Institution: UDur: University of Durham

Unit of Assessment: Unit 10: Mathematical Sciences

Title of case study: Statistical methods for urgent medical care call centres and sustainable transport

1. Summary of the impact

The Northern Doctors Urgent Care Group, a not-for-profit organisation that delivers out-of-hours urgent medical services for the NHS, achieved significant efficiency savings and improvements in-patient care as a result of adopting statistical assessment and forecasting processes, developed by Durham University. These improved processes also featured in the Group's successful competitive bids for two new contracts worth £9.2M per year. In addition, the Durham methodology was adapted to assess the results of a Government programme to encourage cycling in six UK towns, producing data on cycle use that helped to influence subsequent allocations of about £700M for sustainable transport projects.

2. Underpinning research

This work has been carried out by David Wooff (lead) with S. Grace Stirling, who was appointed to a two-year Knowledge Transfer Partnership associate position funded by the ESRC and One North East (2008-2010, £105,000).

There was little extant methodology available to provide forecasts for call-centre volumes and daily patterns of arrival for this kind of problem. Forecasting is difficult because (1) there are structural daily effects - the call centre is closed during normal working hours, but open Saturday and Sunday; (2) there are thought to be different typical caseloads for different days of the week, e.g. Friday night heavy loads; (3) there are calendar effects, e.g. national holidays, Easter, Christmas, New Year; (4) general seasonal effects; (5) occasional epidemic effects, such as swine flu; (6) drift in demand because of population change or policy changes affecting service provision or organisation. The forecasting methodologies tend to fall into two camps; one is quite finely detailed, but over-tuned to special features of the application. Another is insufficiently detailed, for example standard methodology such as X-ARIMA-12 as used by the US Government for economic forecasting, which cannot be used for within-day forecasts. In seeking a completely general and widely applicable solution, the Durham team chose to model the daily volume of calls using regression models to identify and adjust for the crucial factors. Daily arrival rates were modelled using a mix of generalized smoothing and a Poisson approximation to arrival times. The resulting models offer excellent forecasts both for day-to-day forecasts and for patterns of call arrivals through the day.

A second research theme was identified in the summer of 2009 as a result of the Swine Flu epidemic. In addition to forecasting normal patient volumes, there was an urgent need to react to increasing volumes because of swine flu. The Durham team thus developed diagnostic models to disentangle the normal load from the epidemic load. In collaboration with the North East England Strategic Health Authority, thresholds were thereby determined for use within a pandemic escalation framework for North East England healthcare institutions in order to prepare the institutions for their responsibilities during pandemics, and to trigger response modes as pandemics escalate.

The methodology developed in this body of work turned out to be of relevance beyond the health-care sector, and was also used in the analysis of cycling data for the Department of Transport and SUSTRANS.

3. References to the research

[1] Wooff, D. A. & Stirling, S. G. (2013), *Practical statistical methods for call centres with a case study addressing urgent medical care delivery*, http://dro.dur.ac.uk/11457. To appear, with minor revisions, in the Annals of Operations Research.

[2] Stirling, S.G. & Wooff, D.A. (2011), *Statistical Methods for supporting urgent care delivery through call centres***,** in Keynote Papers YoungOR 17, Nottingham, UK, Monks, T. ed, The Operational Research Society, pp. 57-78.

[3] Wooff, D. A. & Stirling, S. G. (2011), *Forecasting for urgent medical care call centres*, in *Forward look mathematics and industry – success stories,* Lery, T. ed., European Science Foundation, Strasbourg, p.68.

[4] Stirling, S.G. & Wooff, D.A. (2010), *Forecasting for medical emergency call centres*, Conference presentation, Institute for Mathematical Statistics 73rd annual conference, 2010, Gothenburg, Sweden.

4. Details of the impact

Northern Doctors Urgent Care Group (NDUC) is a not-for-profit organisation, based in Newcastle, which is commissioned by the NHS to deliver out-of-hours urgent GP services. It has a turnover of £15M and 600 staff. Trained call handlers liaise with clinicians to provide patients with appropriate care, including: telephone advice, visit to an Urgent Care Centre, home visit, or hospital admission.

In 2008, NDUC was receiving 100,000 calls per annum from the Northumbria health region (population 929,000) when it approached Knowledge House, an organisation that facilitates links between companies and universities in North East England, requesting a research partnership aimed at reducing costs and improving patient care by more accurately forecasting call volumes and daily patterns of call arrivals. Durham University responded and entered into a Knowledge Transfer Partnership, placing an early career researcher, Grace Stirling, at NDUC from 2008-10, supervised by Professor Wooff. The research was conducted during the period of the KTP and the results were announced in the talk **[4]** and summary note **[3]**, the details being published in **[2]** and **[1]**.

The statistical methodology developed in Durham in these works provided NDUC with a forecast of numbers of calls arriving during every 30 minutes. Forecasts are made up to a year in advance and are highly accurate, facilitating optimum clinical staffing, which accounted for 64% of expenditure. NDUC was able to save about £65,000 per year by changing GP shift patterns in response to better forecasting. A further £35,000 per year was saved by introducing a new rota for call handlers working at weekends.[1]

These improvements aided business expansion. In 2011 NDUC won a £4.5M per year contract to handle non-emergency calls in Teesside (565,000 population) and in 2012 a £4.7M per year contract to provide a similar service in Staffordshire (700,000 population).

