A Multi-Faceted Approach for Assessing the Safety of Israeli Arab Children in their Travel to and from School

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ABSTRACT

Road crashes are considered as one of the main threats to human life around the world. Children pedestrians are most at risk to be seriously injured in road crashes, in particular, those from economically disadvantaged communities. Various factors contribute to their high involvement in road crashes. Some of these factors are related to the characteristics of the children and their parents, while others are related to the physical urban road environment. The share of Arab children in Israel (<15 years old) in pedestrians’ fatalities far exceeds their fraction in their age group. Therefore, effective and immediate measures to increase their safety are required.

The present research, a part of a larger ongoing project, proposes a multi-faceted approach and applies it to a real case study in the Arab local council of Jadeidi-Makr in Israel. The proposed approach is based on: (1) data collected by means of questionnaires posted to the children and their parents concerning the travel characteristics of the children to school; (2) objective data on the children walking routes collected by GPS-enabled watches; and (3) road safety auditing of the school environment and the main routes to the school.

The results of this study found that children’s characteristics, their travel behavioral patterns, their parents’ safety perceptions, and the road environment are all significant factors when considering children’s safety as pedestrians. Thus, improvements in the infrastructure, children and parents’ safety awareness, and police enforcement are essential to increase Arab children’s safety. The responsible authorities, decision and policy makers are called to join forces and take immediate actions to realize the suggested improvements in reality.

KEY WORDS

Children, Pedestrians, Exposure, Safety Perception, Behaviour, Road Safety Auditing
INTRODUCTION

The high involvement of children in the Arab sector in Israel in road crashes is an alarming phenomenon. A recent study by Magid et al. (1) stated that Arabs in Israel are at increased risk of injury and mortality from road crashes compared to Jews. While Arab children (<14 years old) constitute nearly 28% of all children in Israel, about 61% of the children’s fatalities and 36% of the children’s injuries in road crashes are Arabs. In particular, Arab children constitute a dominant group among pedestrian casualties of road crashes. Accordingly, about 73% of the children pedestrians’ fatalities are Arabs (2).

Involvement in crashes is determined by the risks that the road environment entails and the level of exposure to those risks. While recent studies on children's commuting patterns to and from school have shown a rapid decline in active commuting across the world (e.g., 3, 4, & 5), a recent study by Levi et al. (6) found that above 80% of Israeli Arab children's trips to schools are done by foot. Simultaneously, the poor condition of the infrastructure and the lack of urban planning in Arab towns dramatically increase the risks for pedestrians, and specifically for children (7). Previous studies on Arab children’s injuries in road crashes as pedestrians revealed that in many cases this results from the lack of appropriate and dedicated playgrounds for children. This lack of playgrounds leads children to play on the street and as a result increase their exposure to traffic risks. This is exacerbated by the low levels of parents’ supervision. The low socio-economic status was found by many studies to play a major role (8).

Unsafe environment, dangerous walking patterns, and poor safety norms could adversely affect road safety and specifically the safety of children not only in the short term but also in the long term. Therefore, effective and proven measures should be applied to mitigate this trend.

The main aim of this study is to propose a multi-faceted approach in order to understand in depth the unique and various factors that contribute to the involvement of the Arab children in crashes as pedestrians. The multi-faceted approach, as it is termed, investigates various aspects related to exposure, behaviour, safety perception, and risks in the road environment to better understand the role of each of these factors in increasing the vulnerability of the Arab children in road crashes. Surveys, GPS, and road safety audits are used for this purpose. The rest of the paper is structured as follows: the next section introduces the main findings from the literature review; this is followed by a description of the study methodology including the chosen case study, the collected data and the challenges that the researchers faced during this process. Then a description of the measures used, and the statistical analysis are proposed. Finally, the results are introduced followed by a summary section including conclusions, limitations, and policy implication.

LITERATURE REVIEW

Advancing the safety of children as pedestrians has gained an increasing interest in the research community in the last two decades and attracted researchers from various domains. Active transport to school is in particular important because of its association with increasing children’s physical activity levels, and as a result their psychological and physiological well-being (8, 9).
Many factors and their interactions affect the exposure and safety of children as pedestrians. These range from the demographical, socio-cultural, and psychological factors to the environmental and infrastructural characteristics. The following paragraphs summarize the findings from the literature regarding the impact of these factors on active commuting to school and methods to measure active commuting to school. Finally, the research objective is stated.

**Active commuting to school**

Levi et al. (6) found that above 80% of Arab children's trips to school are done on foot. Similarly, Elias and Katoshevski-Cavari (11, 12) found in a nationwide study that 58% of children in the Arab sector walk to school in the morning. Travel to school in local buses was found to be rare (< 1%) among Arab children, pointing out the lack of proper public transportation system in Arab localities. With regard to gender differences within the Arab community, significant differences in school-to-home travels were found, where more boys than girls walked from school, and more girls than boys were driven from school by car.

Multiple studies show that distance from school is highly and negatively correlated with active commuting to school (e.g., 12, 13, 14, 15 & 16). Beyond inter-ethnic differences in commuting patterns, the family's socioeconomic status, and particularly parent's income, was found to be among the strongest predictors of active school commuting (14, 15). Moreover, the number of children in the family was found to be positively associated with active commuting to school (13).

Pertaining to child characteristics, boys tend to travel from/to school by walking more than girls (18, 19). Children's gender was found to not only influence their travel mode, but also the route children choose to walk from/to school, as boys tend to choose more risky routes (18). Pertaining to age, a recent review by Davison et al. (19) found an inconsistent pattern, and claim that the relationship between age and travel mode may not be universal or linear, and can vary across other child and family characteristics. These results were replicated in the Israeli-Arab context (12).

