Institution: Newcastle University

Unit of Assessment: 12

Title of case study: Predicting Road Traffic Collision Hotspots - Saving Lives Globally

Period when the underpinning research was undertaken: 2008-2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Dr Neil Thorpe	Lecturer in Transport Engineering	1996-present
Dr Lee Fawcett	Senior Lecturer in Statistics	2006-present
Dr Joe Matthews	Lecturer in Statistics	2018-present

Period when the claimed impact occurred: 2014-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

An interdisciplinary team of researchers in transport studies encompassing engineering and mathematical science colleagues has created software for a) predicting the future location of road traffic collision hotspots and b) evaluating site-based road safety interventions in terms of reduced casualty numbers. Corroborated health, commercial and economic impacts have occurred on a regional, national and global scale including:

- reducing average annual traffic casualties by 514 to 436 in North Yorkshire, with £22.5M estimated accident prevention savings;
- influencing traffic and road safety policy in over 60 countries through the International Transport Forum;
- impacting the design of a low emission zone in Lisbon, Portugal; and
- developing new software applications with a sales value of €1.1M from licences held by 140 organisations in 40 countries through the PTV Group, Germany.

These research impacts address the 2030 Agenda for Sustainable Development targets 3.6 and 11.2 directly and are helping towards achieving the UN supported global initiative of Vision Zero - "*the aim of achieving a highway system with zero accidents or fatalities involving road traffic*".

2. Underpinning research (indicative maximum 500 words)

Background

Each year approximately 1.35M people die on our roads globally and an estimated further 50M are injured (World Health Organisation), costing 3% of many countries' annual GDP. Traditionally, engineers implement road safety countermeasures retrospectively at sites (e.g. junctions) in response to a threshold rate of fatalities and injuries being surpassed. By comparison, collision prediction enables a proactive (as opposed to reactive) approach and guides engineers where to implement safety measures *before* the collisions occur. A cornerstone of the 'Safe Systems' approach to road safety which underpins the UN's 2nd Decade of Action for Road Safety (2020-2030) is "proactive road safety design". Being able to predict the location of future collision hotspots enables proactive preventative engineering action to help avoid unnecessary death and injury.

The research challenges

Predicting future locations of collisions on road networks involves extrapolating observed collision counts at sites from previous time periods. Interpreting collision data is difficult as collision counts at individual sites fluctuate over time, due to the random nature of collisions. This is problematic when establishing if a site is indeed becoming more dangerous or if a recent rise in collision counts is due to randomness, and that collision levels will fall without

intervention. This is also an issue when evaluating the impact of safety interventions - what portion of a reduction in collisions is due to your investment, and what portion might have occurred anyway due to this statistical phenomenon of regression-to-mean (i.e. unusually high/low counts returning over time to the underlying mean level without intervention)? Empirical Bayes is a statistical technique for controlling for regression-to-mean in count data and became the internationally adopted approach for analysing collision count data from the 1980s. Thorpe's research at Newcastle began in 2008 as Principal Investigator in a project funded by the Northumbria Safer Roads Initiative (NSRI) to evaluate the impact of mobile road safety cameras, as a result of the team's concerns over the suitability of the then-standard Empirical Bayes approach. As a result, Dr Neil Thorpe (School of Engineering) and Dr Lee Fawcett (School of Mathematics, Statistics and Physics) developed a novel fully Bayesian approach which they applied to data from police collision and NHS casualty records to estimate the anticipated financial savings, due to safety cameras, from reduced numbers of road users being killed or injured. This is of substantial interest to healthcare providers [P1, P2].

In 2013, Thorpe and Fawcett attracted research council and international industry funding to extend their initial modelling approach for scheme evaluation with a new focus on collision prediction in collaboration with the traffic and logistics software company PTV based in Germany, and with the objective to commercialise the approach and make it accessible to road safety practitioners [P3]. Further substantial improvements have been demonstrated in collaboration with transport researchers in Texas and Shanghai [P4]. Since 2008, the research programme has been funded by a continuation of internal, research council, industry and government funding to support research and development, and commercialisation activities.

