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# Association of adolescents' independent mobility with road traffic injuries in Karachi, Pakistan- A Cross-sectional study



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# Association of adolescents' independent mobility with road traffic injuries in Karachi, Pakistan- A Cross-sectional study

**Authors** Uzma Rahim Khan (MBBS, MSc)*[1,2], Junaid A Razzak (MD, PhD, FACEP)[3], Martin Gerdin Wärnberg (MD, PhD)[1]

[1] Karolinska Institutet, Department of Global Public Health, Stockholm, Sweden

[2] Aga Khan University, Department of Emergency Medicine, Karachi, Pakistan

[3] NewYork-Presbyterian Hospital, Weill Cornell Medical Center, Weill Department of Medicine, New York, US

***Corresponding Author:**

**Uzma Rahim Khan**
Department of Global Public Health
Karolinska Institutet
Tomtebodavägen 18 A
171 77 Stockholm
Widerströmska Huset
Sweden
Email: uzma.khan@ki.se

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## A B S T R A C T

**Objective** The association between adolescents' independent mobility and road traffic injuries is unclear. The purpose of this study is to determine measures of adolescents' independent mobility associated with road traffic injuries (RTIs) in an urban lower middle-income setting.

**Study design** Cross-sectional study

**Setting** Survey from 75 schools in Karachi, Pakistan.

**Participants** Adolescents (aged 10 to 19 years) in grades 6 to 10 were enrolled from the participating schools.

**Outcome** Any RTI that resulted in any first aid or consultation in a healthcare setting.

**Results** Adolescents who had weekend activity/ies outside the home by themselves (adjusted odds ratio (aOR) 1.68; 95% confidence interval (CI) 1.02 to 2.80) or had activities accompanied with adults as well as alone (aOR1.63; 95% CI 1.03 to 2.64) had higher odds of RTIs. This variable is also statistically significant in subgroup analysis of adolescents aged 10-15 years along with allowed to cross main roads alone (aOR 1.43; 95% CI 1.02 to 1.99).

**Conclusions** Measures of independent mobility, i.e., engaging in weekend activities outside the home and crossing main roads, are associated with an increased risk of RTIs among adolescents.

**Strengths and limitations of this study**

- This is the largest survey of adolescents' independent mobility due to coverage of 75 schools including both public and private schools.
- The methodology was strengthened due to cluster random sampling of schools with at least one classroom of students per school and equal number of grades 6 to 10.
- Lack of information of independent mobility (exposure) of adolescents when road traffic injury (outcome) occurred limits the understanding of association between exposure and outcome.

## Introduction

Independent mobility, which refers to the freedom of children and adolescents to move around without being accompanied by an adult, can contribute to physical activity and positively impact psychological, social, cognitive and spatial development.[1, 2] Independent mobility has positive effects on health, reducing the risk of obesity, hypertension, diabetes and many other non-communicable diseases, but may also increase road traffic injuries (RTIs).[3, 4]

Adolescents are vulnerable to RTIs, which are the leading cause of death in adolescents aged 10-19 years. In 2013, the RTI death count in adolescents was 115,186 globally, and 90% of these deaths occurred in low- and middle-income countries.[5] Deaths and injuries from RTIs are most common among pedestrians, cyclists and motorcyclists in low- and middle-income countries, where the built environment is least likely to be adapted to the needs of vulnerable road users.[6, 7]

Research on the independent mobility of adolescents and RTIs is scarce, and an association between independent mobility and road traffic injuries has not been determined. A study from New Zealand showed that adult accompaniment of children aged 5 to 12 years old was associated with reduced pedestrian injury risk, but this result was not statistically significant.[4] A study from India of children aged 11 to 14 years old showed no significant association of independent mobility and RTIs.[8] Pedestrians injuries aged 16 years and less in Singapore involved walking unaccompanied by adults.[9]

The sustainable development goals (SDGs) advocate for safe transport and the improvement of road safety by targeting the special needs of children.[10] It is important to determine whether

adolescents' independent mobility is associated with an increased risk of RTIs in deciding how to advocate for independent mobility. The aim of this study is to determine measures of adolescents' independent mobility associated with RTIs in an urban lower middle-income setting in Karachi.

## Methods

### Study design

We conducted a cross-sectional study between September and December 2014.

### Setting

We surveyed students from schools in Karachi, Pakistan. Overall, 75 schools participated in the study, of which 26 (34%) were public schools and 49 (65%) were private schools. The ratio of public versus private schools in sample was determined based on the distribution of schools in the urban Pakistan.[11] We used cluster random sampling to select the schools. We obtained permission to conduct the study from the principal of each school. It was classroom based survey where classroom was identified by school administration. At least one classroom per each school was included. There was almost equal representation of all grades from 6 to 10.The written informed consent was obtained from the parents/guardians of the study participants and informed verbal assent was obtained from study participants.

### Participants

Adolescents (aged 10 to 19 years) in grades 6 to 10 were enrolled from the participating schools.

### Outcome

Any RTI that resulted in any first aid or consultation in a healthcare setting.

**Exposures**

Adolescents' independent mobility was assessed as parental permission to cross main roads on own, travel from school to home alone, travel by public bus on own, and engagement in weekend activities (alone, together with adults, or a mixed pattern with some activities alone and some with adults). The possible responses to the questions related to independent mobility were either "yes" or "no".

**Other covariates**

Age, gender and the type of school (public or private) were included as covariates.

**Data sources/measurements**

The study questionnaire was adapted from London Policy Studies Institute [12-14]. It had multiple-choice questions, was available in English, and translated in Urdu. We piloted the questionnaire to assess its effectiveness, acceptability, and clarity for the study participants, and modifications were made accordingly before launching the main data collection process. Research assistants explained each question to students to ensure clarity in comprehension. The questionnaire took approximately 25 minutes to be completed by a class of students.

**Study size**

The sample size for the original survey was 1,270 school students, based on the assumption that at least 50% of students were active commuters (since no past information on adolescents' school mobility patterns in Pakistan was available). We used a 95% confidence level (CI), a bound-on error of ± 5%, and a design effect of 3, and we inflated the sample size by 10% to account for non-responders.

In this study, we used logistic regression to determine the associations between the measures of independent mobility and RTIs. The sample size requirements for this type of analysis have been described as between 10 to 25 events (participants with the outcome) and at least as many non-events per parameter in the model.[15] With 265 events, we were able to accommodate up to 10 parameters in the model.

**Statistical analysis**

We performed the analysis using R.[16] The categorical variables are described using frequencies and percentages. We used logistic regression to the estimate unadjusted and adjusted associations as well as the 95% CIs between the measures of independent mobility and RTIs. We adjusted for age, gender, and school type. We conducted a subgroup analysis including only adolescents aged 10 to 15 years. We adjusted for age in the subgroup analysis.

**Results**

Data from 1264 10- to 19-year-old adolescents were included. The majority of the participants were girls (60%), and 59% were 10 to 14 years old. Majority walk to school (72%). Almost half of the adolescents reach school between 5 to 15 minutes. Overall, 21% reported RTIs (Table 1).

**Table 1 Descriptive of adolescents 10-19 years surveyed from schools in Karachi, Pakistan 2014. (n=1264)**

| | Sample distribution | |
|---|---|---|
| **Variables** | **n** | **(%)** |
| Age groups | | |
| 10-14 | 746 | 59 |
| 15-19 | 518 | 41 |
| Gender | | |
| Girl | 755 | 59.7 |
| Boy | 509 | 40.3 |
| Grade | | |
| 6 | 261 | 20.6 |
| 7 | 255 | 20.2 |
| 8 | 200 | 15.8 |
| 9 | 344 | 27.2 |
| 10 | 204 | 16.1 |
| Type of School | | |
| Private | 753 | 59.6 |
| Public | 511 | 40.4 |
| Accompaniment on the school-home trip | | |
| Either with a parent or any other adult | 141 | 11.2 |
| Alone or with someone of the same age | 1080 | 85.4 |
| Mixed travel pattern , i.e. , alone or with parents | 43 | 3.4 |
| Time to reach school in minutes | | |
| < 5 | 462 | 36.6 |
| 5 to 15 | 642 | 50.8 |
| 16 to 30 | 89 | 7 |
| 31 to 45 | 48 | 3.8 |
| > 46 | 23 | 1.8 |
| Mode of transport on the school-home trip | | |
| Walking | 954 | 75.5 |
| Two or Three Wheelers | 107 | 8.5 |
| Four Wheelers | 203 | 16.1 |
| Allow to cross main roads on own | | |
| No | 714 | 56.5 |
| Yes | 550 | 43.5 |
| Allowed to travel on public buses on own | | |
| No | 1026 | 81.2 |
| Yes | 238 | 18.8 |
| Engaged in activities outside home over the last weekend | | |
| With a parents or other adult | 229 | 18.1 |
| No activities on the weekend | 139 | 11 |
| On his or her own or with another young person | 454 | 35.9 |
| Mixed activities , i.e. , either with parents or alone | 442 | 35 |
| Road traffic injuries | | |
| No | 999 | 79 |
| Yes | 265 | 21 |

Continued

**Table 1 Continued**

In the unadjusted analyses, boys (OR 2.24, 95% CI 1.7 to 2.95), students with parental permission to cross main roads alone (OR 1.64; 95% CI 1.25 to 2.16), students with parental permission to use public buses (OR 1.92; 95% CI 1.39 to 2.63), students who engaged in weekend activities alone (OR 2.51; 95% CI 1.63 to 3.96) and students with mixed patterns of weekend activities (OR 2.07; 95% CI 1.34 to 3.29) had increased odds of RTIs (Table 2).

**Table 2** Univariate association of road traffic injuries with the independent mobility variables in adolescents in Karachi, Pakistan

| | 10-19 years (n=1264) | | | 10-15 years (n=976) | | |
|---|---|---|---|---|---|---|
| **Variables** | **No RTIs n=999 (%)** | **RTIs n=265 (%)** | **OR (95% CI)** | **No RTIs n=780 (%)** | **RTIs n=196 (%)** | **OR (95% CI)** |
| *Age (mean and SD) | - | - | - | 13.4(1.31) | 13.6(1.23) | 1.11(0.99,1.27) |
| 10-14 years | 600(60.1) | 146(55.1) | 1 | | | |
| 15-19 years | 399(39.9) | 119(44.9) | 1.23(0.93,1.61) | | | |
| Gender | | | | | | |
| Girl | 638(63.9) | 117(44.2) | 1 | 484(62.1) | 91(46.4) | 1 |
| Boy | 361(36.1) | 148(55.8) | 2.24(1.7,2.95) | 296(37.9) | 105(53.6) | 1.89(1.38,2.59) |
| Type of school | | | | | | |
| Private | 589(59.0) | 164(61.9) | 1 | 516(66.2) | 127(64.8) | 1 |
| Public | 410(41.0) | 101(38.1) | 0.88(0.67,1.17) | 264(33.8) | 69(35.2) | 1.06(0.76,1.47) |
| Accompaniment on the school-home trip | | | | | | |
| Either with a parent or any other adult | 115(11.5) | 26(9.8) | 1 | 94(12.1) | 19(9.7) | 1 |
| Alone or with someone of the same age | 849(85.0) | 231(87.2) | 1.2(0.78,1.92) | 654(83.8) | 171(87.2) | 1.29(0.78,2.24) |
| Mixed travel pattern, i.e., alone or with parents | 35(3.5) | 8(3.0) | 1.01(0.4,2.35) | 32(4.1) | 6(3.1) | 0.93(0.32,2.41) |
| Allowed to cross main roads on own | | | | | | |
| No | 590(59.1) | 124(46.8) | 1 | 498(63.8) | 101(51.5) | 1 |
| Yes | 409(40.9) | 141(53.2) | 1.64(1.25,2.16) | 282(36.2) | 95(48.5) | 1.66(1.21,2.28) |
| Allowed to travel on public buses on own | | | | | | |
| No | 834(83.5) | 192(72.5) | 1 | 681(87.3) | 156(79.6) | 1 |
| Yes | 159(16.5) | 73(27.5) | 1.92(1.39,2.63) | 99(12.7) | 40(20.4) | 1.76(1.17,2.63) |
| Engaged in activities outside home over the last weekend | | | | | | |
| With a parent or other adult | 200(20.0) | 29(10.9) | 1 | 161(20.6) | 19(9.7) | 1 |
| No activities on the weekend | 126(12.6) | 13(4.9) | 0.71(0.35,1.39) | 85(10.9) | 9(4.6) | 0.9(0.37,2.02) |
| On his or her own or with another young person | 323(33.3) | 121(45.7) | 2.51(1.63,3.96) | 257(32.9) | 80(40.8) | 2.64(1.57,4.63) |
| Mixed activities, i.e., either with parents or alone | 340(34.0) | 102(38.5) | 2.07(1.34,3.29) | 277(35.5) | 88(44.9) | 2.69(1.61,4.7) |

