Financial Impact of Personal Electric Transportation Platforms in an Urban Area: A Cohort of Injuries over 18 Months at a Level 1 Urban Trauma Center

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Article

Financial Impact of Personal Electric Transportation Platforms in an Urban Area: A Cohort of Injuries over 18 Months at a Level 1 Urban Trauma Center

Short title: Cost of E-Platform Injuries at an Urban Trauma Center

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Highlights

- Describe the epidemiology and morbidity of large-scale e-commuting in a dense urban area.
- Investigate and compare the financial burden of e-commuting with various platform types.
- Identify risk factors for increased medical charges.
- Recommend appropriate steps (legislative, financial, developmental) for urban municipalities planning to increase the use of such transportation systems.

Abstract: The use of e-scooters and e-bicycles has been on the rise with an increased medical and financial burden. Our purpose was to identify risk factors for increased medical charges and recommend appropriate steps. We studied a retrospective cohort presenting to a level 1 urban trauma center from January 2018 through July 2019 due to micro-mobility platforms. The primary outcome for comparison was total billing cost and a regression analysis was performed to identify variables associated with higher cost. A total of 4073 patients were identified. The majority of which were males (67%), aged 20-30 years (41%). Helmet use reported in only 39.8%. Radiologic studies were performed more often in the e-bicycle group. Total billing charges amounted to 28.3 million New Israeli Shekels ($7.9 million). Average total cost was higher for e-bicycle injuries and in non-helmet users. Other factors associated with higher cost were age, and time of day 12:00-18:00. We recommend that urban cities invest in infrastructure in advance to micro-mobility introduction, regulate the use of e-platforms, designate resources for education on personal protective equipment and prepare medical centers in advance.

Keywords: financial; policy; planning; injury-prevention; cost; micro-mobility; e-bicycle; e-scooter

Introduction

The use of electronic scooters and electronic bicycles has been on the rise in recent years in many urban areas around the world. These platforms, both private or shared, provide a convenient mode

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of transportation for people living in the midst of highly populated areas negating their need to own a private vehicle, as well as providing a means for transportation for the first and last mile for people commuting into urban areas and back home every day [1,2]. However, these positive effects also include a darker side, and ongoing increase in injuries and financial cost.

Tel-Aviv is the largest metropolitan area in Israel. 0.5 million people reside in the city limits (owning over 250,000 private vehicles) with a total of 4 million residing in the entire metropolitan area. Over 750,000 vehicles travel into and out of a city of only 50 square kilometers. Shared bicycles systems have been in use in the city since 2014. Privately owned electronic bicycles have been in use in Israel since 2010 in small numbers (~1,000/year) which have been growing since (over 70,000/y in 2016) [3]. The national institute for epidemiology and health policy research reported in a five year summery (2015-2019) that most injuries happen in the street in the absence of bicycle lanes, are usually first person injuries and that micro-mobility usage is on the rise [4]. Shared electronic scooters were introduced to the city in January 2018 with more companies joining in during the summer of 2018 and January of 2019. At the time, there were 120km of dedicated bicycle lanes in the city.

Alongside the many advantages the shift to e-commuting brings, which include lowering the number of private vehicles, lowering carbon emissions, lowering usage and spending on gasoline, lowering time wasted in traffic jams and improving social mobility, the increased usage also causes an increase in accidents, morbidity and mortality and an increase in the medical and financial burden on medical centers, municipalities, and the healthcare system et large [5,6].

In an attempt to increase safety and mitigate risk for users, the state of Israel department of transportation (DOT) has passed and revised laws and regulations [7]. As of 2017 the minimum age for commuting on e-platforms was increased to 16, the maximum speed allowed is 25 km/h, use is allowed only on dedicated bicycle pathways or roads and not on sidewalks, mandatory licensing is required and helmet use is mandatory. These changes are important and increase safety, but the burden of enforcing them is high and increasing.

Various reports have shown this increase in recent years describing both demographics and the financial burden in various world origins. Bekhit et-al described Regional Healthcare costs and burden of injury associated with electric scooters in New Zealand [8], Lavoie-Gagne et-al described the demographics and financial impact on an urban trauma center in Los-Angeles [9], Dimaggio et-al reported on the demographic differences of injuries from e-bikes and e-scooters compared to pedaled bicycles [10], Toofany et-al described injury patterns of e-scooter collisions in British Columbia, Canada [11] and Genc Yavuz et-al reported on e-scooter injuries in Turkey [12].

