Issue 5.3

Nosokinetics News

June 2008

Bi-monthly Newsletter of the UK Nosokinetics Group
Past issues at http://www.nosokinetics.org/

Highlights:

Call for papers for a special volume of Studies in Computational Intelligence, (Springer) on Intelligent Patient Management. Deadline 30th June 08

How do you communicate? Words or models?

Mark Mackay tells the story of his PhD: The road continues—a journey

A new style of references to modelling papers—seeking semi-automation

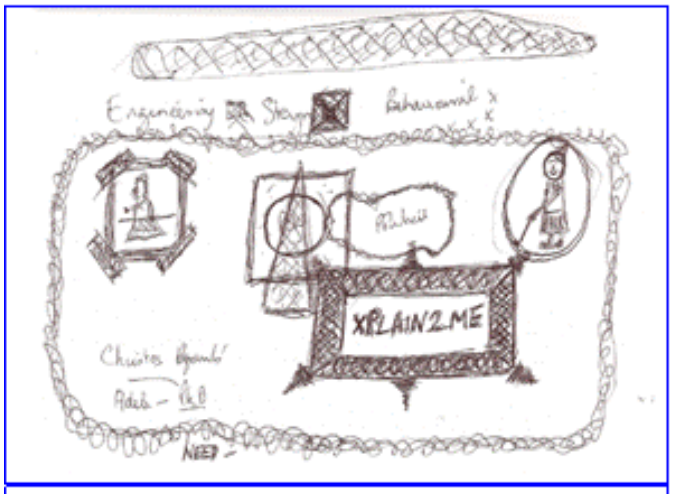
Congratulations: Adele Marshall Reader in Mathematics and Statistics at Queen's University Belfast

Adele is the Director of the Centre for Statistical Science and Operational Research (CenSSOR) at Queen's University. After gaining a First Class degree with distinction at the University of Ulster, Adele's 2001 PhD with Sally McClean was on 'Bayesian Belief Networks using conditional phase-type distributions.' Since joining Queen's University in 2002 as a Lecturer, Adele has gained a national and international recognition of her work. Three years ago she was promoted to Senior Lecture and this promotion is further recognition of the contribution she is making to research and scholarship. Her web site lists her research interests as Survival Analysis; Bayesian Networks; Coxian Phase-Type Distributions; Simulation; Stochastic Processes; Markov Modelling; Patient Length of Stay; Patient Costs/Expenditure; Probabilistic Cost-effectiveness Analyses in Healthcare.

Modelling Health and Social Care Systems

Do you communicate in words or models (See page 2)

Have you ever scribbled on a piece of paper (or even a table napkin) a sketch, a model, to describe your ideas. In the early days of my collaboration with Sally McClean we would draw ideas on envelopes whilst imbibing Guinness in a Portrush bar. I remember, as if it was yesterday, the evening in 1993 when Sally put her finger on a line in a sketch and said "If you rub that line out, I can solve that". "How long will that take?' I naively replied. "A couple of days" she said "but it will make a good PhD."



Idle scribbles during an international phone call with Mark Mackay. Top left .Is the Iceberg a suitable logo?. Top middle symbiotic systems with political intervention. Top right, shouldn't I be playing golf instead. XPLAIN2ME: three things structure, persons and behaviour.

Four years later Gordon Taylor's 1997 doctoral thesis '*Geriatric Flow Rate Modelling'* used stochastic Markov models to extend the two compartment Harrison bed census model of flow, first to a four, then to a five or a six compartment model of flow to explain the interactions between hospital and community care of patients admitted to the St. George's Hospital department of Geriatric medicine.

Since then six theses have extended the knowledge base: Adele Marshall 2002 University of Ulster thesis ''*Bayesian Belief networks using conditional phase-type distributions'*; Christos Vasilakis 2003 at University of Westminster '*Simulating the flow of patients: an OLAP-enabled decision support environment'* ; Haifeng (Kevin) Xie (ibid) 2004 *'Modelling issues in institutional long-term care*'; Brijesh Patel 2007 (ibid), '*Performance and the National Health Service modelling for formative policy evaluation and strategic planning'* ; and Mark Mackay 2007 University of Adelaide *'Compartmental flow modelling of acute care hospital bed occupancy for strategic decision making'* . And four more are in the pipeline.

