data Section. Control variables are the following: mean wage for the employed population, percent of 18-year olds eligible for matriculation exam certification during that school year, vehicles per 1000 residents, unemployment benefits recipients per 1000 residents, gini coefficient for wages among employed residents, percent aged 0-14, percent aged 15-29, percent 65 and over, annual percent change in population, mean age of private cars in metro area, and percent of the population who are Jewish. Standard errors clustered at the metro area level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

and the second column is the Friday versus non-Friday DDD specification. The day versus night DDD specification is robust to the exclusion of all regions, with the exception of excluding the Southern metro areas with injuries as the dependent variable, where the p-value on the coefficient estimate is 0.185. For the Friday versus non-Friday specification, the coefficient estimates for the effect of night buses on accidents are not statistically significant at conventional levels, but with the exception of when the Far North and Central metro areas are excluded, the p-value for the coefficient estimates ranges between 0.10 and 0.20, thus the estimated effect is marginally statistically significant as was the case in the Friday versus non-Friday specification in Table 5. When the effect of night buses on injuries from car accidents is examined, the coefficient estimates are all negative and statistically significant, with the exception of when the Far North metro areas are excluded, for which the p-value is 0.118.

7 Conclusions

This study presents empirical evidence that late-night buses in Israel decreased accidents among the adolescent and young adult population and injuries resulting from these accidents. These reductions are observed using both DID and DDD frameworks, and within these frameworks, we utilize two different specifications that exploit different sources of variation - time of day and days of the week. Our preferred framework is the DDD, which controls for general trends in accidents within metro areaa using accidents occurring either during the day or on Friday nights. Within the DDD framework, the day versus night specification covers the full sample and is less sensitive to the exclusion of different regions within Israel.

The day versus night DDD specification shows a decrease in accidents involving 15-29 year olds in response to night bus services during the weekend that is 37% of the mean. For injuries resulting from these accidents, this figure is 24%. These are large effects that suggest a very substantial benefit from the introduction of late-night buses in Israel. In Israel, as in the rest of the world, young drivers (ages 17-24) are involved in car accident more than any other age group. [18] Furthermore, severe accidents involving young drivers are more likely to occur during weekend nights both in Israel and throughout the world (Thusday night though Sunday dawn in Israel and Friday night through Monday dawn in other countries). Based on data from the Israeli CBS for 2008-2010, drivers aged 15-34 were involved in 50% of all car accidents in Israel.[19] Most of these accidents occur during weekend nights, which suggests that our calculated decreases in accidents and injuries resulting from accidents among adolescents and young adults represent substantial decreases in the overall rate of accidents for the entire population in Israel. Furthermore, our assessment of night buses in Israel may underestimate their actual effect, as the analysis only covers inner-city night buses and inner-city accidents. Inter-city accidents are more severe, and in Israel, slightly more accidents occur on inter-city roads as opposed to inner-city roads. Thus, the effect of night buses on inter-city

[18] In Israel, 17-24 year olds comprise 15% of the population, but they are involved in 20% of all accidents and in 21% of all severe and fatal accidents (Lotan and Grimberg (2011)). In OECD countries, drivers under 25 represent 10% of the population but are more than a quarter of car drivers killed on the road (OECD (2006)).

[19] Source: http://www.nrg.co.il/online/1/ART2/273/323.html (in Hebrew)