While these reports have merit, they mostly discuss relatively small numbers of cases presenting to the emergency department (ED), they do not include a large-scale comparison between types of vehicles (e-scooters vs. e-bikes), and they lack significant discussion as to the role of urban infrastructure development and its role in mitigating risks. The purpose of this study is to: (1) Broadly describe the epidemiology and morbidity of large-scale e-commuting in a dense urban area, (2) Investigate and compare the financial burden of e-commuting with various vehicle types, (3) Identify risk factors for increased medical charges and (4) Recommend appropriate steps (legislative, financial, developmental) for urban municipalities planning to increase the use of such transportation.

Methods

Study Design

In this retrospective, registry-based cohort study, we queried the institutional electronic patient records database from January 2018 through July 2019 for all encounters in the ED containing free-text keywords relating to bicycles, e-bicycles, and e-scooters. The period was chosen corresponding with the Tel-Aviv municipality decision to introduce shared e-scooter systems to the urban region, in which in which private use of e-bikes and e-scooters was on the rise. Of-note, the Tel-Aviv Sourasky Medical Center (TASMC), is the only medical center in the Tel-Aviv city limits and is one of the three major Level-1 trauma centers in the Tel-Aviv larger metropolitan area. As such it has the highest number of daily ED visits (the second highest in the country).

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The Institutional Review Board approved the study and waived written informed consent requirements. The manuscript was written and edited according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [13].

Variables

Electronic patient records identified using free-text keywords were manually reviewed by the research team for demographic characteristics, injury characteristics, hospitalization and treatment variables, and total cost. Following review duplicate records were removed, as well as non-trauma related referrals to the ED and first party users aged 12 or under.

Variables were grouped into categories of body region based on the injury reported. Time of day was grouped into groups of six hours based on a daily work / leisure cycle: 6:00-12:00 (arrival at work), 12:00-18:00 (mid-day), 18:00-24:00 (departure from work and evening), 24:00-6:00 (party goers and graveyard shift).

The primary outcome for comparison and multi variable regression analysis was total billing cost.

Statistical Analysis

Categorical variables were compared using the chi-squared test or Fisher's exact test. Quantitative variables were compared using the Kruskal Wallis test. Categorical variables are presented as n (%), and continuous variables as mean (standard deviation [SD]) or median (IQR) as appropriate. Significance was set at a p-value of 0.05 .

Linear regression analysis was performed to assess relationships between possible risk factors and total billing cost. Independent variables included in the analysis were: age, gender, type of vehicle, first vs third party involved, weekday, time of day and helmet use.

Univariate analyses were conducted using R version 4.1.3 (R Core Team, Vienna, Austria). Regression models were applied using IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. (Armonk, NY: IBM Corporation).

Results

Demographics and Clinical Course

Screening of the ED electronic health record (EHR) identified 4482 cases. After meeting exclusion criteria 4,073 were studied as described in Figure 1. Of them, 3,819 were first-party users and 254 were third parties involved. The different platforms were represented in a similar fashion with 1,433 using bicycles, 1,227 using e-bicycles and 1,413 using e-scooters (Tables 1 and 2). A majority of users were male on all three platforms (67%), the largest age group was users aged 20-30 years (41%), which was most remarkable in the e-scooter group with 55% of all users in that group (P<0.001). Use was distributed equally between weekdays with a relative equal split during high use hours (14:00-0:00). Helmet use data was available in 1228 cases (32%), of which only 489 reported using helmets in adherence with regulations (39.8%), with an equal distribution between platforms. Distribution of hospitalizations of first-party users on all three platforms showed a trend to be lower for e-scooters (7.6%-9.5%, p=0.176), with a higher rate of admissions for third parties injured by e-bicycles and a lower rate injured by e-scooters (18.1% vs. 4.2%, p=0.005). X-ray was the most frequent imaging in use (76%), with higher use among e-bicycles and lower among e-scooters (79% vs. 73%, p=0.003), followed by computer tomography (32%) with a similar higher use in the e-bicycle group and lower among bicycles and e-scooters (35% vs. 30%-31%, p=0.01). This was in contrast with the finding of a lower total rate of injury for the e-bicycle group (36.6% vs. 41%-42%, p=0.007). A trend towards less surgery performed in the e-scooter third party group was found (1.4% vs. 10.6%, p=0.053), with no difference in the first party groups (6.9%-8.5%, p=0.315). ICU treatment was required in only 49 (1.3%) cases, with a median LOS ranging between 1-2 days.

Figure 1. Cohort build-up diagram of micro-mobility related injuries presenting to the ED January 2018 through July 2019.

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Figure 2. Monthly use of micro-mobility platforms throughout study period.

Healthcare Encounter Cost

Total billing charges for all platform acquired injuries amounted to 28.3 million New Israeli Shekels (NIS) during the period studied ($7.9 million). Cost was analyzed for four groups according to first- or third-party encounter and according to hospitalization or discharge from ED (Table 3).

