Issue 7.3 **Nosokinetics News** July 2010

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

Nosokinetics
HEALTH & SOCIAL CARE MODELLING

Climbing the mountain: Manna from heaven—multistage models

Gary Harrison

Length of stay and imminent discharge probability distributions from multi stage models: variation by diagnosis, severity of illness, and hospital. Harrison, G. W. and G. J. Escobar (2010). Health Care Management Science 13: 268-279.

Back view Gary climbing at the Giant's causeway Portrush 2008

On the 23rd of June, an email from Gary Harrison, Prof of Mathematics at the College of Charleston. South Carolina, USA, brought manna from heaven. We first met in 1989 when I was on a mini sabbatical in Charleston. Coincidently, researching death on movement, we had confirmed an early observation made by Struthers in1963 that an equation with two exponents describes the pattern of bed occupancy in departments of geriatrics with short stay and long stay patients.

Given the evidence Gary developed the first mathematical solution to a two compartment model of flow through departments of geriatric medicine. I well remember the time that I heard the first equation. Ac = Lv. Put simply. In a department of geriatric medicine with a constrained bed allocation, providing inpatient care for short stay and long stay patients, the conversion rate of short stay patients to long stay must equal the availability of beds in the long term care system. If Ac > Lv then the number of long stay patients increase and the number of beds available for short stay patients decrease. Vice versa, when Ac < Lv, admissions increase.

Chaos Hurricane Hugo

When Hurricane Hugo struck, Our face to face collaboration ceased abruptly. However, ever since on one side of the Atlantic Gary in Charleston and Sally McClean in Northern Ireland, have step by step driven forward the development of deterministic models of care processes in health and social care systems.

Now 21 years after we first met, Gary in collaboration with Gabriel Escobar at the Kaiser Permanente Medical Care Program has developed a methodology, which shows that probability distributions are strongly influenced by the degree of physiological derangement on admission, pre-existing comorbidities, or a summary mortality risk combining these with age, sex, and diagnosis.

The data concerns the length of stay of 317,876 hospitalisations between 1st May 2003 and the £0th April 2005. 5/1/03 through 4/30/05 to the 17 hospitals in the Northern California KPMCP, serving 3.3 million members: 3.5% of admissions ended in death. The multistage mathematical model assumes that patients require varying degrees of treatment, with some patients going through more phases of inpatient care. Mathematically, the stages represent transitions in the healing process of the patient and not physical location in the hospital.

Multistage models describe the shape of the entire LOS distribution and how it is affected by initial patient characteristics. Skewed distributions and extreme outliers are not a problem, they were designed for it.

Multistage model of resource use by 1000 pneumonia patients with high predicted mortality

	Percent in phase	*Time in phase*	*Bed days*	*Resources used (%)*
Stage One	*100%*	*0.28 days*	*280*	*3.6%*
Stage Two	*98.3%*	*1.28 days*	*1258.2*	*16.4%*
Stage Three	*88.5%*	*5.72 days*	*5060.3*	*65.8%*
Stage Four	*2.9%*	*37.03 days*	*1081.3*	*14.0%*

Adapted from page 278 Health Care Manag Sci (2010) 13:268-279

For pneumonia patients, the greater severity of illness changes the most frequent changes the most frequent LOS only slightly, but makes the distribution much more dispersed. And as the table shows, as in geriatrics so in general medicine small numbers make big differences. Simply put the longer you are in a clinical service the longer you will stay. Moreover, considering the big picture, early discharge, far from being a goal to aim for may be a false economy and a sub-optimal approach to inpatient care, even more so if one in ten come back.

References: P4 early evidence, Gary's contribution and KPMCP, COPS and LAPS research

Capacity Planning of a Perinatal Network: A Loss Network Framework.

PhD Thesis March 2010. Md Asaduzzman. Thierry Chaussalet's HSCMGroup University of Westminster

Editor's comment.

Collaboration with the clinicians in the University College Hospital Neonatal Service underpins this research. Changing patterns of parental behaviour, socially postponing birth to convenient times, and increasing use of artificial insemination , coupled with increasing technical skills in clinical care create the need. The question then becomes how, when, and where should facilities be developed to meet the need.

Abstract. Capacity planning in the neonatal health care system has become a major issue in the UK, since admission rejection in neonatal units has increased over past years due to capacity shortage. The thesis builds a capacity planning model for a perinatal network, based on admission rejection probability, with specific application to the North Central London Perinatal Network.(NCLPN),

First, a decomposition method has been performed to obtain steady state behaviour for a perinatal network due to higher dimensionality and complex transfers and back transfers. Then, a standard Erlang loss model has been applied to all neonatal units in the network. Since the model cannot capture overflow, an overflow loss network framework has been developed capturing the actual patient flow in the perinatal network.