Household transportation options and parents' availability were also found to be strongly correlated with school commuting mode (14). Children whose parents possessed a driver license and were available to drive them to school were less likely to walk to school and more likely to be driven by private car (20).

In a theoretical model, McMillan (5, 13) hypothesize that children of parents who held high concerns about traffic and neighborhood safety are less likely to actively commute to school. Nevertheless, Davison et al. (19) argue that most studies do not find association between parents' traffic safety perceptions and commuting to school. The influence of parental perceptions of the child's safety behavior (for example, as the extent to which the parent believes that the child is aware of dangers on the road, and trusts the child to be careful when walking to school) on travel mode choice, to our knowledge, was not yet examined.

**Methods to measure active commuting**

The relative scarcity of research on children's travel patterns and routes has long been attributed to methodological and procedural difficulties (21). Studies in the field traditionally use self-report data (22), such as travel diaries, but it was found that children tend to underreport travels (23). A significant advancement has been made with the use of Geographic Information System (GIS) to evaluate not only quantitative travel data, but also the influence of the physical environment on...
children's pedestrian behavior, through map-based analysis. For example, in Israel, Lipman (24) used GIS to analyze safety-related characteristics in walking routes to school in a case study of a Jewish community.

The use of Global Positioning System (GPS) for studying travel behaviour is very common. It is particularly useful for studying children travel behaviour since children have difficulty to remember complex travel routes and to report them in a reliable manner (23). Several recent studies have used GPS to examine physical activities among school children, including travel to and from schools (e.g., 16, 25, 26). However, limited number of these studies focused on examining children’s walking routes as recorded by the GPS from the perspective of road safety. Recently, Levi et al. (6) studied children's travel patterns and safety using multiple methods, including travel diaries and GPS data collected during one day among families of 200 household of Jewish and Arab residents of Jerusalem, and analyzed travel patterns in relation to environmental and road characteristics. We are unaware of additional studies that investigated children's pedestrian safety using GPS data.

**Research objective**

The main objective of this research is to gain deeper insight into the reasons why Arab children are highly involved in crashes as pedestrians. To do so, this study investigates the characteristics of the Arab children travel mode to and from school and the factors that influence travel mode choice. Then, the study tries to identify the infrastructural, behavioral, safety perceptual risks that can increase children’s involvement in crashes. This study is expected to contribute in understanding what needed to be done to improve children’s safety as pedestrians in the Arab sector in Israel.

**STUDY METHODOLOGY**

Baron-Epel and Ivancovsky (8) emphasize the need for a broad perspective and a multi-level analysis and interventions that target multiple settings and utilize multiple intervention strategies to understand public health challenges. The involvement of Arab children in road crashes is directly affected by several interacting factors related to the surrounding physical environment, behavioral characteristics, and the social environment. Therefore, the methodology that will be proposed in this study is based on a multi-faceted approach. To fulfill this target, multiple research tools will be used including: questionnaires, GPS data collection of actual children walking routes, and road safety auditing. The following paragraphs describe these tools with more details.

**Choosing an Arab Town as a Case Study**

The present study uses data collected in the Arab local council of Jadeidi-Makr in the North District of Israel. Jadeidi-Makr was selected after examining several potential locations due to its high rates of casualties in road crashes. The average annual rate of children casualties in road crashes in Jadeidi-Makr between 2008 and 2012 was 1.66 per thousand children, higher than the average annual rate of children casualties in the Arab sector (1.54).

Jadeidi-Makr total population in 2012 was approximately 19.6 thousand residents. It has a low socio-economic ranking (cluster 2 out of 10) which is typical also for many other Arab towns. About 23.4% of the residents are 5-14 years old.
Sample and Procedure

Child and Parent Surveys

To gain insights about the travel modes used by Arab children (ages 6-15) to commute to school, their characteristics and correlations to child and parent related characteristics cross-sectional data analysis was conducted by two surveys in Jadeidi-Makr in March and April 2014.

The first survey aimed to encompass the majority of schools for children at the ages of 10-15 in the locality. A total of 1,326 school children (above 50% of the local population in this age group) completed an online questionnaire administrated in each school, with a fairly balanced representation of boys (51.9%) and girls (48.1%). With regard to age, 52.3% were in elementary schools and 47.7% in middle schools.

A second survey was held among parents of elementary school children. Two sampling and corresponding data collection methods were employed: First, a sample was obtained by geographical random sampling in all neighborhoods of Jadeidi-Makr. An interviewer was sent to conduct face-to-face interviews and obtained 78 completed questionnaires. As this turned out to be very time consuming, a second sampling procedure was adopted. A single class was randomly selected for each grade-level in two elementary schools (Al-Razi and Al-Najah). Students in those classes were asked to give their parents questionnaires (identical to those used in the first sample) and return them completed to school. Response rate was approximately 55% on average, and 175 completed questionnaires were obtained.

In both methods (total n=253), the child's mother was requested to complete the questionnaire, and if she was not available, the father was asked to complete it. The child and parent surveys are independent.

GPS Data

To investigate the safety of the school’s environment and the main routes leading to school GPS data on the children’s walking routes was collected and road safety auditing was conducted on these routes. To enable a meaningful analysis, the GPS measurements were limited to the central neighborhoods of Jadeidi (approximately 0.3 Km²) and to children who reside in this area and study in Alrazi elementary school, which is the largest elementary school in the town. A convenience sample was recruited among children at the 5th and 6th grades (ages 10-12). The chosen children had to meet two main criteria: (1) walk to and from school most of the days; (2) reside in different locations around the school. This was meant to enable us to obtain an environmentally heterogeneous data within the limited selected area.

