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Shifting Gears in Healthy and Sustainable Cities
Monash University Active Transport Showcase
Monash College, 750 Collins Street, Melbourne

TRAM BIKE CRASH RISKS

A cyclist market survey

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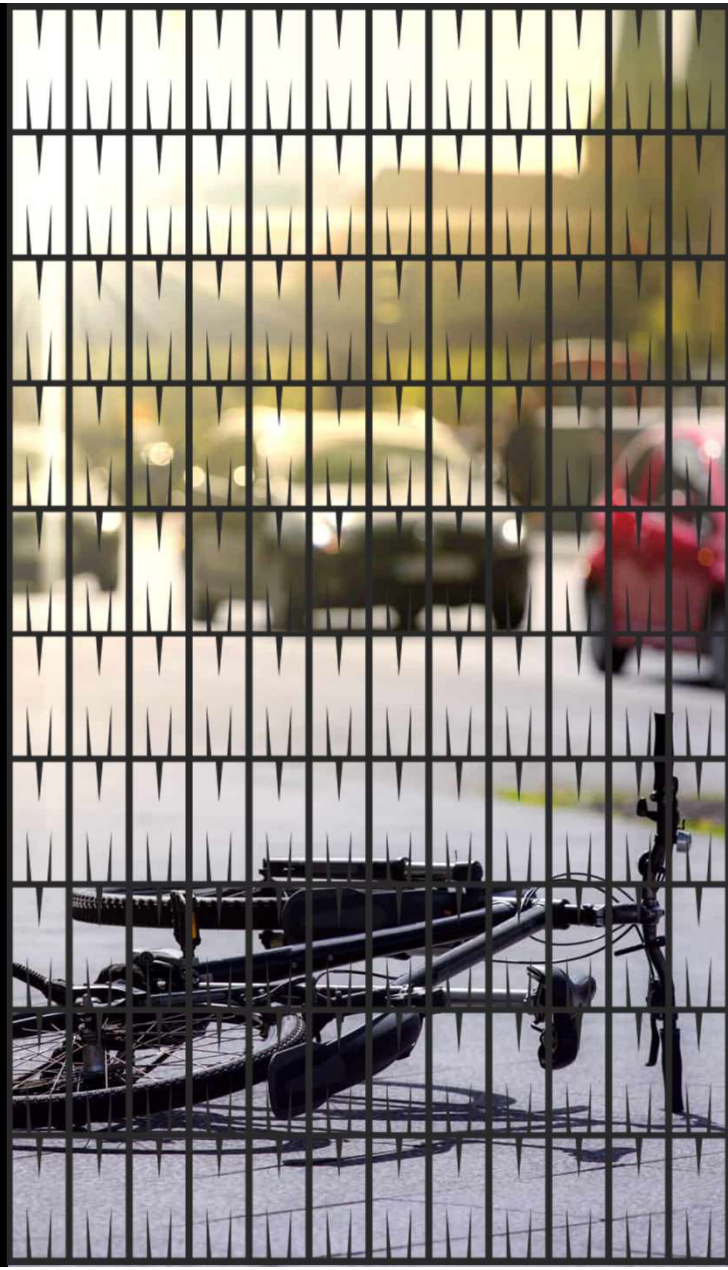

Agenda

- Introduction
- Research Context
- Methodology
- Results
- Discussion and Conclusions

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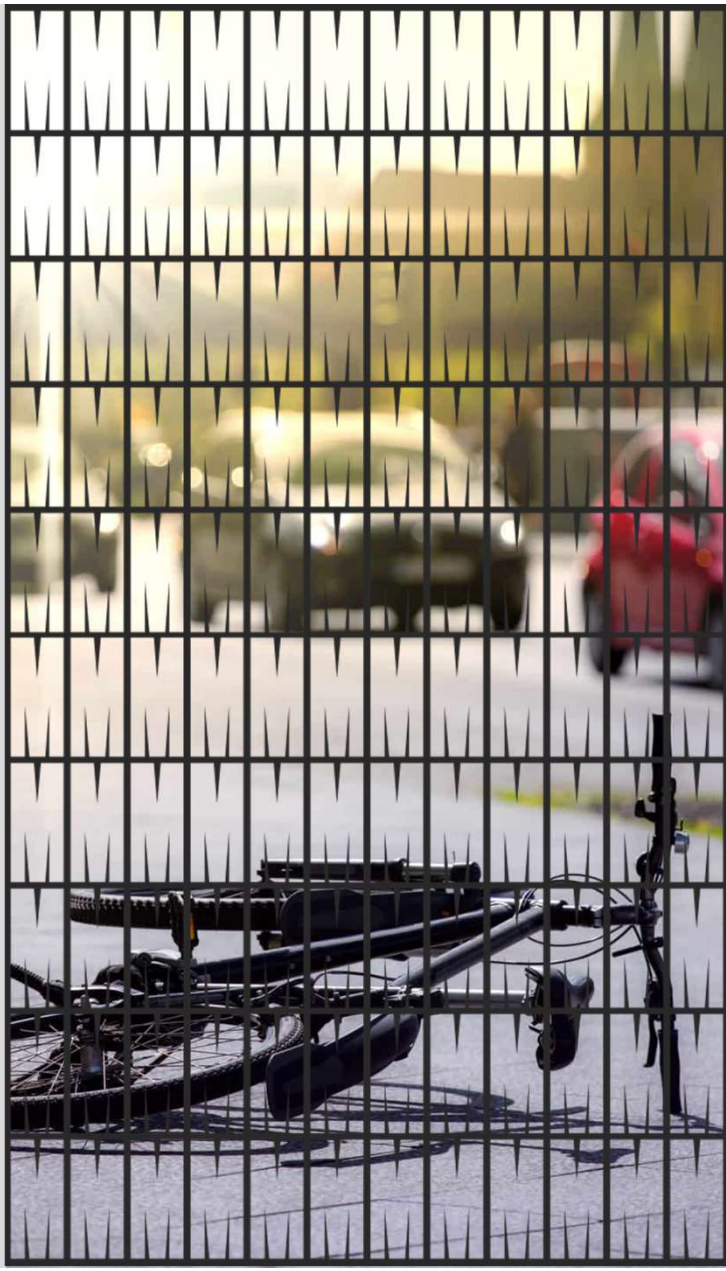

VIDEO Warning – Don’t watch if your upset by watching people getting hurt

Source: Chris R Cherry, University of Tennessee (2014) SEALABLE – VeloGleis English Version
URL: https://www.youtube.com/watch?v=DZT3qbQCNs4

Research evidence confirms tram systems present safety risks to cyclists, but most studies are based on hospital or crash data…

Tram and bicycle safety research

- Research Methods
  - Crash data
  - Hospital data
  - Interviews
- Crash types
  - Collisions
  - Slips or skids on tracks
  - Track-wedging
- Outcomes
  - Fracture / dislocations
  - Head injury
  - Spinal injury
  - Hospitalisations
  - Death

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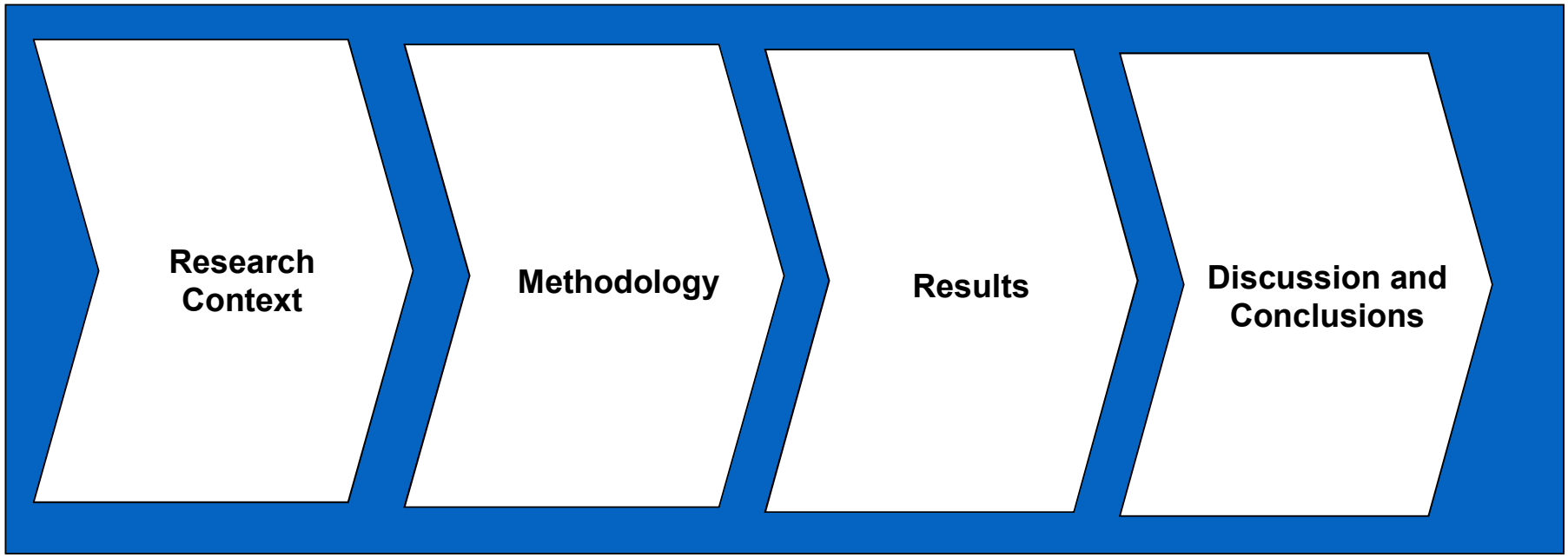
This is the first known study to engage directly with all cyclists* about their experiences of safety around trams and tram tracks

Presentation structure



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*Not just those cyclists involved in crashes reported to police or resulting in hospital treatment.

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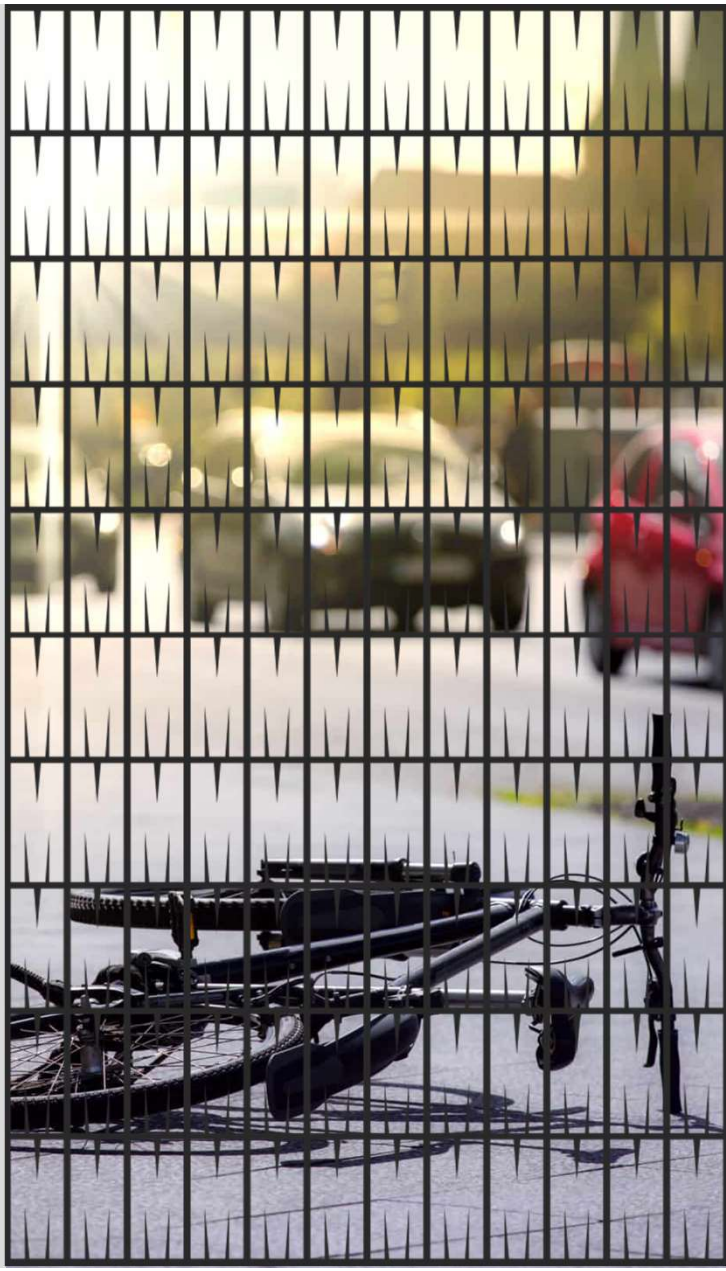