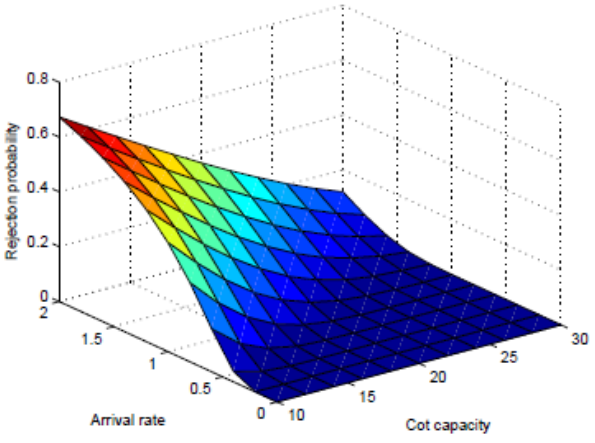
The steady state expressions for overflow and rejection probabilities have been derived for each neonatal unit of the network. Using the model, decisions on number of cots can be made for specific levels of admission rejection probability for each level of care at each neonatal unit of the network and specific levels of overflow to temporary care.

The overflow model framework assumes that inter-arrival and LoS in the neonatal units are Markovian which might be impractical occasionally. Therefore, a generalised model framework has been derived, which is based on a two moment approximation, mean and variance of the inter-arrival and LoS.

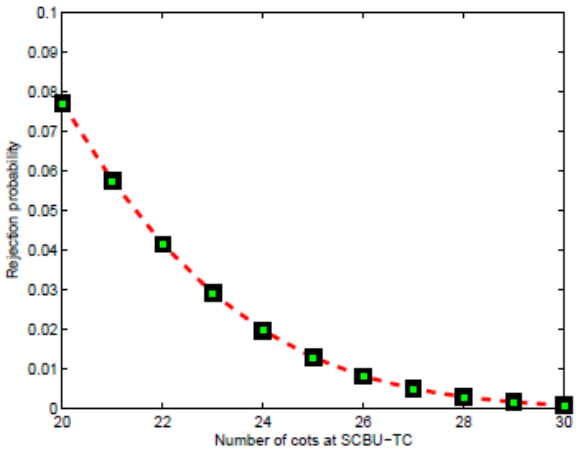
Finally a simulation model has been developed to check the consistency of analytical results derived via the decomposition method. We believe the model developed in this thesis would help on planning capacity for neonatal units in the perinatal networks.

The model framework should be of great interest to the Department of Health (DH), perinatal network managers, clinicians, health service planners and researchers.

Length of stay and imminent discharge probability distributions from multi stage models: variation by diag



(c) Rejection probability against arrival rate and number of cots at SCBU-TC



(d) Rejection probability against number of cots at SCBU-TC

PS. Asad has now returned to Bangladesh. We wish him well and every success in his research and teaching career. It was a pleasure and a privilege to know him and to witness his determination to succeed.

Ahmed, A. A., C. I. Hays, et al. (2010). "Predictors of in-hospital mortality among hospitalized nursing home residents: an analysis of the National Hospital Discharge Surveys 2005-2006." J Am Med Dir Assoc **11**(1): 52-58.

Chronic morbidities were not associated with in-hospital mortality., age 85 years or older and several acute conditions, but not chronic morbidities, predicted in-hospital mortality..

Bain, C. A., P. G. Taylor, et al. (2010). "Myths of ideal hospital occupancy." Med J Aust **192**(1): 42-43.

Significant problems in health care, such as access block and long waiting lists for elective surgery, have led to calls for keeping hospital occupancy at no more than 85%. It is elementary queueing theory that a finite-capacity system with variable demand cannot sustain both full utilisation and full availability. However, the statement that there is a single level of ideal or safe occupancy suitable for all situations is a simplistic interpretation and application of the underlying science. We argue that specific study and action are necessary to understand and deal with the problems of long waiting lists and access block in any given health care facility.

Boutsioli, Z. (2009). "Measuring unexpected hospital demand: the application of a univariate model to public hospitals in Greece." Hosp Top **87**(4): 14-21.

Eijkemans, M. J., M. van Houdenhoven, et al. (2010). "Predicting the unpredictable: a new prediction model for operating room times using individual characteristics and the surgeon's estimate." Anesthesiology **112**(1): 41-49.

Detailed information on the operative session, the team, and the patient substantially improves the prediction of OR times, but the surgeon's estimate remains important. The prediction model may be used in OR scheduling.

Fletcher, A. and D. Worthington (2009). "What is a 'generic' hospital model?--a comparison of 'generic' and 'specific' hospital models of emergency patient flows." Health Care Manag Sci **12**(4): 374-391.

Distinguishing three types of genericity and identifying 24 important features of models and the associated modelling process. Many features are common across model types, but there are also important distinctions, with implications for model development.

Hintz, S. R., C. M. Bann, et al. (2010). "Predicting time to hospital discharge for extremely preterm infants." Pediatrics **125**(1): e146-154.

Predictive models that use a few key risk factors are comparable to the full models and may offer a clinically applicable strategy.

Nager, A. L. and K. Khanna (2009). "Emergency department surge: models and practical implications." J Trauma **67**(2 Suppl): S96-99.

Parenti, N., L. Ferrara, et al. (2009). "Reliability and validity of two four-level emergency triage systems." Eur J Emerg Med **16**(3): 115-120.