Table 6: Excluding Metro Areas from DDD Specifications

	Accidents per 1000 Residents Ages 15-29		Injuries per 1000 Residents Ages 15-29	
	Day vs. Night	Friday vs. Non-Friday	Day vs. Night	Friday vs. Non-Friday
Excluding Far North Metros				
Thurs. & Sat. Night Bus Frequency per	-0.0150***	-0.0074	-0.0237**	-0.0284
1000 Res Ages 15-29 * Night/Non-Friday	(0.0041)	(0.0092)	(0.0092)	(0.0167)
Thurs. & Sat. Night Bus Frequency per	0.0044	0.0013	0.0114	-0.0013
1000 Res Ages 15-29	(0.0051)	(0.0063)	(0.0077)	(0.0173)
Number of Observations	358	306	358	306
R-squared	0.20	0.33	0.24	0.32
Excluding North (Haifa Area) Metros				
Thurs. & Sat. Night Bus Frequency per	-0.0210***	-0.0144	-0.0384***	-0.0596**
1000 Res Ages 15-29 * Night/Non-Friday	(0.0041)	(0.0107)	(0.0081)	(0.0273)
Thurs. & Sat. Night Bus Frequency per	0.0060	0.0067	0.0121	0.0221
1000 Res Ages 15-29	(0.0086)	(0.0132)	(0.0165)	(0.0348)
Number of Observations	384	358	384	358
R-squared	0.21	0.27	0.22	0.28
Excluding Central-North Metros				
Thurs. & Sat. Night Bus Frequency per	-0.0169***	-0.0216	-0.0320***	-0.0723**
1000 Res Ages 15-29 * Night/Non-Friday	(0.0051)	(0.0121)	(0.0092)	(0.0315)
Thurs. & Sat. Night Bus Frequency per	0.0001	0.0105	0.0081	0.0412
1000 Res Ages 15-29	(0.0050)	(0.0172)	(0.0146)	(0.0406)
Number of Observations	358	306	358	306
R-squared	0.21	0.29	0.20	0.31
Excluding Jerusalem Metro				
Thurs. & Sat. Night Bus Frequency per	-0.0174***	-0.0158	-0.0301***	-0.0628**
1000 Res Ages 15-29 * Night/Non-Friday	(0.0047)	(0.0108)	(0.0089)	(0.0256)
Thurs. & Sat. Night Bus Frequency per	0.0032	0.0041	0.0100	0.0159
1000 Res Ages 15-29	(0.0062)	(0.0140)	(0.0126)	(0.0391)
Number of Observations	410	358	410	358
R-squared	0.20	0.28	0.21	0.29
Excluding Central (Tel Aviv Area) Metros				
Thurs. & Sat. Night Bus Frequency per	-0.0173***	-0.0204	-0.0313***	-0.0842**
1000 Res Ages 15-29 * Night/Non-Friday	(0.0050)	(0.0165)	(0.0095)	(0.0376)
Thurs. & Sat. Night Bus Frequency per	0.0040	0.0013	0.0123	-0.0079
1000 Res Ages 15-29	(0.0065)	(0.0167)	(0.0140)	(0.0442)
Number of Observations	332	280	332	280
R-squared	0.20	0.28	0.22	0.30
Excluding Southern Metros				
Thurs. & Sat. Night Bus Frequency per	-0.0131*	-0.0172	-0.0185	-0.0631**
1000 Res Ages 15-29 * Night/Non-Friday	(0.0068)	(0.0110)	(0.0131)	(0.0286)
Thurs. & Sat. Night Bus Frequency per	0.0093	0.0143	0.0153	0.0468
1000 Res Ages 15-29	(0.0145)	(0.0171)	(0.0257)	(0.0426)
Number of Observations	338	312	338	312
R-squared	0.21	0.29	0.21	0.28

Notes: Each column presents results from a separate regression. For the exact definition of the dependent and independent variables, see the Data Section. Control variables are the following: mean wage for the employed population, percent of 18-year olds eligible for matriculation exam certification during that school year, vehicles per 1000 residents, unemployment benefits recipients per 1000 residents, gini coefficient for wages among employed residents, percent aged 0-14, percent aged 15-29, percent 65 and over, annual percent change in population, mean age of private cars in metro area, and percent of the population who are Jewish. Standard errors clustered at the metro area level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

accidents may be greater and more substantial in terms of preventing severe accidents and injuries.

According to the World Health Organization, car accidents are the single greatest cause of death for men aged 15-29, and the second greatest cause of death for the overall population aged 15-29 (OECD (2006)). This paper shows that the availability of public transportation - in particular on weekend nights - can be one successful policy measure for reducing car accidents among this population.

The results of this paper can also be extended to the availability of public transportation in general. It remains open how much of the actual decrease in car accidents or injuries is attibuted to reduced congestion resulting from greater use of public transportation and how much is attributed to less drunk drivers or a reduction in reckless driving, factors which may be more specific to late-night buses serving the adolescent and young adult populations for outings. However, considering the large effect estimated, then even if just some of the large reduction in accidents derived from our analysis is attributed to the mere decrease in traffic and on-the-road vehicles, then this is evidence that greater availability of public transportation can reduce the incidence of car accidents. Car accidents are among the leading causes of death in the world among the population under 40 years old and in the U.S. in particular. In the U.S. the annual car fatality rate is more than 37,000 while in the world it is 1.3 million, with roughly 3,000 deaths every day.[20] Besides the loss of lives, the economic costs of road accidents are considerable, in terms of healthcare costs, victims' loss of future earnings (Halla and Zweimüller (2013)), and even insurance premiums (Edlin and Karaca-Mandic (2006)). If public transportation is indeed a mean for decreasing accidents, then this is a factor urban planners and policy makers should consider when aggregating all the potential benefits of public transportation and assessing their worthiness.

[20]Source: http://asirt.org/initiatives/informing-road-users/road-safety-facts/road-crash-statistics

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