Research context: much focus on track-related crashes, especially tires wedging in the groove

Tram and bicycle safety research

- Tram-related crashes
  - Frequency increasing
  - Consume more emergency department resources than other cyclist-involved crashes (Swiss study from Gerber et al 2021)
  - Sizeable minority of cyclists give up on cycling after a tram-related crash (Edinburgh and West Lothian study from Maempel et al 2018)
- Countermeasures
  - Rubberized track inserts
  - Increasing crossing angles
  - Separation / segregation
  - Hook turns

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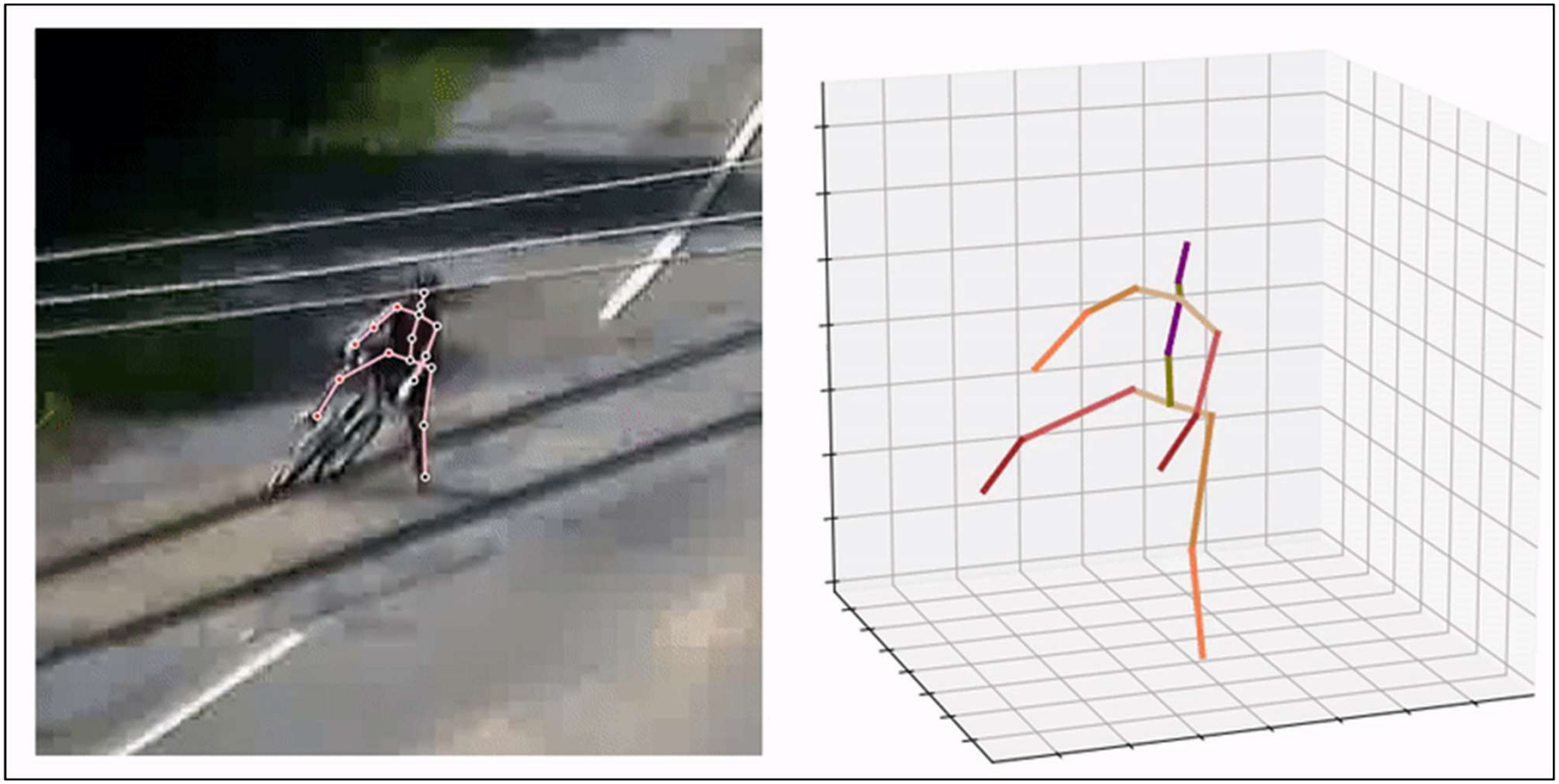
Source: Ekko (2006), Wikimedia Commons

Research context: track-wedge crashes an area of research focus, because of typical severity.



Source: Cherry et al (under review), paper related to crash biomechanics at a track crossing

Research context: Safe System and Vision Zero

Human error is inevitable, but the consequences should never be a fatal or serious injury

Road designers and managers (rather than road users) hold the primary responsibility for maintaining safety

Primary Treatment	• Road planning, design and management considerations that virtually eliminate the potential of fatal and serious injuries occurring in association with the foreseeable crash types
Supporting (step towards)	• Road planning, design and management considerations that improve the overall level of safety associated with foreseeable crash types, but not expected to virtually eliminate the potential of fatal and serious injuries occurring • Improves the ability for a Primary Treatment to be implemented in the future
Supporting Treatment	• Road planning, design and management considerations that improve the overall level of safety associated with foreseeable crash types, but not expected to virtually eliminate the potential of fatal and serious injuries occurring • Does not change the ability for a Primary Treatment to be implemented in the future
Non-Safe System Treatment	• Road planning, design and management considerations that are **not expected to achieve an overall improvement in the level of safety** associated with foreseeable crash types occurring • **Reduces the ability for a Primary Treatment** to be implemented in the future

Source: Woolley et al (2018) Towards Safe System infrastructure: a compendium of current knowledge

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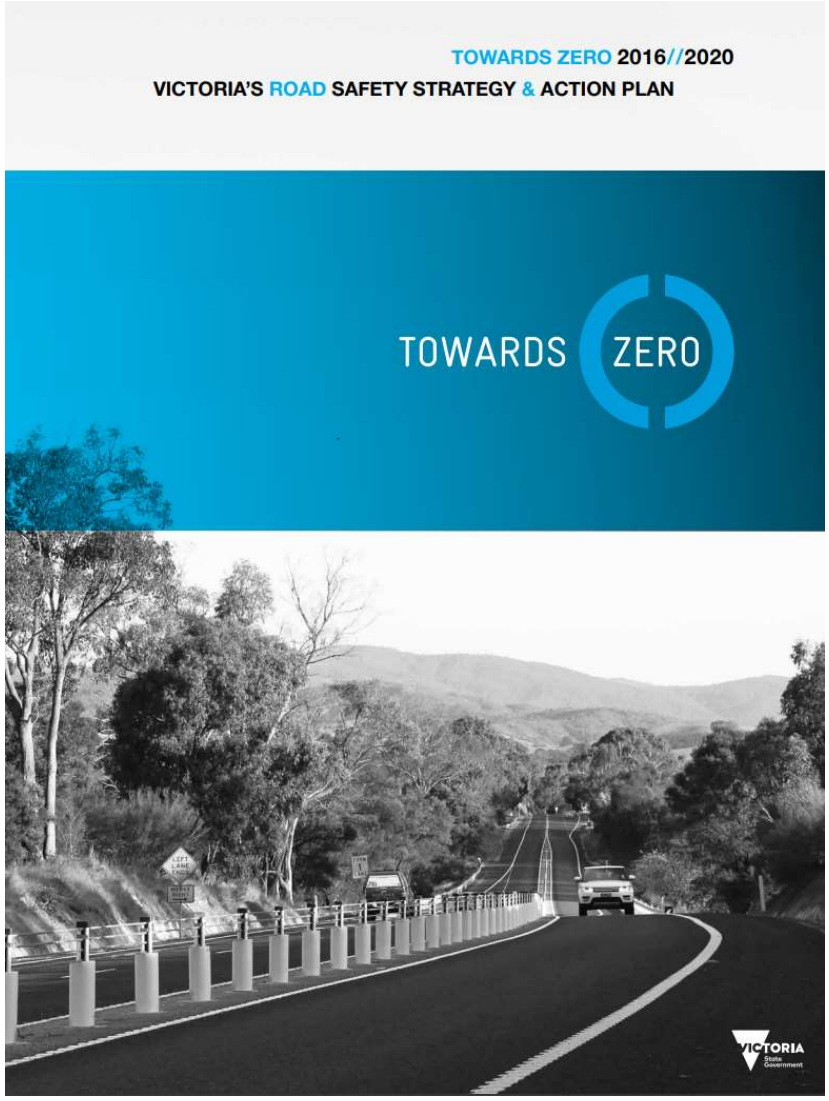
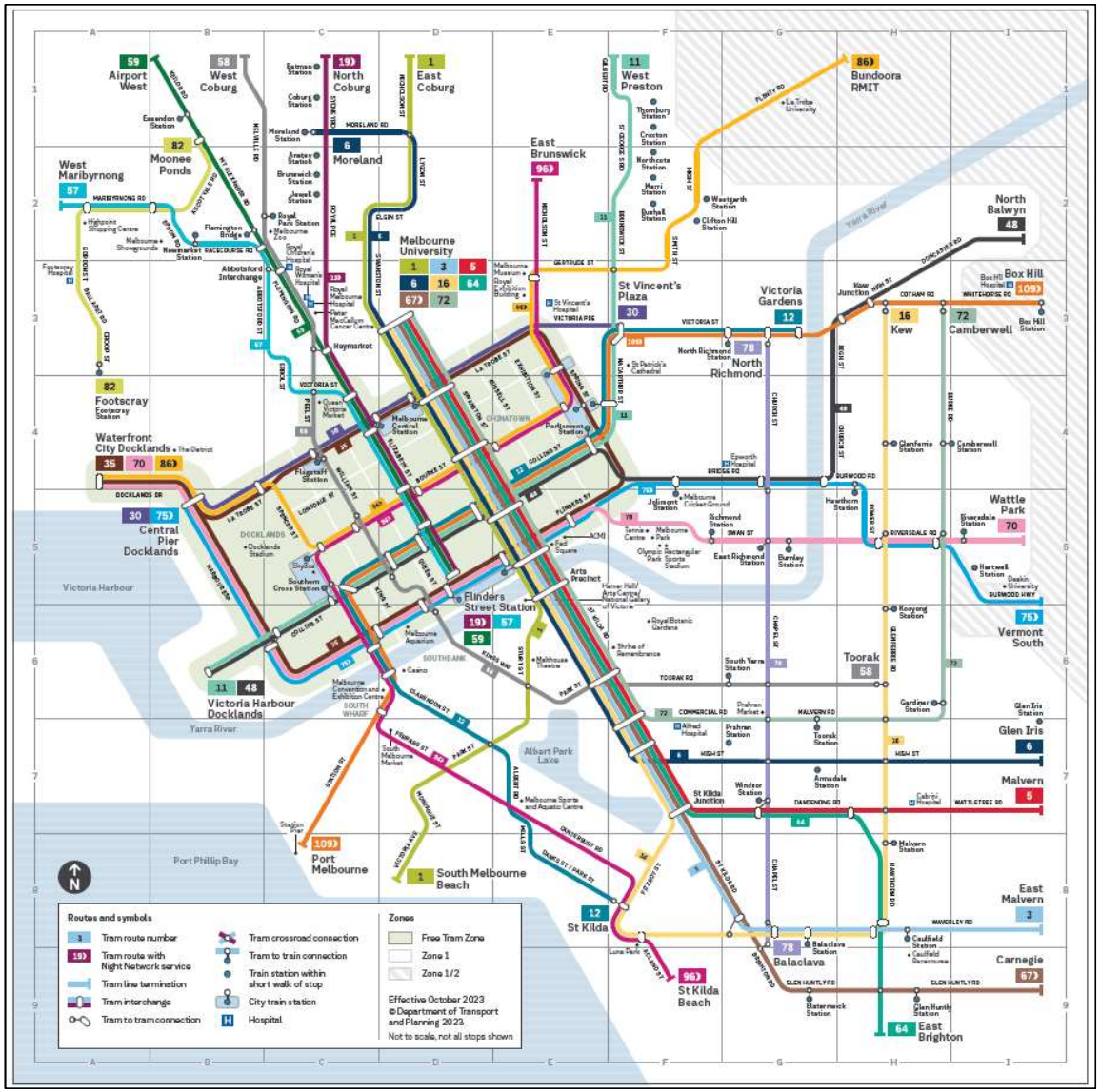


