Statistical Errors in Anti-Helmet Arguments

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TARS Research

CHSSR CENTRE FOR HEALTH SYSTEMS AND SAFETY RESEARCH

November 2013

Outline

1. Bicycle Helmets and Laws
2. Anti-helmet Arguments
   - Helmets are ineffective
   - Helmet laws deter cycling
   - Helmets increase the risk of an accident
   - No population level effect
   - Net health reduction
3. Discussion

The Most Controversial Topic in Cycling

Bicycle Helmets and Laws

- Designed to mitigate head injury in a crash
  - Helmeted cyclists have fewer head injuries in a crash
  - Not a panacea for all bicycle related injuries
- Australian states and New Zealand mandated helmet use in early 1990's
  - Associated with increased helmet wearing
  - Associated with decreased head injury rates
- Bicycle helmets and helmet laws have been criticised in the peer-reviewed literature, media and various advocacy groups
  - The anti-helmet advocacy group Bicycle Helmet Research Foundation is the main proponent of these criticisms[1]
  - These criticisms are ALL statistically flawed

[1] www.cyclehelmets.org

Common Criticisms of Helmets and Laws

Criticism 1

Helmets are ineffective

Criticism 2

Helmet laws deter cycling

Criticism 3

Helmet wearing increases the risk of an accident

Criticism 4

No evidence MHL reduces head injury at a population level

Criticism 5

MHL results in a net health reduction

Helmets are ineffective

- Biomechanical evidence helmet use lessens the kinetic energy to the head (dummy test)[2]
- Randomised controlled trials are not possible (considered unethical)
- Must rely on observational studies
  - Numerous case-control studies
  - Cochrane Review[3]
  - Meta-analysis[4]
  - Re-analysis of meta-analysis[5]

[2] McIntosh, Lai & Schilter (2013)
[3] Thompson, Rivara & Thompson (1999)
[4] Attewell, Glase & McFadden (2001)
[5] Elvik (2011)

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  - All indicate helmets are effective at mitigating head injury in a crash

[2] McIntosh, Lai & Schilter (2013)
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[5] Elvik (2011)

Rotational Injuries

- Curnow (2003) suggested helmets exacerbate rotational injuries (diffuse axonal injury)
- DAI hypothesis taken as fact among many organisations
- No evidence exists to support DAI hypothesis
  - Helmet did not increase angular acceleration in a dummy test[6]
  - No DAI cases among 110 Sydney cyclists in trauma registry[7]
  - 12 potential DAI cases for NSW cyclists in MVC for 2001-2009 (7 with no helmet, n=6745)[8]
  - Computer simulation found helmets did not increase likelihood of neck injury among adults[9] or children[10]

[6] McIntosh, Lai & Schilter (2013)
[7] Dinh, Curtis & Ivers (2013)
[8] Walter, Olivier, Churches & Grzebieta (2013)
[9] McNally & Whitehead (2013)
[10] McNally & Rosenberg (2013)

