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Author:
Poulos, Roslyn; Hatfield, Julie; Rissel, Chris; Grzebieta, Raphael; McIntosh, Andrew S

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Authors

Roslyn G. Poulos[1]

Julie Hatfield[2],

Chris Rissel[3]

Raphael Grzebieta[2]

Andrew S McIntosh[4]

Affiliations and contact details

[1] School of Public Health and Community Medicine, The University of New South Wales, Sydney 2052, Australia.

[2] Transport and Road Safety (TARS) Research, The University of New South Wales, Sydney, New South Wales, Australia.

[3] School of Public Health, Sydney Medical School, University of Sydney, Sydney, Australia.

[4] Risk and Safety Science, The University of New South Wales, Sydney, New South Wales, Australia.

Correspondence to

Roslyn G Poulos, School of Public Health and Community Medicine, The University of New South Wales, Sydney 2052, Australia; r.poulos@unsw.edu.au

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Abstract

Introduction: There are clear personal, social and environmental benefits of cycling. However, safety concerns are among the frequently cited barriers to cycling. In Australia, there are no exposure-based measures of the rates of crash or 'near miss' experienced by cyclists.

Design and setting: A prospective cohort study over 12 months, with all data collected via web-based online data entry.

Participants: Two thousand adults aged 18 years and older, living in New South Wales (Australia), who usually bicycle at least once a month, will be recruited from March to November 2011.

Methods: In the 12 months following enrolment, cyclists will be surveyed on 6 occasions (weeks 8, 16, 24, 32, 40, and 48 from the week of the enrolment survey). In these survey weeks, cyclists will be asked to provide daily reports of distance travelled; time, location and duration of trips; infrastructure used; crashes, near misses and crash-related injuries. Information on crashes and injuries will also be sought for the intervening period between the last and current survey. A subsample of participants will receive bicycle trip computers to provide objective measurement of distance travelled.

Discussion: This study protocol describes the prospective cohort study developed to assess near misses, crashes and injuries among cyclists by time and distance travelled and by type of infrastructure used, with recruited participants entering data remotely using the internet. We expect to be able to calculate event rate according to exposure overall and for different infrastructure types and to report in-depth information about event causation.

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Background

There are clear personal, social and environmental benefits of cycling. These benefits increase as individuals cycle more and as more people cycle.[1] Personal benefits of recreational or transport cycling include substantial health gains,[2] with a significant reduction in all-cause mortality and cardiovascular risk. [3, 4] Cycling may also be an important tool in the fight against the obesity epidemic, with ecological studies noting lower rates of obesity in regions with high rates of cycling.[5] The value of current cycling to the Australian health system has been conservatively estimated at $227 million per annum.[1]

Cycling, and urban environments that support cycling and walking and discourage car use, can improve social interactions and increase community attachment, liveability and amenity.[6] There is also evidence that the more compact, permeable urban designs that support cycling and walking lead to crime reduction through increased street activity and 'natural surveillance'.[7]

Where cycling replaces a motor vehicle trip there are environmental benefits, such as reduced carbon dioxide emissions and other pollutants.[1] Additionally, an increase in transport cycling may ease traffic congestion, reduce motor vehicle crashes and thus potentially reduce road trauma costs.[8]

The transportation cycling rate in Australia is low compared to other developed countries such as the Netherlands, Denmark or Germany.[5] Countries with high cycling rates tend to have better cycling facilities, effective traffic calming measures and well-developed cycling infrastructure, cycling-friendly urban design, restrictions on motor vehicle use and comprehensive traffic education about how to interact with cyclists.[9]

Cycling-specific infrastructure is generally recognised as a necessary starting point to attract new non-cyclists to cycling.[1] However, it is not always clear what type of infrastructure will produce the maximal adoption of cycling with the greatest safety benefits. For example, introducing shared-use paths for pedestrians and cyclists may decrease cyclist crash rates with motorists but could increase pedestrian injury rates. [10]

Significant numbers of cyclists are killed or seriously injured in Australia every year, and these numbers appear to be increasing. More than 15 000 bicyclists were involved in police reported crashes in the Australian states of Victoria, Queensland, South Australia, and Western Australia during 2000-2004,[11] and there were more than 2000 motor-vehicle-related crashes leading to hospitalisations in bicyclists in the state of New South Wales between 1999/2000 and 2004/2005.[12] Further, it is likely that these data underenumerate the problem because many less serious cycling incidents go unreported to police, or because the data do not include deaths and injuries arising from falls and collisions not involving motor vehicles and do not include casualties receiving outpatient treatment. Recently published data from Victoria reports a significant increase in emergency department and hospital admissions for bicycle injuries from 2001 to 2006 and a marked increase in the number of cyclists sustaining severe injury.[13] However, the interpretation of these data is severely limited by the quality of data in terms of cycling exposure and contributing factors.[13, 14]