We approached 20 children and asked for a written consent from parent/guardian. The parents of 18 children agreed and 2 declined. There was one drop-out due to medical reasons, leaving a total of 17 participants, 11 (65%) of whom are boys. A local assistant visited all children and parents at their home and explained the study purposes and procedures. The children received a wrist-wear GPS device at school and attended a group guidance session. They were asked to wear the device on their wrist for a total of 10 consecutive school days when walking from home to school and back. Parents and school teachers were requested to remind children to wear and use the device. Each participating family received at the end of the data collection period a gift card to purchase sports and safety products of the value of approximately $35 as a compensation for their participation.
**Challenges**

Several challenges were encountered along the study and during the different data collection procedures. The first challenge is related to the computer lab facilities available at the different schools that participated in the study. In some schools, the number of appropriately working computers in the lab was limited (10-15), which required 2-3 sessions for each class (30-35 students per class). The second challenge is related to the face-to-face parents’ survey. This required the recruitment of 3-4 reliable and experienced interviewers who went from door-to-door to conduct face-to-face interviews in selected neighborhoods in Jadeidi-Makr using an iPad. However, this method turned to be time consuming, therefore, a second method was adopted of asking the students to give their parents the questionnaires and return them back to the teacher couple of days later. The third challenge is related to the GPS watches which need to be recharged every night and children needed to activate them and deactivate them at the start and end of each trip, respectively. However, surprisingly, this was not problematic. Parents and teachers were very cooperative, and the children followed the instructions that were given to them during the guidance session.

**Measures**

**Child Questionnaire**

Children were asked to select their usual *school travel mode* (back from school) in a multiple choice format. The presented categories were: "walking", "private car", "organized transport (school bus)", "public transport (local bus)", "bicycle", and "sometimes walking and sometimes by car". To learn about *accompanied walking*, children indicated whether and by whom they are typically accompanied when walking back from school, using three categories: "with siblings or friends", "with parents or other adults", and "alone". Finally, *worry of risks as pedestrians* was measured with four attitude items, each rated on a 4-point scale ranging from "not true at all" (1) to "very true" (4). The items were: "It bothers me that there are no sidewalks on the way to school", "it is difficult for me to cross roads on the way to school", "when I walk outside, I'm afraid of cars driving in high speed", and "when I walk, it bothers me when cars park on the sidewalk". The scale was computed as an arithmetic mean of all item scores ($\alpha=0.50$ and $\alpha=0.66$ for elementary and middle school children, respectively). Finally, children entered their gender and grade (as proxy of age groups), which will be used as between-subject factors in the analysis.

Before analysis, child respondents were categorized into two age groups: students in grades 5th and 6th in elementary school, and students in grades 7th-9th in middle school.

**Parent Questionnaire**

The parent questionnaire measured children travel patterns and characteristics, as well as parental safety perceptions. Parents were instructed to answer with regard to their youngest child in elementary school.

Child's travel mode to school and accompanied walking were examined with regard to both home-to-school and school-to-home daily travels. The measure of travel mode was identical to the child questionnaire, with an additional category referring to "mixed mode", namely "part of the way by car or bus and the rest on foot". Accompanying when walking to (from) school was measured similarly to the child questionnaire, albeit with different categories, namely "walks with children his age", "children older than him", "parents or other adults", and "alone". Since the child...
and parent samples are independent, we were unable to examine convergent validity. A recent analysis of test-retest reliability of parent and child reports of school travel mode found high levels of reliability (kappa range: 0.62-0.97, (27)).

To measure crossing independency, which is particularly relevant for children under the age of nine, parents were asked whether they allow their child to cross the street alone. Response options were: "always", "only in certain situations", and "never".

To estimate child's school travel time, parents were asked how many minutes it takes their child to walk from home to school. Responses were used as a continuous variable and a proxy of home-school distance.

Parents' familiarity with the child's walking route to school was measured on a 4-point scale ranging from "not familiar at all" (1) to "very familiar" (4). Multiple single-item measures of parental perceptions and concerns were employed. The following three variables were measured on a 5-point scale, ranging from "to a very small extent" (1) to "to a very large extent" (5). Perceived safety of the child's walking route to school measured the extent to which parents believe their child's route to school is safe for walking (higher scores indicating safer routes). Another question measured satisfaction of road safety education in the child's school (higher scores reflecting more satisfaction). Two variables measured parental perceptions pertaining to the child's pedestrian behavior: parents were asked to what extent they believe their child is aware of dangers when walking outside (perceived awareness). Finally, parents rated the level of trust they have in their child to be careful as a pedestrian on an 11-point bipolar scale, ranging from "don't trust at all" to "trust to a large extent". Higher scores reflect more trust.

The parent questionnaire also included several demographic and background variables. Three age groups were coded for the analysis of the parent survey, all referring to children in elementary schools: Children at the 1st and 2nd grades, at the 3rd and 4th grades, and at the 5th and 6th grades.

**GPS measurements**

Children's walk to school was monitored using GPS-enabled watch ("fitness tracker") from the type "Garmin Forerunner 10" (Garmin International Inc, sites.garmin.com/forerunner10). A cost of a GPS-enabled watch unit is about 130 $. The watches required no action from the child during the walk, but they have to be activated/deactivated at the beginning/end of each trip. The device measured and recorded position points based on geographic coordinates and altitude every 1 to 10 seconds, depending on the child's direction and speed.