None of this comes without considerable effort and we welcome Mark's contribution on the benefits and burdens, pro's and con's of undertaking doctoral research work while in full time occupation and a young family. Indeed a tough task not to be taken lightly.

Modelling Health and Social Care Systems

Do you communicate in words or models?

Four recent papers on the theme caught my eyes ...

Visualization and model formulation: an analysis of the sketches of expert modellers

Waisel et al develop a quantitative approach to interpretation of models. Exploring experts at work they find that sketches are used more when the focus is on structure or realization, and the more complex the problem sketches begin earlier. There findings are part of ongoing research to develop a quantitative approach to the science of modelling and to the teaching of novice modellers.

Waisel, L. B., Wallace, W. A. and Willemain, T. R. *2008. Journal of the Operational Research Society. 353-361*

Conceptual modelling for simulation Part I: definition and requirements

Two papers in JORS focus on the need for a framework to underpin conceptual models, primarily in discrete event simulation. The Clients own and receive the results of the model; the Modeller creates the model, and the Domain experts provide data and information for the project. Put simply conceptual modelling requires five stages: understanding the problem; determining the model and the objectives; identifying the model outputs (responses) and the inputs (experimental factors) and determining the model content (scope and level of detail) assumptions and simplifications. In general the modeller should keep the model as simple as possible to meet the objectives. The central theme is to aim for simplicity through evolutionary development.

Robinson, S. 2008. Journal *of the Operational* Research *Society. 278-290*,

Conceptual modelling for simulation Part II: a framework for conceptual modelling

Part two illustrates the process of conceptual modelling using a project with the Ford Motor Company focusing on the four requirements of validity, credibility, utility and feasibility. No conceptual model is exactly right as the evolutionary process involves the different perceptions of the modellers and the domain experts. Thus the final goal of a complete perfect model is unobtainable. Instead, the aim should be to provide a framework as a means of communicating, debating and agreeing a simulation model, while also allowing for creativity in the modelling process.

Robinson, S. 2008. Journal *of the Operational Research Society. 291-304*

System Dynamics: Modelling acute care

Sponsored by the Department of Health (UK). Describes the development and use of a hybrid form of qualitative mapping - stock/flow symbols - derived from system dynamics—to model the flow of acute patients within the NHS. Preliminary activities included London-centred expert interviews and hospital site visits using a semi-structured agenda. Core and sub-systems flow maps provided materials for group activities in Regional Workshops. Responses finalised 'Suite Models' (core and sub-system maps) which led to Intervention themes.

Conceptual frameworks described service specific (surgical) and whole system models of the care of acute patients. Three workshops, involving middle and senior level managers, corrected inaccuracies and introduced important new elements. The internal report focused on two clusters or themes. One improving flow of acute patients and a move to a seven day a week service. The other focusing on creating improved patient filtering prior to admission. The hypothesis being that investment in community care, step-down facilities and admission prevention, could reduce admissions and prevent hospital acquired dependency.

Lane, D. C. and Husemann, E. 2008 *Journal of the Operational Research Society. 213-224,*

Compartmental Flow Modelling of Acute Care Hospital Bed Occupancy for Strategic Decision-Making or the Road Continues – a Journey

Dr Mark Mackay

Senior Consultant, Policy and Intergovernment Relations Division, SA Health Government of South Australia and Visiting Research Fellow, School of Psychology, University of Adelaide

Introduction

This short article is about my doctoral thesis. The idea for research stemmed from a real problem – how to look at hospital bed problems as a consequence of funding implications.

While it was relatively easy to analyse typical administrative data, the dilemma came in that there was no definitive way found that could be used to justify, modify or reject the claim that extra beds were required. Indeed, it was stated "*there's nothing but the average length of stay that can be used. We've tried getting someone to model this – but they couldn't. There's nothing in the literature*."

