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Circumstances and outcome of active transportation injuries: protocol of a British Columbian inception cohort study

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ABSTRACT

Introduction Active transport (AT) is promoted by urban planners and health officials for its environmental, economic and societal benefits and its uptake is increasing. Unfortunately, AT users can be injured or killed due to falls or collisions. Active transport injury (ATI) prevention efforts are hindered by limited research on the circumstances, associated infrastructure, injury pattern, severity and outcome of ATI events. This study seeks to address these knowledge gaps by identifying built environment features associated with injury and risk factors for a poor outcome following ATI.

Methods and analysis This prospective observational study will recruit an inception cohort of 2000 ATI survivors, including pedestrians, cyclists and micromobility users aged 16 years and older who arrive at a participating emergency department within 48 hours of sustaining an ATI. Baseline interviews capture demographic and socioeconomic information, pre-injury health and functional status, as well as circumstances of the injury event and recovery expectations. Follow-up interviews at 2, 4, 6 and 12 months postinjury (key stages of recovery) use standardised health-related quality of life tools to determine physical and mental health outcomes, functional recovery and healthcare resource use and lost productivity costs.

Ethics and dissemination The Active Transportation Injury Circumstances and Outcome Study is approved by our institutional research ethics board and the research ethics boards of all participating sites. This study aims to provide healthcare providers with knowledge of risk factors for poor outcome following ATI with the goal of improving patient management. Additionally, this study will provide insight into the circumstances of ATI events including built environment features and how those circumstances relate to recovery outcomes. This information can be used to inform city engineers and planners, policymakers and public health officials to plan roadway design and injury prevention policy.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study uses an inception cohort design, recruiting a large sample size of approximately 2000 active transport injury survivors and following them for 12 months after injury.
⇒ Accident location, circumstances and details will be captured using structured interviews and Google Maps functionality.
⇒ Health outcomes will be self-reported using validated tools during key phases of injury recovery.
⇒ There is a potential risk of non-respondent bias and recall bias, especially for self-reported pre-injury health status.
⇒ We are unable to capture active transport injury victims who never seek medical care in a hospital setting or who seek care days later.

INTRODUCTION

Active transport (AT) is any form of human-powered travel that integrates physical activity into daily life.[1] It is promoted by urban planners and health officials for its environmental, economic and societal benefits.[2] By promoting physical activity and reducing sedentary behaviour, AT improves multiple health conditions including cardiometabolic disease, obesity, diabetes and mental illness and reduces all-cause mortality.[1 3] Cities with higher AT rates have improved air quality, less noise, lower carbon emissions, reduced road congestion, more green space and improved social interaction.[4] According to the 2016 census, 5.5% of Canadian adults walk to work as their primary transport mode; a further 1.4% bike and 12.4% use public transit (usually includes walking to/from bus stop).[5 6] Given these benefits, uptake of AT, particularly cycling, is increasing.

Unfortunately, AT users are vulnerable road users and can be injured or killed due to falls or collisions. In Canada, approximately 300 pedestrians and 40 cyclists are killed annually, and many more injured, in largely preventable collisions with motor vehicles.[7] Recent reports suggest an increase in pedestrian and cyclist fatalities, especially for females.[8–12] People are more likely to engage in AT when it is perceived to be safe,[13] and AT is safer in communities with higher

AT rates.[14 15] In Europe, where AT is perceived as safer than in North America, AT prevalence is higher and there have been greater declines in pedestrian and cyclist fatality rates since the 1990s.[16] Conversely, fear of injury and personal experience of a near miss are deterrents to AT.[17–20] Women tend to be more risk averse and cycle less than men, especially on routes near high-speed roads or in the absence of cycling infrastructure.[21 22] Measures to promote AT must incorporate injury prevention. Without such efforts, injuries are likely to increase as more people engage in AT. Unfortunately, prevention efforts are hindered by limited research on the circumstances, associated infrastructure, injury pattern, severity and outcome of active transport injury (ATI) events.