A total of 226 completed trips were recorded (about 66% of the total theoretical possible trips) with a total distance of 125.85 km, distributed almost equally between home-school (60.49 km) and school-home trips (65.36 km). In addition to missing trips, there were 23 incomplete trips, with either small trip segments or distorted GPS signal.

**Road safety auditing**

In this study, stage 5 road safety auditing was conducted, i.e. road safety auditing for existing roads by an independent and qualified team composed of two road safety experts, the school's principal, and the community safety officer. Before visiting the site, the team studied the neighborhood and contacted the school principal to further
understand the existing problems. The site visits were conducted during a regular school day. The team focused on identifying potential hazards that can endanger children around the school area and on the main approaches that lead to the school. Following this, the team suggested recommendations on how to improve the safety of the school area and its neighborhood.

**Data Statistical Analysis**

A series of log-linear analysis with follow-up $\chi^2$ tests or factorial ANOVAs were used to examine differences in categorical or continuous variables between gender (boys vs. girls) and age groups (5-6 grades and 7-9 grades in the child survey, and 1-2 vs. 3-4 vs. 5-6 grades in the parent survey) in both surveys. Additional specific tests were conducted and are detailed in the results section.

Multivariate analysis was conducting through two analyses of logistic regressions predicting the odds of walking from and to school (vs. not walking). All categorical predictors were binary-coded (0,1) based on frequencies, while continuous variables were retained as such. Prior to the regression models, the association of all potential explanatory variables with the outcome variables was assessed with bivariate Pearson correlations. Due to the exploratory nature of the analysis, all variables of theoretical importance were retained for the analysis regardless of the strength of their correlation with the outcome. This includes binary-coded socio-demographics and household-related variables, estimated school travel time, parental perceptions with regard to the child's travel route, satisfaction of school's road safety education, and child-related safety perceptions. In addition, we examined multiple interactions between child's gender and age, parental crossing supervision, and perceived awareness and trust. All variables were entered as one block, and multicollinearity was assessed. Regression coefficients B(S.E), Odds ratios, and confidence intervals (95%) are provided.

The GPS-based data was analyzed using both quantitative and geographical means. Since the sample size was small (n=17), descriptive data was summarized for each participant and separately for home-school and school-home travels, with means and standard deviations for (1) walking trip length in km, (2) total walking time in seconds, (3) moving walking time in seconds, and (4) average moving speed in km/h. We described patterns across these four variables at the aggregate level (using participants' summaries, n= 17), focusing on differences between home-to-school and school-to-home walks. Second, we utilized spatial analysis of travel routes using Geographic Information Systems (GIS). Location data was digitally depicted on a detailed map. This was achieved by entering processed location data in GPX files into a web-based service, "GPS Visualizer" (www.gpsvisualizer.com), which layered trips' location points on Esri's ArcGIS urban maps (www.arcgis.com). The maps provide limited information on land use such as building locations.

In all analyses, statistical significance was determined by a p value less than 5%. Statistical calculations and tests were conducted with SPSS 22.0.

**RESULTS**

**School Travel Mode by Gender and Age**

Travel modes back from school as reported in the child survey were analyzed. 325 (29.7%) of all children reported that they sometimes walk to school and sometimes are being driven by car. School-to-Home travel modes were found to be significantly
different between the two age groups, $\chi^2(4) = 59.09$, $p < 0.001$, Cramer’s $V = 0.21$, and between boys and girls, $\chi^2(4) = 19.43$, $p = 0.001$, Cramer’s $V = 0.12$. The percentage of children in middle school who usually walk to school (63.8%) is significantly higher than in elementary school (50.1%). Children in elementary school also travel more by organized transport (11.5%) compared to middle school children (2.4%), mostly due to the high prevalence of students using organized transport in one particular elementary school (Al-Najah school): 53%, compared to between 1% and 16.1% in other schools in Jadeidi-Makr. In addition, more boys (61.7%) walk to school than girls (51.2%). Finally, cycling back from school was found to be a negligible category for all age and gender groups ($n \leq 6$).

The results of the parents’ survey regarding their children school travel mode from school to home showed similar trends. Walking was reported as the usual mode for boys (72.2%) and children in the age groups of 3rd-4th grades (74.5%) and 5th-6th grades (81.4%), but was a significantly less popular mode among girls (58.0%) and children in the 1st-2nd grades (47.5%). The later groups travel more by organized transport.

McNemar’s test for related dichotomous variables shows that the distribution of walkers and non-walkers in travels from home to school is not significantly different from that in travels from school to home ($p = 0.21$).

**Accompanied Walking to School**

According to children’s reports, among children who usually or sometimes walk back from school, the vast majority of children walk back from school with siblings or friends. In both gender groups combined, the percentage of 5th-6th graders who walk back from school alone is higher than in 7th-9th graders, 17.3% versus 11.5%, $\chi^2(2)=7.97$, $p=0.02$, Cramer’s $V=0.09$. A similar but smaller difference was found between male and female students in both age groups combined: more boys (16.8%) than girls (11.7%) walk back from school alone, $\chi^2(2)=6.92$, $p=0.03$, Cramer’s $V=0.08$. Finally, only a small percentage of children are accompanied by a parent or another adult when walking back from school (2.4%). This percentage is the highest among girls in elementary school (4.2%) and the lowest for boys in elementary school (1.1%).

