Squaring the Circle: Modelling Frailties

Congratulations Dr Shola Adeyemi in Prof Thierry Chaussalet's Group at the University of Westminster on the successful defence of his PhD: Patient Flow: Random Effects Modeling of Patient Pathways. Shola's research interests are in the use of generalized linear and nonlinear mixed models in investigating patterns of length of stay in health care institutions. His doctoral research opens the way for degrees of difficulty (complexity) to be included in mathematical models of health and social care systems.
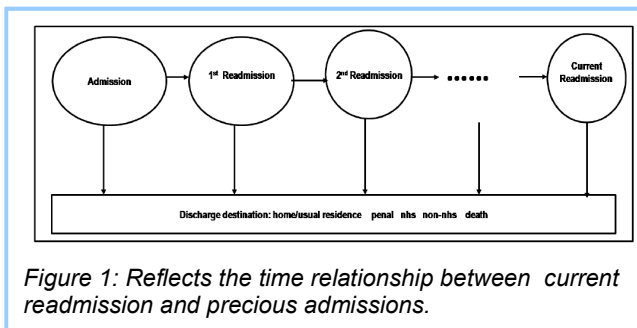
In 1973, discussing bed norms, we wrote:

'*We believe that there is now an urgent need for more sophisticated methods for obtaining the ratio of beds to the size of the elderly population. Many factors must be taken into account, including the age structure and social class of the local population, quality of housing, the mortality rate, the proportion of women in full time employment as well as the adequacy of the local authority services*'. (Exton-Smith & Millard 1973)

Little did we know that, within a decade, market forces would displace normative planning. Constant change; Targets; Winners and losers etc—irrespective of degrees of difficulty and local circumstances– the strong, well placed hospitals get richer and the poor get poorer. Such are the fatal flaws of market forces and short term econometric models.

Given the gulf between health and social care' in Africa and the Western World, between rich and poor countries in Europe, and within countries, one size will never fit all. There has to be a better way. Here, using the slides Shola created for his viva on 21st October 2009, we introduce his research.
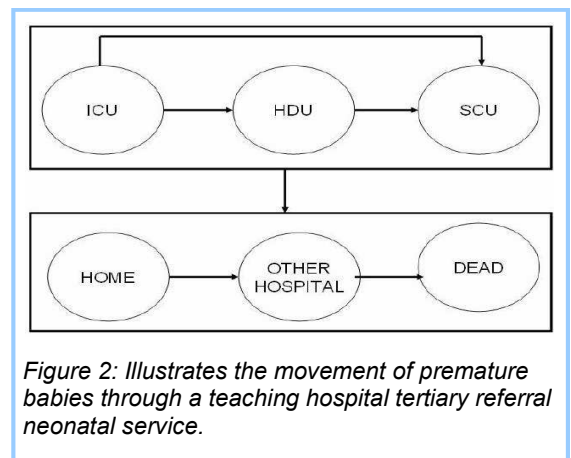
From a clinical perspective, patient flow represents the progression of a patient's health status. (Figure 1). From an operational perspective, patient flow can be thought of as the movements of patients through a set of locations in a health care facility (Figure 2).

Background: The Sandwich

GaPeSa

Disclaimer: This slide is intended as an illustration ONLY.

Figure 1: Reflects the time relationship between current readmission and precious admissions.

Figure 2: Illustrates the movement of premature babies through a teaching hospital tertiary referral neonatal service.

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Shola Adeyemi viva slides continued

Motivation of research Health care is delivered through, via, a series of processes: patients make transitions between these processes, and disease condition progresses in stages. Implicitly these processes impact on the flow of patients and drop out (e.g. discharge home), and lead to changes in the patients conditions (e.g. Frailties.)

Aims and objectives

- To develop appropriate models to capture the transition through pathways, the time spent in each state and / or in the system, the frailties and multiple outcomes.
- Subject specific inference could be carried out.
- Therefore, we develop a random effects modelling framework, to capture variability, to extract useful information about the health care system, and to predict subject-specific discharge probabilities.

Modelling patient pathways A number of models have been developed.

- *A multinomial logit model;*
- *A latent regression model.*
- *A non– proportional cumulative logit model.*
- *Continuation Ratio and the Generalized Continuation ratio logit Model.*
- *Joint modelling of [pathways and LOS.*

For each model, we explore non-normal random effects distributions.

Shortcomings Difficulty of usage of the models. Data requirement. Computational complexity.

Future directions Joint modelling of many outcomes. Finite Markov Mixture Models. Grid implementation.