Source: TAC and Victoria State Government

Research context: Melbourne, largest street-running tram system in the world

Melbourne transport

- Trams
  - 250 km of double track
  - 75% in mixed traffic
- Cycling
  - 16% of all vehicle movements into central city in morning peak (City of Melbourne 2017)



Source: Victoria Department of Transport and Planning (2023), not to scale.

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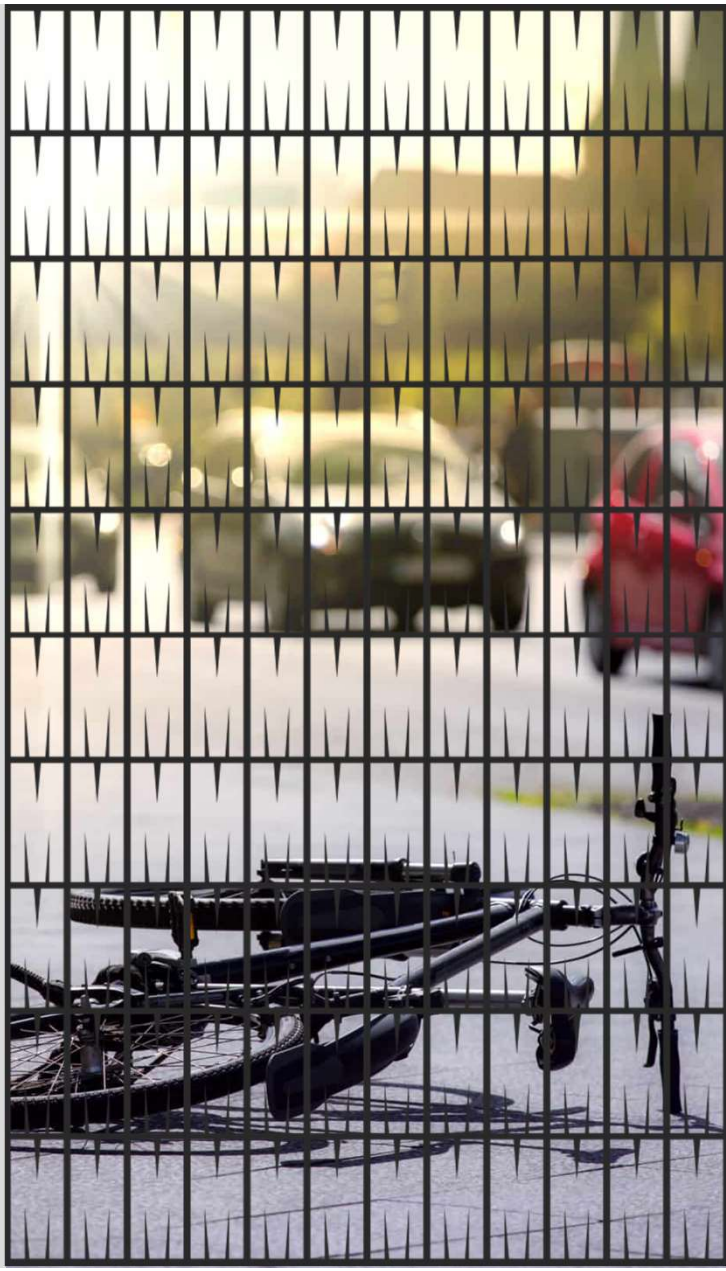
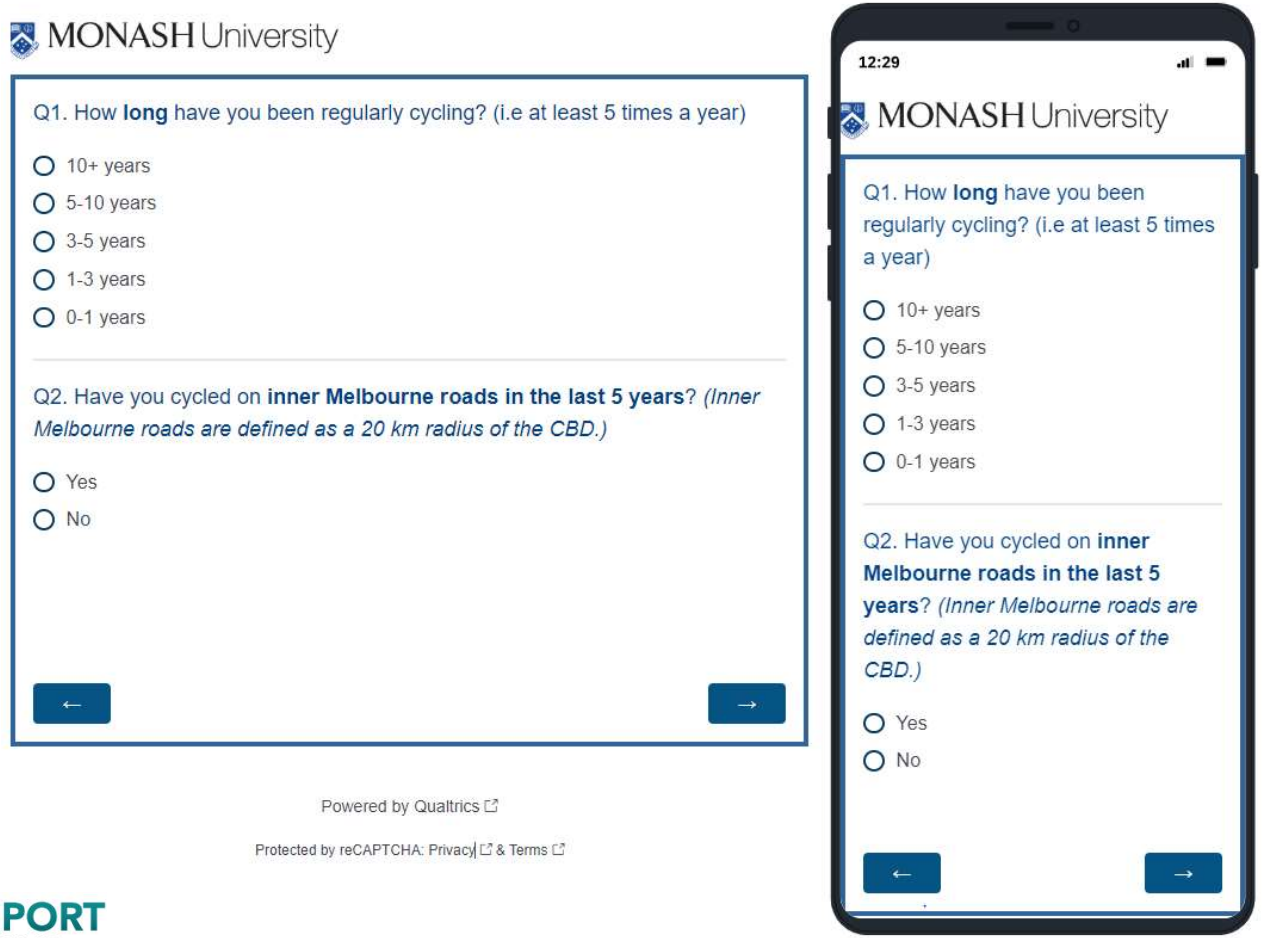


Survey of 287 people who frequently cycle in inner Melbourne

Survey

- Recruitment
  - Online (Facebook, Instagram etc)
  - Via inner-city bicycle user groups
  - August 1 to September 5, 2022
- Online questionnaire
- Cohort
  - 24% female
  - Age
    - 32% 18 to 34 years old
    - 32% 35 to 44 years old
    - 36% 45 years or older
- Asked about cycling in the last 5 years
- Chi-square tests and binary logistic regression



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Hospital data also reviewed

Victorian Injury Surveillance Unit (VISU)

- Run by Monash University Accident Research Centre (MUARC)
- Collects data on:
  - Admissions to hospital
  - Attendance at emergency departments