The interaction between age, gender, and accompanied walking as a dichotomous variable (accompanied walking vs. walking alone) was examined through log-linear analysis with follow-up $\chi^2$ tests, and was found to be insignificant, $\chi^2(1)=0.05$. The log-linear model retained second-order effects, $\chi^2(1)=14.11$, $p=0.007$. The association between age and accompanied walking was significant among boys, $n=578$, $G^2(1)=3.85$, $p<0.05$, and among girls, $n=530$, $G^2(1)=4.27$, $p<0.05$. The odds of children to walk alone back from school are 1.58 and 1.71 times higher in the highest cohort of elementary school than in middle school, for boys and girls respectively.

**Safety-Related Concerns as Children Pedestrians**

The relationships between children’s gender (boys/girls), age (5th-6th vs. 7th-9th), travel mode (walkers vs. non-walkers), and concerns as pedestrians (continuous) was examined by performing a three-way Analysis of Variance (ANOVA). All three main effects were significant, albeit with rather small effect sizes. It was found that boys ($M=2.34$, $SD=0.74$) are less worried of safety risks as pedestrians than girls ($M=2.57$, $SD=0.73$), $F(1,1261)=14.99$, $p<0.001$, partial $\eta^2=0.01$; Older children in middle school ($M=2.35$, $SD=0.77$) are less worried than younger children in elementary
school (M=2.54, SD=0.71), F(1,1261)=18.14, p<0.001, partial $\eta^2=0.0$; and non-walkers (M=2.39, SD=0.77) are slightly less worried by risks they encounter as pedestrians than walkers (M=2.46, SD=0.74), F(1,1261)=7.49, p=0.01, partial $\eta^2=0.01$.

The interaction between travel mode and age was statistically significant, F(1,1261)=4.18, p=0.03, partial $\eta^2=0.003$. Bonferroni-corrected multiple comparisons show that only among middle school students, non-walkers (M=1.93, SD=0.81) are significantly less worried about safety than walkers (M=2.38, SD=0.76), t(601)=-3.31, p=0.001, d=0.56, whereas no parallel travel mode differences were found among 5th and 6th graders, t(664)=-0.39.

Children Travel Behavior and Parental Perceptions

Multiple factorial ANOVAs were used to examine gender and age differences in continuous variables obtained from parents. With regard to self-reported parental perceptions of school travel and child pedestrian behavior, we found that on average, parents of children in all gender and age groups claim to be well familiar with their child's walking route to school. No significant mean differences (between gender; among age groups) were found pertaining to the perceived safety of that route (F(1,21)=1.15; F(2,21)=0.51, accordingly), as well as pertaining to parents' satisfaction of road safety education in their child's school (F(1,24)=0.74; F(2,24)=0.82, accordingly). Parents of children in the older cohort believe that their children are aware of dangers on the road significantly more than parents of the younger cohort (F(2,24)=3.49, p<0.05), and trust their children to be careful when walking outside significantly more than parents of the two younger cohorts (F(2,24)=5.94, p<0.01). On average, parents express high levels of trust in their children's behavior as pedestrians.

Correlation analysis shows that parents who believe that their child is aware of dangers also put a higher trust in him/her as a pedestrian, r=0.44, p<0.001. Trust is also higher among parents who are satisfied from road safety education in the child's school, r=0.28, p<0.001. Education satisfaction is also somewhat positively correlated with perceived route safety, r=0.21, p<0.01.

Parental Supervision of their Children Crossing and Travel to School

Parental supervision was found to be effective in preventing child pedestrian risks and injuries (28). The Israeli law requires adult supervision when crossing the street until the age of six. Nevertheless, the National Road Safety Authority recommends that children under the age of nine should not be allowed to cross the street alone (29).

Based on the results of the parents’ survey, significant differences were found between the child's age group and crossing independency, $\chi^2(4)=42.01$, p<0.001, V=0.29. Only 39% of parents allow their children to cross the street alone, compared to 21% and 2% in the 3rd-4th and 5th-6th grade groups, respectively (all percentages are significantly different from each other). Moreover, exactly half of the parents to 1st and 2nd graders (<9 years old), allow them to cross the streets "in certain situations", and additional 11% allow them to do so "always". Differences were also found between parents' practices toward boys and girls, with higher percentage of female students (30.3%) whose parents "never" allow them to cross the streets alone, compared to male students (17.3%), $\chi^2(2)=5.98$, p=0.05, V=0.15.
Predicting Home-to-School and School-to-Home Walking Odds

Multivariate analysis was employed through two logistic regressions predicting the odds of walking (vs. not walking) from and to school, from a set of variables that include socio-demographics, travel characteristics, and parental perceptions. All categorical predictors were binary-coded (0,1) based on frequencies, while continuous variables were retained as such. Due to the exploratory nature of the analysis, all variables of theoretical importance were retained for the analysis and entered as one block regardless of the strength of their correlation with the outcome. TABLE 1 presents the results of the analyses. It was found that the odds of walking versus non-walking is higher for the older age group and families with low socio-economic status, and lower for higher estimated walking time indicating that the greater the distance from school, the less likely the child will walk to and from school. The important role of distance in school travel mode choice among Israeli Arabs was also found recently by Elias and Katoshevski-Cavari (12).