Contribution to knowledge This research provides a novel approach in modelling patient flow by capturing individual patient experience in the process of care. The novelty lies in the intuitive adaptation / extension of advanced statistical methods in modelling patient flow. The models are useful in the identification of interesting patterns of flow: e.g. pathways with the longest (shortest) length of stay etc., This research contribute to the academic community and to the community of healthcare managers for better understanding the management of the process of care.

The study differs from the other research works mentioned previously on several points. It focuses on initiating and developing a methodology that has rarely been used in patient flow and LOS modelling. It is in line with current notion of personalised medical care. The methodology is transferable, i.e. it can be applied in many areas, e.g. tertiary referral, personnel management, education, migration and market research, etc.

References

Shola Adeyemi: Patient flow: Random Effects Modeling of Patient Pathways. PhD University of Westminster

Exton Smith, A. N. and Millard, P. H. *Hospital Services for the Elderly* 1973. Joint DHSS / BGS Conference on the Care of the Elderly. London

About Shola Adeyemi

Shola received a first degree in Statistics from the University of Ibadan, Nigeria, and an MSc from the Obafemi Awolowo University, Ile-Ife, Nigeria where he was also a lecturer in undergraduate mathematics and statistics. His MSc thesis was written in the area of Distribution theory and Applications (Properties and Applications of the Generalized Gumbel Distribution). He worked briefly at the Statistical Science Group of the Los Alamos National Laboratory US as a Staff Research Assistant in 2004. Shola was a predoctoral student at the Katholieke Universiteit, Leuven, Belgium before coming to the University of Westminster as a PhD student in Health and Social Care Modelling.

University of Westminster, Health and Social Care Modelling Group (http://www.healthcareinformatics.org.uk/)

Surges in need for overnight inpatient care: where, when and why.

Three articles by Rod Jones in the British Journal of Health Care Management throw light on the darkness. In "Trends in emergency admissions", using longitudinal data, discounting seasonal and ageing effects, Rod describes a series of cyclical events occurring in medicine every four to six years, and even longer cycles in surgery and orthopaedics. The cusum plot illustrates a 2007 surge in medical admission in Scottish hospitals and in a English hospital.
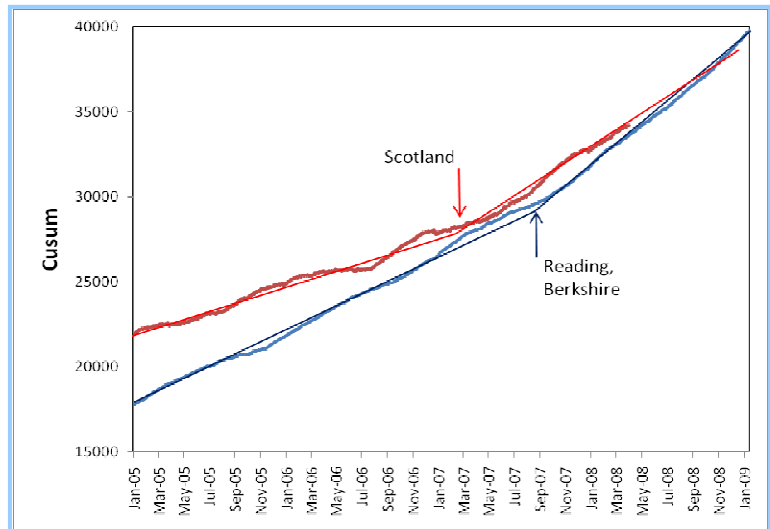
Demographic change, readmissions and rising expectations account for less than 2% per year increase. A major part is played by short stay (mainly zero day) admissions. Seasonal variation is very high, and cannot be discounted. Hence new methods are needed which more appropriately measure the process of care.

"Cycles in emergency admissions" considers the possible causes of four to six year cycles, suggesting a trigger point with a 10-13% step. Clinically, one component is an increase in ill-defined diagnoses, with a modest increase in deaths in the first two months. If the 4-6 year cycle is not incorrect, Rod forecasts that medical emergency admissions should increase by 10-13% in 2009/10 compared with 2007/08.

"Emergency admissions and hospital beds" discusses the issues of bed planning for emergency admissions in the light of seasonal differences (summer and winter) long-term cycles, ending mixed sex wards and zero days admissions. Concluding that any specialty with less than 70 beds should operate at an average occupancy of less than 85%.