*Age is used as categorical variable in 10-19 years while it is used as continuous variable in 10-15 years with mean and standard deviation

In the adjusted analysis, boys (aOR2 1.58; 95% CI 1.15 to 2.18), adolescents who did any activity outside home on their own on last weekend (aOR 1.68; 95% CI 1.02 to 2.80) or had a mixed pattern of weekend activities (aOR 1.63; 95% CI 1.03 to 2.64) had increased odds of RTIs. The following four variables were associated with increased odds, but the CIs were compatible with both reduced and increased odds: age 15-19 years compared to age 10-14 years (aOR 1.12; 95% CI 0.83 to 1.50), school-home trips alone compared to school-home trips accompanied by adults (aOR 1.01; 95% CI 0.64 to 1.64), permission to cross main roads (aOR 1.32; 95% CI 0.99 to1.77) and use of public buses (aOR 1.28; 95% CI 0.89 to 1.82) (Table 3).

**Table 3** Multivariable logistic regression of the association of road traffic injuries with the independent mobility variables in adolescents

| Variables | Adolescents aged 10-19 years OR (95% CI) | Adolescents aged 10-15 years OR (95% CI) |
|---|---|---|
| Age | | |
| 10-14 years | 1 | |
| 15-19 years | 1.12(0.83,1.50) | |
| Gender | | |
| Girl | 1 | 1 |
| Boy | 1.58(1.15,2.18) | 1.32 (0.92,1.91) |
| Accompaniment on the school-home trip | | |
| Either with a parent or any other adult | 1 | 1 |
| Adolescent alone or with someone of the same age | 1.01 (0.64,1.64) | 1.10 (0.92,1.91) |
| Mixed travel pattern, i.e., alone or with parents | 0.94 (0.36,2.23) | 0.74 (0.25,1.99) |
| Allowed to cross main road alone on own | | |
| No | 1 | 1 |
| Yes | 1.32 (0.99,1.77) | 1.43 (1.02,1.99) |
| Allowed to travel on public buses on own | | |
| No | 1 | 1 |
| Yes | 1.28 (0.89,1.82) | 1.29 (0.82,1.99) |
| Engaged in activities outside home over the last weekend | | |
| With a parent or other adult | 1 | 1 |
| No activities on the weekend | 0.68 (0.33,1.34) | 0.86(0.36,1.95) |
| On his or her own or with another young person | 1.68 (1.02,2.80) | 1.94(1.09,3.57) |
| Mixed activities, i.e., with either with parents or alone | 1.63 (1.03,2.64) | 2.25(1.32,4.02) |

In the unadjusted subgroup analysis of adolescents aged 10 to 15 years, boys (OR 1.89, 95% CI 1.38 to 2.59), students with parental permission to cross main roads alone (OR 1.66; 95% CI 1.21to 2.28), students with permission to use public buses (OR 1.76; 95% CI 1.17 to 2.63), students who engaged in weekend activities alone (OR 2.64 95% CI 1.57 to 4.63) and students with mixed patterns of weekend activities (OR 2.69; 95% CI 1.61 to 4.7) had increased odds of RTIs (Table 2).

In the adjusted subgroup analysis, adolescents who were allowed to cross main roads alone (aOR 1.43; 95% CI 1.02 to1.99), adolescents who did any activity outside home alone over the last weekend (aOR 1.94; 95% CI 1.09 to 3.57) and adolescents with mixed patterns of weekend activities (aOR 2.25; 95% CI 1.32 to 4.02) had greater odds of RTIs. Boys (aOR 1.32; 95% CI 0.92, 1.91), adolescents alone who made school-home trips alone rather than accompanied by an adult (aOR 1.10; 95% CI 0.92 to 1.91) and adolescents who used public buses (aOR 1.29; 95% CI 0.82 to 1.99) showed increased odds of RTIs, but the CIs were compatible with both reduced and increased odds. (Table 3)

**Discussion**

This study shows that parental permission to cross main roads alone and weekend activities alone as measures of independent mobility are significantly associated with adolescent road traffic injury risks. Other measures of independent mobility, such as being allowed to use public buses and traveling from school to home, had point estimates that indicated increased odds but had CIs compatible with both reduced and increased odds.

The finding that adolescents who were allowed to cross main roads on their own had greater odds of RTIs is consistent with previous studies finding that the number of streets crossed by adolescents is associated with injuries.[17] In our study, being allowed to cross main roads was associated with RTIs in young adolescents aged 10 to 15 years but not in adolescents aged 10 to 19 years, probably because older adolescents have more of this type of exposure.

Karachi does not have a safe road environment for pedestrians; for example, there are no pedestrian signals to assist in crossing roads, and vehicles do not yield to pedestrians at crosswalks. In addition, a qualitative study from India – a neighbouring country of Pakistan with a similar road environment – reported that adolescents displayed various distracted behaviours as pedestrians, such as using ear phones and mobile phones as well as talking and playing with friends.[18]

Adolescents' activities over the last weekend on own were associated with RTIs. The odds were greater when adolescents were alone or with their peers during weekend activities or when they had mixed patterns of weekend activities than when they engaged in activities accompanied by adults. It is understandable that leisure time activities with peers provoke riskier behaviours. Previous studies have shown that children and adolescents with unsafe road safety behaviours have peers with similar behaviours.[19] The means of mobility in weekend activities was not captured in our study but in our context, we assume it could be walking, motorcycles, public buses or private cars. Underage driving is also witnessed in young adolescents in study setting.[20]

In our study, travelling from school to home was associated with slightly higher odds of RTIs when adolescents were alone than with an adult in both age groups; 10-19 years old (aOR 1.01; 95% CI 0.64-1.64) and 10-15 years (aOR 1.10; 95% CI 0.92-1.91). The 95% CIs were compatible with both reduced and increased odds in both the main and subgroup analyses. The school-home trip is regular and fixed for adolescents, which might acclimatize them to the daily routes and traffic patterns. A previous study in Auckland showed a protective effect of adult accompaniment on school-home trips, but the effect was not significant (aOR 0.31; 95% CI 0.07-1.49.[4] Similarly, being allowed to travel on public buses had a point estimate that indicated increased odds of RTIs but a confidence interval compatible with both reduced and increased odds.

More boys had RTIs, but this finding is not surprising in the setting of Karachi. In our study context, boys are mostly responsible for chores outside the home. A previous study from India, which is a similar setting to our study setting, reported that boys had more road trips than girls.[21] Boys received parental permission for more activities than girls. Boys have also been found to show less risk perception in general as well as less road-related risk perception than girls.[22]

The point estimates of all measures of independent mobility indicate that these measures were associated with increased odds of RTIs, but several estimates were uncertain, with CIs compatible with both reduced and increased odds. This uncertainty indicates that within groups of adolescents, independent mobility reduces the odds of RTIs for some but increases the odds in others. Future research should focus on identifying the traits that distinguish these groups.

Two measures of independent mobility; crossing main road alone and weekend engagements alone, were significantly associated with increased odds of RTIs but these are not causative relationships. Independent mobility has many inherit benefits and it needs to be valued by societies. It is directly related to increase in physical activity. SDGs promote physical activity as well as safe transportation. The study findings call for improvement in road systems as chalked out in Global Plan for the Decade of Action; and improving the safety of vehicles; and enhancing the behaviour of road users.[23] Majority of adolescents in our study attend schools through independent mobility therefore it is highly important for urban planners, environmentalists and public health practitioners to emphasize safe road environment to prevent adolescents' road crashes.[24] The risks of road traffic crashes due to independent mobility could be mitigated by involving education authorities and schools to organize safe school safe routes, deploying volunteers for walking buses or have subsidized school transport. The need for road safety curriculum in schools could be a helpful strategy to create awareness on how to use road traffic environment safely either during school trips or weekend trips despite of unsafe road environment for vulnerable road users such as pedestrians.

**Limitations**

There are limitations of this study. First, our assessment of exposures concerned current practices, whereas the outcome (RTIs) referred to lifetime experience. The study also used a cross-sectional design, which is not meant to assess temporal associations. Second, we did not collect details on the mode of RTIs. The details of whether injury occurred to adolescents as pedestrians or occupants of vehicles could further help to assess the cause of RTIs. Finally, we have not used independent cycling of adolescents in our analysis as only 23% of adolescents 10-

19 years old reported to have cycles. The univariate analysis (not reported) showed statistically insignificant trend of RTIs risk for adolescents who were allowed to ride cycles on their own. The addition of this variable in multivariable was not appropriate as the total data count for this variable is much low (n=277) which would have decreased the sample size for the complete model. Similarly, underage use of motorcycles and cars by adolescents was not captured in this study. These transportation modes need to be explored to determine its relationship with road traffic injuries.

## Conclusions

Measures of independent mobility in adolescents; parental permission to cross main roads and engage in weekend activities alone, are associated with increased risk of RTIs. Other measures – such as making school-home trips alone and being allowed to travel on public buses – had uncertain effects on the odds of RTIs. Strengthening road infrastructure for easy commuting of adolescents as pedestrians and cyclists is warranted. Investment on safe public transport has potential to facilitate independent commuting of adolescents.

## Declarations

### Ethics approval and consent to participate

The study proposal was approved by ethics review committee of Aga Khan University (reference number 2883-EM-ERC-13). The details of study and principles of voluntary participation, confidentiality, autonomy and right to withdraw from study were explained to participants and their parents.

### Competing interests

The author declares no competing interests.

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## Authors' contributions

URK conceptualized, analysed and drafted the study. JAR critically reviewed all drafts. MGW supervised all analyses and drafts.