My own literature search revealed that there were papers being written on the subject of hospital bed management. The papers ranged from reasonably simplistic approaches as suggested by Sorensen (1996) which still relied upon the average length of stay to more sophisticated approaches as suggested by Harrison and Millard (1991). What was perhaps unusual – and still is – that many of the papers on this topic were "oncers" – with the authors seemingly never repeating their efforts again. The work of Millard, however, was different – a body of work was emerging with co-authors including Harrison and McClean (see references for Harrison, McClean, Millard and Taylor).

As it turned out, I had the opportunity to meet Millard in London at St Georges. A brief meeting led to me starting to "play around with BOMPS", the software package that was developed as a consequence of Harrison and Millard's bed research work. Presenting the findings of my work was met with mixed results from "*this is really good*", to blank faces (i.e., I don't get this), to *"this is just black box output – prove it".* The only way to resolve the latter was to undertake the necessary research to find out whether the work by Harrison and Millard (1991) that was based upon geriatric data from another country was relevant to acute care data in Australia. As the initial work clearly indicated that the method seemed to be working.

So what was the research about?

Some background about Australia's health care system
Australia's total health expenditure for 2004-05 was $87.3 billion, the ninth highest among 29 other OECD countries. The use of health care services and expenditure pattern is well established and Australia follows the pattern found in most developed countries, with the greatest expenditure occurring on services for the elderly. Like many other developed countries, Australia is experiencing a shift in population structure, with the proportion of older people forecast to increase. Consequently, it is expected there will be a need for a greater level of expenditure on health care as the number of elderly people increase.

A need for better decision-making – in relation to hospital beds
There is an emerging gap between the ability to supply health services and the demand for them. Furthermore, acute care hospital treatment is generally considered expensive and governments have been keen to control this expenditure.

It is imperative that governments are able to make decisions based upon robust policy advice. There are serious consequences in both economic resource allocation and patient (and population) health outcomes if decisions about future health service structures are incorrect. In particular, there is a need for better decision-making around bed management *at the strategic level.* Strategic decision-making relates to decisions that will occur in a longer time frame.

Decision-making can benefit from the use of modelling. Models represent a simplified version of reality that preserve the essential features of the situation being examined and can be used as a tool to investigate decision-making options, particularly in complex environments such as the health sector.

Historically decision-making relating to hospital beds has used either simple "back of the envelope" calculations or adherence to "rule of thumb" approaches. Most of the approaches have relied upon using the average length

of stay metric. While the modelling of hospital bed numbers is not new, much of this work has relied upon the average length of stay measure, which is known to a poor measure of occupancy, as the distribution of stay tends to be highly skewed.

Harrison and Millard (1991) introduced the application of the compartmental flow model for modelling hospital bed occupancy and noted its potential to be used to influence policy decision-making. Their research relied upon data from a geriatric health service in the United Kingdom and used a single day census approach to collect the data. The flow model results are plausible and easily interpreted. However, relatively little work has focused on the ability of these models to be generalized and be used for predictive purposes.

The research

My thesis focused on the investigation of whether the compartmental flow models of bed occupancy originally described by Harrison and Millard for decision-making around geriatric service care in the English National Health Service can be used to describe data from acute care hospitals in Australia and New Zealand.

The research consisted of a series of modelling experiments that can be broken into two key stages:

1. whether the models could be successfully applied to the acute care data; and
2. whether the models could be used for novel purposes, such as forecasting, evaluation of service change, and benchmarking.

This entailed the further development of the model, and a consideration of basic modelling issues such as the balance between data-fit and model complexity, in order to capture better variation in the data and also to facilitate linkage to population change.

While the research relied on approaches that are often mathematical or statistical in nature, it was deliberately presented in a style that is devoid of extensive mathematical notation to so that it could be communicated to a multi-disciplinary audience.

The research findings

The findings included:

- Confirmation that acute care hospital data could be described by the Harrison and Millard (1991) compartmental flow model;
- The use of more data resulted improved model fit;
- Use of the Bayesian information criterion to assist with model choice;
- Application of the modelling approach to consider the impact of population change;
- Introduction of new simulation and sensitivity approaches;
- Modification of the approach to incorporate seasonality; and
- Use of the model for benchmarking at the service and case mix level.