Communicating the research to the transport engineering community

The Newcastle research has attracted widespread interest amongst the traffic management community internationally. Subsequent to the initial publications, the research team has given invited presentations on the approach to the annual US Transportation Research Board Conference (2016-2020), the London Transport Practitioners' Meeting (2014; 2017), and the Road Safety GB National Data Analysts' Conference in Birmingham (2018; 2020). Also, within the UK the team has been invited to present the research to a range of road authorities including the UK Department for Transport, Highways England, local road authorities, transport consultancies (e.g. Jacobs, WSP, and SWECO) and police forces. In 2017 the team ran a Latin American Knowledge Transfer Workshop in Mexico City on Statistical Methods and Software for Predicting Road Traffic Collisions. The team have also delivered knowledge transfer workshops specifically on the collision prediction and scheme evaluation methods to road safety engineers and academics in Brazil (2014;2019), Bolivia (2016) and Qatar (2015). The team has given invited presentations on the approach to the Abu Dhabi Police Force and Dubai Roads and Transport Authority (2017) and to the Deputy Mayor for Mobility, Safety, Economy and Innovation in the City of Lisbon and his road safety team (2018) and, also in Lisbon in 2019, an invited presentation to the International Transport Forum's Safer City Streets Network. In May 2018 the team delivered an invited workshop on Software Tools for Road Safety Data Analysis at the New York City Department of Transportation.

Development of Software Applications:

Since 2014, the Newcastle team have been developing RAPTOR, a research software application available to road safety practitioners for the practical implementation of the method for predicting collision hotspots and evaluating road safety interventions [P5]. Before RAPTOR, no such software existed for road safety practitioners.

3. References to the research (indicative maximum of six references)

[P1] Thorpe N, Fawcett L. (2012) 'Linking road casualty and clinical data to assess the effectiveness of mobile safety enforcement cameras: a before and after study.' BMJ Open, 2(6), e001304. (http://bmjopen.bmj.com/content/2/6/e001304?ct)

[P2] Fawcett, L. and Thorpe, N. (2013) Mobile safety cameras: estimating casualty reductions and the demand for secondary healthcare. Journal of Applied Statistics, DOI: 10.1080/02664763.2013.817547. (http://www.tandfonline.com/doi/abs/10.1080/02664763.2013.817547)

[P3] Fawcett, L., Thorpe, N., Matthews, J. and Kremer, K. (2017). A novel Bayesian hierarchical model for road safety hotspot prediction. Accident Analysis & Prevention, 99, pp.262-271. (http://www.sciencedirect.com/science/article/pii/S0001457516304341)

[P4] Guo, X; Wu, L; Zou, Y; Fawcett, L. Comparative Analysis of Empirical Bayes and Bayesian Hierarchical Models in Hotspot Identification. Journal of the Transportation Research Board. DOI: 10.1177/0361198119849899. (https://doi.org/10.1177/0361198119849899)

[P5] Matthews, J., Newman, K., Green, A., Fawcett, L., Thorpe, N. and Kremer, K., 2019, March. A decision support toolkit to inform road safety investment decisions. In Proceedings of the Institution of Civil Engineers–Municipal Engineer (Vol. 172, No. 1, pp. 53-67). Thomas Telford Ltd. (winner of the ICE Publishing James Hill Prize) https://www.icevirtuallibrary.com/doi/full/10.1680/jmuen.16.00057

Grants
[G1] Funding from Northumbria Safer Roads Initiative/Gateshead Council (£140K), including health impacts study funding from the NSRI, collaborative with Northumbria NHS Trust (£25k).
[G2] Three internal University Research Council pump prime grants to enable impact activity (£15K)
[G3] EPSRC PhD award (£70k)
[G4] EPSRC NPIF PhD award (£78k)

4. Details of the impact (indicative maximum 750 words)

Health, economic and commercial benefits have occurred at a regional, national and global level. This case study details examples with corroborated impact from the UK, Europe, South America and within the International Transport Forum (ITF).