Source: van Sherly (2020), Wikimedia Commons

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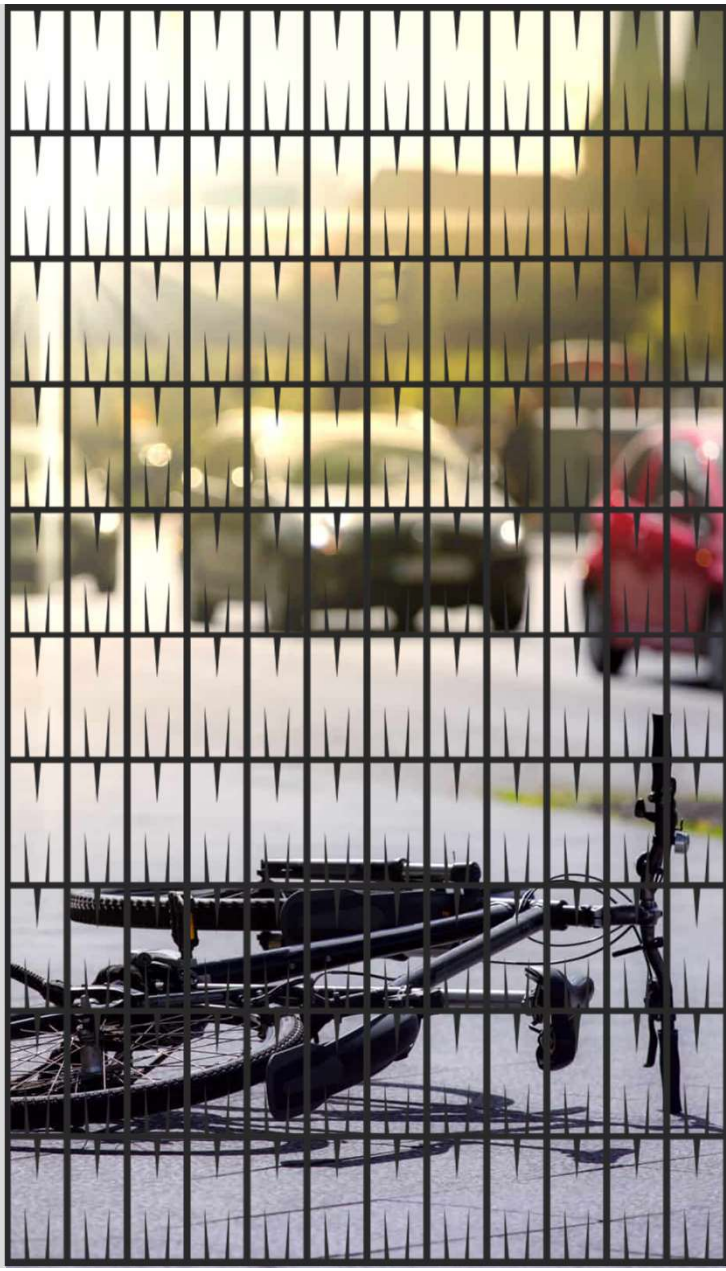
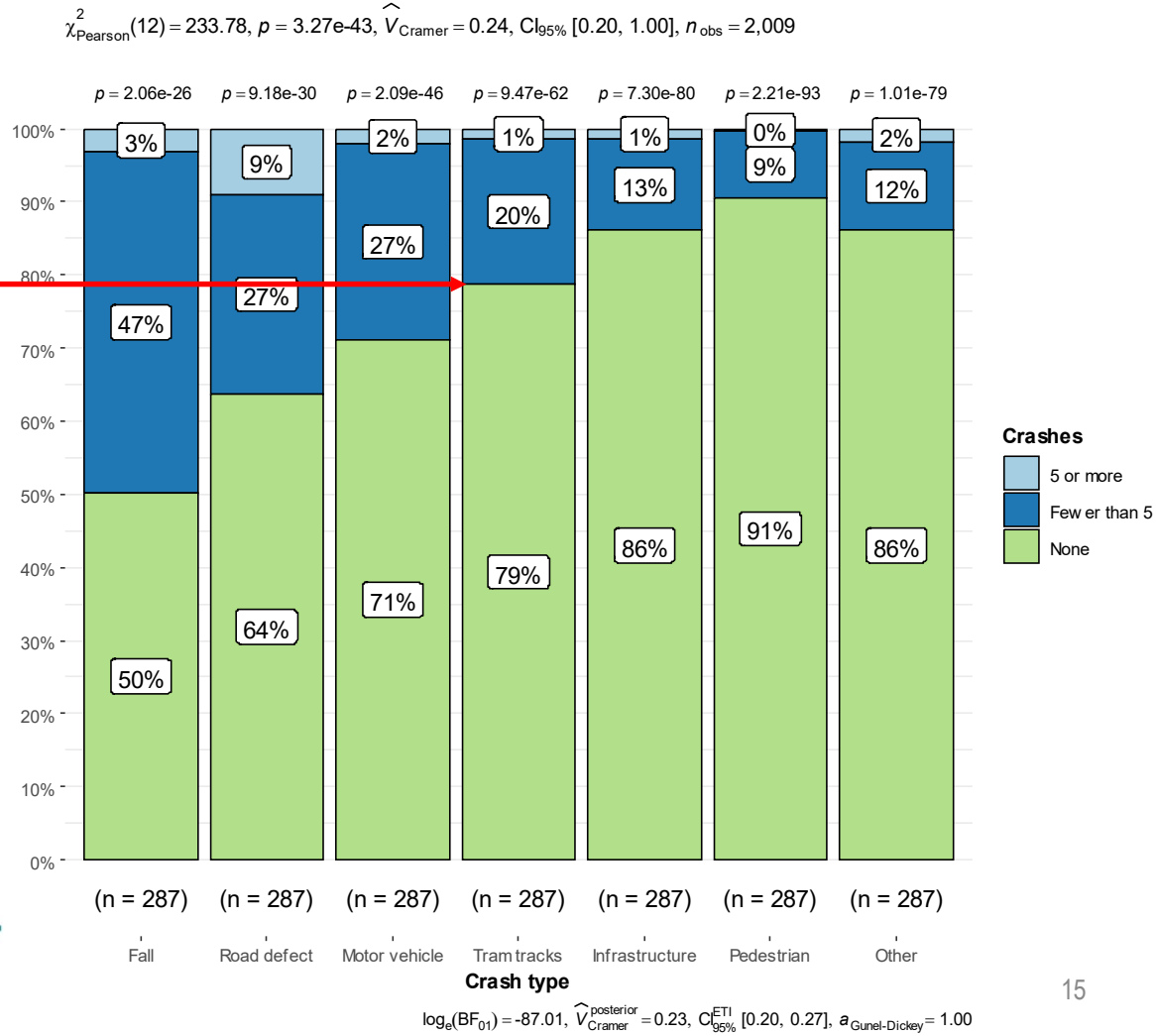


Average of 1.66 total crashes per respondent in the past 5 years, 21% involving tram tracks

21% of respondents had at least one crash involving tram tracks in last 5 years



Source: Aug-Sep 2022 online survey
- Q6: In the last 5 years, how many times have you had the following incidents?

Number of Bike Crashes by Type over the last 5 Years

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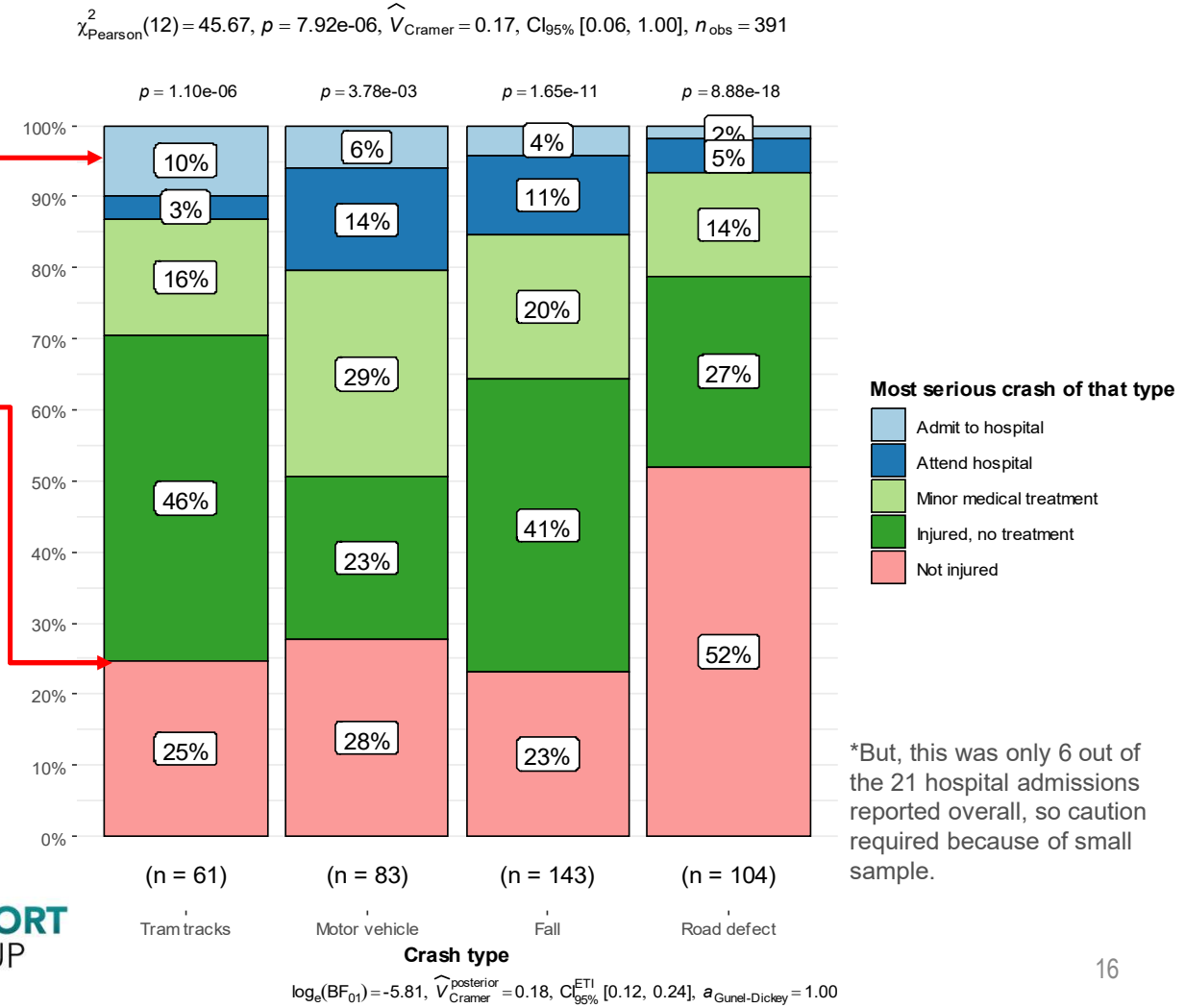
Those involved in a tram-track-related crash were more likely to have been hospitalised*

10% admitted to hospital in worst tram-track-related crash – highest rate of all crashes

75% injured in their worst tram-track-related crash



Injury Status of Most Serious Crash by Type of Crash

*But, this was only 6 out of the 21 hospital admissions reported overall, so caution required because of small sample.

Source: Aug-Sep 2022 online survey
- Q8: At the time of your most serious bike crash incident, were you injured?

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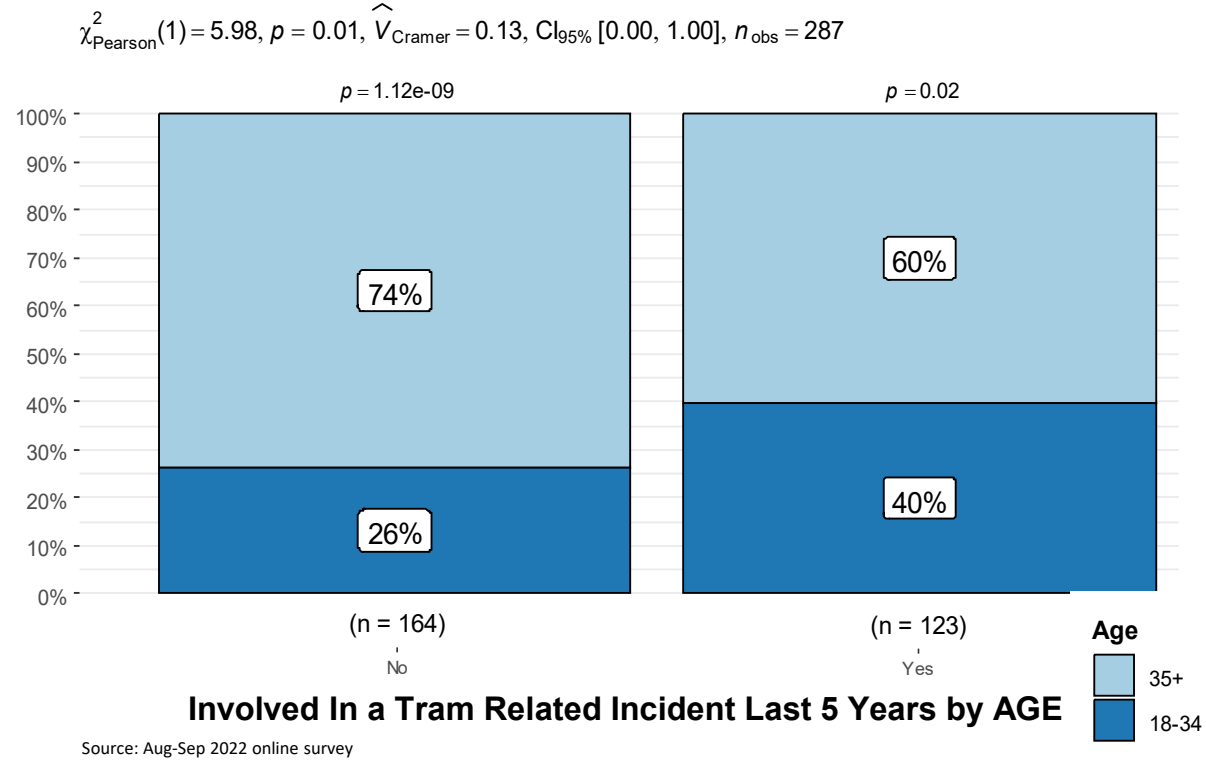
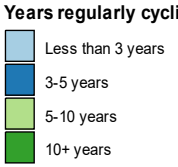
Tram-related incidents in last five years: 43% involved in at least one. Average 1.4 per respondent. Youth and inexperience associated...