Elvik Paper

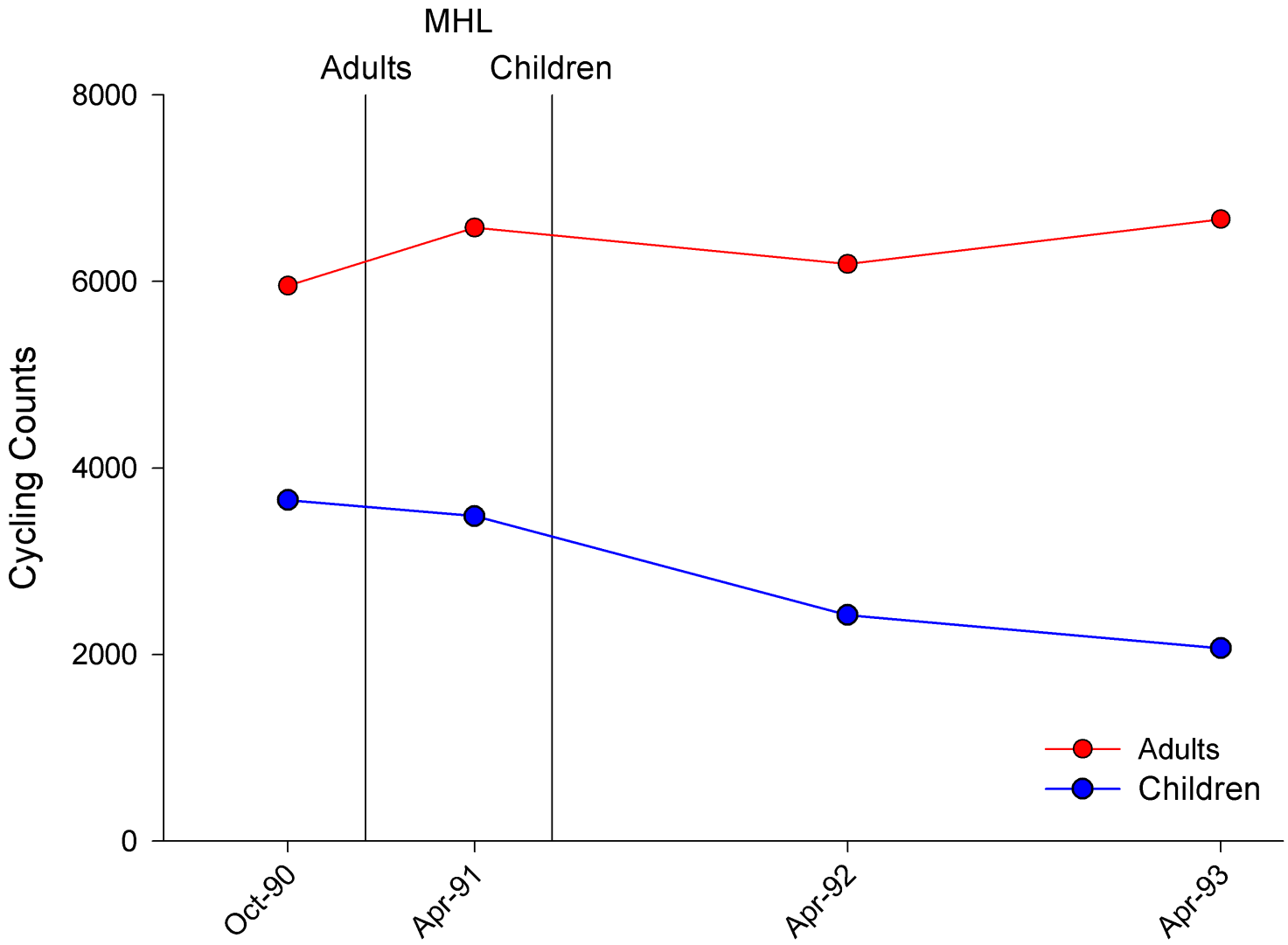
- Performed separate analyses combining **head**, **face** and **neck** injuries[11]
  - OR: 0.74, 95% CI: 0.64-0.86
- Data and analytic errors were identified and corrigendum published[12]
  - OR: 0.79, 95% CI: 0.69-0.90
- Random effects models still incorrect[13]
  - OR: 0.60, 95% CI: 0.50-0.73
- Latest online version corrects results, yet...
  - "...no statistically significant overall effect of bicycle helmets could be found when injuries to head, face or neck are considered as a whole."

[11] Elvik (2011)
[12] Elvik (in press)
[13] Churches (2013)

Helmet laws deter cycling

- Robinson (1996) concluded helmet law reduced cycling numbers not head injuries
  - Taken as fact by many researchers and advocacy groups
  - Conclusion drawn from NSW hospitalisations (1989-1993) and helmet wearing survey data for children (1991-1993)
- Regarding adult data, Robinson (1996) states
  - *"Comparable figures were not available for adults"*
- In a later paper, Robinson (2006) states
  - *"...all available long and short term data show cycling is less popular than would have been expected without helmet laws."*
- Adult cycling counts do exist for NSW as well as 1990 data for children
  - Why was it not part of her analyses?

Counts of Cyclists in NSW



Counts of Cyclists in NSW

- Only 4 out of 48 months were surveyed (8.3% response rate)
- Adult cycling in Sydney increased 22% after the helmet law
- From 2nd to 4th survey, adult recreational cycling increased 141%
- Adult bicycle related head injury hospitalisations decreased by 30% with the helmet law[14]
  - Limb injuries did not significantly change
- Small decline in children cycling pre-law with inclusion of 1990 data

[14] Walter, Olivier, Churches & Grzebieta (2013)

Safety in Numbers

- Robinson (2005) hypothesised MHL increases injuries per cyclist
  - Variation of Smeed's Law

$$\frac{I}{C} \propto C^{-0.6}$$

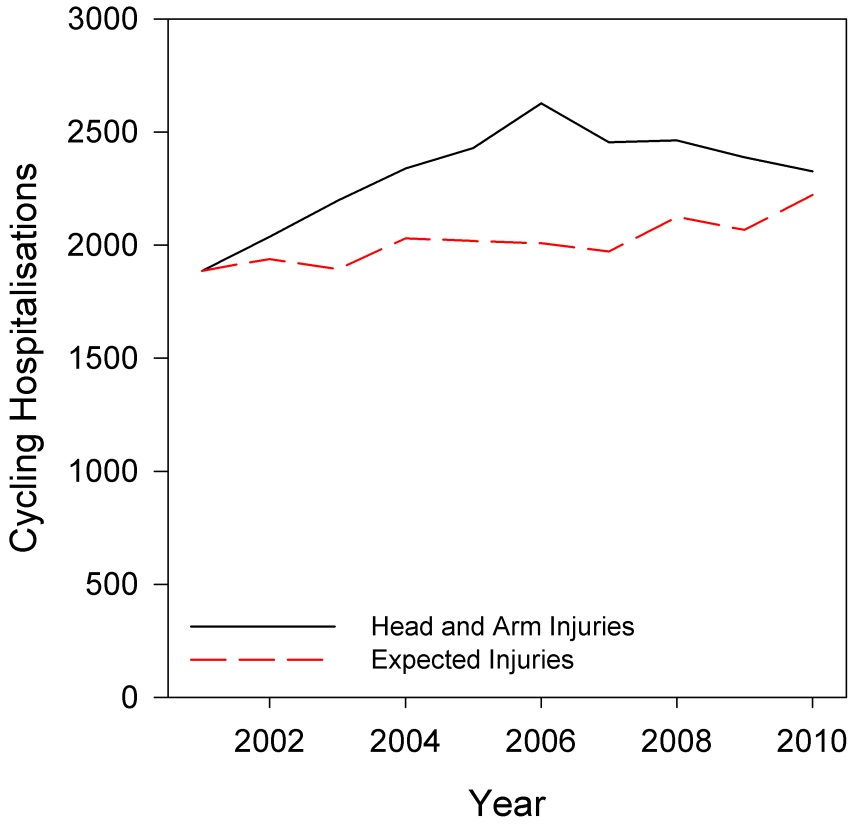
- Using initial values I_0 and C_0, the relationship between numbers of cyclists and injuries is

