Institution: Newcastle University

Unit of Assessment: 10

Title of case study: Safer roads and cost savings through statistical analysis

Period when the underpinning research was undertaken: 2008-2019

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 Lee Fawcett	Senior Lecturer in Statistics	2006-present
Mr Joe Matthews	Lecturer in Statistical Data Science	2018-present
Dr Neil Thorpe	Lecturer in Transport Engineering	1996-present

Period when the claimed impact occurred: 2016-2020

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

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

A Newcastle University Mathematical Sciences research team developed and applied novel Bayesian statistical methods to create software for (a) predicting traffic collision hotspots and (b) evaluating site-based road safety interventions. Corroborated impacts have occurred on a regional, national and global scale, including:

- a significant contribution to reducing average annual traffic casualties from 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;
- developing new software applications with a sales value of €1.1M for 140 global organisations in 40 countries through PTV Group, Germany.

The research benefits address the 2030 Agenda for Sustainable Development Goals 3.6 and 11.2 directly, and help towards achieving the United Nations-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 in the UK there are in the region of 200,000 injuries, 20,000 serious injuries and 2,000 deaths because of road traffic accidents (RTAs). Since 1998 the UK government has considered road safety (speed) camera placement to be an important part of its strategy to reduce RTAs and consequent casualties. Road safety cameras are known to be effective in reducing RTAs but they are expensive to maintain and perhaps more importantly they are most effective when strategically and adaptively sited. This leads to the need for effective collision prediction analysis, to identify future hotspots and to determine the consequences of site-based interventions such as moving cameras between locations.

The research challenge

The assessment of the effectiveness of road safety measures necessarily requires the analysis of observational data, bringing with it consequent difficulties in interpretation. For example, the problem of selection bias is well known in the road safety literature. A new safety measure (e.g. a speed camera) implemented at a site because of an unusually high number of accidents or casualties might seem subsequently to be effective simply because of the effect of regression to the mean (RTM).
Empirical Bayes (EB) methods were therefore developed in the 1990s to forecast RTA frequency in the absence of intervention, usually based on a simple Poisson random effects model with gamma prior distributions and an exchangeability assumption across all sites being analysed. The EB approach to analysis became the gold standard internationally for separating RTM effects from genuine treatment effects of road safety measures.

Research at Newcastle University (NU) began in 2008 because of concerns regarding the effectiveness of the then-standard procedures. In collaboration with the Northumbria Safer Roads Initiative (NSRI) and the Newcastle upon Tyne Hospitals NHS Trust, Dr Lee Fawcett (School of Mathematics, Statistics and Physics (MSP)) and Dr Neil Thorpe (School of Engineering) developed a Fully Bayesian (FB) approach that incorporated multivariate traffic flow predictors, flexible prior distributions, temporal trends, more realistic uncertainty quantification and sensitivity analyses [P1]. The methods can be applied alongside linked data from police collision and NHS casualty records to allow the financial consequences of proposed safety measures to be explored, which is of substantial interest to NHS secondary healthcare providers [P1, P2]. Since 2014, Mr Joe Matthews (School of MSP) has contributed to the work, first in his role as a PhD student (jointly supervised by Fawcett and Thorpe) and more recently in his lecturer role. Various grants [G1-G6] have funded the research.

The modelling has subsequently been extended and refined, with more focus on predictive capability and uncertainty quantification in collaboration with the German traffic and logistics global software company PTV Group [P3]. Most recently, further substantial improvements over EB methods have been demonstrated in collaboration with transport researchers in Texas and Shanghai [P4].