Conclusion (or where to from here)

I was fortunate to already have worked in the health sector while undertaking my doctoral research. I continue to work in the health sector. The completion of any PhD is a landmark for the individual. So what did I get from this experience? I have learnt a lot along the way, met some interesting people whose insights have been valuable to me, had the opportunity to do some interesting research and made some friends that I wouldn't have otherwise made.

However, the completion of a PhD does not mark the end of the need for more work, and so the work on bed modelling continues and additional research is planned with others. Also, opportunities to apply the research are also being sought and development of a means of enabling others to create similar models with readily available software is occurring. I am also involved in other areas of health services research, including the development of health work force analysis methodologies. I am fortunate to be able to continue my involvement in academia through appointment as a visiting research fellow at the University of Adelaide.

Would I recommend others take this path? In hindsight, undertaking a PhD on a part-time basis, with a young family and while working primarily full-time, is a difficult task. Researching a topic that is multi-disciplinary in nature is also more difficult than taking on research that is well defined in a single discipline. Health services research is, despite the problems being encountered by the health sectors around the world, poorly funded compared to many other areas of research.

I believe undertaking such research will be important in the future, and the reception to such work is slowly increasing now. I think, however, the pluses outweigh the minuses, and providing you can juggle the necessary workload, I would recommend starting on the road to more study! If you don't already work in the health sector, I would, however, suggest that you think strongly about doing any doctoral research on a part-time basis and also aim to work

Acknowledgments

I was fortunate to have two particularly outstanding supervisors for my doctoral studies – Professor Peter Millard (editor of Nosokinetics News) and Associate Professor Michael Lee (formerly of University of Adelaide and now at University of California, Irvine). Dr Simon Dennis stepped into the breach to help facilitate my work when Michael left for California (although Michael continued to provide his valuable advice from afar). Simon has also since followed Michael's lead and departed for America.

Of course, while it was my journey, it would not have been possible without the support of my supervisors and the love of my wife, Marisa, and my family. An electronic copy of my thesis can be accessed from the University of Adelaide library.

For further information

An electronic copy of my thesis can be accessed from the University of Adelaide library at:
http://digital.library.adelaide.edu.au/dspace/handle/2440/41204 or email mark.mackay@adelaide.edu.au

Group References cited by Mark — 1989-1998

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Taylor G, McClean S and Millard P (1998). Continuous-time Markov models for geriatric patient behaviour. *Applied Stochastic Models and Data Analysis,* 13: 315-323.

An estimation of distribution algorithm with intelligent local search for rule-based nurse rostering

Modelling enables decision makers to better understand the task which needs to be done. Building on previous research, a probabilistic model of nurse scheduling is created and tested using an estimation of distribution algorithm, local search and ant colony optimization. The model may be suitable for other scheduling problems where schedules are built systematically according to specific rules.
Aickelin, U., Burke, E. K. and Li.J. 2007 Journal of the Operational Research Society. 1574-1585.

Effects of clinical characteristics on successful open access scheduling

Squaring the Circle. Review article describing benefits and drawbacks to open access policies. Four variables interact: the fraction of patients needing open access; the scheduling horizon for long-term appointments; provider care groups; and overbooking. Uses discrete event simulation and data from an intercity clinic in Indiana. Concludes, that if correctly configured, open access can lead to significant improvement with little sacrifice in continuity of care.
Kopach, R., DeLaurentis, P. C., et al 2007. Health Care Management Science. 111-24.

Applying systems engineering principles in improving health care delivery

Discusses the fundamental concepts and tools of systems engineering and draws parallels between systems engineering, health services, and implementation research as it pertains to the care of complex patients. Illustrates benefit these concepts bring in the areas of haemodialysis, radiation therapy, and patient flow modelling. Key principles, identify the system of interest, choose appropriate performance measures, select the best modelling tool, study the model properties and behaviour under a variety of scenarios, and make design and operational decisions for implementation. Discusses the challenges and opportunities for bringing people with systems engineering skills into health care. Full report available on line in PubMed.
Kopach-Konrad, R., Lawley, M., et al. N. 2007 Journal of General Internal Medicine. 431-7.