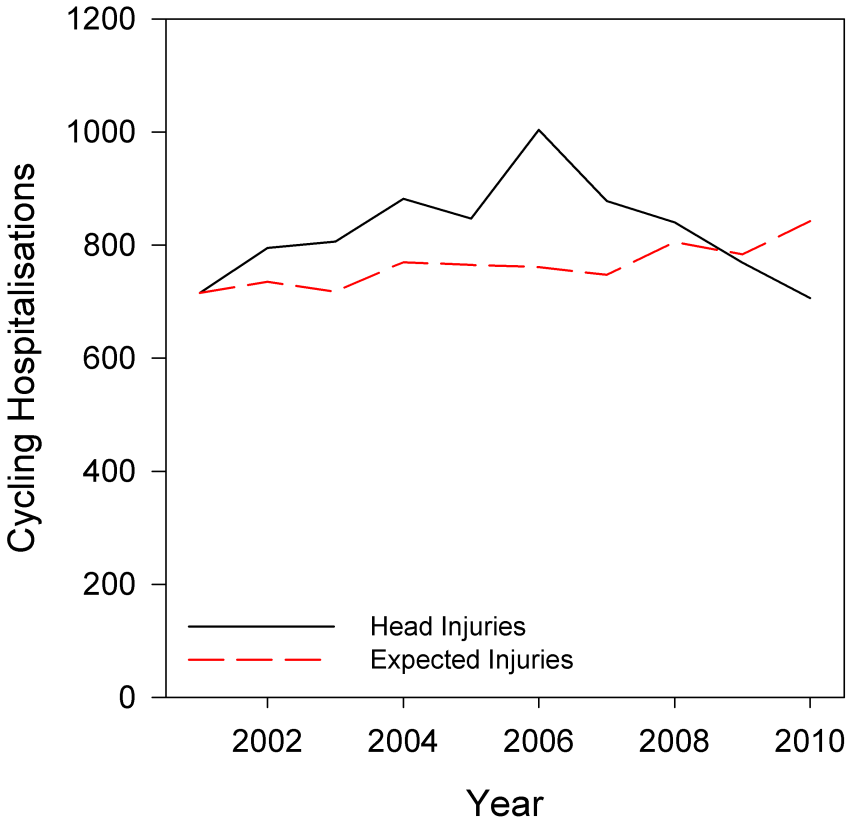
$$I = I_0 \left(\frac{C}{C_0} \right)^k$$

  where $k < 1$ indicates injuries per cyclist declines with increased cycling numbers (Robinson claims $k = 0.4$)
- Does this theory hold up using NSW hospitalisation and cycling participation data?[15]

[15] Olivier, Walter & Grzebieta (2013)

Safety in Numbers





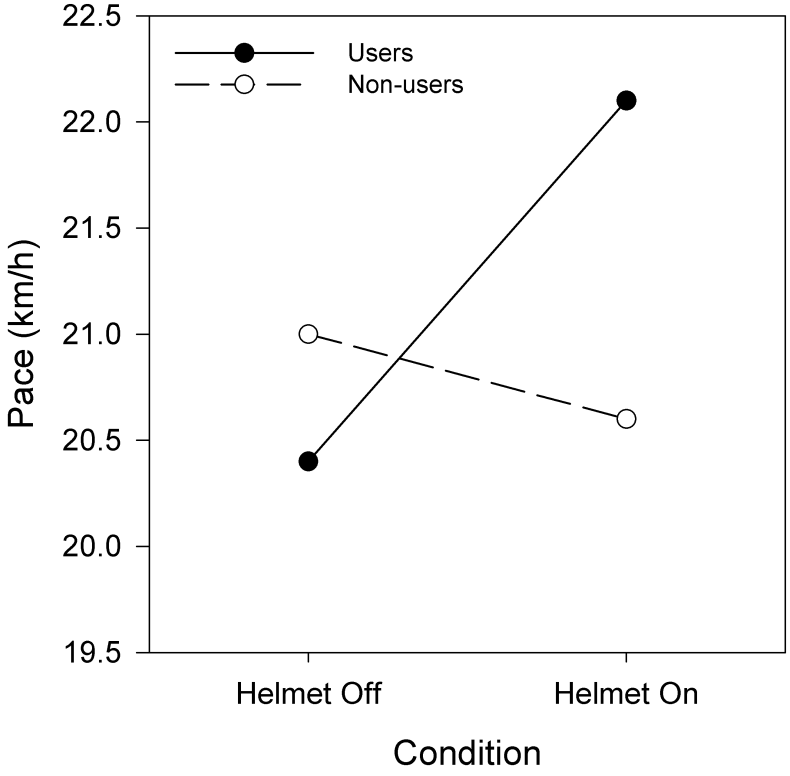
- Data estimate $\hat{k} = 0.94$ (95% CI: 0.59-1.30)