Quite surprisingly, parents who are more satisfied from road safety education in their child's school, and who trust their child more as a pedestrian, are less likely to choose walking as their child's usual travel mode to and from school. It may be that higher trust characterizes parents from higher socioeconomic levels (r=0.29, P<0.001), whose children are more likely to arrive to and from school in motorized means.
### TABLE 1 Multivariate Logistic Regression Analysis Predicting the Odds of Walking vs. Non-Walking to and from School

<table>
<thead>
<tr>
<th>Variable</th>
<th>Corr. with outcome (r)</th>
<th>B (S.E)</th>
<th>Wald</th>
<th>Odds ratio (95% CI)</th>
<th>Corr. with outcome (r)</th>
<th>B (S.E)</th>
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<th>Odds ratio (95% CI)</th>
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<td><strong>Child characteristics</strong></td>
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<td>Gender (1 = female)</td>
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<td>-0.54 (0.49)</td>
<td>1.19</td>
<td>0.59 (0.22-1.53)</td>
<td>-0.20**</td>
<td>-1.16 (0.58)*</td>
<td>3.97</td>
<td>0.31 (0.10-0.98)</td>
</tr>
<tr>
<td>Age group (1 = 3rd-6th grades)</td>
<td>0.22**</td>
<td>1.63 (0.54)**</td>
<td>9.23</td>
<td>5.12 (1.79-14.68)</td>
<td>0.23**</td>
<td>2.71(0.72)**</td>
<td>13.94</td>
<td>14.95 (3.62-61.84)</td>
</tr>
<tr>
<td><strong>Parental and family characteristics</strong></td>
<td></td>
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<tr>
<td>Parent's age (1 = 40 and above)</td>
<td>0.13</td>
<td>0.47 (0.53)</td>
<td>0.81</td>
<td>1.61 (0.57-4.49)</td>
<td>0.14</td>
<td>0.74 (0.60)</td>
<td>1.56</td>
<td>2.14 (0.60-6.75)</td>
</tr>
<tr>
<td>Parent’s education (1 = higher education)</td>
<td>-0.20**</td>
<td>0.19 (0.57)</td>
<td>0.11</td>
<td>1.21 (0.40-3.69)</td>
<td>-0.11</td>
<td>0.76 (0.65)</td>
<td>1.39</td>
<td>2.14 (0.60-7.60)</td>
</tr>
<tr>
<td>SES (1 = average income and above)</td>
<td>-0.39***</td>
<td>-2.14 (0.63)**</td>
<td>11.63</td>
<td>0.12 (0.03-0.40)</td>
<td>-0.31***</td>
<td>-2.20(0.72)**</td>
<td>9.52</td>
<td>0.11 (0.03-0.45)</td>
</tr>
<tr>
<td>No. of children</td>
<td>-0.22**</td>
<td>0.07 (0.21)</td>
<td>0.13</td>
<td>1.07 (0.72-1.61)</td>
<td>0.02</td>
<td>0.17 (0.24)</td>
<td>0.52</td>
<td>1.19 (0.75-1.90)</td>
</tr>
<tr>
<td>Driving license (1 = yes)</td>
<td>-0.06</td>
<td>-2.27 (1.06)*</td>
<td>4.64</td>
<td>1.29 (0.51-3.27)</td>
<td>-0.13</td>
<td>-3.41(1.15)**</td>
<td>8.78</td>
<td>0.33 (0.03-0.32)</td>
</tr>
<tr>
<td>Driving time per day (1 = driving)</td>
<td>0.07</td>
<td>1.54 (0.89)</td>
<td>3.00</td>
<td>4.68 (0.82-26.84)</td>
<td>-0.08</td>
<td>2.45 (0.95)**</td>
<td>6.71</td>
<td>11.64 (1.82-74.59)</td>
</tr>
<tr>
<td>Children involved in crashes (1 = yes)</td>
<td>-0.18*</td>
<td>0.71 (0.64)</td>
<td>1.25</td>
<td>2.04 (0.59-7.08)</td>
<td>0.14*</td>
<td>0.48 (0.71)</td>
<td>0.45</td>
<td>1.61 (0.40-6.45)</td>
</tr>
<tr>
<td><strong>Characteristics and perceptions by parents of child’s school travel</strong></td>
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<tr>
<td>Estimated travel time (min)</td>
<td>-0.22**</td>
<td>-0.12 (0.05)*</td>
<td>6.01</td>
<td>0.89 (0.81-0.98)</td>
<td>-0.24***</td>
<td>-0.13 (0.56)*</td>
<td>5.23</td>
<td>0.88 (0.79-0.98)</td>
</tr>
<tr>
<td>Route familiarity</td>
<td>-0.06</td>
<td>0.26 (0.48)</td>
<td>0.29</td>
<td>1.29 (0.51-3.27)</td>
<td>-0.2</td>
<td>0.43 (0.60)</td>
<td>0.51</td>
<td>1.53 (0.47-4.98)</td>
</tr>
<tr>
<td>Perceived route safety</td>
<td>0.07</td>
<td>0.24 (0.22)</td>
<td>1.12</td>
<td>1.27 (0.82-1.96)</td>
<td>0.04</td>
<td>0.31 (0.27)</td>
<td>1.28</td>
<td>1.36 (0.80-2.30)</td>
</tr>
<tr>
<td>Satisfaction of school's road safety education</td>
<td>-0.18*</td>
<td>-0.598 (0.22)**</td>
<td>7.59</td>
<td>0.55 (0.36-0.84)</td>
<td>-0.19**</td>
<td>-0.72(0.25)**</td>
<td>8.17</td>
<td>0.49 (0.30-0.80)</td>
</tr>
<tr>
<td><strong>Characteristics and perceptions by parents of child’s pedestrian behavior</strong></td>
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<tr>
<td>Independent crossing (1 = always allow)</td>
<td>-0.00</td>
<td>0.07 (0.59)</td>
<td>0.02</td>
<td>1.07 (0.34-3.38)</td>
<td>0.11</td>
<td>3.52 (1.36)**</td>
<td>6.72</td>
<td>33.72 (2.36-82.24)</td>
</tr>
<tr>
<td>Child’s awareness</td>
<td>-0.08</td>
<td>0.08 (0.26)</td>
<td>0.09</td>
<td>1.08 (0.65-1.80)</td>
<td>-0.08</td>
<td>-0.16 (0.30)</td>
<td>0.28</td>
<td>0.86 (0.48-1.53)</td>
</tr>
<tr>
<td>Parents’ trust in their child to be careful as a pedestrian</td>
<td>-0.21**</td>
<td>-0.19 (0.12)</td>
<td>2.63</td>
<td>0.83 (0.66-1.04)</td>
<td>-0.22**</td>
<td>-0.30 (0.15)*</td>
<td>4.35</td>
<td>0.74 (0.56-0.98)</td>
</tr>
<tr>
<td><strong>Interactions</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Age group X Crossing independency</td>
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<tr>
<td>Model Summary</td>
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<td></td>
</tr>
<tr>
<td>n = 186</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n = 186</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant: B (S.E) = 4.24 (2.31)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Constant: B (S.E) = 5.17 (2.84)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R² = .33 (Cox &amp; Snell), .49 (Nagelkerke)</td>
<td>-2 Log likelihood = 133.59 (only constant = 208.08)</td>
<td></td>
<td></td>
<td></td>
<td>R² = .35 (Cox &amp; Snell), .55 (Nagelkerke)</td>
<td>-2 Log likelihood = 108.93 (only constant = 188.35)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>χ²(16) = 74.50, p &lt; .001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>χ²(17) = 79.42, p &lt; .001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** † Coefficients are point-biserial for continuous predictors and Phi for dichotomous predictors; *p ≤ .05. **p < 0.01. ***p ≤ .001
The odds of independently-crossing children to arrive to school by walking were higher than non-independent children. This effect was significant over and above that of age. Moreover, there was a marginally significant interaction between the child's age group and crossing independency, suggesting that the association between independency and walking is stronger for younger children compared to older children.