## Acknowledgements

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## Data availability

De identified participant data is available upon reasonable request from Uzma Rahim Khan, uzma.khan@aku.edu

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | Describe any efforts to address potential sources of bias |
| Study size | 10 | Explain how the study size was arrived at |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | (*b*) Describe any methods used to examine subgroups and interactions |
| | | (*c*) Explain how missing data were addressed |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | (b) Give reasons for non-participation at each stage |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | (b) Indicate number of participants with missing data for each variable of interest |
| Outcome data | 15* | Report numbers of outcome events or summary measures |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | (*b*) Report category boundaries when continuous variables were categorized |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |

| | | |
|---|---|---|
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Association of adolescents' independent mobility with road traffic injuries in Karachi, Pakistan- A Cross-sectional study

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# Association of adolescents' independent mobility with road traffic injuries in Karachi, Pakistan – A Cross-sectional study

**Authors** Uzma Rahim Khan (MBBS, MSc)*[1,2], Junaid A Razzak (MD, PhD, FACEP)[3], Martin Gerdin Wärnberg (MD, PhD)[1,4]

[1] Karolinska Institutet, Department of Global Public Health, Stockholm, Sweden

[2] Aga Khan University, Department of Emergency Medicine, Karachi, Pakistan

[3] New York-Presbyterian Hospital, Weill Cornell Medical Center, Weill Department of Medicine, New York, US

[4] Karolinska University Hospital, Function Perioperative Medicine and Intensive Care, Stockholm, Sweden

***Corresponding Author:**

**Uzma Rahim Khan**
Department of Global Public Health
Karolinska Institutet
Tomtebodavägen 18 A
171 77 Stockholm
Widerströmska Huset
Sweden
Email: uzma.khan@ki.se

Word Count: 3413

## A B S T R A C T

**Objective** Participation in walking, cycling, and taking public transportation without adult supervision is defined as independent mobility of children and adolescents. The association between adolescents' independent mobility and road traffic injury (RTI) is unclear. The purpose of this study is to determine measures of adolescents' independent mobility associated with RTIs in an urban lower middle-income setting.

**Study design** Cross-sectional survey.

**Setting** Schools in Karachi, Pakistan.

**Participants** Adolescents aged 10-19 years in grades 6-10 were enrolled from private and public schools.

**Outcome** Any self-reported lifetime RTI sustained as a pedestrian, as a cyclist, or while in a car or another vehicle that resulted in any first aid at home/school or consultation in a healthcare setting.

**Exposure** Self-reported independent mobility was assessed by four variables. 1) Any travel companion from school to home on the survey day, 2) Parental permission to cross main roads alone, 3) Parental permission to travel by public bus alone, and 4) Activity/activities outside the home on the previous weekend alone.

**Results** Data from 1264 adolescents, 10-19 years old, were included. Most were females (60%). Adolescents who had parental permission to cross main roads alone (adjusted odds ratio (aOR) 1.39; 95% confidence interval (CI) 1.04 to 1.86) and who participated in one or more activities outside the home alone on the previous weekend (aOR 2.61; 95% CI 1.42 to 5.13) or participated in a mixture of activities with and without adult accompaniment (aOR 2.50; 95% CI 1.38 to 4.89) had higher odds of RTIs.

**Conclusions** Parental permission to cross main roads alone and participation in activity/activities outside the home on the previous weekend alone were two measures of independent mobility associated with an increased risk of RTIs among adolescents. The study provides an understanding of the risk posed by adolescents' independent mobility in road traffic environments.

**Strengths and limitations of this study**

- This is one of the largest face to face surveys of adolescents' independent mobility covering 73 schools which is the highest number of schools compared to previous studies.
- Multistage stratified random cluster sampling of schools with at least one classroom of adolescents per school with an approximate equal number of classrooms of grades 6 to 10 was conducted.
- The ability to assess a temporal relationship between independent mobility (exposure) and road traffic injury (outcome) is lacking.

## Introduction

Independent mobility refers to the freedom of children and adolescents to move around in public spaces without being accompanied by an adult. Independent mobility positively impacts psychological, social, cognitive, motor, spatial, and analytical development.[1, 2] Independent mobility facilitates physical activity and decreases the risk of obesity, hypertension, diabetes, and many other noncommunicable diseases.[3, 4] Children's and adolescents' independent mobility is influenced by many psychosocial factors, such as the parent's concerns about weak ties at the neighbourhood level, encounters with strangers, and fears of road traffic, which are also attributed to adolescents' limited independent mobility.[5, 6 7, 8]

Adolescents are vulnerable to road traffic injuries (RTIs), which are the leading cause of death in adolescents aged 10-19 years. In 2019, 95,586 deaths from RTIs in adolescents aged 10-19 years occurred worldwide,[9] and 90% of these deaths occurred in low- and middle-income countries.[10] Male sex and low socioeconomic status are risk factors associated with RTIs in adolescents.[11] Deaths and injuries from RTIs are most common among pedestrians, cyclists, and motorcyclists in low- and middle-income countries, where the constructed environment is least likely to be adapted to the needs of vulnerable road users.[12-14] The number of severe injuries per distance travelled was higher in young adolescents than in any other age group, as reported by a study in the Netherlands.[15] RTIs are also a leading contributor to disability adjusted life years (DALYs) in children and adolescents.[16] The rate of permanent disability due to RTIs among children and adolescents aged 1 to 17 years is 20 per 100,000 children.[17]

Studies on independent mobility are mostly descriptive studies of school travel, and in some analytical studies, its association with physical activity and distance was determined.[18] Research on the independent mobility of adolescents and RTIs is scarce, and an association between independent mobility and RTIs has been assessed previously in very few studies. A study from New Zealand that determined the effect of adult accompaniment in RTI showed that adult accompaniment of children and adolescents aged 5 to 12 years old was associated with reduced risk of pedestrian injury, but this result was not statistically significant.[4] A study from India considered independent mobility as a confounding variable in association of distance and mode of travel with RTIs in adolescents aged 11-14 years.[19] In a study from Singapore, pedestrian injuries in adolescents aged 16 years and younger involved walking alone.[20]

Sustainable development goals (SDGs) advocate for safe transportation and an improvement in road safety by targeting the special needs of children and adolescents.[21] It is important to determine whether adolescents' independent mobility is associated with an increased risk of RTIs to decide how to advocate for independent mobility. The aim of this study is to determine measures of adolescents' independent mobility associated with RTIs in an urban lower middle-income setting in Karachi.

## Methods

### Study design

We conducted a cross-sectional study between September and December 2014.

**Setting and participants**

Adolescents (aged 10-19 years) in grades 6 to 10 were enrolled from the participating schools in Karachi, Pakistan. The city has an estimated population of 20 million. In 2019, Pakistan reported approximately 2393 deaths due to RTIs in 10-19-year-olds.[9] In Karachi, the annual incidence of RTIs was 54.7 per 100,000 population, and the mortality rate was 1.5 per 100,000 population aged less than 15 years, of which 89% were male.[22] A previous travel survey from Pakistan reported that 10 to 14 years old adolescents who were males made 36% more trips than females. At 15 years and older, this sex gap increases to more than 50%.[23] The public transportation system is inadequate in the city. There is a lack of paved areas for pedestrians, and vendors occupy space for their roadside businesses.[24] Roads have potholes and are in poor condition. [25]

Overall, there were 4098 private schools and 2828 public schools in Karachi at the time of data collection, as per official lists from the education department. A total of 73 schools participated in our study, of which 26 (36%) were public schools and 47 (64%) were private schools (figure 1). The ratio of public to private schools in the sample was determined based on the distribution of schools in urban Pakistan.[26] We used multistage stratified random cluster sampling to select the schools. In the first stage, schools were stratified by private and public secondary schools (grades 6 to 10) status. The random sample of schools was chosen with quotas of 60% private schools and 40% public schools, proportional to school enrolment in Karachi. In the next stage, at least one classroom in each school was selected as a convenience cluster sample. Approximately equal numbers of grades 6, 7, 8, 9, and 10 were selected within each stratum of public and private school. Research assistants informed school management beforehand about

grade selection from that school, while the school management guided the section selection of the selected grades.

**Outcome**

An RTI is any self-reported lifetime RTI sustained as a pedestrian, as a cyclist, or while in a car or another vehicle that resulted in any first aid at home/school or consultation in a healthcare setting.

**Exposures**

Adolescents' self-reported independent mobility was assessed by four variables. 1) Any travel companion from school to home on the survey day ["with a parent or adult", "alone or with an adolescent of the same age", or "mixed travel pattern either with parents or alone"]. 2) Parental permission to cross main roads alone ["yes" or "no"]. 3) Parental permission to travel by public bus alone ["yes" or "no"]. 4) Participation in at least one activity outside the home on the previous weekend alone ["no activities", "with a parent or adult", "alone or with an adolescent of the same age", or "mixed activity pattern either with parents or alone"].

**Other covariates**

Age, grade, sex, type of school (public or private), travel time to school by any mode of transportation, and mode of transportation home from school were included as covariates based on their association with RTIs in previous literature.[11, 19, 27] The type of school was included as a proxy variable for the children's socioeconomic status, as public schools cater to low-income families; furthermore, the type of school indicates the style of parental licensing.[19] Travel time to

school was included as a proxy variable for distance, which is associated with RTI in previous literature.[19]

**Data sources/measurements**

The study questionnaire was adapted from London Policy Studies Institute. It had multiple-choice questions, was available in English, and was also translated into Urdu. The adapted questionnaire has been used in many countries, including Sri Lanka and India, which are in the same region as Pakistan and have similar population dynamics.[28, 29] In India, the questionnaire was found to be reliable.[29] Questions on RTI outcomes were not in original questions. They were added in Indian study and also used in the current study with some modifications.

The questionnaire was piloted to assess its effectiveness, acceptability, and clarity, and modifications were made accordingly before launching the main data collection process. The pilot study was completed in 2 private schools and 1 public school, and 196 children and adolescents participated. Aspects of the questionnaire were changed to clarify some questions. For example, some modifications were made to adapt the questions to the local context, such as replacing “local buses” with “public buses”. Definitions of a few variables were added; for example, adults were defined as a person aged 18 years and older. Traffic crashes were clarified by adding the word “road” to “traffic crash”. Research assistants supervised the survey and read and explained each question to adolescents in each class to ensure that the adolescents understood the questionnaire clearly. The questionnaire took approximately 25 minutes to be completed by a class of adolescents.

In each class, a parental permission letter that provided details of the study (in either Urdu or English language, as advised by the school administration) was distributed to each adolescent. Adolescents were instructed to obtain letters signed by their parents or guardians within one week. It was confirmed that a weekend fell between the distribution of permission letters and the research assistants' second school visit to allow parents adequate time to read the permission letters. Written informed consent was obtained from the parents/guardians of the adolescents, and informed verbal assent was obtained from the adolescents.

**Study size**

The sample size calculated for the original survey was 1,270 school adolescents. The original question was designed to assess the prevalence of travel modes to school based on the assumption that at least 50% of adolescents were active commuters (since no past information on adolescents' school mobility patterns in Pakistan was available). We used a 95% confidence level (CI), an error bound of ± 5%, and a design effect of 3, and we inflated the sample size by 10% to account for nonresponders.

**Statistical analysis**

The analysis was performed by using R.[30] Categorical variables are described using frequencies and percentages. Logistic regression was used to estimate unadjusted and adjusted associations, as well as 95% CIs, between the measures of independent mobility and RTIs. Four models were developed by using each of the four exposures with RTI as the outcome. The models were adjusted for age, sex, type of school, travel time to school by any mode of transportation, and mode of transportation home from school. However, the model with the exposure "activities on

the weekend alone" was adjusted only for age, sex, and type of school, because the travel time to school and mode of transportation to school were not related to activities on weekends. The sample size requirements for this type of analysis have been described as between 10 and 25 events (participants with the outcome) and at least as many nonevents per parameter in the model.[31] With 265 events, less than 10 parameters were accommodated in the models.

