Institution: University of Warwick

Unit of Assessment: B10 Mathematical Sciences

Title of case study: The impact of research on life expectancy on people with cerebral palsy and other neurological injuries

1. Summary of the impact

Professor Hutton has applied her research on statistical models for survival analysis to cerebral palsy, a neurological disorder which afflicts around 1 in 500 of newborn children globally. The body of research has established medically-accepted norms for the life expectancy of people with cerebral palsy. Her research extends to the study of life expectancy for patients suffering from spinal cord injuries.

The impact of this work has been internationally substantial, influencing medical and legal professionals, and informing lay people with involvement in cerebral palsy. Her work is also widely cited by patient-networks and textbooks.

Hutton is regularly called by both defence and plaintiff lawyers, as an expert witness worldwide, assessing life expectancy for damages arising from negligence in obstetric or paediatric care, or from accidents. Her expertise is also used in brain and spinal cord injury cases, which also result in substantial awards. The award of appropriate damages in legal cases ensures that patients receive the best care for the rest of their lives. From Jan 2008 to July 2013 Hutton has provided expert evidence in 103 such cases around the world, which had impact on decisions about compensation totalling in the range £100M-450M.

2. Underpinning research

The underpinning research contains two main and symbiotic strands: underpinning methodological statistical research, and applied statistical analyses focused on the survival of patients with cerebral palsy and related neurological disorders.

Between 2000 and 2005, Professor Hutton's statistical research in survival analysis was focussed on reliable and robust estimation of lifetime distributions. Her research with two PhD students [1, 2] derived the distributions of estimators of regression coefficients under mis-specified proportional hazard and accelerated life models, and thus demonstrated the increased power and precision of accelerated life models. Hutton with Hemming (research fellow at Warwick on an MRC grant [8]) proposed a Bayesian methodology for assessing assumptions about the *missingness* status of covariate data, and the effects this has on inference for accelerated failure time models [3].

Hutton's methodological statistical research determined the use of accelerated life models for the substantive clinical analyses. The increased power of inference using these models allowed more subtle effects to be detected. In particular, in 2002, Hutton, with Pharoah (Department of Public Health, University of Liverpool), published [4] the first article to establish that visual disability is strongly associated with survival of people with cerebral palsy, both univariately and after allowing for motor and mental disabilities. The publication [4] also demonstrated a decline in survival since 1966 for certain sub-groups. Hutton, Hemming and two clinical colleagues established that after disabilities were taken into account, survival did not differ between regions of the UK, but it did differ by socio-economic status and birth weight [5], and the same research team subsequently showed that the socio-economic effect was best explained by intra-uterine growth [6].

In related applied research using the same underpinning statistical methodology for survival analysis (from [1, 2, 4]) Hutton has also analysed survival of people with spinal cord injuries [7].

Professor Hutton has been a full-time member of academic staff in the Department of Statistics at Warwick, where she carried out this research, since October 2000. She took the lead on all

statistical research described above and also initiated the clinical papers listed.

Dr Hemming was funded as a post-doctoral research fellow on MRC grant G9900630 - Feb 2001 - June 2005 [8]. Dr GPS Kwong was a Statistics Department-funded PhD student Oct 2000-June 2003. Dr K Boyd was an EPSRC-funded PhD student Oct 2003-Feb 2007. Key clinical research contributions contributing to this body of research have been made by Professor POD Pharoah, Dr MJ Platt (University of Liverpool); Dr A Colver (Newcastle University); and Prof J Kurinczuk (Oxford University).

3. References to the research

Publications: (Warwick researchers in bold)
1. **J. L. Hutton** and P. F. Monaghan. Choice of Parametric Accelerated Life and Proportional Hazards Models for Survival Data: Asymptotic Results. Lifetime Data Analysis, 8(4) 375-393. (2002) DOI: 10.1023/A:1020570922072
2. **G. P. S. Kwong**, and **J. L. Hutton,** Choice of parametric models in survival analysis: applications to monotherapy for epilepsy and cerebral palsy. Journal of the Royal Statistical Society: Series C (Applied Statistics), 52: 153–168. (2003) DOI: 10.1111/1467-9876.00395
3. **K. Hemming and J. L. Hutton.** Bayesian sensitivity models for missing covariates in the analysis of survival data. J. Eval. Clin. Pract. (2010) DOI: 10.1111/j.1365-2753.2010.01569.x.
4. **J. L. Hutton** and P.O.D. Pharoah. Effects of cognitive, motor, and sensory disabilities on survival in cerebral palsy. Arch.Dis.Child 86:84-89. (2002) DOI: 10.1136/adc.86.2.84
5. **K. Hemming, J. L. Hutton,** A. Colver and M.J. Platt. Regional variation in survival of people with cerebral palsy in the United Kingdom. Paediatrics, 116(6) 1383-1390. (2005) DOI: 10.1542/peds.2005-0259
6. **K. Hemming, J. L. Hutton,** S. Bonellie and J. Kurinczuk. Intrauterine growth and survival in cerebral palsy. Arch Dis Child Fetal Neonatal Ed. 93 F121-F126 (2008) DOI: 10.1136/adc.2007.121129
7. **J. L. Hutton,** J.H.W. Watt and E. Wiredu. Letter commenting on 'Survival after short- or long-term ventilation after acute spinal cord injury: a single-centre 25-year retrospective study.' Spinal Cord 50 859-860. (2012) DOI: 10.1038/sc.2012.106.