Interdisciplinary research

The mathematical sciences research has enabled advancements within the field of transport engineering and has attracted widespread interest amongst the international traffic management community. Subsequent to the first publications, Fawcett, Matthews and Thorpe have given invited talks to the annual US Transportation Research Board Conference (every year since 2016), the London Transport Practitioners' Meeting (2017), and the Road Safety GB Conference in Birmingham (2018). In 2017 they led a Latin American Knowledge Transfer Workshop in Mexico City on Statistical Methods and Software for Predicting Road Traffic Collisions. They have given invited presentations to, and established memorandums of understanding with, the Abu Dhabi Police Force and the Dubai Road Transport Authority (both 2017), and to the Deputy Mayor for Mobility, Safety, Economy & Innovation and his team in Lisbon (2018). In May 2018 they delivered an invited workshop on Software Tools for Road Safety Data Analysis at the New York City Department of Transportation. Within the UK they have been invited to visit several national organisations, local authorities and police forces including Highways England, Gateshead Council and North Yorkshire Police.

Software development

NU's Bayesian statistics research is the bedrock of RAPTOR, a software application for predicting collision hotspots and evaluating site-based road safety interventions [P5, P6]. Before RAPTOR, no such software existed for road safety practitioners. The mathematical methods are embedded in PTV's *VISUM Safety*, a commercial software product that allows planners and road safety analysts to assess the most critical points in a transport network.

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

[P1] 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)
[P2] 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)
[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. (2019) 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.T., Newman, K., Green A.C., Fawcett, L., Thorpe, N., and Kremer, K. (2019). A decision support toolkit to inform road safety investment decisions. *Municipal Engineer*, 172, 1, pp. 53-67. (winner of the ICE Publishing James Hill Prize)
(https://www.icevirtuallibrary.com/doi/full/10.1680/jmuen.16.00057)
[P6] Road Safety Analysis. Software application for predicting collision hotspots and evaluating site-based road safety interventions. http://roadsafetyanalysis.org/raptor/

Grants

[G1] Two grants from Northumbria Safer Roads Initiative/Gateshead Council to develop RAPTOR (£40K)
[G2] Three internal University Research Council pump prime grants to enable impact activity (£15K)
[G3] Funding over 5 years from the Northumbria Safety Camera Partnership (NSRI) (£75K)
[G4] Health impacts study funding from the NSRI, collaborative with Northumbria NHS Trust (£25K).
[G5] EPSRC PhD award (£70K)
[G6] 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 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].

Three-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**.

The **Police, Fire and Crime Commissioner** states: *"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."* [E3].

"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** [E4].

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, Portugal

In 2018, the Municipality of Lisbon, Portugal and NU agreed a memorandum of understanding to develop and improve road safety in Lisbon. NU researchers undertook an analysis to assess the effects of road safety cameras on casualty reduction within the city. Subsequently, NU researchers used their statistical methodology embedded in PTV's *VISUM Safety* software to predict the safety impacts ("what-if scenarios") of a new low emission zone scheme in the Baixa-Chiado district of Lisbon. *"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, City of 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, NU researchers delivered a series of road safety workshops about their methods for analysing collision data, the rationale behind their research and a demonstration of the software solutions in Santa Cruz, Bolivia. The work 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 participants calling for an 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 collaboration with PTV Group, a global German company specialising in software solutions for traffic and mobility. Statistics-based algorithms, used within RAPTOR, have been embedded within *VISUM Safety* software

[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 of License value of approximately €1,1M"–* ***Vice-President Business Development & New Mobility, PTV Group*** [E9].

Global Policy Impact

The International Transport Forum (ITF), within the Organisation for Economic Cooperation and Development, 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. NU's novel 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.

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 pages 30-31. *Provides evidence of the research collaboration and NU research leading to the expansion of the safety camera fleet.*

[E3] Testimonial from the North Yorkshire Police, Fire & Crime Commissioner. *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 and collision 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 impact on the design of the low emission zone scheme.*

[E6] Testimonial from the GRSF/CAF Road Safety Advisor. *Provides evidence of the grant for the development of road safety strategies and influence on Bolivian cities.*

[E7] PTV Group and *VISUM Safety* 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 PTV Group. https://www.iamigniting.com/neilandteam/ *Provides evidence of the NU research team and collaboration with PTV Group.*

[E9] Testimonial from PTV Group. *Provides evidence of the research collaboration, the integration of the statistics research within VISUM Safety 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 and 30. *Provides evidence of the research influencing international transport policies.*