Impact in North Yorkshire (NY)

Following Newcastle University (NU) RAPTOR research in 2016, North Yorkshire Police (NYP) expanded their fleet of safety camera vans to further reduce the number of collisions, deaths, and serious injuries on the region's roads [E1]. *"…independent research by academics at Newcastle University shows an estimated 20% reduction in casualties owing specifically to the presence of mobile safety camera vans…In 2017 six new, more agile vehicles were introduced by the police…"* - NY Police & Crime Commissioner [E2].

3-year "before and after" analyses either side of the 2017 £107k fleet expansion, demonstrates the following benefits [E3]:

- a 24% reduction in casualties at 22 specific locations;
- a significant contribution to estimated accident prevention savings of £22.5M p/annum across the whole North Yorkshire region.

North Yorkshire police state: *"Since 2017, the augmented fleet has enabled greater presence on more high-risk routes to influence speeding and anti-social road use. It has also allowed us to provide visibility and reassurance to many communities which had not previously had a safety camera presence."* and *"The Newcastle research was significant in clarifying the rationale for the expansion of SCVs (Safety Camera Vehicles) and therefore in contributing to a reduction in the annual number of KSI* [Killed or Seriously Injured] *incidents. This has reduced on average from 514 casualties per annum to 436, bringing an estimated accident prevention saving of £22.5M p/annum and significant societal health and economic benefits."* [E3].

Impact in Northumberland and Tyne & Wear

NU's RAPTOR software is used by the Northumbria Safer Roads Initiative (NSRI).

"Since 2018 we have applied RAPTOR to identify traffic collision hotspots in the Northumbria Police Force area (Northumberland and Tyne & Wear) and guide the allocation of enforcement resources. RAPTOR is a key component of traffic strategy and operations and is now an established part of our year-on-year decision-making process" – Senior Transport Planner, NSRI [E4].

All 130 mobile safety camera locations within the region have been assessed by RAPTOR for continuing enforcement. There is an estimated collision event reduction of 38 over a two-year period for the whole of the region since RAPTOR analysis began. Newcastle research has made a significant contribution to estimated collision reduction savings of approximately £4M for the years 2018 and 2019. NSRI also use RAPTOR to evaluate the effect of road safety interventions. Pre- and post-analyses of three-year durations either side of the RAPTOR-driven safety camera redeployment demonstrates a significant decrease in casualties of 33% at four sample locations, resulting in estimated accident prevention savings of £235K over a three-year period for these sample sites [E4].

Impact in Lisbon

In 2018, the Municipality of Lisbon, Portugal and NU agreed a memorandum of understanding to use the Newcastle team's methods to develop and improve road safety in Lisbon. The research team undertook an analysis to assess the effects of road safety cameras on casualty reduction within the city. Subsequently, the team used their statistical method, now embedded in PTV's VISUM Safety software, to predict the safety impacts ("what-if scenarios") of a proposed low emission zone in the Baixa-Chiado district. *"The results from the assessment impacted upon the design of the scheme. The Low Emission Zone was presented by the Mayor in January 2020, but unfortunately had to be temporarily suspended due to the (Covid-19) pandemic situation. The Newcastle research methodology has been playing a role in the design of a safer Lisbon…"* Deputy Mayor of Mobility, Safety, Economy and Innovation in Lisbon [E5]. It is expected that benefits from the scheme would now have been evident without the outbreak of Covid-19.

Impact in Bolivia

In 2016, Thorpe delivered a series of invited lectures on the team's methods for analysing collision data, the rationale behind the Newcastle research and a demonstration of the software solutions as part of a road safety workshop in Santa Cruz. This highlighted the benefits of collision prediction and scheme evaluation from the appropriate interrogation of collision data. One of the significant outputs from the event was a Road Safety Charter signed by all participants calling for increased investment in road safety in Bolivia. Based on this Road Safety Charter, which included specific NU research, the Global Road Safety Facility (GRSF) provided the CAF bank a grant of US$200,000 to enhance the development of road safety strategies in four cities in Bolivia: Santa Cruz, Tarija, La Paz and El Alto [E6].
"An understanding of the Newcastle research, specifically i) the methodology for the accurate analysis of collision and casualty data to identify collision hotspots and ii) the evaluation of road safety schemes such as speed cameras, has enabled the cities to develop a system of self-funding road safety strategies." – Road Safety Advisor, GRSF/CAF [E6].