Grant:
8. **J. L. Hutton** (PI) (including a sub-contract to Liverpool - CI POD Pharoah), `Life expectancy in cerebral palsy: UK collaboration' MRC, G9900630, Feb 2001-Jan 2005 (36 months, extended by maternity leave), £229,000

4. Details of the impact

As a direct result of this body of research, Professor Hutton's estimates of life expectancy for those afflicted by cerebral palsy and other neurological injuries are widely requested and used internationally. The impact of this has been broad in both **reach** and **significance** to legal professionals, individuals and healthcare providers, in particular in legal financial settlements.

Evidence for life expectancy in litigation

International reach:

Since 2008, Hutton has provided expert evidence for 73 cases related to cerebral palsy life expectancy, and 30 cases concerning spinal cord and brain injuries. Expert reports use data which are maintained and updated by Hutton and refer to her published research. These include cases in the UK, Australia, Canada, Hong Kong, South Africa and Eire. In adversarial jurisdictions, two life expectancy reports are usually provided, although in England, Wales and Australia, expert witnesses can receive joint instructions from both sides. Hutton has provided reports for defendants or plaintiffs, or in response to joint instructions. In Scotland, where experts are only allowed to provide reports for one side, Hutton's reports are respected by both pursuers and defenders (for example [9a, 10, 11]). In Scotland, Hutton provided evidence for 33 cases during 2008-13, estimated to be about two thirds of all cerebral palsy births subject to a claim.

Within the UK, there are few expert witnesses instructed on life expectancy after neurological injuries besides Hutton, and they all typically cite Hutton's research in their evidence. Internationally, the only other experts routinely instructed are the California-based *Life Expectancy Project.* Their reports cite Hutton's research, and she regularly appears in the same cases (for example [12]).

Hutton has been approached on behalf of the [text removed for publication] to secure her services as expert witness for future cases and instructions [13].

Significance and applications of life expectancy expert reports:
The majority of high-value medical negligence cases address allegations of obstetric failures, which lead to cerebral palsy.

Annual payments by the NHS Litigation Authority (England) on clinical claims increased from £863M in 2010/11 to £1.28 billion in 2011/12. 35% of these claims result from cerebral palsy cases [9b].

Since settlements are generally confidential, it is not possible to give precise figures to quantify the financial impact of Hutton's work. Minimum disagreements between the pursuers and defendants are of the order of five years, but are more usually ten or more years in cerebral palsy. As annual costs for care for a severely disabled person are at least £200,000 (see for example [14]), this equates to £1 million per case for a discrepancy of 5 years, and to £2m per case when the discrepancy is ten years. Moreover, for a person who might require two paid staff in attendance for 24 hours a day, the annual cost of care would be twice as much. The economic impact of Hutton's research in the years 2008-2013, for 100 cases, would therefore be conservatively estimated in the range £100M-450M.

Corroborating evidence of the majority of the 103 cases that Hutton has provided expert evidence for (2008-2013) can be provided by the HEI but due to limitations on space and references allowed, only one will be described below.

One example of a motor and industrial case is the largest individual settlement in the UK, awarded to Agnes Collier, who suffered spinal cord injury in a car accident on 18 March 2009, resulting in a settlement agreed on 19 November 2012. The sum awarded, £23 million, was calculated directly from Hutton's evidence on life expectancy. [15]
"[text removed for publication]

[text removed for publication] "[15].

Patient networks:
Hutton provided information for a 'CP factsheet on cerebral palsy research' [16] provided by a Scottish charity, Capability Scotland, which supports people with cerebral palsy and their families. This factsheet is updated annually, and she has commented on the 2013 version, at the request of Capability Scotland. The factsheet links to a four-page leaflet on CP research providing information for the general public on Hutton's website, which also attracts references from an internet forum of SCOPE, the cerebral palsy charity for England [16]. She and Professor Pharoah have also provided specific advice about life expectancy to a few individual members of the public who have approached them (e.g., [17]).

Further practitioner reach:
Hutton's cerebral palsy research is cited in two textbooks for paediatricians and epidemiologists (2010, 2009) [18].

Hutton has given seminars on life expectancy as part of continuing professional education for lawyers, through the Association for Victims of Medical Accidents (AVMA) (London, 2008) [19].

5. Sources to corroborate the impact

9a. [text removed for publication]

[text removed for publication]

9b. NHSLA (http://www.nhsla.com/Claims/); BMJ 2013;346:f978 doi: 10.1136/bmj.f978

10. [text removed for publication]

11. [text removed for publication]

12. Strauss D and Brooks J (California Life Expectancy Project); *Report on Life Expectancy of Ryan Coyle*, dated 25th April 2013.

13. [text removed for publication]

14. [text removed for publication]

15. Agnes Collier case: Settlement was widely reported in the media. For example, http://www.dailymail.co.uk/news/article-2235334/Agnes-Collier-17-paralysed-crash-killed-mother-awarded-23m-compensation-payout.html).

[text removed for publication]

16. Capability Scotland factsheet "Cerebral Palsy Research". http://www.capability-scotland.org.uk/media/57746/cerebral_palsy_research_2013.pdf; and
SCOPE forum which refer to leaflet "J L Hutton and K Hemming - Life expectancy of children with cerebral palsy" on Hutton's website at http://www2.warwick.ac.uk/fac/sci/statistics/staff/academic-research/hutton/scope4.pdf

17. [text removed for publication]

18. Textbooks: 'Textbook of perinatal epidemiology' (2010), E Shiener (editor)
'Paediatric Rehabilitation Principles & Practices: 4th Edition' (2009) MA Alexander, DJ Matthews

19. Event programmes with Hutton's name as a lecturer for AVMA conferences can be requested from: http://www.avma.org.uk/ (0845 123 23 52)