**Involvement of patients and the public**

Patients and/or the public were not involved in this study.

**Results**

There were 1288 children and adolescents included in the survey. The complete case analysis was performed on a sample of 1264 adolescents after removing cases with missing values and the three cases who were either younger or older than the age criteria for adolescents10-19 years old.

The majority of the adolescents were females (60%) and in the 10-14-year- age group (59%). Most of them walked to school (72%). Almost half of the adolescents arrived at the school within 5 to 15 minutes. Overall, 21% reported RTIs (Table 1). Approximately 55% of RTIs occurred in the 10-14 year age group, and 45% occurred in the 15-19-year age group. More than half of RTIs were among males (56%). The majority of RTIs (71%) happened to adolescents whose mode of transportation home from school was walking (Table 1).

**Table 1 Characteristics of adolescents surveyed from schools in Karachi, Pakistan**

| Variables | 10–19 n=1264 n (%) | No RTIs n=999 n (%) | RTIs n=265 n (%) |
|---|---|---|---|
| Age group (years) | | | |
| 10 to 14 | 746 (59.0) | 601 (60.2) | 145 (54.7) |
| 15 to 19 | 518 (41.0) | 398 (39.8) | 120 (45.3) |
| Sex | | | |
| Female | 757 (59.9) | 639 (64.0) | 118 (44.5) |
| Male | 507 (40.1) | 360 (36.0) | 147 (55.5) |
| Grade | | | |
| 6 | 262 (20.7) | 197 (19.7) | 65 (24.5) |
| 7 | 255 (20.2) | 216 (21.6) | 39 (14.7) |
| 8 | 200 (15.8) | 147 (14.7) | 53 (20.0) |
| 9 | 342 (27.1) | 285 (28.5) | 57 (21.5) |
| 10 | 205 (16.2) | 154 (15.4) | 51 (19.2) |
| Type of school | | | |
| Private | 753 (59.6) | 588 (58.9) | 165 (62.3) |
| Public | 511 (40.4) | 411 (41.1) | 100 (37.7) |
| Mode of transportation home from school on the day of the survey | | | |
| Walking | 954 (75.5) | 766 (76.7) | 188 (70.9) |
| Two- or three-wheeled vehicle | 107 (8.5) | 83 (8.3) | 24 (9.1) |
| Four-wheeled vehicle | 203 (16.1) | 150 (15.0) | 53 (20.0) |
| Travel time to school by any mode of transportation (minutes) | | | |
| < 5 | 462 (36.6) | 511 (51.2) | 131 (49.4) |
| 5 to 15 | 642 (50.8) | 29 (2.9) | 19 (7.2) |
| 16 to 30 | 48 (3.8) | 67 (6.7) | 22 (8.3) |
| 31 to 45 | 89 (7.0) | 14 (1.4) | 9 (3.4) |
| > 46 | 23 (1.8) | 511 (51.2) | 131 (49.4) |
| Companion for travel home from school on the day of the survey | | | |
| With either a parent or any other adult | 139 (11.0) | 111 (11.1) | 28 (10.6) |
| Alone or with someone of the same age | 1039 (82.2) | 817 (81.8) | 222 (83.8) |
| Mixed travel pattern, i.e., alone or with parents | 86 (6.8) | 71 (7.1) | 15 (5.7) |
| Parental permission to cross main roads alone | | | |
| No | 716 (56.6) | 591 (59.2) | 125 (47.2) |
| Yes | 548 (43.4) | 408 (40.8) | 140 (52.8) |
| Parental permission to travel on public buses alone | | | |
| No | 1028 (81.3) | 835 (83.6) | 193 (72.8) |
| Yes | 236 (18.7) | 164 (16.4) | 72 (27.2) |
| Activity/activities outside the home on the previous weekend | | | |
| With a parent or another adult | 229 (18.1) | 200 (20.0) | 29 (10.9) |

| | | | |
|---|---|---|---|
| No activities on the weekend | 139 (11.0) | 126 (12.6) | 13 (4.9) |
| Alone or with another young person | 455 (36.0) | 334 (33.4) | 121 (45.7) |
| Mixed activities, i.e., either with parents or alone | 441 (34.9) | 339 (33.9) | 102 (38.5) |
| Road traffic injuries | | | |
| No | 999 (79.0) | - | - |
| Yes | 265 (21.0) | - | - |

In the unadjusted analyses, male sex (OR 2.21, 95% CI 1.68 to 2.91), use of four-wheeled transportation home from school (OR 1.44, 95% CI 1.01 to 2.04), travel time of 31 to 45 minutes to school (OR 2.95, 95% CI 1.56 to 5.48) and travel time of 46 or more minutes to school (OR 2.89, 95% CI 1.17 to 6.82), parental permission to cross main roads alone (OR 1.62; 95% CI 1.24 to 2.13), parental permission to use public buses alone (OR 1.9; 95% CI 1.38 to 2.6), engagement in weekend activities alone (OR 3.51; 95% CI 1.98 to 6.74), and a mixed pattern of weekend activities (OR 2.92; 95% CI 1.63 to 5.62) were associated with an increased OR of RTIs (Table 2).

**Table 2 Unadjusted associations of road traffic injuries with the variables of independent mobility and other covariates in adolescents in Karachi, Pakistan, n= 1264**

| Variables | OR (95% CI) |
|---|---|
| Age group (years) | |
| 10 to 14 | 1 |
| 15 to 19 | 1.25 (0.95, 1.64) |
| Sex | |
| Female | 1 |
| Male | **2.21 (1.68, 2.91)** |
| Type of school | |
| Private | 1 |
| Public | 0.87 (0.65, 1.14) |
| Mode of transportation home from school on the day of the survey | |
| Walking | |
| Two- or three-wheeled vehicle | 1.18 (0.71, 1.88) |
| Four-wheeled vehicle | **1.44 (1.01, 2.04)** |
| Travel time to school by any mode of transportation (minutes) | |
| < 5 | 1 |
| 5 to 15 | 1.15 (0.85, 1.57) |

| | |
|---|---|
| 16 to 30 | 1.48 (0.85, 2.5) |
| 31 to 45 | **2.95 (1.56, 5.48)** |
| > 46 | **2.89 (1.17, 6.82)** |
| Travel home from school on the day of the survey | |
| With either a parent or any other adult | 1 |
| Alone or with someone of the same age | 1.08 (0.7, 1.7) |
| Mixed travel pattern, i.e., alone or with parents | 0.84 (0.41, 1.66) |
| Parental permission to cross main roads alone | |
| No | 1 |
| Yes | **1.62 (1.24, 2.13)** |
| Parental permission to travel on public buses alone | |
| No | 1 |
| Yes | **1.9 (1.38, 2.6)** |
| Activity/activities outside the home on the previous weekend alone | |
| No activities on the weekend | 1 |
| With a parent or another adult | 1.41 (0.72, 2.89) |
| Alone or with another young person | **3.51 (1.98, 6.74)** |
| Mixed activities, i.e., either with parents or alone | **2.92 (1.63, 5.62)** |

In the adjusted analysis, travel home from school (adjusted odds ratio (aOR) 1.14; 95% CI 0.71 to 1.89) was compatible with reduced odds, increased odds, and no association with RTIs. Adolescents who had parental permission to cross main roads (aOR 1.39; 95% CI 1.04 to 1.86) had significantly higher odds of RTIs. Adolescents who had parental permission to use public buses had statistically insignificant odds compatible with reduced odds of, increased odds of, and no association with RTIs (aOR 1.34; 95% CI 0.93 to 1.91). Unaccompanied adolescents who performed any activity outside the home on the previous weekend (aOR 2.61; 95% CI 1.42 to 5.13) or had a mixed pattern of weekend activities, either accompanied or alone (aOR 2.50; 95% CI 1.38 to 4.89), had significantly higher odds of RTIs (Table 3).

**Table 3 Adjusted association of road traffic injuries with the variables of independent mobility in adolescents**

| Variables | Travel home from school on the day of the survey OR (95% CI) | Parental permission to cross main roads alone OR (95% CI) | Parental permission to travel on public buses alone OR (95% CI) | Activity/activities outside the home on the previous weekend alone OR (95% CI) |
|---|---|---|---|---|
| Age group (years) | | | | |
| 10 to 14 years | 1 | 1 | 1 | 1 |
| 15 to 19 years | 1.28 (0.95, 1.71) | 1.23 (0.91, 1.65) | 1.22 (0.91, 1.65) | 1.28 (0.96, 1.71) |
| Sex | | | | |
| Female | 1 | 1 | 1 | 1 |
| Male | **2.18 (1.63, 2.92)** | **2.06 (1.53, 2.77)** | **2.03 (1.49, 2.76)** | **1.73 (1.26, 2.38)** |
| Type of school | | | | |
| Private | 1 | 1 | 1 | 1 |
| Public | 1.05 (0.76, 1.44) | 1.00 (0.73, 1.39) | 1.04 (0.75, 1.43) | 1.01 (0.74,1.36) |
| Mode of transport home from school on the day of the survey | | | | |
| Walking | 1 | 1 | 1 | - |
| Two- or three-wheeled vehicle | 1.13 (0.66, 1.89) | 1.10 (0.65, 1.78) | 1.07 (0.64, 1.73) | - |
| Four-wheeled vehicle | 1.30 (0.84, 1.99) | 1.25 (0.82, 1.88) | 1.22 (0.80, 1.84) | - |
| Travel time to school by any mode of transportation (minutes) | | | | |
| < 5 | 1 | 1 | 1 | - |
| 5 to 15 | 1.12 (0.82, 1.55) | 1.10 (0.80, 1.52) | 1.11 (0.81, 1.54) | - |
| 16 to 30 | 1.30 (0.72, 2.29) | 1.24 (0.69, 2.20) | 1.28 (0.71, 2.26) | - |
| 31 to 45 | **2.61 (1.32, 5.11)** | **2.61 (1.32, 5.11)** | **2.60 (1.31, 5.08)** | - |
| > 46 | 2.50 (0.97, 6.18) | 2.34 (0.90, 5.79) | 2.40 (0.93, 5.95) | - |
| Companion for travel home from school on the day of the survey | | | | |
| With either a parent or any other adult | 1 | - | - | - |
| Alone or with someone of the same age | 1.14 (0.71,1.89) | - | - | - |
| Mixed travel pattern, i.e., alone or with parents | 0.84 (0.40,1.71) | - | | - |
| Parental permission to cross main roads alone | | | | |
| No | - | 1 | - | - |
| Yes | - | **1.39 (1.04,1.86)** | - | - |
| Parental permission to travel on public buses alone | | | | |
| No | - | - | 1 | - |
| Yes | - | - | 1.34 (0.93,1.91) | - |
| Activity/activities outside the home on previous weekend | | | | |
| No activities on the weekend | - | - | - | 1 |
| With a parent or another adult | - | - | - | 1.48 (0.75,3.06) |
| Alone or with another young person | - | - | - | **2.61 (1.42,5.13)** |
| Mixed; both with parents and alone | - | - | - | **2.50 (1.38,4.89)** |

## Discussion

This study shows that the odds of RTIs for adolescents with parental permission to cross main roads alone was 1.39 times higher than that for adolescents without parental permission to cross main roads and that the odds of RTIs for adolescents who participated in activities outside the home on the previous weekend alone was 2.6 times higher than that for adolescents who participated in no activities on the previous weekend. Other measures of independent mobility, such as parental permission to use public buses and travel home from school alone, had point estimates that indicated increased odds but had CIs compatible with reduced odds , increased odds , and no association with RTIs.