Micromobility refers to transportation provided by lightweight vehicles such as e-bikes and electric scooters. Like cyclists, micromobility users are vulnerable road users, travel at similar speeds and share the same AT infrastructure.[23] Micromobility devices run on battery or human power alone or in combination. City planners want to know more about injuries associated with these devices as micromobility is rapidly increasing. A recent systematic review found that e-scooter collisions often cause injury but understanding of the circumstances of these events is limited.[24]

Most studies of outcome after road trauma focus on motorists although some include small numbers of pedestrians/cyclists.[25–40] In most countries, including Canada, road trauma statistics do not capture ATI events unless a motor vehicle is involved.[41] Events such as pedestrians tripping on a curb or cyclists colliding with roadside hazards are common (and potentially preventable) but seldom captured in traffic injury data. As such, there is limited understanding of the circumstances of ATI events, associated injury patterns and outcomes. In particular, it is likely that ATI outcome differs from that after trauma involving vehicle occupants. The Active Transportation Injury Circumstances and Outcome (ATICO) study seeks to address these knowledge gaps by providing insight into the circumstances of ATI events and how those circumstances relate to outcomes, identifying built environment features associated with severe injuries and/or poor outcome following ATI and identifying factors associated with poor health-related quality of life (HRQoL) outcomes following an ATI event. This manuscript presents the methodology for this multicentre study.

METHODS AND ANALYSIS

Study design and setting

This prospective observational study involves an inception cohort of ATI survivors with all levels of injury severity. Recruitment started in January 2022 and the study will run for 4 years. Participants are recruited from four British Columbian (BC) emergency departments (ED): Vancouver General Hospital (Vancouver), St. Paul's Hospital (Vancouver), Royal Columbia Hospital (New Westminster) and Surrey Memorial Hospital (Surrey). These hospitals serve rural, suburban and urban populations similar to those served by other trauma centres across Canada. The ATICO study uses similar methods for recruitment and follow-up as the Road Trauma Outcome Study (RTOS), an inception cohort study that investigated outcome following a motor vehicle collision.[42 43] The ATICO study differs from the RTOS, in that it includes only people with ATIs and it gathers details about the circumstances of the injury event.

Patient and public involvement

The study was designed in consultation with public health stakeholders. Patient partners were recruited and will be invited to participate in advisory group meetings to provide an ATI survivor perspective on enrolment, questionnaire content, interpretation of findings and knowledge translation plans. Research findings will be posted on our team website to be shared with study participants and the general public.

Inclusion and exclusion criteria

Pedestrians, cyclists and other micromobility users aged 16 years and older who arrive in the ED within 48 hours of sustaining an ATI are included. We include injuries occurring on or alongside a public road due to falls (eg, pedestrian trip and fall, cyclist loses control) or collisions (with a motor vehicle or with another road user or with a stationary object). Children younger than 16 years old are excluded as they have a different recovery trajectory and require different tools to measure HRQoL. Non-BC residents are also excluded as follow-up healthcare information is not available for out-of-province participants. Non-English speakers are interviewed through a translator. Cognitively impaired patients (eg, dementia) are excluded as it may be difficult to obtain accurate information. Patients who are inappropriate to approach (suicidal, violent/aggressive or in police custody) for the entire duration of their hospital visit are excluded as reliable information cannot be obtained and it may be unsafe for research staff to approach the patient. Fatalities within 30 days following the hospital visit or admission are excluded. Patients who are under the influence of substances are excluded if their injuries were due to severe intoxication (eg, collapse as a result of substance use).

Recruitment

Research assistants (RAs) recruit participants from the ED from early morning to late evening. Eligible patients who visit the ED when RAs are not present will be identified by review of visit logs and mailed a letter of invitation with a consent form; RAs will then call the patient 3 days after the letter was sent to ensure sufficient time for receipt of the letter. Demographics and reasons for refusal are logged for missed and refused patients. The recruitment goal for the study is 2000 ATI survivors (approximately 1100 pedestrians, 750 cyclists and 150 micromobility users).

Data sources and data management

Data are collected from baseline interviews, medical records, follow-up interviews and administrative health records. Follow-up interviews at 2, 4, 6 and 12 months following injury correspond to key phases of recovery: acute treatment, rehabilitation, adaptation and stable end situation.[44] We use Research Electronic Data Capture (REDCap) online database for data management.[45]

Baseline interviews

Baseline interviews determine demographic and socioeconomic information, pre-injury health and functional status, as well as circumstances of the injury event and recovery expectations. These interviews are conducted within 2 weeks post-event either in-person during the ED visit or hospital admission or by telephone after patients leave the hospital. All ATI survivors are approached up to three times or until a decision on participation in the study is obtained.