Involved In a Tram Related Incident Last 5 Years by AGE

Involved In a Tram Related Incident Last 5 Years by YEARS CYCLING



Source: Aug-Sep 2022 online survey
- Q11: Which of the following tram-related incident(s) have you experienced over the last 5 years?
- Q18: How old are you?

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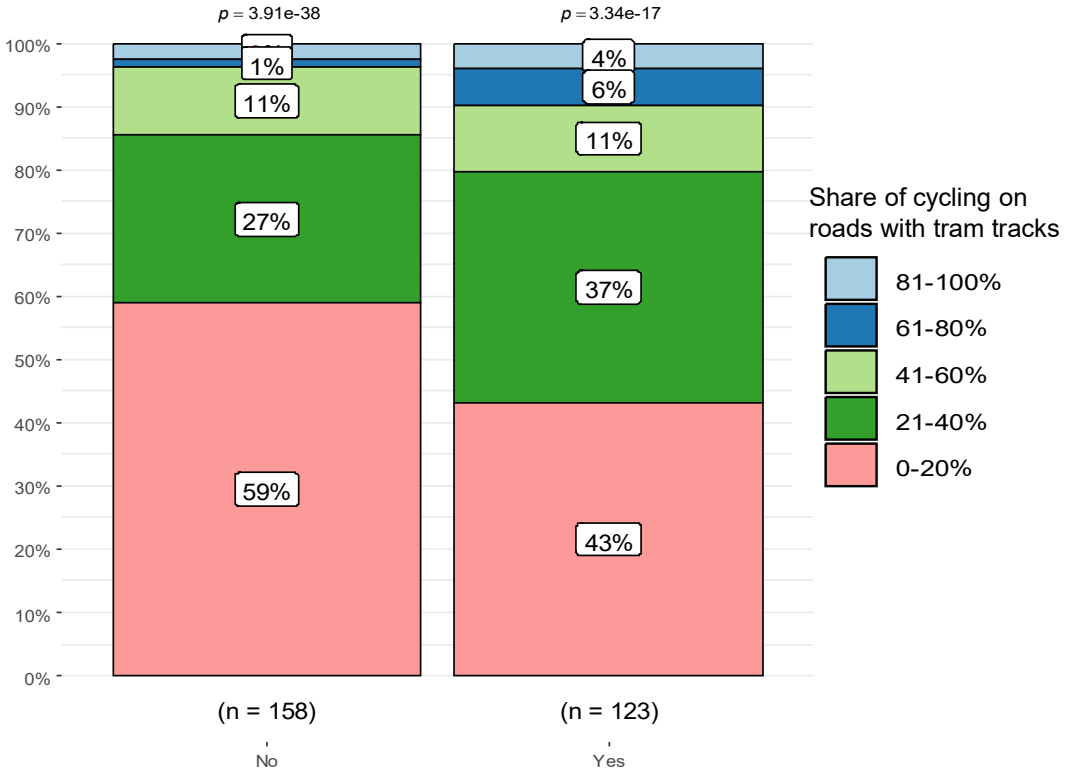
…also associated with cycling on roads with tracks more often

$\chi^2_{Pearson}(4) = 10.28$, $p = 0.04$, $\widehat{V}_{Cramer} = 0.15$, $CI_{95\%}$ [0.00, 1.00], $n_{obs} = 281$



Involved In a Tram Related Incident Last 5 Years by SHARE OF CYCLING ON ROADS WITH TRAM TRACKS

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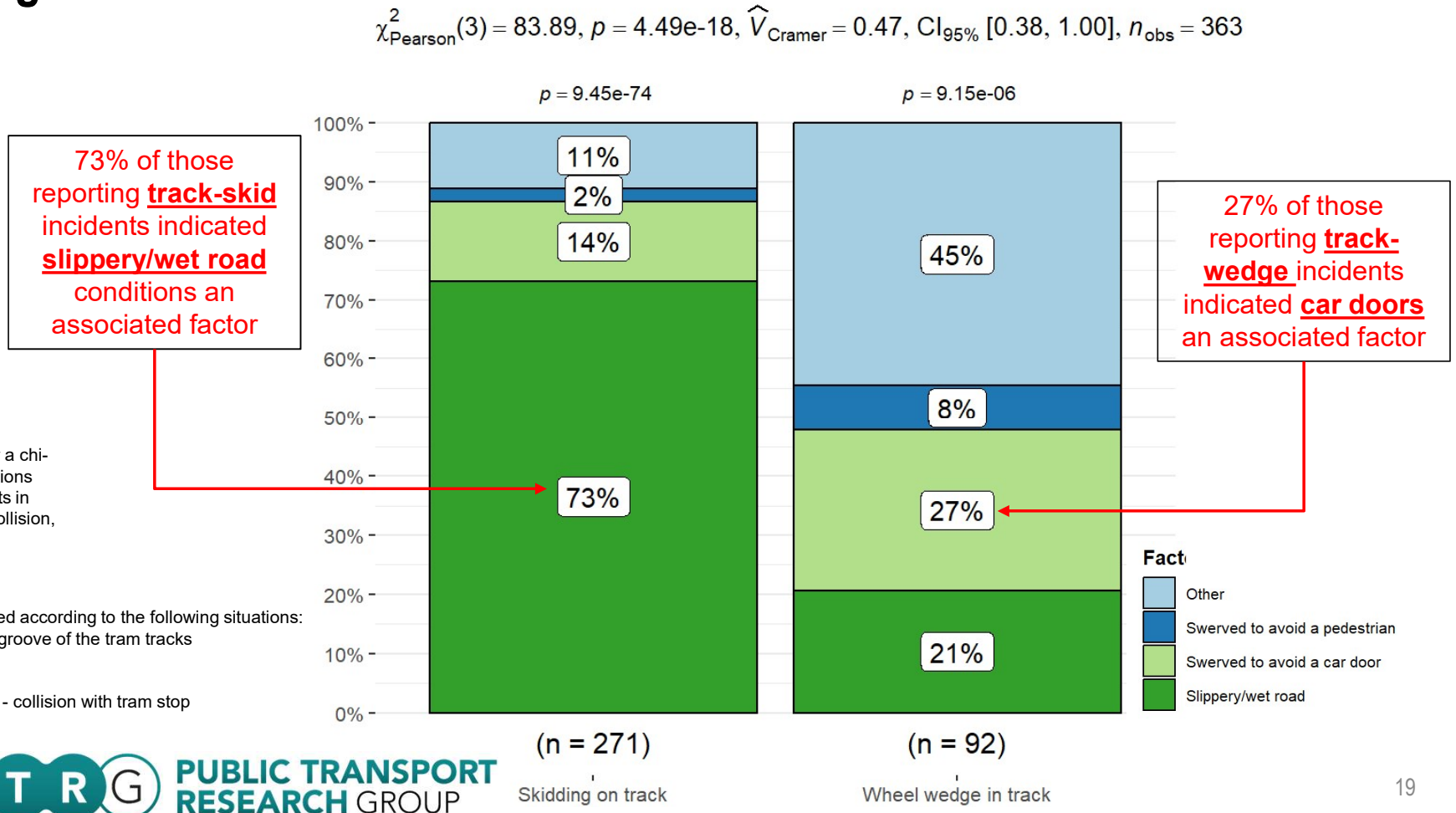
Regression: likelihood greatest if riding with tracks 61-80% (5.8x) and riding for only 3-5 years (3.4x)

Characteristic	OR[1]	95% CI[1]	p-value
Years regularly cycling			
10+ years	—	—	
5-10 years	**2.57**	1.34, 5.04	**0.005**
3-5 years	**3.35**	1.32, 9.28	**0.014**
Less than 3 years	0.8	0.33, 1.81	0.6
Share of cycling with track			
0-20%	—	—	
21-40%	**1.81**	1.04, 3.16	**0.037**
41-60%	1.44	0.62, 3.25	0.4
61-80%	**5.75**	1.22, 41.8	**0.042**
81-100%	2	0.48, 8.76	0.3

[1] *OR = Odds Ratio, CI = Confidence Interval. Null deviance = 385; Null df = 280; Log-likelihood = -180; AIC = 372; BIC = 394; Deviance = 360; Residual df = 275; No. Obs. = 281*

Track Skids are mostly linked to wet roads; Track Wedging; many issues biggest is car door opening



1. The test assumptions were not met for a chi-squared test involving all response options due to the small number of respondents in tram collision, passenger/pedestrian collision, tram stop collisions and other groups.

Source: Aug-Sep 2022 online survey
- Q13: How many of these incidents occurred according to the following situations:
  - bicycle wheel getting wedged within the groove of the tram tracks
  - skidding on the tram track surface
  - collision with tram
  - collision with tram passenger/pedestrian - collision with tram stop
  - other