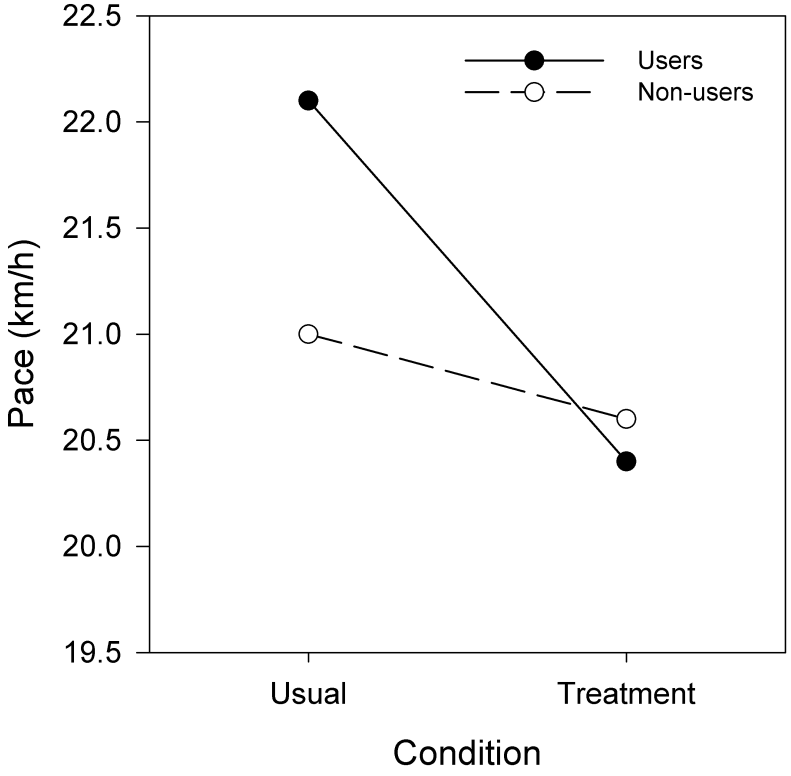
Helmet wearing increases the risk of an accident

- Robinson (1996, 2006) suggested a cyclist will exhibit riskier behaviour when wearing a helmet (risk compensation)
  - Walker (1991) concluded "the evidence available provides no support for the risk hypothesis."
- Case-control studies found non-helmet wearers in a crash were more likely to exhibit illegal behaviour[16]
- Fyhri and Phillips (2011) conclude "Routine helmet users ... cycled slower when they did not wear their helmet... give some support to those urging caution in the use of helmet laws"

[16] Lardelli-Claret et al. (2003); Bambach et al. (2013)

Fyhri and Phillips (2013)





- Incorrect temporal ordering, both groups cycled slower when not in **usual** condition
- McNally et al. found helmet protection increased with greater speed

Motorists are more aggressive to helmeted cyclists

- Ian Walker, University of Bath
- Two sensors: one for overtaking distance and the other the distance to the kerb
- Alternated between wearing and not wearing a helmet (also wore a blonde wig)
- Vehicles overtook, on average, at a closer distance when helmeted
- Data available online[17]
  - Large sample (n=2355)
  - Significant (but small) effects

[17] http://drianwalker.com/overtaking/

Helmets not associated with 'close' passing

- Walker data re-analysed by 1 metre rule[18]
- Vehicle size, city of occurrence and distance to kerb are all important factors
  - Helmet wearing is not significant (OR: 1.1, p=0.54)
- Average difference in passing distance at various intervals

Interval	Diff (cm)	95% CI
$[0, 75cm)$	-5.2	$-22.4, 12.1$
$[75, 100cm)$	0.3	$-6.1, 6.7$
$[100, 150cm)$	0.7	$-1.2, 2.7$
$[150, 200cm)$	1.7	$-0.3, 3.7$
$[200cm, \infty)$	7.2	$3.4, 10.9$