A comprehensive simulation for wait time reduction and capacity planning applied in general surgery

Describes a discrete event simulation model analysing waiting times to aid capacity planning and performance in a Canadian Health Authority. Outcome of redistributing beds and achieving standard lengths of stay are contrasted with current and additional resource options. Multiple independent and combined options for stabilizing and decreasing waits for elective procedures are proposed.
VanBerkel, P. T. and Blake, J. T. 2007 Health Care Management Science. 373-85.

Case based reasoning technology for medical diagnosis

Case based reasoning addresses the problems found in traditional Artificial Intelligence techniques, e.g. the problems of knowledge acquisition, remembering, robust and maintenance. Discusses the CBR methodology, the research issues and technical aspects of implementation. Successful applications in cancer and heart diseases developed by Medical Informatics Research Group at Ain Shams University are also discussed.
Salem, A.-B. M. (2007). Proceedings of World Academy of Science November 2007 ISSN 1307-6884.

The use of simulation in emergency medicine; a research agenda

In 2005, the Society for Academic Emergency Medicine created a Simulation Task Force. Citing over a 100 references, the task force reports the creation of a research agenda for simulation in emergency medical education. Opportunities include the study of reflective experiential learning, behavioural and team training, procedural simulation, computer screen-based simulation, the use of simulation for evaluation and testing, and special topics in emergency medicine. Challenges are discussed, including the impact of simulation on patient safety. Outcomes-based research and multicentre efforts will serve to advance simulation techniques and encourage their adoption.
Bond, W., F,, Lammers, R., L,et.al 2007. Academic Emergency Medicine. 353.

Modeling length of stay as an optimized two-class prediction problem

Develops a predictive model for the outcome length of stay at the Intensive Care Unit (ICU LOS), including the choice of an optimal dichotomization threshold for this outcome. Introduces the MALOR performance statistic. The class probability tree method is used to develop predictive models in cardiac surgery. The best model precision is found at the threshold of seven days. The method can be applied to all prediction problems where the outcome variable needs to be dichotomized, and is insensitive to changes in the prevalence of positive cases with different dichotomization thresholds.
Verduijn, M., Peek, N., Voorbraak, V.,et al.. 2007. Methods of Information in Medicine. 352.

Issue 5.3 **Nosokinetics News** June 2008

Bi-monthly Newsletter of the UK Nosokinetics Group

Call for Papers

The Second International Health and Social Care Modelling Conference (HSCM2008) has been a great success (see http://info200.infc.ulst.ac.uk/events/hscm2008/).

A special volume of Studies in Computational Intelligence, published by Springer, on Intelligent Patient Management will be published as post conference proceedings and is open to quality papers not presented at the conference. All submitted papers will undergo the normal peer review process.

We welcome papers in the broad areas of computational patient-centred practical and theoretical approaches for measuring and modelling, managing and evaluating health and social care systems. Topics include but are not limited to:

- Capacity /Resource planning
- Planning
- Community Care Management
- Disease Monitoring and Management
- Early Diagnosis and Screening
- Forecasting
- Forward planning
- Impact of E-Health and Smart technology on patient management
- Implementing Change
- Length of stay modelling
- Long Term Care
- Long Term Planning
- Patient flows
- Queues and occupancy
- Resource Usage
- Strategic planning
- Waiting List Management
- Workforce Planning

Important dates

- Deadline for paper submission: End of June 2008
- Deadline for the first round of refereeing: End of Oct. 2008
- Deadline for submitting revised papers: End of Dec 2008
- Publication: Late 2009

Please submit by email (PDF or Word file) to Sally McClean si.mcclean@ulster.ac.uk
Final versions of accepted papers should follow the Springer style, available at: www.springer.com/series/7092

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Chris Nugent (University of Ulster)

Nosokinetics News is the newsletter of the UK Nosokinetics Group

Nosokinetics is the science / subject of measuring and modelling the dynamic aspects of patient and client movement (flow) through health and social care systems. From the Greek, literally, *noso* (sickness) and *kinetics* (movement).

The group collaborates to organise conferences and disseminates news of our and others research and practical use of modelling to enhance decision making in health and social care systems.
Past issues in PDF at http://ww.nosokinetics.org/

Thanks to IMS our web archive of full texts of submitted papers between 2006-2007 is at:
http://www.iol.ie/~rjtechne/millard/index0.htm

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