The finding that adolescents who had parental permission to cross main roads alone had greater odds of RTIs is consistent with previous studies that conclude that the number of streets crossed by adolescents is associated with injury.[32] In addition, a qualitative study from India – a neighbouring country of Pakistan with a similar road environment – reported that adolescents displayed various distracted behaviours as pedestrians, such as using earphones and mobile phones as well as talking and playing with friends.[33] Both the distracted behaviours and the unsafe road environment for pedestrians in Pakistan could be linked to an increased risk for RTIs. The roads are dilapidated with potholes, pedestrian signals to assist in road crossing are lacking, and vehicles are generally considered to have the right of way; therefore, poor yield compliance for pedestrians at crosswalks is substantially higher by vehicle drivers.[34, 35] [24]

Adolescents' activities outside the home on the previous weekend alone were associated with RTIs. The odds were higher when adolescents were alone or with their peers during weekend

activities or when they had mixed patterns of weekend activities than when they engaged in activities accompanied by adults. It is understandable that leisure activities with peers provoke several comparatively risky behaviours, for example, smoking, substance abuse, risky driving, and risky pedestrian behaviours.[36] Previous studies have shown that children and adolescents with unsafe road safety behaviours have peers with similar behaviours.[37] Multiple risk behaviours are associated with injuries in youth.[38] The means of mobility in weekend activities was not captured in our study, but in our context, we assume it could be walking, motorcycles, public buses, or private cars. Underage driving is also witnessed in young adolescents in the study setting.[39]

The other two exposures – travelling from school to home alone and parental permission to travel on public buses alone – were associated with slightly higher odds of RTIs, but the 95% CIs were compatible with reduced odds of, increased odds of, and no association with RTIs. This uncertainty indicates that within the groups of adolescents, some had reduced odds of RTIs, while others had increased odds. A previous study in Auckland showed that adult accompaniment on the school-home journey may be associated with reduced pedestrian injuries, but the effect was not statistically significant, similar to the findings of our study.[4] Future research should focus on identifying those traits that distinguish these groups of adolescents with increased and reduced odds for RTIs.

The independent mobility of adolescents has many inherent benefits and needs to be valued by society. Children need to move in public spaces for different activities, such as to travel to school, their work and other leisure activities, which are important for the development of social

skills. However, parents are the licensing bodies that control their children's independent mobility, and their willingness to allow their adolescents to move independently is influenced by many factors, such as traffic and public safety. Safe public spaces lead to an increased number of children who move independently, a factor that has important public health implications.[40]

SDGs promote physical activity as well as safe transportation. The study findings call for improvement in road systems as chalked out in Global Plan for the Decade of Action; improving the safety of vehicles; and enhancing the behaviour of road users.[41] The majority of adolescents in our study attend schools through independent mobility; therefore, it is highly important for urban planners, environmentalists and public health practitioners to emphasize a safe road environment to prevent adolescents' road crashes.[42] Pedestrian sidewalks, pedestrian signals, use of pedestrian bridges, provision of safe routes to school, and deployment of volunteers to accompany adolescents who walk or travel by bus to school or provision of subsidized school transportation are some important aspects to be improved. The addition of road safety curricula in schools could be a helpful strategy to create awareness on safe conduct in road traffic environments.

**Limitations**

This study has limitations. First, the study design is cross-sectional and is not meant to assess the temporal associations of independent mobility and RTI. It is unclear when an injury occurred, as lifetime injuries were reported, and there is a possibility that any previous RTI might lead to a decrease in independent mobility. Second, we did not collect details on the modes of RTIs. Determining the details of whether an injury occurred to an adolescent as a pedestrian or as a

vehicle occupant could further help to assess the cause of an RTI. Third, our current analysis included more females, as the sample was not stratified based on sex; however, the number of males' and females' schools was approximately equal in our study. There were fewer males in public schools, and it was found that the number of males enrolled per class was lower than that of females in public schools in Karachi. There might be additional reasons for the lower numbers of males in public schools, such as lower attendance. It was also observed in our study that more males than females forgot their consent forms. Any future study should also consider the enrolment rates of males and females separately in private and public schools in sampling. Furthermore, including a lower number of males in the study would have meant that fewer injuries were reported in the study, as injuries are more common in males, which would have impacted the strength of the association. Finally, we did not consider independent cycle use by adolescents in our analysis, as only 23% of adolescents 10-19 years old reported having a cycle. The unadjusted analysis (not reported) showed a statistically insignificant association between being allowed to ride a cycle on their own and RTIs. The addition of this variable in the multivariable analysis was not appropriate, as the total data count for this variable was much lower (n=277) than those for the other variables, which would have decreased the sample size for the complete model. Similarly, underage use of motorcycles and cars by adolescents was not evaluated in this study. These transportation modes need to be explored to determine their relationship with RTIs.

## Conclusions

The study is one of the first studies in the context of the independent mobility of adolescents in low-middle income settings where opportunities for physical activities, both structured and

unstructured, are less likely because of a lack of safe public spaces. Independent mobility is an easy strategy for physical activity and has many health and social benefits for children and adolescents. This study highlights the risk of RTIs associated with measures of independent mobility. Measures of independent mobility in adolescents – parental permission to cross main roads and independent mobility in weekend activities – are associated with an increased risk of RTIs. Effect size of association of measures of independent mobility with RTIs may be biased towards null because of underrepresentation of boys in the sample compared to the actual adolescent population.

Learning road safety is an important need for children and adolescents to enhance their safe mobility. These findings may help policy makers to consider the concept of independent mobility and apply relevant findings to policies for urban planning, road traffic, transportation, school, and supervision. It is critical for public health officials, urban and transportation planners, and policy makers to recognize growing transportation problems in school catchment areas around school start and end times and respond to the transportation needs of children and adolescents. Investment in making road infrastructure and policies friendly for commuting pedestrians and cyclists as well as providing safe public transportation is warranted to facilitate independent commuting of adolescents.

**Figure 1:** Flow chart of adolescents'recruitment from schools

## Declarations

### Ethics approval and consent to participate

The study proposal was approved by the ethics review committee of Aga Khan University (reference number 2883-EM-ERC-13). The details of the study and principles of voluntary participation, confidentiality, autonomy and right to withdraw from study were explained to participants and their parents.

### Competing interests

The author declares no competing interests.

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### Authors' contributions

URK conceptualized, analysed and drafted the study. JAR critically reviewed all drafts. MGW supervised all analyses and drafts.

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## Data availability

Deidentified participant data are available upon reasonable request from Uzma Rahim Khan, uzma.khan@aku.edu.

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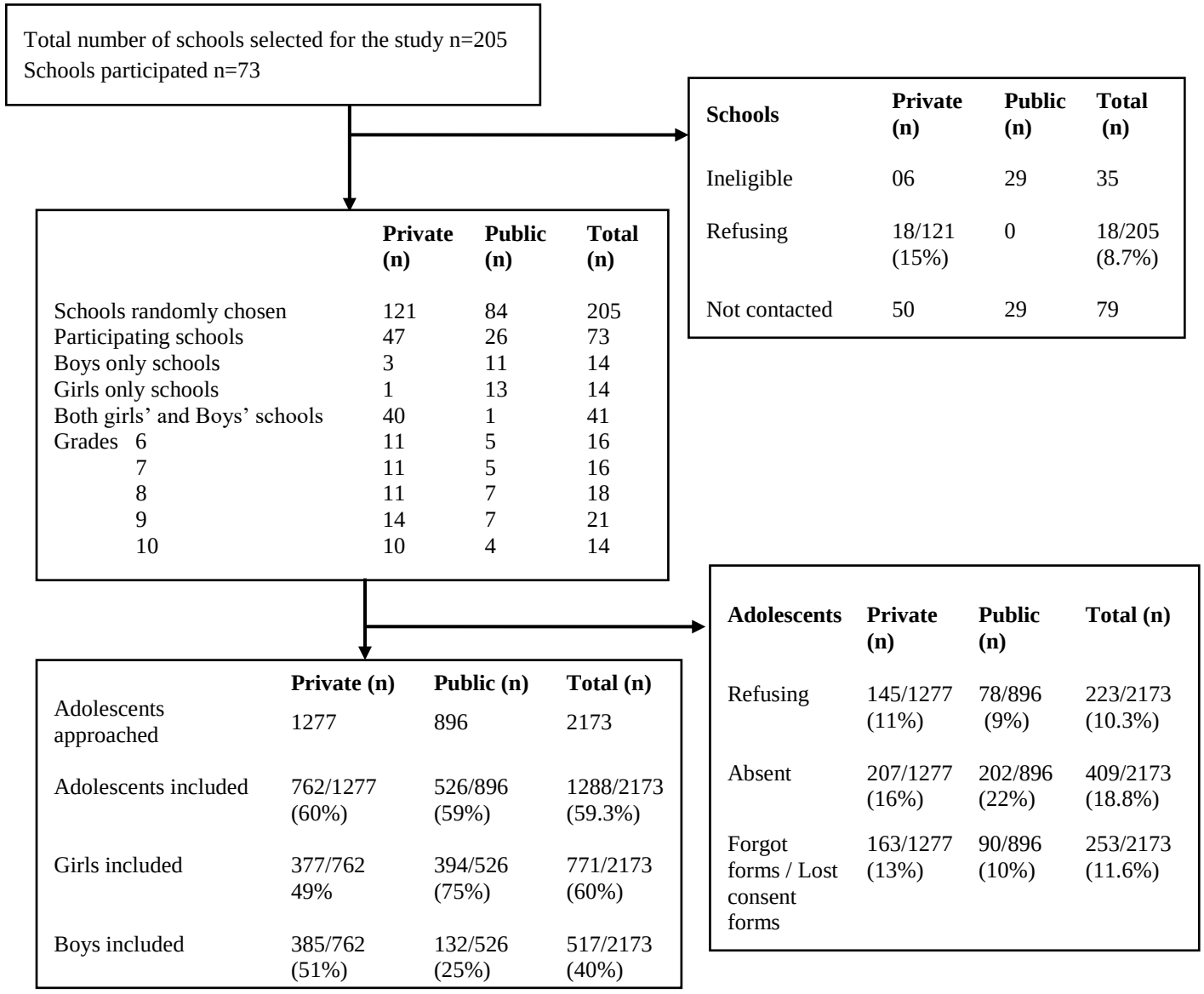


**Figure 1: Flow chart of adolescents' recruitment from schools**

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

| | Item No | Recommendation | Manuscript Page |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 and 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 and 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 and 7 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 8 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 9 and 10 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 19 and 20 |
| Study size | 10 | Explain how the study size was arrived at | 10 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 10 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 10 and 11 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | NA |
| | | (*c*) Explain how missing data were addressed | 10 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | NA |
| | | (*e*) Describe any sensitivity analyses | NA |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 7 |
| | | (b) Give reasons for non-participation at each stage | 7 |
| | | (c) Consider use of a flow diagram | 7 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 11 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 11 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 11 and 12 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear | 13,14 and 15 |

| | | | |
|---|---|---|---|
| | | which confounders were adjusted for and why they were included | |
| | | (*b*) Report category boundaries when continuous variables were categorized | NA |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | NA |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 16 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 18-19 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 19-20 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 20 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 21 |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Association of adolescents' independent mobility with road traffic injuries in Karachi, Pakistan- A Cross-sectional study

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# Association of adolescents' independent mobility with road traffic injuries in Karachi, Pakistan – A Cross-sectional study

**Authors** Uzma Rahim Khan (MBBS, MSc)*[1,2], Junaid A Razzak (MD, PhD, FACEP)[3], Martin Gerdin Wärnberg (MD, PhD)[1,4]

[1] Karolinska Institutet, Department of Global Public Health, Stockholm, Sweden

[2] Aga Khan University, Department of Emergency Medicine, Karachi, Pakistan

[3] New York-Presbyterian Hospital, Weill Cornell Medical Center, Weill Department of Medicine, New York, US

[4] Karolinska University Hospital, Function Perioperative Medicine and Intensive Care, Stockholm, Sweden

***Corresponding Author:**

**Uzma Rahim Khan**
Department of Global Public Health
Karolinska Institutet
Tomtebodavägen 18 A
171 77 Stockholm
Widerströmska Huset
Sweden
Email: uzma.khan@ki.se

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## A B S T R A C T

**Objective** Participation in walking, cycling, and taking public transportation without adult supervision is defined as independent mobility of children and adolescents. The association between adolescents' independent mobility and road traffic injury (RTI) is unclear. The purpose of this study is to determine measures of adolescents' independent mobility associated with RTIs in an urban lower middle-income setting.