Global Commercial Impact

Corroborated international impact is demonstrated through collaborations with the PTV Group, a global company based in Germany specialising in software solutions for traffic and mobility. Since 2017, the statistics-based algorithms used within RAPTOR have been embedded in PTV's VISUM Safety package. This is a commercial software product used by city planners and road authorities worldwide, that allows collision data analysts and road safety engineers to assess the impacts of hypothetical land-use and transport planning scenarios on the future number and location of collisions [E7, E8]. *"Algorithms developed by Newcastle University have been integrated within our VISUM safety software from 2017 through to the latest edition VISUM*

Safety 21 , http://vision-traffic.ptvgroup.com/en-uk/products/ptvvisum-safety/ , which is licensed currently to 140 organizations in 40 different countries, with a total of 3700 licenses so far."
"…Newcastle University research has helped us to achieve estimated license sales of our VISUM Safety Module at an estimated License value of approximately €1,1M"– Vice-President Business Development & New Mobility, PTV Group [E9].

Global Policy Impact

The International Transport Forum (ITF) and the Organisation for Economic Cooperation and Development (OECD), is an intergovernmental organisation with 61 member countries. The ITF acts as a platform for discussion and pre-negotiation of policy issues across all transport modes at a global level. Newcastle University's collision prediction research is detailed in the section on 'proactive network management' within the ITF policy document, "New Directions for Data Driven Transport Safety" published in 2019 [E10]. Subsequently the research is used by global member countries of ITF to influence future transport policies and the effective use of data to drive safety decision making e.g. in Portugal (Lisbon).

5. Sources to corroborate the impact (indicative maximum of 10 references)

[E1] Online media article. https://www.yorkpress.co.uk/news/ryedale/15223085.six-new-mobile-speed-cameras-launched-in-north-yorkshire/ *Provides evidence of the research collaboration and NU research leading to the expansion of the safety camera fleet in North Yorkshire.*

[E2] Public report by the North Yorkshire Police & Crime Commissioner: Making North Yorkshire's Roads Safer https://www.northyorkshire-pfcc.gov.uk/content/uploads/2018/09/Report-Making-North-Yorkshires-Roads-Safer.pdf e.g. page 4 (foreword by the Commissioner) and page 30. *Provides evidence of the research collaboration and NU research leading to the expansion of the safety camera fleet.*

[E3] Testimonial from North Yorkshire Police. *Provides evidence of the investment in safety cameras, casualty reductions and estimated accident prevention savings.*

[E4] Testimonial from the NSRI. *Provides evidence of the casualty reductions and estimated accident prevention savings in Northumberland and Tyne & Wear.*

[E5] Testimonial from the Deputy Mayor of Mobility, Safety, Economy and Innovation in Lisbon. *Provides evidence of the investment in safety cameras and the initiation of the reduced-emission zone scheme.*

[E6] Testimonial from the CAF bank. *Provides evidence of the grant for the development of road safety strategies.*

[E7] VISUM Safety 21 https://discover.ptvgroup.com/road-safety-evaluation-prediction *Provides evidence of the research collaboration and the integration of the statistics research within VISUM Safety.*

[E8] Media Article from the PTV Group. https://www.iamigniting.com/neilandteam/ *Provides evidence of the Newcastle University research team and collaboration with the PTV Group.*

[E9] Testimonial from the PTV Group. *Provides evidence of the research collaboration, the integration of the statistics research within VISUM Safety 21 and the increase in revenue.*

[E10] International Transport Forum (ITF) policy document. https://www.itf-oecd.org/sites/default/files/docs/new-directions-data-driven-transport-safety_0.pdf pages 28-30. *Provides evidence of the research influencing international transport policies.*