The baseline interview (online supplemental material) includes the following domains: (1) event details and circumstances including capture of accident location on Google Maps (https://www.google.com/maps); (2) medical history (cardiorespiratory, neurological, gastrointestinal, musculoskeletal, psychiatric, other); (3) pre-event anxiety and depression with the Patient Health Questionnaire-4 (PHQ-4);[46 47] (4) somatic symptoms with the PHQ-15[48] and (5) pain catastrophising and coping with the Short Form Pain Catastrophizing Scale.[49 50] Baseline HRQoL is measured with the five-level EuroQol instrument (EQ-5D-5L; the day before injury) and the Short Form 12 survey (SF-12; 4 weeks prior to event). The EQ-5D-5L and SF-12 are validated tools that assess mental health (depression, anxiety), discomfort/pain, restrictions to bending or lifting, ambulation, self-care and daily and social activities. These tools have Canadian population norms and can be used retrospectively to determine HRQoL.[37 51] As another measure of pre-injury health, the chronic disease score will be calculated using the previous year prescription data (available with participant consent) from PharmaNet, a database that captures all prescriptions from BC community pharmacies.[52] Pre-injury productivity 4 weeks prior to the injury is assessed using the iMTA Productivity Cost Questionnaire (iPCQ).[53] Participants are also asked about their expectations for recovery ('How long do you think it will take for you to fully recover from your injuries?'). Gender differences in impulsivity/risk taking will be explored using the Abbreviated Barratt Impulsiveness Scale.[54 55] We also ask open-ended questions on attitude changes towards AT and how to improve the road infrastructure.

Follow-up interviews

ATI survivors' recovery trajectory and outcomes are assessed by follow-up interviews at 2, 4, 6 and 12 months postinjury. Follow-up interviews (online supplemental material) include the SF-12, EQ-5D-5L, PHQ-15, Glasgow Outcome Scale Extended (GOS-E), the post-traumatic stress disorder (PTSD) checklist (PCL-S) and iPCQ. The SF-12 and EQ-5D-5L are most applicable to people who live independently whereas the GOS-E differentiates between different levels of severe disability. The PCL-S is validated for detecting PTSD following a traumatic event.[56] The iPCQ is used to evaluate productivity losses related to absenteeism and reduced productivity at paid and unpaid work (eg, housework).[53] Questions on recovery progress are included. For example, participants are asked 'How well do you feel you are recovering from your injuries?' (options: 'all better (recovered)', 'quite a bit of improvement', 'some improvement', 'no improvement', 'a little worse' and 'much worse'). Responses to this question correlated well with other recovery indicators, such as levels of pain and return to work.[57] Follow-up interviews also include open-ended questions, developed with input from patient partners, focusing on the following domains: challenges experienced during recovery following an ATI event, impact of ATI on personal life and overall quality of life, attitude towards road safety and AT post-ATI event and opinions on road infrastructure and clinical care improvements.

Follow-up interviews are conducted by telephone, online survey, self-filled paper questionnaire or in-person depending on participant's preference. For each follow-up interview, participants are contacted via telephone, text, mail and/or email. Participants receive honorariums for completing the baseline and follow-up interviews. For those unable to complete interviews independently (eg, cognitive disability, language barrier), a proxy may either assist the participant or complete the questionnaire on the participant's behalf.

Medical chart review

Medical chart review of the index visit for all participants is the sole source of information for (1) injury type (eg, fracture) and location (eg, lower extremity); (2) injury severity;[58 59] (3) ED visit details (eg, arrival mode, acuity, duration, discharge diagnosis) and (4) ED investigations: diagnostic tests (eg, X-rays) and procedures (eg, sutures). Chart reviews are also used to supplement baseline interviews for information on: (1) event details: transportation mode, location and circumstances; (2) medical history and (3) medication history. Standardised forms and protocols guide data extraction to ensure accuracy and consistency between RAs.