Pines, J. M., A. Prabhu, et al. (2010). "The effect of ED crowding on education." The American journal of emergency medicine **28**(2): 217-220.

Harrison, G. W. and G. J. Escobar (2010). Health Care Management Science 13: 268-279.

Escobar supporting papers

Risk adjusting community-acquired pneumonia hospital outcomes using automated databases
Escobar, G. J., B. H. Fireman, et al. (2008). Am J Manag Care 14(3): 158-166.
America Abbreviated Fine Severity Score (AFSS), 6147 hospitalised with community-acquired pneumonia in all Provide clinically relevant risk-adjusted outcomes reports to clinicians in an integrated healthcare delivery system. Concludes It is possible to apply risk-adjustment methods from research settings to operational ones.

Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases
Escobar, G. J., J. D. Greene, et al. (2008). Med Care 46(3): 232-239.
America. Logistic regression. Data 50% random sample of 259,699 admissions to 17 hospitals. Inpatient mortality 3.50%; 30-day mortality 4.06%; Develops a risk-adjustment methodology that maximizes the use of automated physiology and diagnosis data from the time period preceding hospitalization. .Final model includes sex, age, admission type, admission diagnosis, a Laboratory-based Acute Physiology Score (LAPS), and a COmorbidity Point Score (COPS). Best model forecasting 30 day mortality c statistic 0.88

Harrison References 1991—2005

Balancing acute and long-term care: the mathematics of throughput in departments of geriatric medicine
Harrison, G. W. and P. H. Millard (1991). Methods of Information in Medicine 30(3): 221-228.

Harrison, G. W. and P. H. Millard (1992). A model of patient flow through a geriatric department. *La sociedas ante el envejecimiento y la minusvalía. SYSTED 91. Volume 2*. J. M. Via and E. Portella, Fundació Barcelona**:** 631-636.

Harrison, G. W. (1994). Compartmental models of hospital patient occupancy patterns. *Modelling hospital resource use: a different approach to the planning and control of health care systems*.
P. H. Millard and S. I. McClean editors. London, Royal Society of Medicine**:** 53-64.

Modelling hospital and social care bed occupancy and use by elderly people in an English health district
Millard, P. H., G. Christodoulou, et al. (2001). Health Care Management Science 4: 57-62.

Implications of mixed exponential occupancy distributions and patient flow models for health care planning
Harrison, G. W. (2001). Health Care Management Science 4: 37-45.

Mathematical modelling: how and why
Harrison, G., P. Millard, et al. (2003). British Journal of Health Care Management 9(4): 144-150.

Modelling variability in hospital bed occupancy
Harrison, G. W., A. Shafer, et al. (2005). Health Care Manag Sci 8(4): 325-334.

First report that exponential equations fit bed census data

Struthers, J. L. (1963). The elderly in hospital British Medical Journal i: 470

Millard, P. H. (1989). Geriatric medicine: a new method of measuring bed usage and a theory for planning. London, University of London. MD available in publications www.nosokinetics.org

Throughput in a department of geriatric medicine: a problem of time, space and behaviour
Millard, P. H. (1992). Health Trends 24: 20-24.

UK

'Optimization' stream at the OR52 Conference, Royal Holloway University of London, UK, September 7-9, 2010: http://www.orsoc.org.uk/orshop/%

POLAND

MI&E'10 Workshop on Medical Informatics and Engineering

At International Multiconference on Computer Science and Information Technology (IMCSIT),Wisła, Poland, October 18-20,2010 http://mie2010.imcsit.org visit theMI&E'10 web site at http://www.imcsit.org/pg/319/259

Australia

IEEE CBMS 2010 IEEE CBMS 2010
23rd IEEE International Symposium on Computer-Based Medical Systems 2010
Perth, Australia, 12-15 October 2010
http://www.cbms2010.curtin.edu.au/ Submission deadline for regular papers and Tutorials 12 July 2010

Australia

23rd IEEE International Symposium on Computer-Based Medical Systems 2010

Perth, Australia, 12-15 October 2010

http://www.cbms2010.debii.curtin.edu.au/

CSEDU 2011 (International Conference on Computer Supported Education) has an open call for papers, whose deadline is on September 30, 2010. The conference is sponsored by INSTICC and held in cooperation with the Workflow Management Coalition (WfMC). CSEDU 2011 DU will be held in Noordwijkerhout, Netherlands next year, on May 6-9, 2011.

Stop Press Congratulations to Shola Ademi in Thierry Chaussalet's Group at University of Westminster. His submission for the Society's PhD Prize or 2009 has been shortlisted as one of the three winners (one winner and two runners-up). The announcement of the winner will be made at the Society's Annual Conference (OR52). Society's Annual Conference (OR52).

Nosokinetics News on MASHNET web site http://mashnet.info/resources/ The UK Network for Modelling & Simulation in Healthcare. Further details in next newsletter

Nosokinetics News is the newsletter of the UK Nosokinetics Group

Nosokinetics is the science / subject of measuring and modelling 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.

To join or leave the mailing list http://www.jiscmail.ac.uk/lists/NOSOKINETICS-NEWSLETTER.html