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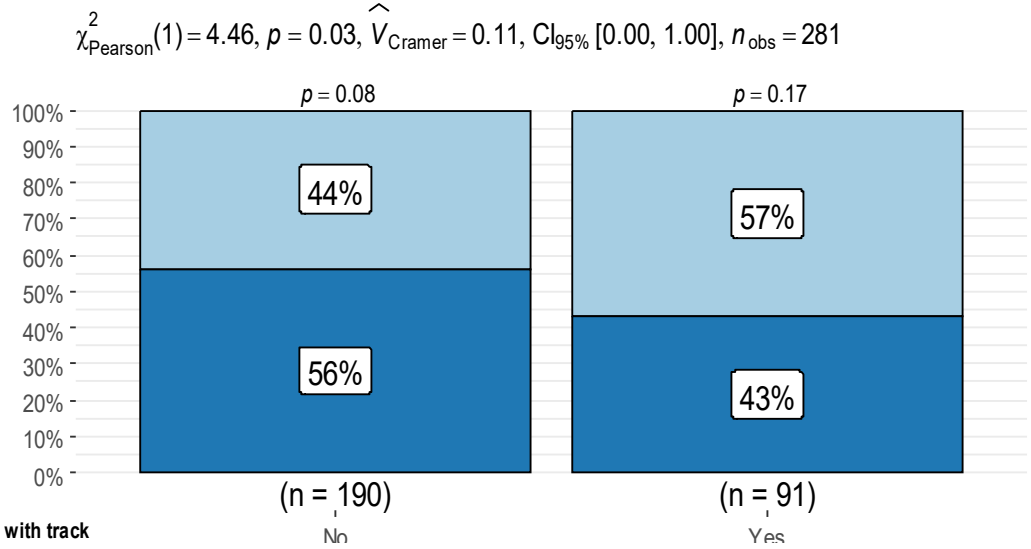
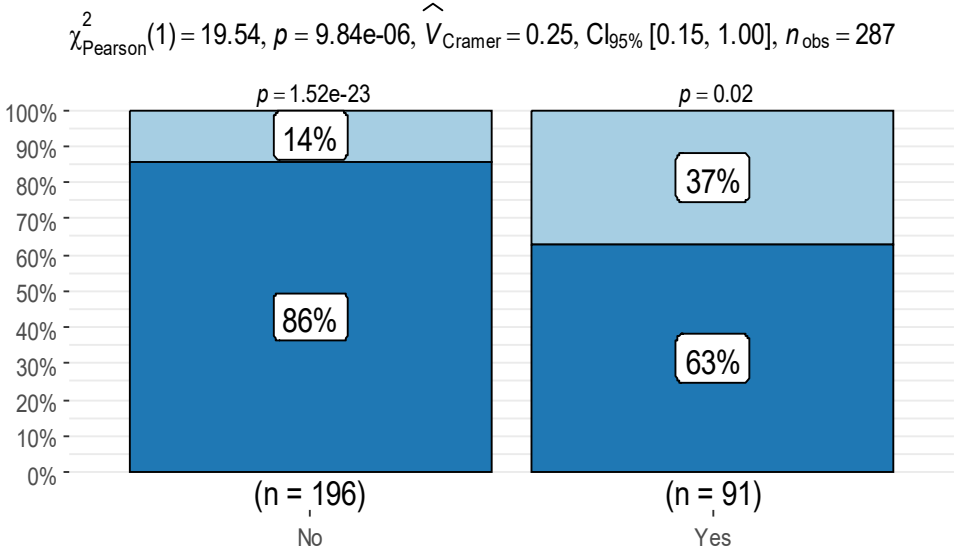
Factors Associated with Track Skid or Track Wedge Incidents

Track-skid incidents associated with cycling on roads with tracks more often, and also having been involved in a track-wedge



Track Skid Incidents Experience and Share of Cycling on Roads with Tracks



Track Skid Incidents Experience and Experience with Track Wedge Incidents

Source: Aug-Sep 2022 online survey

- Q13: How many of these incidents occurred according to the following situations
  - bicycle wheel getting wedged within the groove of the tram tracks
  - skidding on the tram track surface
  - collision with tram (not shown)
  - collision with tram passenger/pedestrian (not shown)
  - collision with tram stop (not shown), - other (not shown)
- Q10: On average, what share of your cycling is on roads with tram tracks?

Those cycling **>20%** on roads with track **1.8x more likely** to have been involved in a track-skid incident

Characteristic	> 0 track-skid incidents OR[1]	95% CI[1]	p-value
Years regularly cycling			
Less than 3 years	—	—	
3 or more years	2.29	0.95, 6.44	0.085
% of cycling with track			
0-20%	—	—	
21-100%	**1.81**	1.09, 3.04	**0.022**

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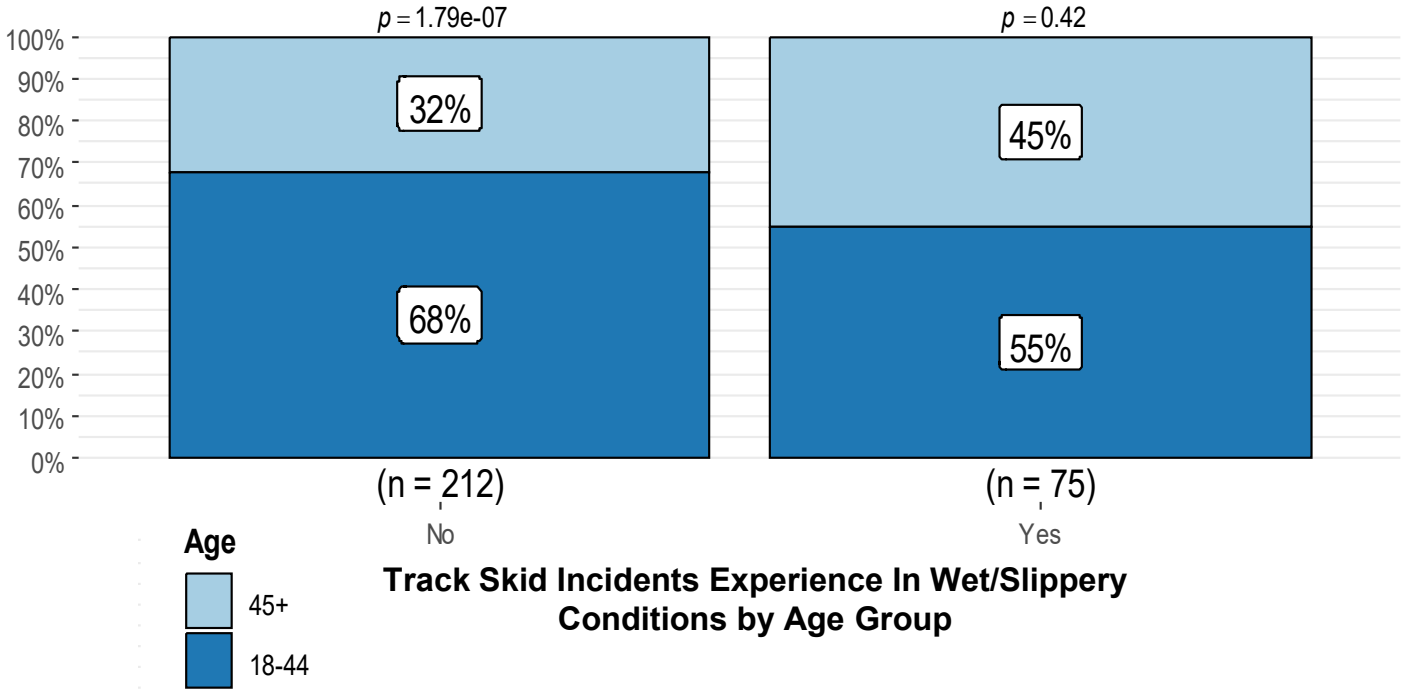
Cyclist 45 years or older were 1.76x more likely to have been involved in track-skid in wet conditions

$\chi^2_{Pearson}(1) = 4.25, p = 0.04, \hat{V}_{Cramer} = 0.11, CI_{95\%}\ [0.00, 1.00], n_{obs} = 287$



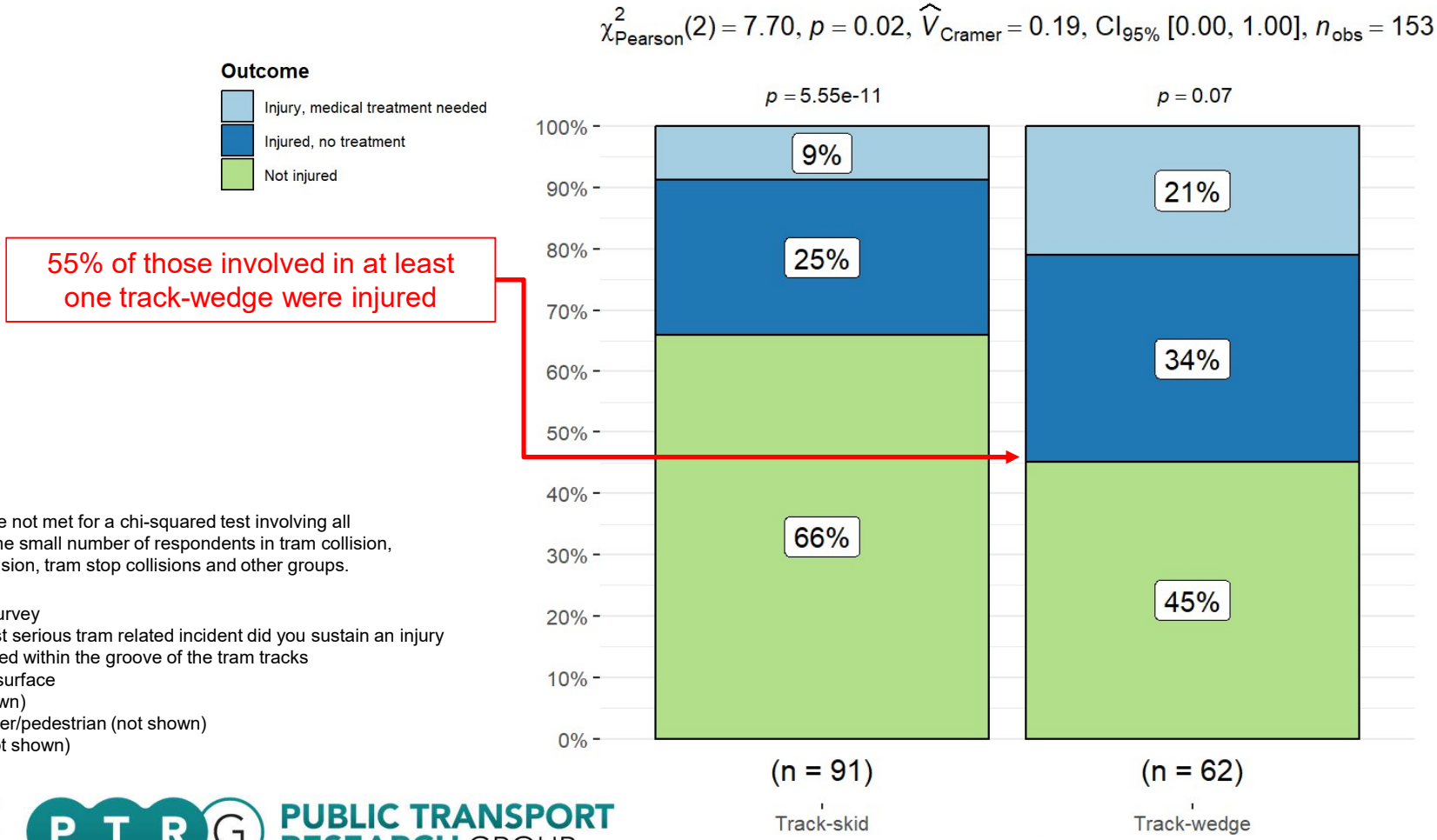
Track Skid Incidents Experience In Wet/Slippery Conditions by Age Group

Characteristic	> 0 track-skid incidents with slippery &/or wet road a factor		
	OR[1]	95% CI[1]	p-value
Age			
18-44	—	—	
45+	**1.76**	1.02, 3.01	**0.040**

Source: Aug-Sep 2022 online survey

- Q13: How many of these incidents occurred according to the following situations
  - bicycle wheel getting wedged within the groove of the tram tracks
  - skidding on the tram track surface
  - collision with tram (not shown)
  - collision with tram passenger/pedestrian (not shown)
  - collision with tram stop (not shown)
  - other (not shown)
- Q18: How old are you?

Track-wedges are more likely to result in injury (55%) compared to Track Skid (34%)



Track Skid and Track Wedge Incidents – Share Involving Injury

1. The test assumptions were not met for a chi-squared test involving all response options due to the small number of respondents in tram collision, passenger/pedestrian collision, tram stop collisions and other groups.