Average total cost for first-party encounters was highest for e-bicycles (7,137 NIS, n=1111) and lowest for e-scooters (5,668 NIS, n=1341) ($p<0.001$). Subgroup analysis showed an average cost for non-hospitalized cases as 2,556 NIS (n=1005) and 2189 NIS (n=1238) respectively ($p<0.001$), as well as an average cost for hospitalized cases as 50,569 NIS (n=106) and 47,477 NIS (n=103) respectively ($p=0.917$).

Average total cost for third-party encounters was highest for e-bicycles (8,955 NIS, n=116) and lowest for e-scooters (2589 NIS, n=72) ($p=0.032$). Subgroup analysis showed an average cost for non-hospitalized cases as 2,575 NIS (n=95) and 2,215 NIS (n=69) respectively ($p=0.536$), as well as an average cost for hospitalized cases as 37,817 NIS (n=21) and 11,186 NIS (n=3) respectively ($p=0.257$).

Average total cost for casualties using helmets was 4,634-5,615 NIS with no difference between the subgroups ($p=0.476$), with a higher total cost found in the non-helmet e-bicycle users (8,393 NIS, $p=0.003$).

Risk Factors for Increases Medical Charges

Multi-variant linear regression analysis was preformed to assess the relationship between possible risk factors and total billing cost. A correlation was found for age, first- vs third-party involvement, time of day and the use of helmets. A trend was also found in e-bicycles compared to other vehicles. The determination coefficient (R2) was found to be 0.021 suggesting that there are additional risk factors for cost (Table 4).

Discussion

During the 19 months between January 2018 and July 2019, 4,073 patients presented to the TASMC ED due to an injury related to a micro mobility platform. The total direct burden of cost for medical center treatment of all cases was a staggering 28 million NIS (~$8 million), with the cost of post injury rehabilitation, sick leave days and the decreased work productivity not included. The analysis also exhibited that the average cost of injury incurred using an e-bicycle was higher than using an e-scooter. Subgroup analysis showed this to be true both for first- and third- parties injured and for both hospitalized and discharged patients. The higher cost of injuries using e-bicycles imply a higher severity of injury, due to charges being incurred based mostly on diagnosis related groups (DRG) and LOS, both of which have a correlation with severity of injury.

The number of cases showed a steady increase, climbing from 1,003 during the first half of 2018 to 1,513 during the first half of 2019. The most rapid increase found was in e-scooter related injuries from 159 during the first half of 2018 (16%) to 715 during the first half of 2019 (47%), thus representing a shift ($p<0.001$) to e-scooters as a preferred platform (Figure 2). Current estimations are that over 4,000 cases presented to the ED during 2021, of which an estimated 2/3 are e-scooter related. This increase coincides with the reported use of e-scooters in the Tel-Aviv municipality. The reports by the city of Tel-Aviv show a steady daily increase in personal commuting on the various platforms from 100,000/day in 2017 to 160,000/day in 2022. Of these, one third are regular bicycles and two thirds are e-platforms, which are divided equally between e-bicycles and e-scooters. Of these ~110,000 rides per day, most are done using privately owned means. Only 30,000 are done through ride-sharing companies. Both private and shared platforms show a growing preference in using e-scooters. We hypothesize that this gap is growing due to several reasons: an increase in bicycles' theft in the city (scooters are easier to take indoors), a prohibition on entering trains with e-bicycles between 6:00-15:00 and an increase in public commuting into Tel-Aviv using trains with scooters being used for the first and last miles. Some of this increase may also be attributed to the COVID-19

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epidemic which has driven more people out of crowded public transportation and onto personal devices as reported by Ayfantopoulou et al. in Thessaloniki, Greece [14], Dean and Garcia in Texas, USA [15], Dias et al. in Braga, Portugal [16], Hosseinzadeh and Kluger in Kentucky, USA [17], and Campisi et al. in Palermo, Italy [18].

Risk Factor analysis using a multi-variant linear regression exhibited higher cost related to age ($P<0.001$) as well as the use of e-bicycles compared to regular bicycles ($P=0.06$). This can be explained by a higher incidence of more severe injuries caused by the same amount of kinetic energy as the human body ages, and the higher cost of e-platform related injuries is explained by higher speeds of travel and a higher kinetic energy involved. Higher cost was related to injury caused by e-bicycles compared to e-scooters, although this trend was not clearly significant ($P=0.106$). This poses an important question of whether urban cities should prefer a specific e-platform. Our study does not answer this question fully and it remains to be proven that e-scooters are a safer platform. Higher cost is also expected for first-party users ($P=0.031$), as well as a decrease of cost with the use of helmets ($P=0.042$). A correlation was also found for time of day with a higher cost during mid-day and early evening hours ($p=0.031$). Our hypothesis is that this correlates with mid-day urban rush hour and a higher volume of vehicles debarking from works in the early evening.