To reduce the risks associated with cyclists sharing traffic lanes with motor vehicles, strategies such as bicycle lanes (i.e., portions of the roadway designed for the use of bicycles) and bicycle paths (a physically separate pathway for bicycles or a shared-use path for bicycles and pedestrians) have been built. The relative merits of these different strategies remain debated, especially in urban areas in major cities, where this question is important due to limited availability of land and finance. Research during the 1970s in the USA indicated that bicycle lanes may have a protective effect for most collision types, but an increased risk for collisions occurring when the cyclist turns left into traffic (turning right in Australia).[15] Later research found that the risk of riding on the sidewalk (including bicycle paths and footpaths) was higher than the risk of riding on the roadway, probably because of blind conflicts at intersections.[16] Early research from England reported that the rate of injury was greater on cycleways compared to local roads and grid roads, but primarily because of poor design including visibility problems, especially at intersections, sharp bends, steep gradients, slippery bridges, loose gravel and mud.[17] Other risks included head-on crashes between cyclists, collisions with dogs, and eye injuries from intruding vegetation.[17] The contested nature of the evidence supporting various infrastructure solutions has led for calls in the international literature for more research around infrastructure and for improved understanding about behaviour, safety and safety perception.[18]

If cycling is to be encouraged as a health-promoting practice, or as a sustainable form of transport, then it is incumbent on authorities to provide an environment that minimises risk, to manage public perception of risk and to promote the activity appropriately. However, because of the lack of exposure data in Australia, [13] actual crash and injury rates related to distance cycled, duration of travel or infrastructure used are unknown.

Cycling is being actively promoted by the Australian health and transport sectors and by government at all levels, [19-21] and infrastructure is being progressively developed across the country. However, there is very little knowledge on which to base decision making. This project is therefore significant because it meets an urgent and rapidly increasing demand for evidence to support policy.

This study aims to:

1. Develop measures of cyclist crash, near miss and injury rates for a broadly representative population of cyclists from metropolitan and regional New South Wales
2. Identify factors that contribute to crash, near miss and injury rates, for example, human factors and road environment.
3. Assess the risks for cyclists associated with cycling on roads, bicycle lanes and paths.
4. Describe the type, location and frequency of hazards identified by cyclists.

Methods

Overall study design: A cohort study of two thousand cyclists (18 yrs and over) who reside in New South Wales and ride at least once per month will be undertaken. Cyclists will be recruited via multiple channels including the extensive email lists of *Bicycle NSW* (a state cycling advocacy organisation), a range of community cycling events, bike shops, media publicity and through word of mouth within the cycling community. Participants will enrol and complete the baseline questionnaire and all subsequent follow-up questionnaires via a secure website. Automatically generated emails plus SMS text messages (for those who select text reminders) will be sent to participants when follow-up questionnaires are due for completion.

To increase the likelihood of accurate measurement of distances and time travelled, bicycle trip computers will be offered to a subset of enrolled cyclists who ride at least once per week and who report not having their own trip computers on enrolment. To ensure the most effective use of limited resources, cyclists will not be offered trip computers if they have more than one bike and do not identify riding one bike at least 90% of the time, if their main bike is a BMX bike as 'off road' cycling is outside the primary aim of the study or if their main bike is classified as 'other' and may not be compatible with the bicycle trip computer (e.g., folding, recumbent or electric bikes). Participants wishing to accept the offer of a trip computer will be asked to supply the data on tyre size from the wall of their bicycle tyre and the diameter of their wheel. Trip computers are individually programmed by research staff using the tyre circumference reference table or calculation instructions supplied by the manufacturer. Trip computers with the manufacturer's installation instructions will be sent by post to participants. Bicycle trip computers will be offered until research stocks are exhausted (estimated to be around 400 computers).

Pilot testing: Paper versions of the questionnaires were piloted with colleagues who cycle (within the University and funding partner organisations) and modified accordingly. Electronic versions were again tested with colleagues who cycle, prior to implementation.

Baseline data collection: At enrolment, demographic data (e.g., age, gender, education, employment status, income, driving licence, car access), cycling experience and confidence, self-identification of cyclist type (transport or recreational), usual cycling habits (average monthly distance and hours cycled, use of infrastructure and cycling equipment over past 12 months), history of crashes and crash-related injuries over the last 12 months, and attitudes to risk and sensation seeking (using previously validated instruments [22, 23]) will be collected.

Follow-up data collection: Over the 12 months following enrolment, there will be 6 survey weeks (weeks 8, 16, 24, 32, 40, and 48 from the week of the baseline survey). At the start of each survey week, participants will be asked about crashes and crash-related injuries for the intervening period between the last and current survey, and then to complete a travel diary for the ensuing 7 days. Cyclists will be asked to provide daily reports of distance travelled; time, location and duration of trips; infrastructure used; crashes, near misses and crash-related injuries experienced. To enable the calculation of rates, participants with bike trip computers will be asked to provide readings from the computer, while other participants will estimate time and distances travelled. Cyclists may enter data via the secure website on a daily basis, or keep a hard copy record of their trips by printing down a 7-day PDF version of the diary, and entering their data at the end of the week.