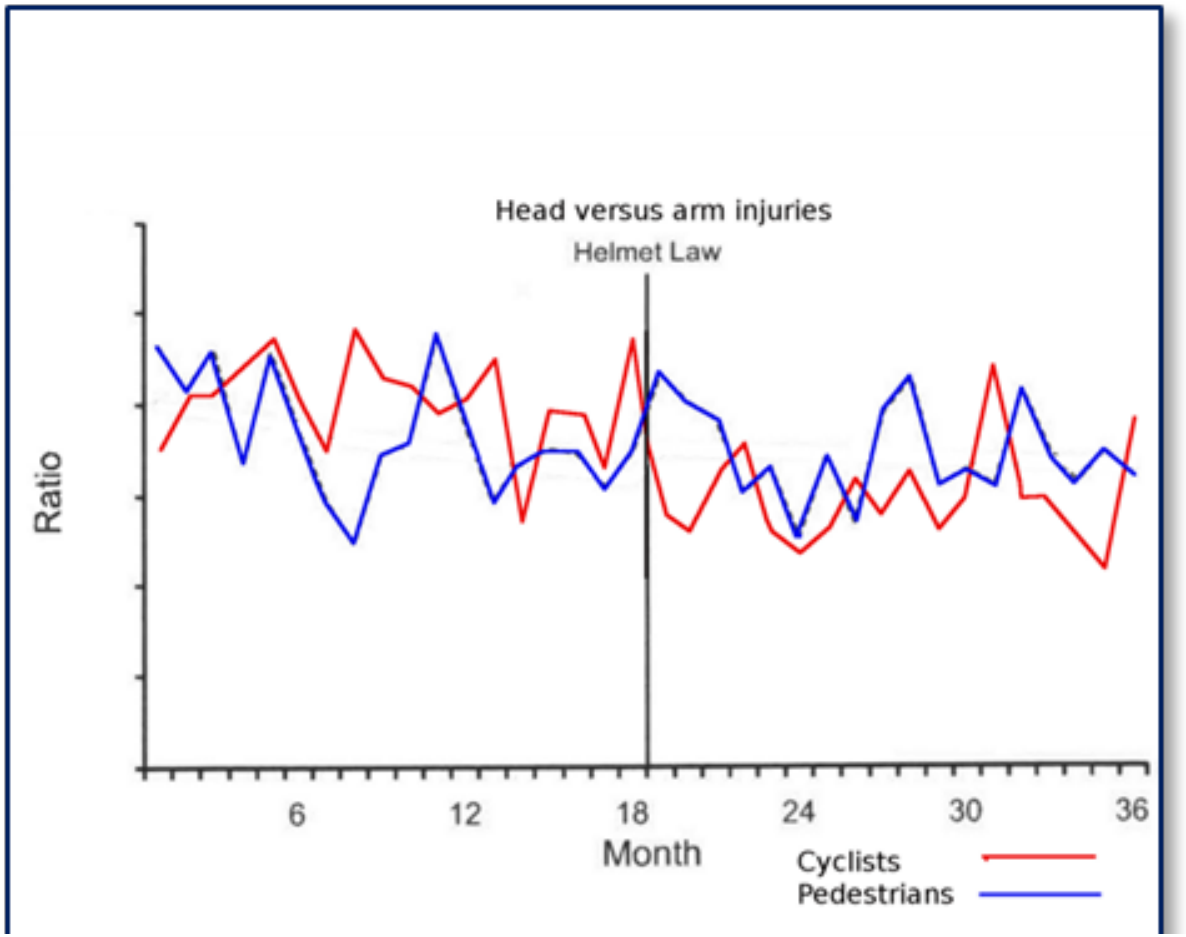
- Helmet wearing is only a significant factor for passing distances greater than 2m

[18] Olivier & Walter (2013)