**Study design** Cross-sectional survey.

**Setting** Schools in Karachi, Pakistan.

**Participants** Adolescents aged 10-19 years in grades 6-10 were enrolled from private and public schools.

**Outcome** Any self-reported lifetime RTI sustained as a pedestrian, as a cyclist, or while in a car or another vehicle that resulted in any first aid at home/school or consultation in a healthcare setting.

**Exposure** Self-reported independent mobility was assessed by four variables. 1) Any travel companion from school to home on the survey day, 2) Parental permission to cross main roads alone, 3) Parental permission to travel by public bus alone, and 4) Activity/activities outside the home on the previous weekend alone.

**Results** Data from 1264 adolescents, 10-19 years old, were included. Most were females (60%). Adolescents who had parental permission to cross main roads alone (adjusted odds ratio (aOR) 1.39; 95% confidence interval (CI) 1.04 to 1.86) and who participated in one or more activities outside the home alone on the previous weekend (aOR 2.61; 95% CI 1.42 to 5.13) or participated in a mixture of activities with and without adult accompaniment (aOR 2.50; 95% CI 1.38 to 4.89) had higher odds of RTIs.

**Conclusions** Parental permission to cross main roads alone and participation in activity/activities outside the home on the previous weekend alone were two measures of independent mobility associated with higher odds of RTIs among adolescents. The study provides an understanding of the risk posed by adolescents' independent mobility in road traffic environments.

**Strengths and limitations of this study**

- This is one of the largest face to face surveys of adolescents' independent mobility covering 73 schools which is the highest number of schools compared to previous studies.
- Multistage stratified random cluster sampling of schools with at least one classroom of adolescents per school with an approximate equal number of classrooms of grades 6 to 10 was conducted.
- The ability to assess a temporal relationship between independent mobility (exposure) and road traffic injury (outcome) is lacking.

## Introduction

Independent mobility refers to the freedom of children and adolescents to move around in public spaces without being accompanied by an adult. Independent mobility positively impacts psychological, social, cognitive, motor, spatial, and analytical development.[1, 2] Independent mobility facilitates physical activity and decreases the risk of obesity, hypertension, diabetes, and many other noncommunicable diseases.[3, 4] Children's and adolescents' independent mobility is influenced by many psychosocial factors, such as the parent's concerns about weak ties at the neighbourhood level, encounters with strangers, and fears of road traffic, which are also attributed to adolescents' limited independent mobility.[5, 6 7, 8]

Adolescents are vulnerable to road traffic injuries (RTIs), which are the leading cause of death in adolescents aged 10-19 years. In 2019, 95,586 deaths from RTIs in adolescents aged 10-19 years occurred worldwide,[9] and 90% of these deaths occurred in low- and middle-income countries.[10] A survey from Turkey reported that 12.5% of high school adolescents aged 14-18 years had RTIs.[11] In Nigeria, RTIs accounted for 10% of all injuries in adolescents aged 11-17 years.[12] While in Qatar, RTIs accounted for 6% of injuries in trauma patients aged 10-18 years presenting to a trauma center.[13]

Male sex and low socioeconomic status are risk factors associated with RTIs in adolescents.[14] Deaths and injuries from RTIs are most common among pedestrians, cyclists, and motorcyclists in low- and middle-income countries, where the constructed environment is least likely to be adapted to the needs of vulnerable road users.[15-17] The number of severe injuries per distance travelled was higher in young adolescents than in any other age group, as reported by a study in

the Netherlands.[18] RTIs are also a leading contributor to disability adjusted life years (DALYs) in children and adolescents.[19] The rate of permanent disability due to RTIs among children and adolescents aged 1 to 17 years is 20 per 100,000 children.[20]

Studies on independent mobility are mostly descriptive studies of school travel, and in some analytical studies, its association with physical activity and distance was determined.[21] Research on the independent mobility of adolescents and RTIs is scarce, and an association between independent mobility and RTIs has been assessed previously in very few studies. A study from New Zealand that determined the effect of adult accompaniment in RTI showed that adult accompaniment of children and adolescents aged 5 to 12 years old was associated with reduced risk of pedestrian injury, but this result was not statistically significant.[4] A study from India considered independent mobility as a confounding variable in association of distance and mode of travel with RTIs in adolescents aged 11-14 years.[22] In a study from Singapore, pedestrian injuries in adolescents aged 16 years and younger involved walking alone.[23]

Sustainable development goals (SDGs) advocate for safe transportation and an improvement in road safety by targeting the special needs of children and adolescents.[24] It is important to determine whether adolescents' independent mobility is associated with an increased risk of RTIs to decide how to advocate for independent mobility. The aim of this study is to determine measures of adolescents' independent mobility associated with RTIs in an urban lower middle-income setting in Karachi.

## Methods

### Study design

We conducted a cross-sectional study between September and December 2014.

### Setting and participants

Adolescents (aged 10-19 years) in grades 6 to 10 were enrolled from the participating schools in Karachi, Pakistan. The city has an estimated population of 20 million. In 2019, Pakistan reported approximately 2393 deaths due to RTIs in 10-19-year-olds.[9] In Karachi, the annual incidence of RTIs was 54.7 per 100,000 population, and the mortality rate was 1.5 per 100,000 population aged less than 15 years, of which 89% were male.[25] A previous travel survey from Pakistan reported that 10 to 14 years old adolescents who were males made 36% more trips than females. At 15 years and older, this sex gap increases to more than 50%.[26] The public transportation system is inadequate in the city. There is a lack of paved areas for pedestrians, and vendors occupy space for their roadside businesses.[27] Roads have potholes and are in poor condition. [28]

Overall, there were 4098 private schools and 2828 public schools in Karachi at the time of data collection, as per official lists from the education department. A total of 73 schools participated in our study, of which 26 (36%) were public schools and 47 (64%) were private schools (figure 1). The ratio of public to private schools in the sample was determined based on the distribution of schools in urban Pakistan.[29] We used multistage stratified random cluster sampling to select the schools. In the first stage, schools were stratified by private and public secondary schools (grades 6 to 10) status. The random sample of schools was chosen with quotas of 60% private

schools and 40% public schools, proportional to school enrolment in Karachi. In the next stage, at least one classroom in each school was selected as a convenience cluster sample. Approximately equal numbers of grades 6, 7, 8, 9, and 10 were selected within each stratum of public and private school. Research assistants informed school management beforehand about grade selection from that school, while the school management guided the section selection of the selected grades.

**Outcome**

An RTI is any self-reported lifetime RTI sustained as a pedestrian, as a cyclist, or while in a car or another vehicle that resulted in any first aid at home/school or consultation in a healthcare setting.

**Exposures**

Adolescents' self-reported independent mobility was assessed by four variables. 1) Any travel companion from school to home on the survey day ["with a parent or adult", "alone or with an adolescent of the same age", or "mixed travel pattern either with parents or alone"]. 2) Parental permission to cross main roads alone ["yes" or "no"]. 3) Parental permission to travel by public bus alone ["yes" or "no"]. 4) Participation in at least one activity outside the home on the previous weekend alone ["no activities", "with a parent or adult", "alone or with an adolescent of the same age", or "mixed activity pattern either with parents or alone"].

**Other covariates**

Age, grade, sex, type of school (public or private), travel time to school by any mode of transportation, and mode of transportation home from school were included as covariates based on their association with RTIs in previous literature.[30] The type of school was included as a proxy variable for the children's socioeconomic status, as public schools cater to low-income families; furthermore, the type of school indicates the style of parental licensing.[22] Travel time to school was included as a proxy variable for distance, which is associated with RTI in previous literature.[22]

**Data sources/measurements**

The study questionnaire was adapted from London Policy Studies Institute. It had multiple-choice questions, was available in English, and was also translated into Urdu. The adapted questionnaire has been used in many countries, including Sri Lanka and India, which are in the same region as Pakistan and have similar population dynamics.[31, 32] In India, the questionnaire was found to be reliable.[32] Questions on RTI outcomes were not in original questions. They were added in Indian study and also used in the current study with some modifications. The Cronbach alpha for the variables that are used in this analysis is found to be 0.70.

The questionnaire was piloted to assess its effectiveness, acceptability, and clarity, and modifications were made accordingly before launching the main data collection process. The pilot study was completed in 2 private schools and 1 public school, and 196 children and adolescents participated. Aspects of the questionnaire were changed to clarify some questions.

For example, some modifications were made to adapt the questions to the local context, such as replacing “local buses” with “public buses”. Definitions of a few variables were added; for example, adults were defined as a person aged 18 years and older. Traffic crashes were clarified by adding the word “road” to “traffic crash”.

Research assistants supervised the survey and read and explained each question to adolescents in each class to ensure that the adolescents understood the questionnaire clearly. The questionnaire took approximately 25 minutes to be completed by a class of adolescents. In each class, a parental permission letter that provided details of the study (in either Urdu or English language, as advised by the school administration) was distributed to each adolescent. Adolescents were instructed to obtain letters signed by their parents or guardians within one week. It was confirmed that a weekend fell between the distribution of permission letters and the research assistants’ second school visit to allow parents adequate time to read the permission letters. Written informed consent was obtained from the parents/guardians of the adolescents, and informed verbal assent was obtained from the adolescents.

**Study size**

The sample size calculated for the original survey was 1,270 school adolescents. The original question was designed to assess the prevalence of travel modes to school based on the assumption that at least 50% of adolescents were active commuters (since no past information on adolescents’ school mobility patterns in Pakistan was available). We used a 95% confidence level (CI), an error bound of ± 5%, and a design effect of 3, and we inflated the sample size by 10% to account for nonresponders.

## Statistical analysis

The analysis was performed by using R.[33] Categorical variables are described using frequencies and percentages. Logistic regression was used to estimate unadjusted and adjusted associations, as well as 95% CIs, between the measures of independent mobility and RTIs. Four models were developed by using each of the four exposures with RTI as the outcome. The models were adjusted for age, sex, type of school, travel time to school by any mode of transportation, and mode of transportation home from school. However, the model with the exposure "activities on the weekend alone" was adjusted only for age, sex, and type of school, because the travel time to school and mode of transportation to school were not related to activities on weekends. The sample size requirements for this type of analysis have been described as between 10 and 25 events (participants with the outcome) and at least as many nonevents per parameter in the model.[34] With 265 events, less than 10 parameters were accommodated in the models.