Source: Aug-Sep 2022 online survey
- Q14: At the time of your most serious tram related incident did you sustain an injury
  - bicycle wheel getting wedged within the groove of the tram tracks
  - skidding on the tram track surface
  - collision with tram (not shown)
  - collision with tram passenger/pedestrian (not shown)
  - collision with tram stop (not shown)
  - other (not shown)

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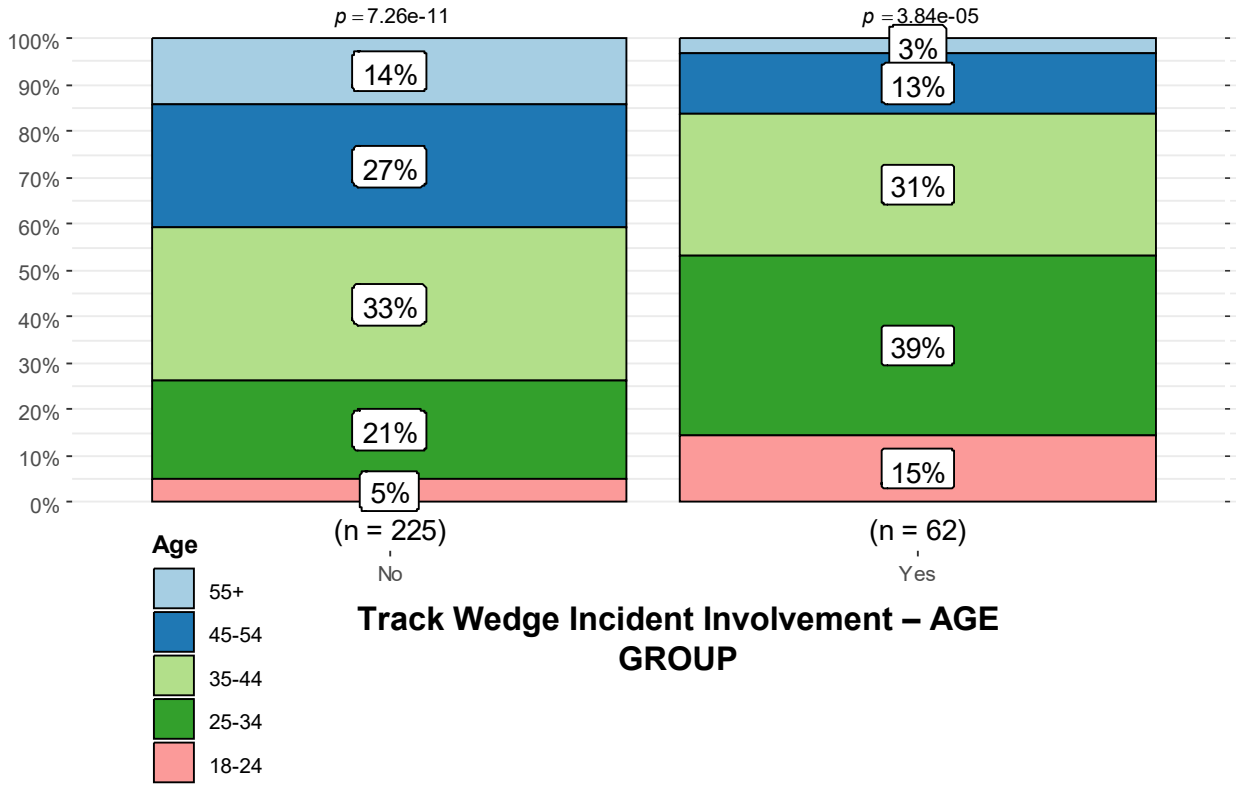
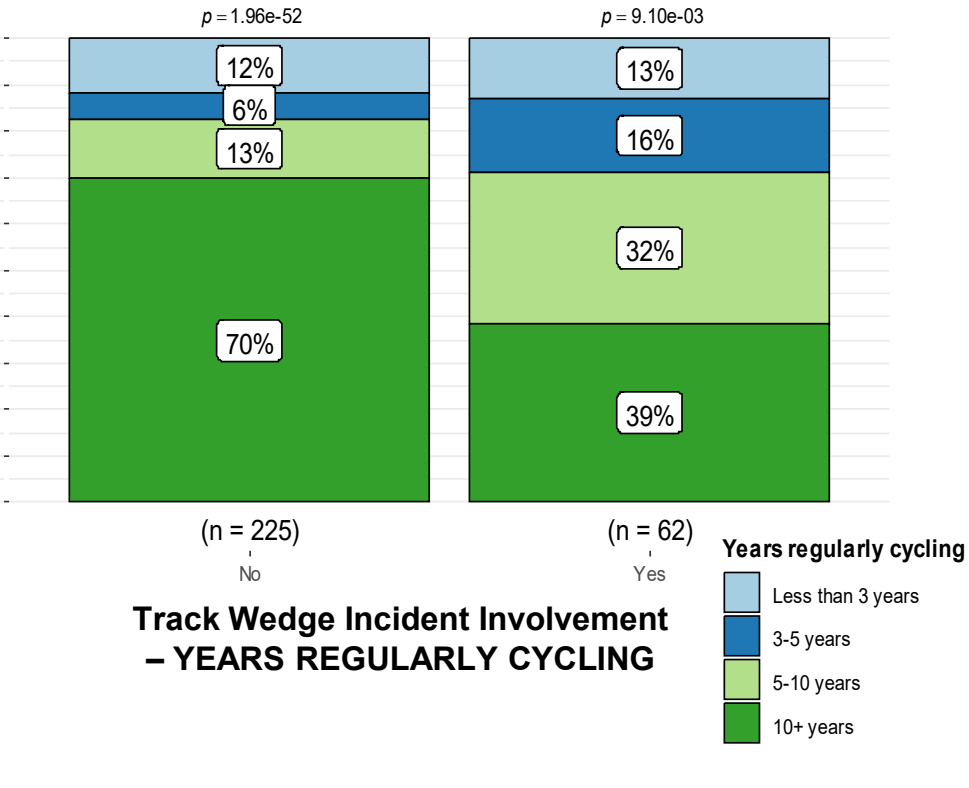
Track-wedge incident involvement associated with being younger…and less experienced

$\chi^2_{Pearson}(4) = 21.24$, $p = 2.84e\text{-}04$, $\widehat{V}_{Cramer} = 0.25$, $CI_{95\%}$ [0.09, 1.00], $n_{obs} = 287$



Track Wedge Incident Involvement – AGE GROUP

$\chi^2_{Pearson}(3) = 24.69$, $p = 1.79e\text{-}05$, $\widehat{V}_{Cramer} = 0.28$, $CI_{95\%}$ [0.15, 1.00], $n_{obs} = 287$



Track Wedge Incident Involvement – YEARS REGULARLY CYCLING

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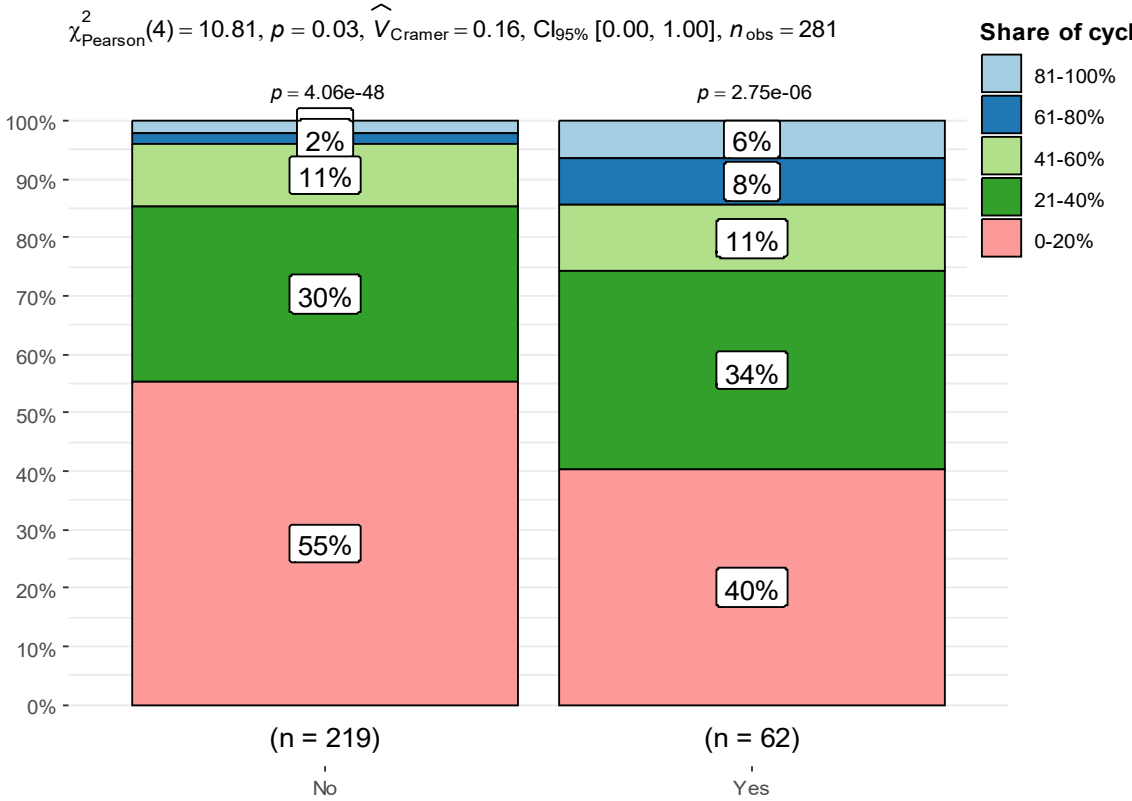
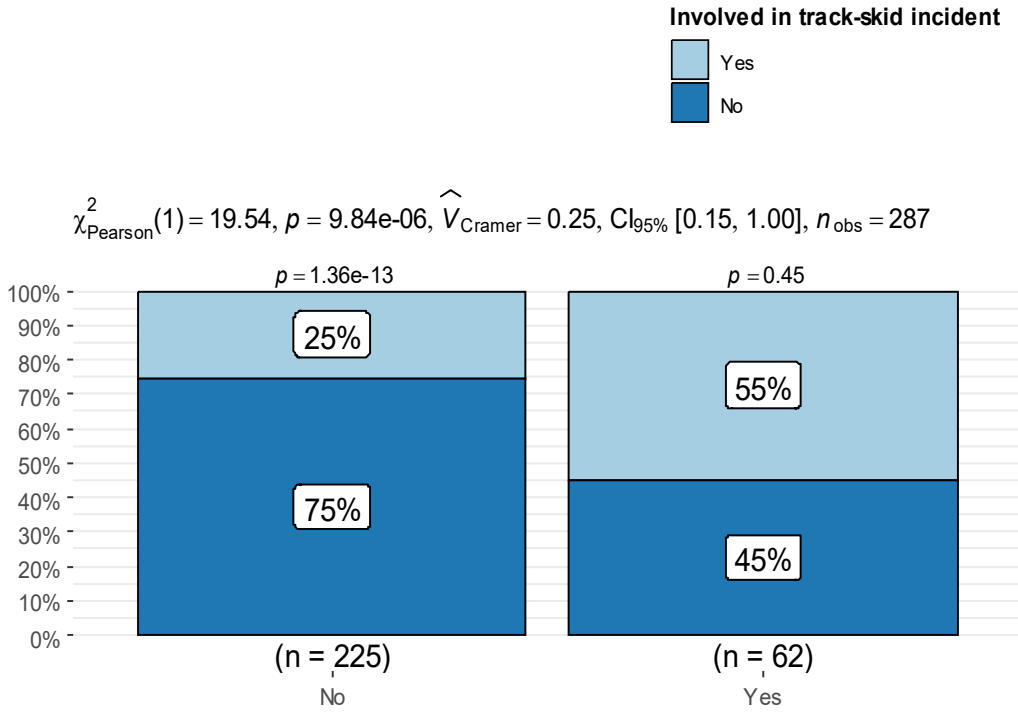
Track-wedge incident involvement associated with … cycling on roads with tracks more often… and having also been involved in a track-skid incident



Track Wedge Incident Involvement – SHARE OF CYCLING ON ROADS WITH TRAMS



Track Wedge Incident Involvement – INVOLVEMENT IN TRACK SKID INCIDENTS

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Track-wedge incident involvement 2.7x more likely for 18-34 year olds (compared to 45+)…

Regression Results – Factors Associated with Track Wedge Incidents

Characteristic	> 0 track-wedges OR[1]	95% CI[1]	p-value
Age			
18-34	**2.66**	1.10, 6.74	**0.033**
35-44	1.82	0.77, 4.47	0.200
45+	—	—	
Years regularly cycling			
10+ years	—	—	
3-10 years	**2.42**	1.17, 5.00	**0.017**
Less than 3 years	1.14	0.38, 3.14	0.800
% of cycling with track			
0-20%	—	—	
21-60%	1.30	0.67, 2.54	0.400
61-100%	**3.48**	1.14, 10.4	**0.026**

…2.4x more likely for those cycling for 3-10 years (compared to 10+)…

…and 3.5x more like for those doing > 60% of their cycling on roads with tracks (compared to 0-20%)

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Hospital data: 85% of tram-related cyclist hospital attendance/admissions relate to track-wedging – one per week!