No population level effect of MHL

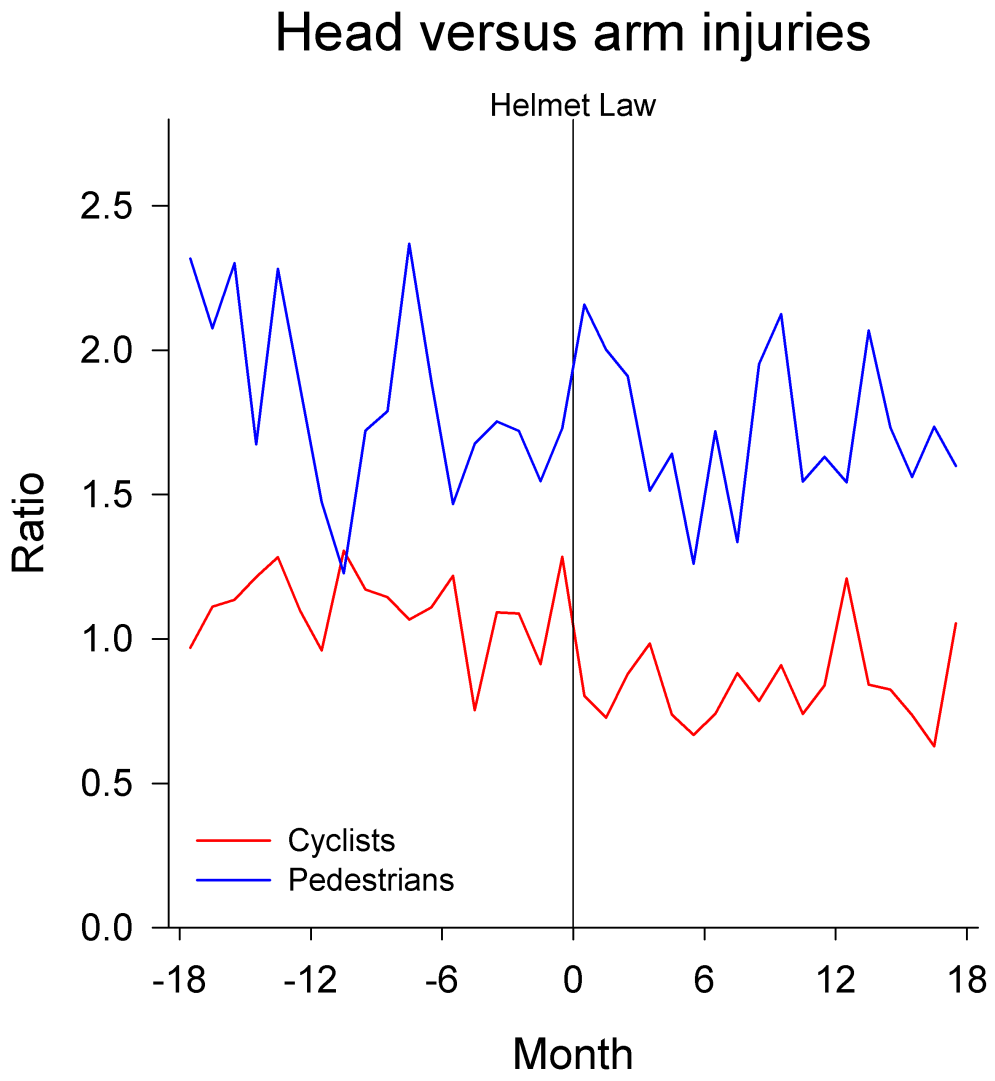
- Robinson (2006, 2007) and Rissel (2012) argue a population level effect has not been detected for jurisdictions with MHL
  - Both authors cite Hendrie et al. (1999), a study that found a significant decline in the ratio of cycling/pedestrian head injuries in WA
- Voukelatos and Rissel (2010) concluded no additional decline in head injury beyond overall declining trend in cycling injuries (compared to arm injuries)
  - Article later retracted due to data and analytic errors (Churches, 2010; Grzebieta, 2011)
  - Rissel (2012) and various websites continue to cite retracted paper
- Walter et al. (2011) estimated a 29% decline in cycling head injuries (relative to limb injuries) using same data source as Voukelatos and Rissel
  - Mindell, Franklin & Wardlaw (2011) disagree

Mindell, Wardlaw & Franklin (2011)



...it is difficult to discern any particular reduction in head injuries to cyclists (red) compared with (pedestrians), although the data are rather "noisy"