## Involvement of patients and the public

Patients and/or the public were not involved in this study.

## Results

There were 1288 children and adolescents included in the survey. The complete case analysis was performed on a sample of 1264 adolescents after removing cases with missing values and the three cases who were either younger or older than the age criteria for adolescents10-19 years old.

The majority of the adolescents were females (60%) and in the 10-14-year- age group (59%). Most of them walked to school (72%). Almost half of the adolescents arrived at the school within 5 to 15 minutes. Overall, 21% reported RTIs (Table 1). Approximately 55% of RTIs occurred in the 10-14 year age group, and 45% occurred in the 15-19-year age group. More than half of RTIs were among males (56%). The majority of RTIs (71%) happened to adolescents whose mode of transportation home from school was walking (Table 1).

**Table 1 Characteristics of adolescents surveyed from schools in Karachi, Pakistan**

| Variables | 10–19 n=1264 n (%) | No RTIs n=999 n (%) | RTIs n=265 n (%) |
|---|---|---|---|
| Age group (years) | | | |
| 10 to 14 | 746 (59.0) | 601 (60.2) | 145 (54.7) |
| 15 to 19 | 518 (41.0) | 398 (39.8) | 120 (45.3) |
| Sex | | | |
| Female | 757 (59.9) | 639 (64.0) | 118 (44.5) |
| Male | 507 (40.1) | 360 (36.0) | 147 (55.5) |
| Grade | | | |
| 6 | 262 (20.7) | 197 (19.7) | 65 (24.5) |
| 7 | 255 (20.2) | 216 (21.6) | 39 (14.7) |
| 8 | 200 (15.8) | 147 (14.7) | 53 (20.0) |
| 9 | 342 (27.1) | 285 (28.5) | 57 (21.5) |
| 10 | 205 (16.2) | 154 (15.4) | 51 (19.2) |
| Type of school | | | |
| Private | 753 (59.6) | 588 (58.9) | 165 (62.3) |
| Public | 511 (40.4) | 411 (41.1) | 100 (37.7) |
| Mode of transportation home from school on the day of the survey | | | |
| Walking | 954 (75.5) | 766 (76.7) | 188 (70.9) |
| Two- or three-wheeled vehicle | 107 (8.5) | 83 (8.3) | 24 (9.1) |
| Four-wheeled vehicle | 203 (16.1) | 150 (15.0) | 53 (20.0) |
| Travel time to school by any mode of transportation (minutes) | | | |

| | | | |
|---|---|---|---|
| < 5 | 462 (36.6) | 511 (51.2) | 131 (49.4) |
| 5 to 15 | 642 (50.8) | 29 (2.9) | 19 (7.2) |
| 16 to 30 | 48 (3.8) | 67 (6.7) | 22 (8.3) |
| 31 to 45 | 89 (7.0) | 14 (1.4) | 9 (3.4) |
| > 46 | 23 (1.8) | 511 (51.2) | 131 (49.4) |
| Companion for travel home from school on the day of the survey | | | |
| With either a parent or any other adult | 139 (11.0) | 111 (11.1) | 28 (10.6) |
| Alone or with someone of the same age | 1039 (82.2) | 817 (81.8) | 222 (83.8) |
| Mixed travel pattern, i.e., alone or with parents | 86 (6.8) | 71 (7.1) | 15 (5.7) |
| Parental permission to cross main roads alone | | | |
| No | 716 (56.6) | 591 (59.2) | 125 (47.2) |
| Yes | 548 (43.4) | 408 (40.8) | 140 (52.8) |
| Parental permission to travel on public buses alone | | | |
| No | 1028 (81.3) | 835 (83.6) | 193 (72.8) |
| Yes | 236 (18.7) | 164 (16.4) | 72 (27.2) |
| Activity/activities outside the home on the previous weekend | | | |
| With a parent or another adult | 229 (18.1) | 200 (20.0) | 29 (10.9) |
| No activities on the weekend | 139 (11.0) | 126 (12.6) | 13 (4.9) |
| Alone or with another young person | 455 (36.0) | 334 (33.4) | 121 (45.7) |
| Mixed activities, i.e., either with parents or alone | 441 (34.9) | 339 (33.9) | 102 (38.5) |

In the unadjusted analyses, male sex (OR 2.21, 95% CI 1.68 to 2.91), use of four-wheeled transportation home from school (OR 1.44, 95% CI 1.01 to 2.04), travel time of 31 to 45 minutes to school (OR 2.95, 95% CI 1.56 to 5.48) and travel time of 46 or more minutes to school (OR 2.89, 95% CI 1.17 to 6.82), parental permission to cross main roads alone (OR 1.62; 95% CI 1.24 to 2.13), parental permission to use public buses alone (OR 1.9; 95% CI 1.38 to 2.6), engagement in weekend activities alone (OR 3.51; 95% CI 1.98 to 6.74), and a mixed pattern of weekend activities (OR 2.92; 95% CI 1.63 to 5.62) were associated with an increased OR of RTIs (Table 2).

| Table 2 Unadjusted associations of road traffic injuries with the variables of independent mobility and other covariates in adolescents in Karachi, Pakistan, n= 1264 | |
|---|---|
| **Variables** | **OR (95% CI)** |
| Age group (years) | |
| 10 to 14 | 1 |
| 15 to 19 | 1.25 (0.95, 1.64) |
| Sex | |
| Female | 1 |
| Male | **2.21 (1.68, 2.91)** |
| Type of school | |
| Private | 1 |
| Public | 0.87 (0.65, 1.14) |
| Mode of transportation home from school on the day of the survey | |
| Walking | 1 |
| Two- or three-wheeled vehicle | 1.18 (0.71, 1.88) |
| Four-wheeled vehicle | **1.44 (1.01, 2.04)** |
| Travel time to school by any mode of transportation (minutes) | |
| < 5 | 1 |
| 5 to 15 | 1.15 (0.85, 1.57) |
| 16 to 30 | 1.48 (0.85, 2.5) |
| 31 to 45 | **2.95 (1.56, 5.48)** |
| > 46 | **2.89 (1.17, 6.82)** |
| Companion for travel home from school on the day of the survey | |
| With either a parent or any other adult | 1 |
| Alone or with someone of the same age | 1.08 (0.7, 1.7) |
| Mixed travel pattern, i.e., alone or with parents | 0.84 (0.41, 1.66) |
| Parental permission to cross main roads alone | |
| No | 1 |
| Yes | **1.62 (1.24, 2.13)** |
| Parental permission to travel on public buses alone | |
| No | 1 |
| Yes | **1.9 (1.38, 2.6)** |
| Activity/activities outside the home on the previous weekend alone | |
| No activities on the weekend | 1 |
| With a parent or another adult | 1.41 (0.72, 2.89) |
| Alone or with another young person | **3.51 (1.98, 6.74)** |
| Mixed activities, i.e., either with parents or alone | **2.92 (1.63, 5.62)** |

In the adjusted analysis, travel home from school (adjusted odds ratio (aOR) 1.14; 95% CI 0.71 to 1.89) was compatible with reduced odds, increased odds, and no association with RTIs. Adolescents who had parental permission to cross main roads (aOR 1.39; 95% CI 1.04 to 1.86) had significantly higher odds of RTIs. Adolescents who had parental permission to use public buses had statistically insignificant odds compatible with reduced odds of, increased odds of, and no association with RTIs (aOR 1.34; 95% CI 0.93 to 1.91). Unaccompanied adolescents who performed any activity outside the home on the previous weekend (aOR 2.61; 95% CI 1.42 to 5.13) or had a mixed pattern of weekend activities, either accompanied or alone (aOR 2.50; 95% CI 1.38 to 4.89), had significantly higher odds of RTIs (Table 3).

**Table 3 Adjusted odds ratios (aOR) of the independent mobility exposures and the outcome road traffic injury (RTI) in adolescents n=1264**

| **Variables** | Model with exposure Companion for travel home from school on the day of the survey | Model with exposure Parental permission to cross main roads alone | Model with exposure Parental permission to travel on public buses alone | Model with exposure Activity/activities outside the home on the previous weekend alone |
|---|---|---|---|---|
| | **aOR for RTI (95% CI)** | **aOR for RTI (95% CI)** | **aOR for RTI (95% CI)** | **aOR for RTI (95% CI)** |
| Companion for travel home from school on the day of the survey | | | | |
| With either a parent or any other adult | 1 | - | - | - |
| Alone or with someone of the same age | 1.14 (0.71,1.89) | - | - | - |
| Mixed travel pattern, i.e., alone or with parents | 0.84 (0.40,1.71) | - | | - |
| Parental permission to cross main roads alone | | | | |
| No | - | 1 | - | - |
| Yes | - | **1.39 (1.04,1.86)** | - | - |
| Parental permission to travel on public buses alone | | | | |
| No | - | - | 1 | - |
| Yes | - | - | 1.34 (0.93,1.91) | - |
| Activity/activities outside the home on previous weekend | | | | |
| No activities on the weekend | - | - | - | 1 |
| With a parent or another adult | - | - | - | 1.48 (0.75,3.06) |
| Alone or with another young person | - | - | - | **2.61 (1.42,5.13)** |
| | - | - | - | **2.50 (1.38,4.89)** |

| | | | | |
|---|---|---|---|---|
| Mixed; both with parents and alone | | | | |
| Age group (years) | | | | |
| 10 to 14 years | 1 | 1 | 1 | 1 |
| 15 to 19 years | 1.28 (0.95, 1.71) | 1.23 (0.91, 1.65) | 1.22 (0.91, 1.65) | 1.28 (0.96, 1.71) |
| Sex | | | | |
| Female | 1 | 1 | 1 | 1 |
| Male | **2.18 (1.63, 2.92)** | **2.06 (1.53, 2.77)** | **2.03 (1.49, 2.76)** | **1.73 (1.26, 2.38)** |
| Type of school | | | | |
| Private | 1 | 1 | 1 | 1 |
| Public | 1.05 (0.76, 1.44) | 1.00 (0.73, 1.39) | 1.04 (0.75, 1.43) | 1.01 (0.74,1.36) |
| Mode of transport home from school on the day of the survey | | | | |
| Walking | 1 | 1 | 1 | - |
| Two- or three-wheeled vehicle | 1.13 (0.66, 1.89) | 1.10 (0.65, 1.78) | 1.07 (0.64, 1.73) | - |
| Four-wheeled vehicle | 1.30 (0.84, 1.99) | 1.25 (0.82, 1.88) | 1.22 (0.80, 1.84) | - |
| Travel time to school by any mode of transportation (minutes) | | | | |
| < 5 | 1 | 1 | 1 | - |
| 5 to 15 | 1.12 (0.82, 1.55) | 1.10 (0.80, 1.52) | 1.11 (0.81, 1.54) | - |
| 16 to 30 | 1.30 (0.72, 2.29) | 1.24 (0.69, 2.20) | 1.28 (0.71, 2.26) | - |
| 31 to 45 | **2.61 (1.32, 5.11)** | **2.61 (1.32, 5.11)** | **2.60 (1.31, 5.08)** | - |
| > 46 | 2.50 (0.97, 6.18) | 2.34 (0.90, 5.79) | 2.40 (0.93, 5.95) | - |

## Discussion

This study shows that the odds of RTIs for adolescents with parental permission to cross main roads alone was 1.39 times higher than that for adolescents without parental permission to cross main roads and that the odds of RTIs for adolescents who participated in activities outside the home on the previous weekend alone was 2.6 times higher than that for adolescents who participated in no activities on the previous weekend. Other measures of independent mobility, such as parental permission to use public buses and travel home from school alone, had point estimates that indicated increased odds but had CIs compatible with reduced odds , increased odds , and no association with RTIs.