The Chief Executive of NDUC commented that the relationship with Durham University and the success of the research-based methodology were 'central' to the successful bid for the

Staffordshire contract, forming a major part of the presentation to the NHS commissioning body and providing a distinct competitive edge over the four other bidders. "In terms of better patient care, I just think it (the Durham methodology) makes the whole organisation operate more effectively… At the busy times, it means we have the right number of staff to deal with the patients, so patients don't experience delays … and then again we are not having to spend a lot of money putting too many doctors on, when they are not really needed… The key thing is that it enables us to provide a consistent service."[2] The resulting contract was very well-received: indeed, the Clinical Director for Unplanned Care for Stoke-on-Trent Clinical Commissioning Group, Dr Chandra Kanneganti, commented to a local newspaper: "This was a comprehensive procurement process involving five possible providers … I am delighted that we will be working with Northern Doctors Urgent Care. They have a proven track record of delivering out of hours services." [3]

The Teesside assessors positively highlighted the NDUC's response to the swine flu epidemic in 2009,[1] when the Durham methodology enabled diagnostic models to forecast patient volumes and disentangle normal load from epidemic load. This allowed NDUC to react to increasing volumes and provided the North East England Strategic Health Authority with timely out-of-hours data to help as an early warning trigger for the rest of the healthcare system. Subsequent impact on public policy was incorporation by the SHA of this second strand of research into its North East Escalation Plan for Pandemic Influenza.

The research **[1-4]** has had further impact in another area of public policy. SUSTRANS is a charity which fosters sustainable transport and had previously collaborated on statistical analysis of cycling data with Durham University, through the relationship with the SUSTRANS Research and Monitoring Unit Project Manager, a Durham graduate. In 2009, the Project Manager approached Professor Wooff to evaluate the first phase of the Cycling Demonstration Town Programme (CDTP), a multi-agency project funded by the Department for Transport and local authorities which had allocated £1m per year to each of six participating towns between 2005-09 for schemes aimed at stimulating levels of cycling.[4] The data concern automatic daily counts of cyclists at 111 locations over four years. Counts of cyclists arriving at locations is structurally the same as volumes of calls arriving at a call centre, and so the Durham methodology of **[1-4]**, which had been developed in the context of call centre data, could be immediately applied to the cycling data.

Professor Wooff's data analysis underpinned two evaluation reports co-authored by the SUSTRANS Project Manager and published by Cycling England and the Department for Transport in 2009[4,5]. This analysis, especially its key figure of a 27% increase in the cycle count (unweighted mean percentage change relative to 2005 baseline)[5], had significant political, economic, environmental and public engagement impacts, as will now be described.

The 27% figure provided an easy to understand measure upon which the Government based further cost-benefit analyses and was quoted extensively in publicity and media campaigns to gain acceptance of its policies on cycling, said the Project Manager:

"David's work gave us the possibility to report the change in one number (27%), which was what the Government wanted. It helped make the case for further funding for the Cycling Cities and Towns (Programme) and other cycling-related projects and more recently helped make the case for the (Local) Sustainable Transport Fund. It is still being used in Government today as one of the pieces of analysis underpinning a lot of benefit cost ratio calculation in city or town wide initiatives." [6]

The Cycling Cities and Towns Programme attracted £43M of government funding for cycle lanes, enhanced junction crossings, cycle parking facilities, training and information, from 2008-2011. An evaluation document[7] says the programme was 'built on earlier experience in six Cycling Demonstration Towns'. This is a reference to the data that was analysed in the reports [4,5] using the Durham methodology.

The Government subsequently allocated a further £600M[6,8], via the Local Sustainable Transport Fund, to integrated projects that encourage green transport. The first tranche of 39 LSTF projects funded in July 2011 included 38 with a cycling element[9]. Further tranches were funded in May 2012 and June 2012. A further £62M has been spent on 'other projects on cycling' during this period[6]. These include projects funded through block allocations by government to local transport authorities.[9]

5. Sources to corroborate the impact

1. Knowledge Transfer Partnership final report (copy held in Durham) and collaboration page http://info.ktponline.org.uk/action/details/partnership.aspx?id=6732

2. Interview with the Chief Executive, NDUC, 6 December 2012. (Sound file held in Durham.)

3. Leek Post and Times (Staffordshire local newspaper), http://www.leek-news.co.uk/Leek-News/New-out-of-hours-provider-announced-04122012.htm

4. Introduction to 'Analysis and Synthesis of Evidence on the Effects of Investment in Six Cycling Demonstration Towns' (November 2009), Department for Transport. http://webarchive.nationalarchives.gov.uk/20110407094607/http://www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2010/03/analysis-and-synthesis-report.pdf

5. Pages 1-2 of 'Cycling Demonstration Towns: Monitoring Project Report 2006 to 2009' (November 2009), Cycling England. http://webarchive.nationalarchives.gov.uk/20110407094607/http://www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2009/12/cdts-monitoring-project-report-2006-09.pdf

6. Written testimony from the SUSTRANS Research and Monitoring Unit Project Manager, April 2013. (Email kept on file in Durham.)

7. Introduction to Executive Summary, Evaluation of the Cycling City and Towns Programme Interim Report (January 2011). AECOM, Centre for Transport and Society, The Tavistock Institute. (Copy kept in Durham.)

8. Written statement to Parliament by Norman Baker, Parliamentary Under Secretary of State for Transport, 27 June 2012, available at https://www.gov.uk/government/speeches/266-million-investment-in-local-sustainable-transport-schemes (accessed 17/10/2013).

9. Parliamentary Questions information, Parliamentary Advisory Council for Transport Safety (24 February 2012), available at http://www.pacts.org.uk/2012/02/pqs-20th-23rd-2/ (accessed 17/10/2013).