Plots distort height and variability

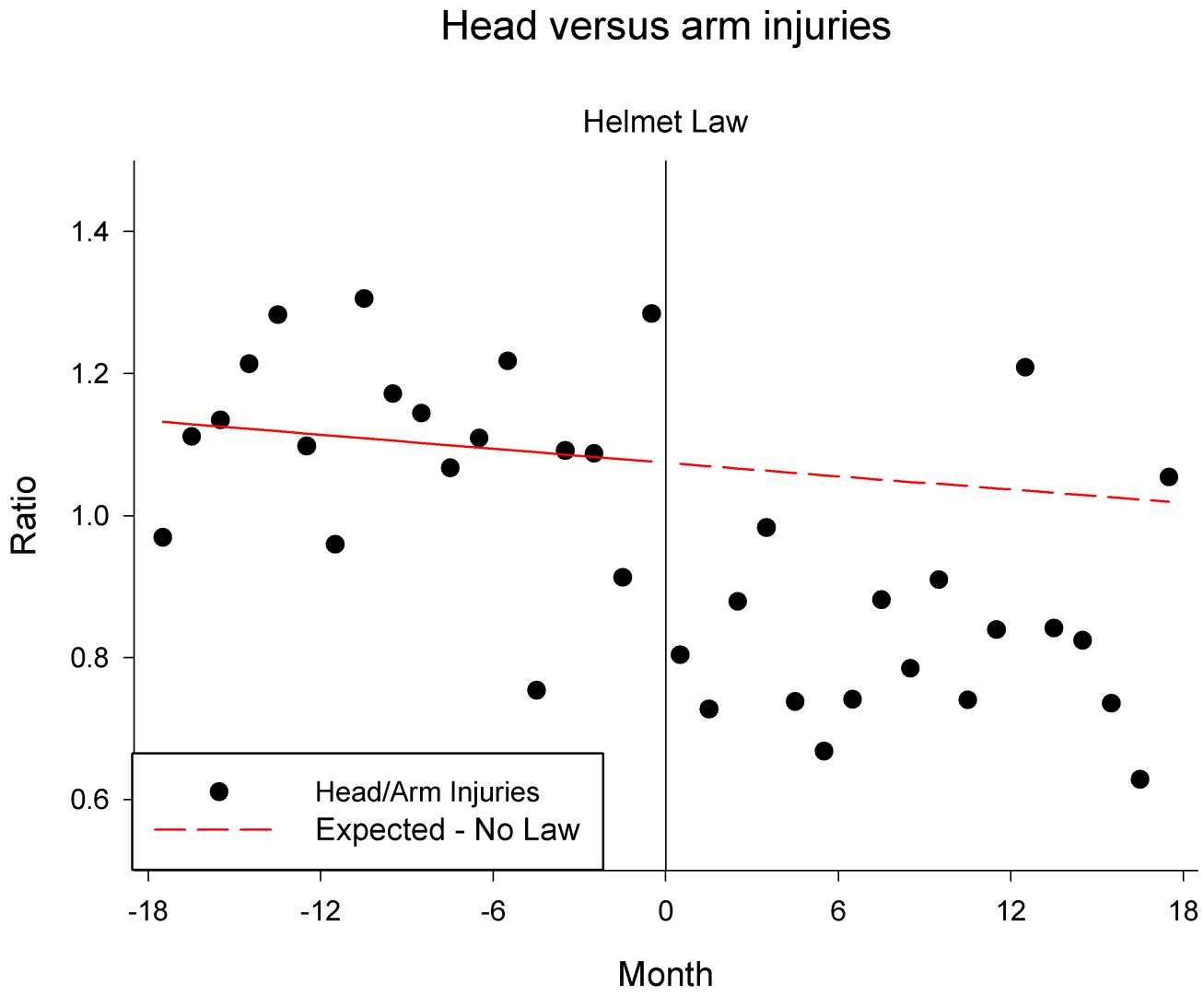


Drawing conclusions from graphs

- Graphs can be misleading
- "Noisy" is a quantitative measure that has no meaning in isolation
  - "Signal" to "noise" ratio
  - Some variables are "noisier" than others
- Numerical analysis of NSW data

	Pre-law	Post-law	% Change	p-value
Head/Arm				
Cyclists	1.075	0.779	-27.5	0.03
Pedestrians	1.579	1.756	+11.2	0.41
Head/Leg				
Cyclists	2.164	1.493	-31.0	0.03
Pedestrians	0.896	0.804	-10.2	0.38