The finding that adolescents who had parental permission to cross main roads alone had greater odds of RTIs is consistent with previous studies that conclude that the number of streets crossed by adolescents is associated with injury.[35] In addition, a qualitative study from India – a neighbouring country of Pakistan with a similar road environment – reported that adolescents displayed various distracted behaviours as pedestrians, such as using earphones and mobile phones as well as talking and playing with friends.[36] Both the distracted behaviours and the unsafe road environment for pedestrians in Pakistan could be linked to an increased risk for RTIs. The roads are dilapidated with potholes, pedestrian signals to assist in road crossing are lacking, and vehicles are generally considered to have the right of way; therefore, poor yield compliance for pedestrians at crosswalks is substantially higher by vehicle drivers.[37, 38] [27]

Adolescents' activities outside the home on the previous weekend alone were associated with RTIs. The odds were higher when adolescents were alone or with their peers during weekend activities or when they had mixed patterns of weekend activities than when they engaged in activities accompanied by adults. It is understandable that leisure activities with peers provoke several comparatively risky behaviours, for example, smoking, substance abuse, risky driving, and risky pedestrian behaviours.[39] Previous studies have shown that children and adolescents with unsafe road safety behaviours have peers with similar behaviours.[40] Multiple risk behaviours are associated with injuries in youth.[41] The means of mobility in weekend activities was not captured in our study, but in our context, we assume it could be walking, motorcycles, public buses, or private cars. Underage driving is also witnessed in young adolescents in the study setting.[42]

The other two exposures – travelling from school to home alone and parental permission to travel on public buses alone – were associated with slightly higher odds of RTIs, but the 95% CIs were compatible with reduced odds of, increased odds of, and no association with RTIs. This uncertainty indicates that within the groups of adolescents, some had reduced odds of RTIs, while others had increased odds. A previous study in Auckland showed that adult accompaniment on the school-home journey may be associated with reduced pedestrian injuries, but the effect was not statistically significant, similar to the findings of our study.[4] Future research should focus on identifying those traits that distinguish these groups of adolescents with increased and reduced odds for RTIs.

The independent mobility of adolescents has many inherent benefits and needs to be valued by society. Children need to move in public spaces for different activities, such as to travel to school, their work and other leisure activities, which are important for the development of social skills. However, parents are the licensing bodies that control their children's independent mobility, and their willingness to allow their adolescents to move independently is influenced by many factors, such as traffic and public safety. Safe public spaces lead to an increased number of children who move independently, a factor that has important public health implications.[43]

SDGs promote physical activity as well as safe transportation. The study findings call for improvement in road systems as chalked out in Global Plan for the Decade of Action; improving the safety of vehicles; and enhancing the behaviour of road users.[44] The majority of adolescents in our study attend schools through independent mobility; therefore, it is highly important for urban planners, environmentalists and public health practitioners to emphasize a safe road

environment to prevent adolescents' road crashes.[45] Pedestrian sidewalks, pedestrian signals, use of pedestrian bridges, provision of safe routes to school, and deployment of volunteers to accompany adolescents who walk or travel by bus to school or provision of subsidized school transportation are some important aspects to be improved. The addition of road safety curricula in schools could be a helpful strategy to create awareness on safe conduct in road traffic environments.

**Limitations**

This study has limitations. First, the study design is cross-sectional and is not meant to assess the temporal associations of independent mobility and RTI. It is unclear when an injury occurred, as lifetime injuries were reported, and there is a possibility that any previous RTI might lead to a decrease in independent mobility. Second, we did not collect details on the modes of RTIs. Determining the details of whether an injury occurred to an adolescent as a pedestrian or as a vehicle occupant could further help to assess the cause of an RTI. Third, our current analysis included more females, as the sample was not stratified based on sex. There were fewer males in public schools, and it was found that the number of males enrolled per class was lower than that of females in public schools in Karachi. There might be additional reasons for the lower numbers of males in public schools, such as lower attendance. It was also observed in our study that more males than females forgot their consent forms. Any future study should also consider the enrolment rates of males and females separately in private and public schools in sampling. Furthermore, including a lower number of males in the study would have meant that fewer injuries were reported in the study, as injuries are more common in males, which would have impacted the strength of the association. Finally, we did not consider independent cycle use by

adolescents in our analysis, as only 23% of adolescents 10-19 years old reported having a cycle. The unadjusted analysis (not reported) showed a statistically insignificant association between being allowed to ride a cycle on their own and RTIs. The addition of this variable in the multivariable analysis was not appropriate, as the total data count for this variable was much lower (n=277) than those for the other variables, which would have decreased the sample size for the complete model. Similarly, underage use of motorcycles and cars by adolescents was not evaluated in this study. These transportation modes need to be explored to determine their relationship with RTIs.

**Conclusions**

The study is one of the first studies in the context of the independent mobility of adolescents in low-middle income settings where opportunities for physical activities, both structured and unstructured, are less likely because of a lack of safe public spaces. Independent mobility is an easy strategy for physical activity and has many health and social benefits for children and adolescents. This study highlights the risk of RTIs associated with measures of independent mobility. Measures of independent mobility in adolescents – parental permission to cross main roads and independent mobility in weekend activities – are associated with an increased risk of RTIs. Effect size of association of measures of independent mobility with RTIs may be biased towards null because of underrepresentation of boys in the sample compared to the actual adolescent population.

Learning road safety is an important need for children and adolescents to enhance their safe mobility. These findings may help policy makers to consider the concept of independent mobility and apply relevant findings to policies for urban planning, road traffic, transportation, school,

and supervision. It is critical for public health officials, urban and transportation planners, and policy makers to recognize growing transportation problems in school catchment areas around school start and end times and respond to the transportation needs of children and adolescents. Investment in making road infrastructure and policies friendly for commuting pedestrians and cyclists as well as providing safe public transportation is warranted to facilitate independent commuting of adolescents.

**Figure 1:** Flow chart of adolescents'recruitment from schools

## Declarations

### Ethics approval and consent to participate

The study proposal was approved by the ethics review committee of Aga Khan University (reference number 2883-EM-ERC-13). The details of the study and principles of voluntary participation, confidentiality, autonomy and right to withdraw from study were explained to participants and their parents.

### Competing interests

The author declares no competing interests.

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### Authors' contributions

URK conceptualized, analysed and drafted the study. JAR critically reviewed all drafts. MGW supervised all analyses and drafts.

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**Data availability**

Deidentified participant data are available upon reasonable request from Uzma Rahim Khan, uzma.khan@aku.edu.

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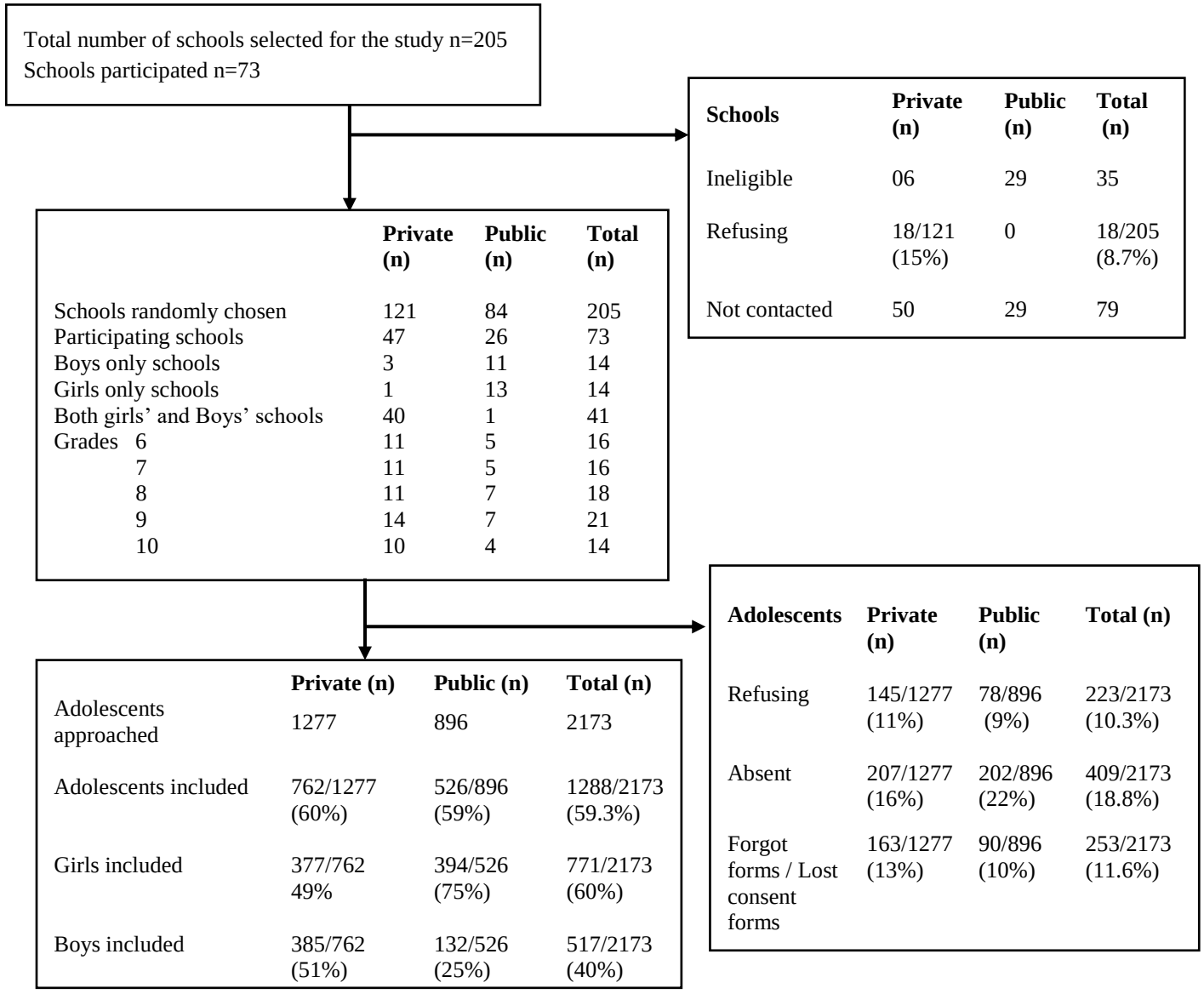


**Figure 1: Flow chart of adolescents' recruitment from schools**

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

| | Item No | Recommendation | Manuscript Page |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 and 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 and 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 and 7 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 8 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 9 and 10 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 19 and 20 |
| Study size | 10 | Explain how the study size was arrived at | 10 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 10 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 10 and 11 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | NA |
| | | (*c*) Explain how missing data were addressed | 10 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | NA |
| | | (*e*) Describe any sensitivity analyses | NA |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 7 |
| | | (b) Give reasons for non-participation at each stage | 7 |
| | | (c) Consider use of a flow diagram | 7 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 11 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 11 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 11 and 12 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear | 13,14 and 15 |

| | | | |
|---|---|---|---|
| | | which confounders were adjusted for and why they were included | |
| | | (*b*) Report category boundaries when continuous variables were categorized | NA |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | NA |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 16 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 18-19 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 19-20 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 20 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 21 |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.