**Spatial Analysis of Children Walking Routes and Safety Perspective: Pilot Study**

The GPS-based data obtained from 226 trips (completed by 17 children) was analyzed using both quantitative and geographical means. First, descriptive data were summarized for each child and separately for each direction, for walking trip length (km), total walking time (sec), moving walking time (sec) and average moving speed (km/h). Then patterns across these four variables were described at the aggregate level. Second, we utilized spatial analysis of travel routes using Geographic Information Systems (GIS).

On average, children spent less time walking from home to school than on their way back, both in terms of total trip time, Home-to-school: $M=515.94$, SD=282.28, School-to-Home: $M=657.66$, SD=396.91, as well as time spent in movement, Home-to-school: $M=479.34$, SD=241.17, School-to-Home: $M=624.59$, SD=359.56. Moreover, their average walking speed was higher when walking to school in the morning, $M=4.27$, SD=0.90, than when walking back at noon, $M=3.78$, SD=0.80. These speeds are lower compared to the average walking speeds found in the recent study by Dessing et al. (16). However, the data suggests that differences in trip's length, duration, and walking speeds might be higher for boys than for girls. Significance tests were not conducted since the sample was relatively small (n=17), and thus this remains to be tested in future studies with larger samples. FIGURE 1 illustrates an example of GIS mapping for travels of two children in 5th grade, one male (blue) and one female (red), to and from school, based on GPS data obtained on June 4, 2014.

![GIS mapping for travels of two children, one male (blue) and one female (red), to and from school.](image)

From the maps in FIGURE 1 it can be said that these two children walked to school mostly on main roads and had at least on average 4 times to cross these roads.
To assess the implications of this, and other potential risks in the school area, from road safety point of view, a road safety auditing was conducted.

In the road safety auditing process, the audit team identified several major safety related problems in the school area and in the main approaches leading to the school. The first major problem is the multiple and unsafe access gates to the school. Al-Razi school has six unregulated access gates that students are allowed to use. The main access gate of the school is also unregulated and used simultaneously as an access gate for the students and as main entrance to the parking lot of the teachers’ vehicles (FIGURE 2(a)). The other access gate also leads the entering students to cross the parking lot in order to enter the school building (FIGURE 2(b)). This obviously increases the potential conflicts between the walking children and the vehicles. Thus, there is an immediate need to physically separate between the parking area and the pedestrian area, and reduce the number of gates to a manageable and regulated number.

![FIGURE 2 (a) Main entrance gate to Al-Razi school; (b) another entrance gate; (c,d) lack of sidewalks, traffic calming, and crossing facilities.](image)

The second major problem is the lack of existence of continuous sidewalks in the principal walking routes to school, lack of adequate crossing facilities, and lack of traffic calming elements (see FIGURE 2(c,d)). The school principal indicated that this lack in pedestrian facilities prevented them by law to operate the road-safety crossing guards program. This program is targeted to protect the children while crossing the road near the school and teach them the importance of obeying the traffic rules. These students undergo training by the Israeli Police and are qualified to operate this program only when the roads are equipped with the needed pedestrian facilities. In the case of Al-Razi school since these elements are missing, the school was not given permission from the Police to operate this program which was proven to have a
positive effect on children’s safety behavior \((30)\). It can also be noticed that the width of the sidewalks is quite narrow (<1.0 meter), compared to the width of the road serving the motorized traffic (~9.0 meters). This obviously prioritizes the motorized traffic over the pedestrians. The intersections in the school surrounding were also found to be dangerous and not safely designed. In many cases the sight distance is limited.