Administrative health records

To measure healthcare resource use and calculate comorbidity scores, administrative health records including hospital admissions (Discharge Abstracts Database), medical service plan billings, ED visits (National Ambulatory Care Reporting System) and prescriptions (BC PharmaNet) are used. For participants who consent to Personal Health Number usage, records will be requested through PopDataBC, a health data depository supporting research with access to individual-level, de-identified longitudinal data on BC residents. Data will be collected for 1 year

prior to, and 1 year following, the ATI event to compare healthcare resource use pre-injury and post-injury.

Analysis

The following dichotomous outcomes will be assessed: (1) self-reported incomplete recovery; (2) reduction from baseline 'pre-event' values on EQ-5D-5L, SF-12 and PHQ-15 that exceed the minimal clinically important difference values reported for these scales; (3) evidence of PTSD and (4) have not returned to work, school or usual activities. At each follow-up period, the percentage of participants who experience each of these poor outcomes will be reported. Descriptive statistics will be generated for all study participants and disaggregated by sex, gender, age group, socioeconomic factors, transport mode and disposition (discharged from ED or admitted to hospital).

The following candidate risk factor categories will be examined: (1) demographic, socioeconomic and gender-related variables (sex, gender, age, ethnicity, residence location, employment status, education level, marital status, single parent, caregiving role); (2) baseline health status (pre-injury SF-12 and EQ-5D-5L scores, chronic disease score, self-reported medical history, previous year hospital admissions and physician visits); (3) psychosocial factors (anxiety, depression, catastrophising/coping); (4) injury type, location and severity; (5) transportation mode (pedestrian, cyclist, micromobility users) and (6) event circumstances (involvement of motor vehicle or another road user, speed limit, grade, infrastructure details).

For outcomes 1–4 defined above, separate mixed effects log-binomial regression models (generalised linear mixed models (GLMMs) using log link function) will be fitted to estimate relative risks (RRs) and CIs for the associations between risk factors and poor outcomes measured at 2, 4, 6 and 12 months. The nested structure of the data will be accounted for by including a random intercept for hospital site and participants nested within each site. Since GLMMs can be unstable in the presence of many predictors, separate models for each risk factor will be fitted first to obtain unadjusted RRs for poor outcome. These models will also include follow-up period (2, 4, 6 or 12 months) as a categorical predictor and an interaction term between period and risk factor. This will allow estimation of recovery trajectories and risk factor impact at different recovery stages. Next, a single model to identify independent predictors of outcome and estimate adjusted RRs will be built. This model will include multiple candidate risk factors identified using Harrell's approach.[60] Specifically, L_1-penalised estimation will be used as this method combines shrinkage with variable selection for GLMMs and works well when there are many influential predictors.[61] Finally, subgroup analysis for pedestrians and cyclists will be conducted to explore whether risk factors vary by mode of transport. A Bonferroni-adjusted significance level will be used.

Missing data

The percentage of participants with missing baseline data is expected to be approximately 2% based on previous research. Assuming missing data are not related to the outcome, no bias will result from exclusion of these participants.[62] For partially complete follow-up interview responses, guidelines of each validated tool will be followed to obtain an outcome score. As a mixed-effects log-binomial regression model is proposed, missing response data for participants who are lost to follow-up will be ignored. GLMMs use all available data and provide unbiased estimates if data are missing at random (ie, the unobserved data depend only on observed data). Further statistical testing using t-tests for continuous risk factors and chi-squared tests for categorical risk factors will be performed to explore differences between ATI survivors who complete the study and those who are lost to follow-up.

Sample size considerations

Sample size calculation is for outcome data at 12 months and conducted for two primary road user types (pedestrians and cyclists). A conservative 30% attrition rate is assumed such that 12 month outcome data will be available for at least 770 pedestrians, 525 cyclists and 105 micromobility users (exploratory analysis only). With an estimated 35% prevalence for each outcome and 50% for risk factors, and using a significance level of 0.0125 corrected for multiple outcomes, this study will have ≥80% power to detect RRs of 1.4 among pedestrians and 1.5 among cyclists at 12 months postinjury. If risk factor prevalence is low (10%), the minimum detectable RRs will be 1.6 among pedestrians and 1.7 among cyclists. In a worst-case scenario (ie, risk factor prevalence of 90%), the minimum detectable RRs will be 2.0 in pedestrians and 2.4 in cyclists. These estimates are based on two-sided comparison of independent proportions using the Normal approximation described by Woodward.[63]

Healthcare resource use

A total healthcare cost will be obtained for every study participant, supplemented by lost productivity costs. Generalised linear models will be fit to explore variation in healthcare and lost productivity costs in the year following injury according to transportation mode, injury severity, age range, sex/gender and disposition. Study participants will be differentiated by those who complete follow-ups and those who are lost to follow-up with respect to baseline characteristics.