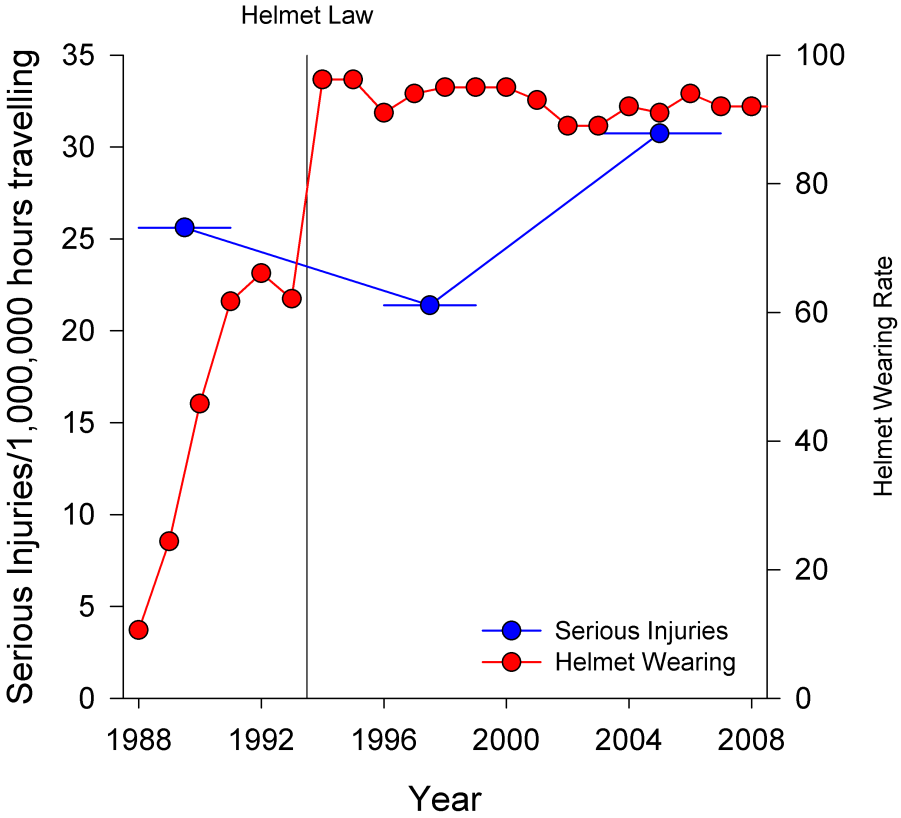
Cycling Head/Arm Injuries Only

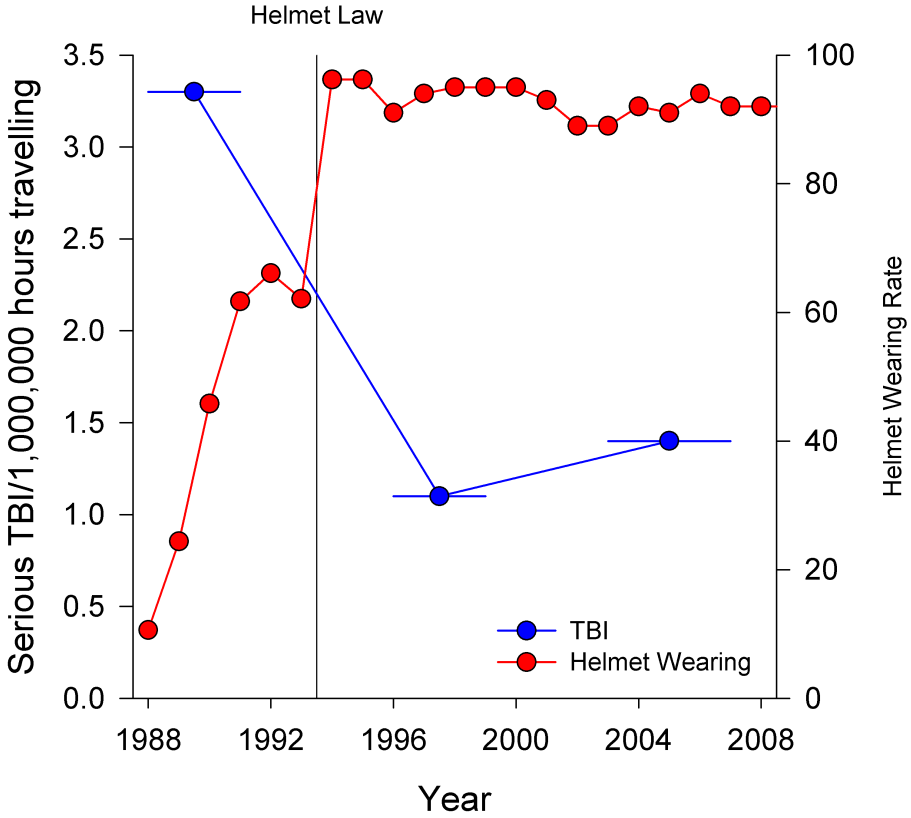


Clarke (2012)

- Argues NZ helmet law associated with increase in injury risk of 20-32% per million hours cycling
- Ignores data nearest the NZ helmet law (1 Jan 1994)
  - Result compares 1988-91 with 2003-07
- Did not analyse head injuries separately
  - Helmets only protect the head
- Much of data comes from Tin Tin, Woodward & Ameratunga (2010)
  - Found 67% decrease in serious traumatic brain injury
  - Clarke (2012) never mentions this result
- Both studies ignore helmet wearing rates

Clarke (2012)





Serious TBI, not all cycling injury, varies with helmet wearing rate

MHL results in a net health reduction

- In a health economics assessment, de Jong (2012) concludes MHL is beneficial under "relatively extreme assumptions"
- His assumptions include helmet legislation can only lead to declines in cycling
  - States motorcyclists don't like helmets, so it is "safe to assume the same is true for bicyclists"
  - Points to Robinson (1996, 2006, 2007) as "main statistical studies"
  - No evidence of decrease in adult cycling
- Other negative effects are not supported by available data
- de Jong's model always estimates a health benefit of helmet legislation under reasonable assumptions

Discussion of Anti-Helmet Arguments

- Not supported by available data
  - DAI hypothesis, safety in numbers
- Rely on the omission of key data
  - Deterrent effects of legislation, lack of population level effects
- Rely on the misrepresentation of data
  - Risk compensation, lack of population level effects
- Negative health benefit
  - Dependent on the above arguments (*spaghetti effect*)

Anti-helmet Advocacy

- Authors against helmets belong to anti-helmet advocacy groups
  - Bicycle Helmet Research Foundation
  - Cyclists Rights Action Group (CRAG)
  - Transport and Health Study Group (THSG) – *To promote a more balanced approach to cycle safety and oppose cycle helmet legislation*
- Journal of Transport and Health (Elsevier)
  - Affiliated with THSG
  - Editorial board littered with anti-helmet advocates
- Arguments pit helmet laws against infrastructure
  - Ian Walker – "Any solution to bicyclist safety should focus on preventing collisions from taking place, not seeking to minimize the damage after a collision occurred"
  - Runs counter to Safe Systems approach
  - Only 12% and 23% of NSW head injury hospitalisations involve a motor vehicle for children and adults respectively
  - Better to minimise risk **AND** minimise injury

Conclusions

- Anti-helmet arguments appear overstated, misleading or invalid
- Much of this work has been conducted by anti-helmet advocates, usually with no research or no higher degree qualifications, no track record in rigorous statistical research methodologies, no track record in having worked for any credible health research institution
- Anti-helmet research ultimately distorts our understanding of the mechanisms helmets protect heads and the factors associated with successful helmet legislation
- Future research and road safety policy should exercise caution when relying on this body of work, unless supported by robust data and analysis in the peer-reviewed literature

Acknowledgements

- School of Mathematics and Statistics, UNSW
  - Jake Olivier, Joanna J.J. Wang
- Transport and Road Safety (TARS) Research, UNSW
  - Joanna J.J. Wang, Raphael Grzebieta
- Centre for Health Systems and Safety Research, UNSW
  - Scott Walter
- NSW Department of Health

Thank You!

Questions?

Something to ponder...

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