At each survey, several additional questions on aspects of cycling will be asked. These will include aggression experienced while cycling with other road users (follow-up period 1); infrastructure preferences and concerning safety issues (follow-up period 2); cycling activities and beliefs in respect of safety (follow-up period 3); observation of the road rules and laws for cyclists (follow-up period 4); cycling for transport (follow-up period 5); and cycling with children (follow-up period 6).

During each follow-up period, participants will receive reminder emails (one on the day prior to the commencement of the reporting period, on days 2 to 7 and a final reminder email on day 8). The computer programming allows for 7 consecutive days of reporting within a 14-day window, after which access to the follow-up questionnaire is blocked. This flexibility will allow cyclists the opportunity of commencing their diary up to 7 days after the start date and still collect their data prospectively (e.g., in cases where cyclists do not access their email daily and therefore receive late notification of their start date) or to allow some flexibility in the number of days available in which data can be entered for those cyclists who have kept a hard copy diary.

Qualitative data collection following crash reports: All cyclists reporting a crash occurring during their reporting week will be contacted by telephone to answer additional questions about the location of the event, the circumstances leading to the event, behavioural or environmental risk factors, injuries sustained (type, severity and treatment), and suggested ways in which the event could have been prevented.

Definitions: Crashes are defined as collisions or falls, based on the definitions given in the review by Reynolds *et al* (2009).[24] A collision is defined as an event in which the bicycle hits or is hit by an object, person or animal, regardless of fault; and a fall is defined as an event (not caused by a collision) where the bicycle and/or bike rider lands on the ground.

A near miss is defined as an unexpected event while cycling that causes the cyclist or another party to take sudden evasive action, and without such action the cyclist believes a crash (collision or fall) would have happened.

For clarity, participants will be provided with images and definitions of all relevant cycling infrastructure, as shown in figure 1.

Figure 1 Cycling infrastructure definitions.

Planned data analysis: Quantitative data analysis will include basic descriptive analysis of the baseline and follow-up data and a calculation of event rates. Event rates will be calculated using the incident number of events (collision, falls or near misses) per hours of cycling or kilometres travelled. The incidence rate of crashes will also be calculated for different forms of infrastructure. Multivariable generalised linear modelling will be used to explore human factors (cyclist characteristics such as cycling experience, attitudes and behaviour) as predictors of outcome (event rate).

Qualitative data will be analysed using 'template analysis'.[21] This method involves the development of a coding template or framework composed of codes representing themes identified in the data through multiple readings of the text.

Discussion

This study protocol describes an original research plan that will enable the calculation of rates of crashes, near misses and injuries relating to time and distance cycled and the type of infrastructure used for cycling. The determination of exposure-based rates will make a significant contribution to knowledge about cycling in Australia, as the only measures currently available are based on 'per head' of population. [13]. It will also allow comparisons of cycling risk to other travel modes in Australia and internationally. Additional questions about cycling experience, attitudes and behaviour will enable the exploration of these variables as predictors of outcome. The study will also help to answer questions which are debated nationally and internationally around the relative merit of different forms of infrastructure. In addition, we will record crashes and injuries that are not captured in the available data collections, such as crashes which are not reported to police or injuries which do not require hospitalisation. Capturing qualitative and quantitative data on these crashes will provide a greater understanding of the surrounding circumstances and is likely to meet the need for additional information on single-vehicle bicycle crashes.[25] It will enable us to better understand cycling risk and to provide evidence to support a best-practice system of cycling infrastructure and effective public education. This should help to promote better management of interactions between all users of transport facilities in the future.

Strengths and limitations

This study is unique. To our knowledge, it is the first to measure exposure-based rates of crashes, near misses and crash-related injuries for cyclists in Australia. It will be conducted completely online, supported by a variety of online engagement and interaction activities such as the Safer Cycling Study Facebook page, a YouTube clip about the study and regular email and/or text message phone reminders to study participants. These are designed to maintain cohort participation through all data collection stages. In addition, all crashes recorded in daily reports will be followed up by interview to explore aspects of the crash that are not elicited by the quantitative questions and to provide a contextual understanding of the crash event. Finally, the prospective nature of the study is expected to reduce recall bias, and the use of bicycle trip computers should reduce measurement error.

The study is likely to have a number of limitations. These include the potential for volunteer and self-report bias. Loss to follow-up is also likely. However, as participants have been asked to supply a number of different contact options (including those of a friend or family member), we expect to be able to identify participants in whom loss to follow-up has been the result of a serious cycling-related injury.

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