Strengths

ATICO recruits an inception cohort of ATI survivors during their ED visit (or hospital admission) following injury, including events with or without motor vehicle involvement. Inception cohorts are ideal for studying outcome and prognostic factors and are less prone to sampling bias compared with retrospective cohorts.[64 65] To maximise generalisability, recruited ATI

survivors include: pedestrians, cyclists and micromobility users with all injury severity levels; non-native speakers (using translators); and those with cognitive limitations (with history obtained from caregivers). Another strength is the use of patient-reported outcomes to study the effects of injury on daily lives of ATI survivors; this study uses validated standardised tools to study HRQoL from physical and psychological domains during key recovery phases.[44 66] Additionally, accident location and details will be captured using Google Maps to identify built environment features associated with injury and risk factors for a poor recovery following ATI; these details have not been well-studied previously and are of interest to stakeholders. This study includes a large sample size, determines healthcare costs associated with ATI and includes productivity loss estimates at work and home. The large sample size will provide sufficient power to study key risk factors for a poor outcome.

Limitations

Our study design has some limitations which have been addressed as best as possible to minimise their effects. Specifically, recall and reporting bias through self-reported standardised tools may be present, especially related to pre-injury health. The 'good-old-days' bias, where patients knowingly or unknowingly exaggerate their pre-injury HRQoL, is common following injury.[67–69] To minimise 'good-old-days' and recall bias, baseline interviews are conducted as soon as possible following injury, ideally within 14 days.[44] Administrative health records, including calculated chronic disease score, will be used as an objective measure of pre-injury health.[67] Another limitation is non-respondent bias which may occur if those who decline to participate differ in important ways from participants. Refusals are tracked and differences between participants and those who refused to participate with respect to age, sex/gender, transportation mode, time of visit and need for hospital admission will be reported. Additionally, using modest honorariums and assurance of confidentiality is intended to minimise refusals, and the analysis plan considers non-respondent bias. Inherently, our study cannot be generalised to ATI victims who never seek medical care in a hospital setting or who seek care days later. Finally, attrition may affect the study findings in terms of overall response rate and baseline characteristics of those who complete follow-ups compared with those lost to follow-up. Different contact methods are used to minimise attrition rate. Strategies to minimise bias and missing data are applied during recruitment and analysis to help reduce the effects of these limitations.

ETHICS AND DISSEMINATION

Ethics approval

This study is approved by the research ethics board of the University of British Columbia (approval certification number: H21-02765) and by the research ethics board of other participating study sites: Providence Healthcare (Vancouver, BC) and Fraser Health Authority (New Westminster and Surrey, BC). Note that there is a harmonised ethics review process for BC sites. Ethics approval is renewed annually and updated throughout the duration of the study. Participants provide informed written or verbal consent. For minors (16–18 years old), legal guardian permission is obtained in addition to participant assent. For participants unable to provide consent (eg, comatose), proxy consent is obtained from a designated caregiver.

Dissemination plan

ATICO will provide insight into the circumstances of ATI events (eg, where/when/how they occur, weather/lighting conditions, action of motor vehicles or other road users and built environment features) and how those circumstances relate to outcomes. This information will inform city engineers and planners, policymakers and public health officials to plan roadway design and prevention policy.

Additionally, findings can help healthcare providers identify ATI survivors who are at high risk for poor outcomes and allow them to better inform ATI survivors on what to expect during their recovery. Estimates of costs and lost productivity incurred by ATI survivors can be used by health policy and public health officials to inform decisions about resource allocation for prevention programmes; potentially reducing the number and severity of injuries. Knowing the outcome and healthcare costs from ATIs can inform policy recommendations on improving infrastructure for safe AT. Additionally, cost estimates will be foundational for future economic analyses of prevention programmes. We will disseminate our findings through reports to stakeholders, peer-reviewed publications and presentations at national and international conferences. Findings will also be posted on our research website (rsph.med.ubc.ca) and summarised in press reports and interviews.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

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