Traffic regulations regarding electronic platforms were initially put into place in 2010, determining the minimum age to be fourteen with no need for licensing. With the gradual increase in usage and injuries, the regulations were gradually changed. Minimum age was changed to sixteen in 2016, helmet usage was mandated in January 2019, and a licensing test was added since July 2019. Enforcing these regulations is the weaker link, especially regarding the age limit. Shah et al. [19] described various e-bicycle and e-scooter injury typology in Tennessee USA and the difficulty in enforcing regulations on users, with an emphasis on age enforcement through shared service operators. This method may be relevant for shared platforms but will have no effect on most privately owned vehicles.

Our study illustrates the obvious. The more these personal devices are used, the more accidents will happen, and more injuries will present to urban medical centers. The obvious, but often neglected, conclusion is that adequate preparation is needed for the city and its medical centers. Both in urban resources (dedicated bicycle lanes, appropriate regulations, and enforcement) and in medical center resources (personnel, training, workflow in the ED, studies regarding common types of injuries and the means to prevent them). The city of Tel-Aviv is amid a mega-project to increase 120km of dedicated cycling paths to 150km. This will no doubt provided safer paths for riders in the following years, especially since the first line of the Light Rail Transit system from the suburbs into the city will be inaugurated in 2023, followed by two more in the following five years and a metro system planned for 2040 [20].

With the hope of decreasing traffic congestion and air pollution and increasing social transport equality and accessibility to more remote urban areas, the use of e-platforms is expected to continue to rise. In light of findings in our study we recommend the following: 1. Planning and building transportation infrastructure before implementing shared platforms, including dedicated lanes and adequate parking areas for the high and rapidly increasing vehicle numbers; 2. Regulating the use of e-platforms regarding age, mandating the use of helmets, mandating formal licensing and deciding what the speed limit should be; 3. Designating significant resources to enforcing these regulations; 4. Increasing resources devoted to preparedness of medical centers with regard to increase in medical personnel, their relevant medical training, response to increase in the radiology load and surgical load and adapting the workflow in order to care for less severely injured patients in the ED, limiting unnecessary admissions; 5. Increasing resources devoted to educating teen-agers about the risks involved; 6. With regard to the choice of e-platform no recommendation can be made at this point.

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Limitations

Our study has several limitations: 1. The period studied was both in the beginning of a high surge in use in e-platforms in the city of Tel-Aviv and before the COVID19 pandemic. We discuss the effect of these changes in this paper, but a formal study of this period is required; 2. In our study we assume that higher health costs are correlated with higher injury scores, due to the use of DRGs and LOS as the basis for billing in the Israeli health system; 3. We did not use any type of injury severity score or ICD code classification in this study. Our focus was the burden of cost and not the detailed comparison of medical injuries between the various platforms. We acknowledge that different vehicles may cause different injuries and this aspect should be further studied; 4. This study was done during a major investment in infrastructure in the city of Tel-Aviv which will change urban transportation significantly. These changes need to be evaluated again in the upcoming years; 5. The R2 index in our regression model was low. This is a result of our attempt at predicting cost through pre-injury variables. A prediction using body area injures may allow a higher predictive value.

Conclusions

In this study we evaluated patients presenting to an urban area ED in Tel-Aviv due to injuries acquired using e-platforms for transit over an 18-month period. While a convenient and attractive commute option, the financial burden of clinical encounters for injuries is high. We identified various predictors of higher cost of injuries and recommended appropriate interventions to lower the burden of injury as well as the burden of cost. We could not prove that e-scooters are a safer platform for use in the urban area and recommend further studies on this subject. There is a major role for education and enforcement of laws and regulations which we have only touched on and both require further development and research.

Authors Contribution: YR, JC, DN and ABr designed the study and reviewed the literature. YR, JC, DN, GS, IB, AR, DS, ZS, AB and ABr collected, cross checked and analyzed the original data. YR, JC, ZS and ABr designed and performed the statistical analysis. YR, JC and ABr were the main authors. All authors critically read and approved the final manuscript.

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Availability of Data and Materials: Data are available upon request from the corresponding author.

Ethics statement: The Institutional Helsinki Review Board approved the study and waived written informed consent requirements. The study number appointed was TLV-20-0089 and the Board approval code number was 202016243.

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