Beside the design issues raised so far, the infrastructure was also found to be poorly maintained: holes in the pavement, no marking of the pedestrian’s crossings, missing pedestrian’s guardrails, and lack of traffic and warning signs on entering a school area. Therefore, the road safety audit team recommended to: (1) Design safe walking approaches to school and emphasize the entrance to the school zone; (2) Arrange the access gates to the school with a complete physical separation between the pedestrians and the parking areas; (3) Install traffic calming elements in the school zone; and (4) Advance and revive the road-safety crossing guards program.

Similar risks and maintenance issues were also found along the main routes approaching the school including lack of adequate pedestrian sidewalks, pedestrian crossings, and proper intersection design.

Improving the infrastructure and the safety of the school environment is a critical element when it comes to educating children pedestrians about safe behavior.

**SUMMARY**

This section summarizes the study conclusions, discusses its limitations and presents the study policy implications.

**Conclusions**

This study proposed a multi-faceted approach to study the unique characteristics of the travel behavior, pattern and safety perception of Arab children in Israel. The Arab local council of Jadeidi-Makr was chosen as a case study. Data was collected by means of questionnaires posted to the children and their parents concerning characteristics of the children travel to school and objective data on the children walking routes collected by GPS-enabled watches. Road safety auditing of the school environment and the main approaches to the school was conducted in order to understand the risks entailed.

The results in this research highlight several critical safety related problems which require immediate intervention. While the results from the questionnaires indicated that walking was the dominant mode of transport to school, road safety auditing indicated very poor infrastructural design of the school area. This includes: lack of continuous sidewalks in the principal walking paths to school, lack of adequate crossing facilities, and lack of traffic calming elements in the principal approaches leading to the school. The high exposure of the children to unsafe road environment increases the probability of their involvement in road crashes. Moreover, it was found that more than half of the parents to children at the 1\textsuperscript{st} and 2\textsuperscript{nd} grade of elementary school (6-7 years old) allow their children to cross the street alone, and have high levels of trust in their child's safety behavior as a pedestrian. The results of this study once again prove, similarly to Baron-Epel and Ivancovsky \((8)\), that a multi-faceted approach is needed when studying public health problems and therefore, it is suggested in this paper to apply this approach to other schools and cities. Moreover, the pioneer use of wearable GPS devices to examine safety-related attributes of
children walking patterns, particularly in a highly complex and risky urban environment, was found to be highly promising.

The second stage of this research study will recruit larger sample of students to participate in the GPS study and will further analyze the GIS map of the routes created from the GPS data collected. The analysis will identify the infrastructural characteristics of these routes and its surrounding, such as density of footpath available in the area, frequency of pedestrian crossings, availability of road furniture, etc., in order to evaluate the level of risk of these routes and recommend the children and their parents to choose safer routes to school. This analysis will also result in drawing recommendations regarding improved infrastructure on the routes used by school children.

**Limitations**

Two limitations should be noted and taken into consideration:

First, we were able to show that in the Israeli-Arab population, parental safety-related perceptions contribute to explaining the choice of school travel mode over and above sociodemographic characteristics. Nevertheless, it was beyond the scope of this study to assess the role of many demographic, socio-cultural, environmental, and psychological factors that were found in previous research to influence parental decisions of child's travel mode (13, 19). In particular, while our results are based on reports by mothers, it is likely that fathers and mothers hold different safety-related perceptions, and in addition, the effect of these perceptions on the child's travel modes differs between them (7).

Second, due to limitations of access and resources, two distinct sampling procedures and modes of administration were employed in the parent survey. Although the questionnaires and measures were identical in both assessments, self-reports, particularly in sensitive questions, are often influenced by various factors related to assessment modes. Accordingly, face-to-face interviews may lead to lower perceived privacy and greater social desirability compared to self-administration, which in turn may bias responses (32). The validity of the above results should be enhanced by future research that applies random sampling and unified data collection techniques, thus minimizing potential error related to data collection techniques. Future studies should also try to obtain a larger dataset and study the interaction of parental gender and safety related variables such as the perceived safety of the child's walking route to school.

**Policy Implications**

The results of this study calls for policy makers and responsible authorities to take immediate actions to increase the safety of Arab pedestrian children in Israel. The Transport Ministry and the National Road Safety Authority in Israel should encourage and support municipalities in the Arab sector to improve the road infrastructure in general, and pedestrians’ facilities around school areas in particular. This can be done first by defining school zones and reducing the speed limit in these zones to 30 km/h. Road design also has an impact on driving speeds, reducing traffic lane width, adding traffic calming elements, and increasing the width of pedestrian’s sidewalks, and in turn prioritizing pedestrians over vehicles, is expected to increase the awareness of drivers to pedestrians.

The Ministry of Education, the National Road Safety Authority, non-governmental organizations, and parents should intensify their efforts in increasing
the awareness of children regarding existing risks on the roads. Traffic safety educational material should be adapted to the reality of the Arab children and should provide children with the needed competencies and skills to safely walk in their localities.

There is consensus among traffic safety professionals around the world and the Israeli Road Safety Authority that children under the age of nine should not cross roads alone (31) because their visual, cognitive and perceptual skills and abilities are not yet developed to handle complex road and traffic environments. This calls for increasing the awareness of parents to this issue and a clear and enforced policy by the responsible authorities.

ACKNOWLEDGMENT

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REFERENCES