Frequency of Tram Related Hospital Admissions (Serious Injury) – 2006-2021

Type	Wedge	Slip/skid	Tram involved	Collision with stop or barrier	Total
Crashes (2006 to 2021)	748	98	34	<5	~885
Per year	49.9	6.5	2.3	<0.3	~60
Per week	1.0	<0.1	<0.1	~0	~1.2
Share	85%	11%	4%	<1%	100%

One per week track-wedging incident

Over one in ten related to track-skidding

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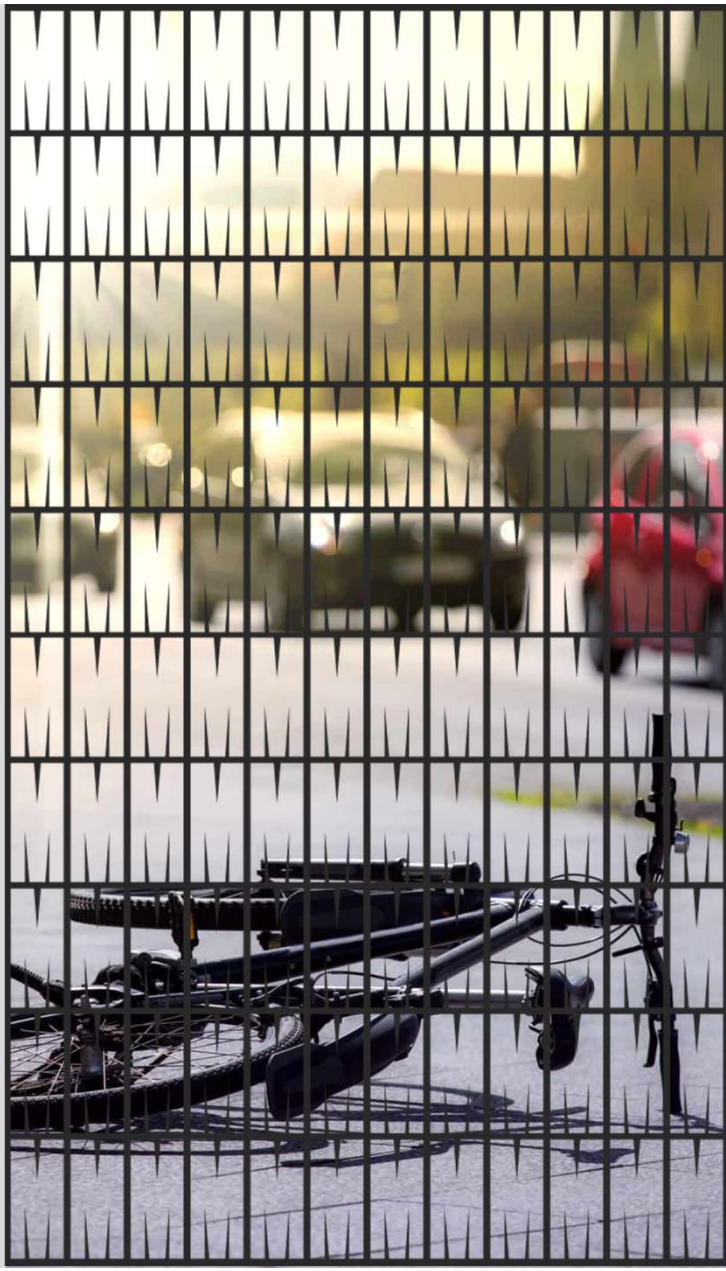
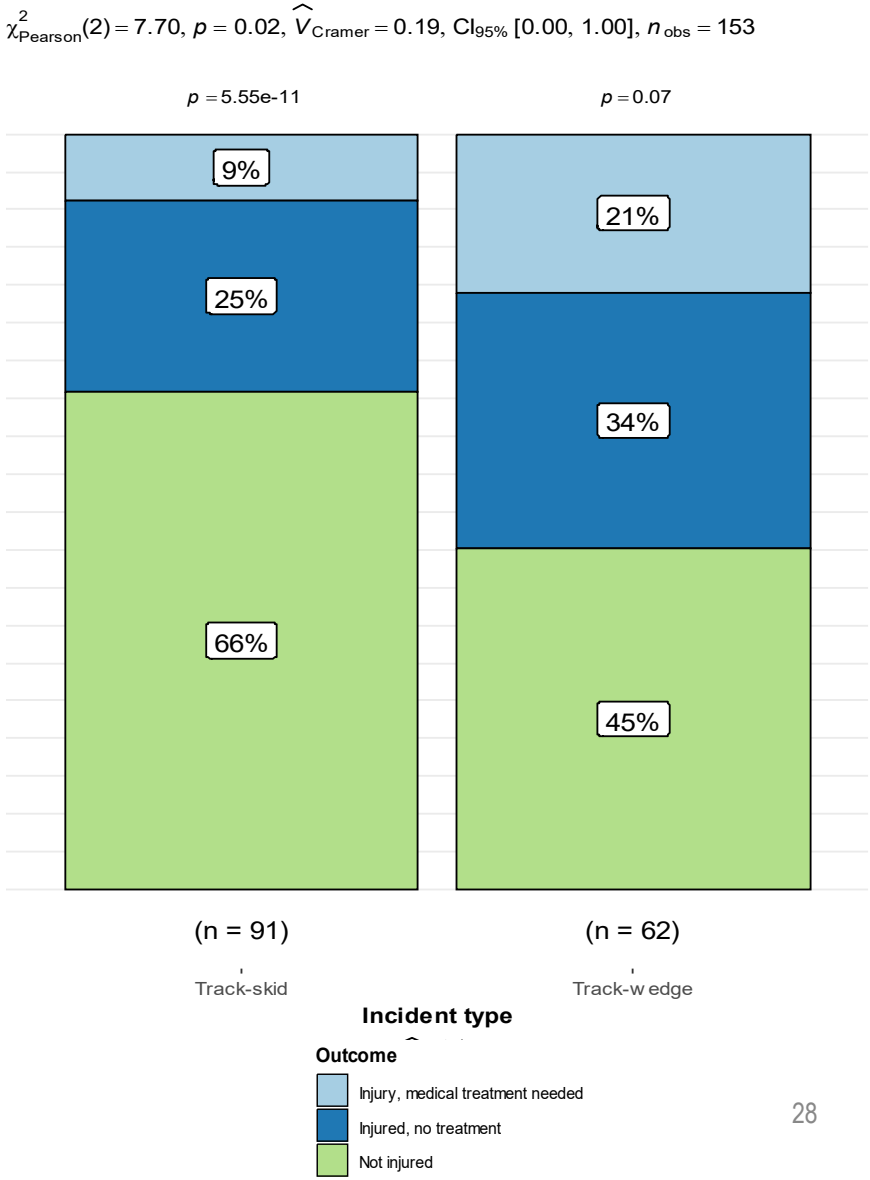


Key findings:

Key findings

- Inner cyclists ; 21% have had at least one Tram Track crash every 5 years
- Track-skids
  - More common than track-wedges
  - Exposure-related:
    - more likely for those cycling on roads with track more often
  - Associated with wet conditions
    - Especially for cyclists aged 45 years or older
- Track-wedging
  - More likely to result in serious injury
  - Exposure-related:
    - more likely for those cycling on roads with track more often
  - Younger and less experienced cyclists
  - Approximately one cyclist per week goes to hospital after a track-wedge incident
- Tram-involved incidents
  - Appear to be infrequent
  - 2.3 hospital attendances per year
  - None reported by survey participants…
    …but maybe those involved never return to cycling



Countermeasures: Segregation* is Primary Safe System Treatment for all crash types…

Source: Woolley et al (2018) Towards Safe System infrastructure: a compendium of current knowledge

Countermeasurses	Crash type		
	Track-wedge	Track-skid	Tram-involved
Segregation	Primary	Primary	Primary
Hook turns/90-degree crossing	Primary	Supporting	Supporting
Rubberised track inserts	Primary	N/A	N/A
Separation	Step towards	Step towards	Step towards
Public education	Supporting	Supporting	Supporting

…rubberised track inserts and increased crossing angles Primary Treatment for track-wedging only

*Segregation: physical barriers between tram & cyclists (e.g. kerb divider)
^Separation: space allocation only (e.g. bike lane clear of tracks)

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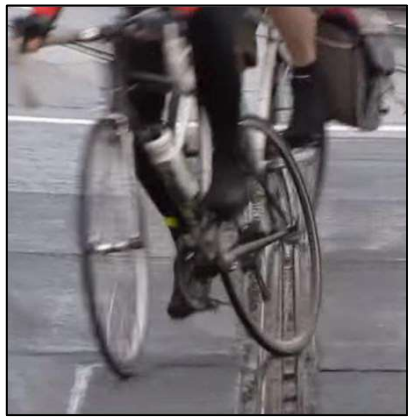
Limitations and further research:

Limitations and further research opportunities

- Further surveys:
  - Sample may not be representative of all cyclists
  - Additional questions about crash and incident location
  - Application to other cities?
- Track-slip incidents:
  - May be under-researched, due to focus on track-wedging (because they tend to be more severe)
  - Track coatings? Shelter from wet
- Rubberised track inserts:
  - Are these practical?
    Installation, reliability, maintainability?
  - Second-order effects?
    Will they encourage cyclists to ride alongside tracks, increasing exposure to tram-involved and track-skid incidents?



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Limitations and further research:

Publications

- PTRG Research Report (Next)
  - Currie G and Reynolds J (2023) “Bike - Tram Track Safety Treatment Review” 26-09-23 for Yarra Trams Melbourne
- Publications
  - Bhuiyan R, Reynolds J Currie G and Johnson M (In Press) “Cyclist safety around trams: Melbourne case study” 44th Australasian Transport Research Forum 2023 Proceedings 29 November – 1 December, Perth, Australia
  - Reynolds J, Bhuiyan R, Currie G and Johnson M (In Press) ‘’ Tram Bike Crash Risks: A Cyclist Market Survey” 103rd Transportation Research Board Annual; Meeting, 7-11 Jan 2024
  - More coming soon
- ARC Linkage Bid – Exploring bike tram track crash incidence and innovative mitigation solutions

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