Footnote: Data courtesy of NHS Scotland and Royal Berkshire NHS Foundation Trust. The cusum was calculated from April 2004 and the data from Reading was scaled up by a factor of 2-times to place the line close to that for Scotland. Note that the cusum is more volatile for Scotland since the data covers a far wider geographic area. In both lines there are the usual summer/winter inflections around the trendline. On most occasions the inflection point occurs earlier in Scotland than England (Reading, Berkshire).

Reference

Jones, R. (2009). "Cycles in emergency admissions " *British Journal of Health Care Management* **15**(5): 239-246.
Jones, R. (2009). "Emergency admissions and hospital beds." ibid **15**(6): 289 - 296.
Jones, R. (2009). "Trends in emergency admissions." ibid **15**(4): 188-196.

PS. YOUR HELP NEEDED. WHAT? WHY? WHERE? WHEN? HOW? WHO?

Looking back I came across this example of a surge in the dimness of time. The plot is of the midnight bed occupancy. General medicine and geriatric medicine. The faint arrows and words indicate, first the opening of a new admission ward, the drop of admissions after Xmas 1995 until a further surge for Xmas 1996 then a decline, till emptiness.

Operationally, the surge represents an increase in over 100 occupied beds. If you have similar data sets wherein you can plot the daily pattern of bed usage, showing short term surges, send them to us. Perhaps then we could make a collage and show whether Rod Jones findings are universal (or just a quirk in the structure and function of the NHS.

Email: phmillard@tiscali.co.uk
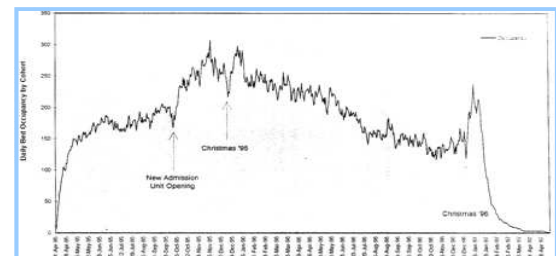
Midnight bed occupancy in a Welsh district general hospital . Medicine and Geriatirics. Cohort data. Admissions commence1st April 1995 ending 31st December 1996.

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In The Literature

AGE CARE

2008 Exploring access block in public hospital systems: understanding

Travers, C. M., G. D. McDonnell, et al. (2008). "The acute-aged care interface: exploring the dynamics of 'bed blocking'." Australas J Ageing **27**(3): 116-20.

The pathway into permanent high-care Residential Aged Care (RAC) is conceptualised as competing queues for available places by applicants from the hospital, the community and from within RAC facilities. The hospital effectively becomes a safety net accommodating people with high-care needs who cannot be admitted into RAC in a timely manner.

1987: Need for control; balancing demand and need

Preston, G. A. (1987). "Modelling the nursing homes system: bed growth, patient turnover and the availability of nursing home places." Aust Health Rev **10**(4): 282-9.

Nursing home admissions increase to fill available places. Decreasing the proportion of low turnover patients amongst admissions and increasing the turnover of the low turnover group are the most effective ways of increasing the availability of nursing home places. Moreover, such increased availability can be achieved without any increase in bed numbers.

1984 Behavioural factors influence demand: an insurance based study

Roos, N. P., E. Shapiro, et al. (1984). "Aging and the demand for health services: which aged and whose demand." The Gerontologist **24**: 31-36

If the looming crisis in old people's care actually develops it is because the real needs of a relatively small number of elderly people using very expensive services were ignored. Ignorance of the real needs of a relatively small number for very expensive services may be aggravated by increasing physicians.

2008 Economic benefits of intermediate care unclear

Armstrong, C. D., W. E. Hogg, et al. (2008). "Home-based intermediate care program vs hospitalization: Cost comparison study." Can Fam Physician **54**(1): 66-73.

Canada. Explores whether daily nurse visits and 24 hour access to care by telephone, lowers the cost of care and increases hospital bed availability. Perversely, or was it cause and effect, enrolled patients stayed longer in hospital (3.3days p<001), used more community care (p<.007) and were more likely to be readmitted (p<012).

SURGERY

2005 Department restructuring increases efficiency

Austin, M. T., J. J. Diaz, Jr., et al. (2005). "Creating an emergency general surgery service enhances the productivity of trauma surgeons, general surgeons and the hospital." J Trauma **58**(5): 906-10.

Restructuring increased critical care/ trauma surgeons; decreased trauma admissions and operations; increased elective general surgery; generated increased use of intensive care beds and operating room resources.

2009 Operating room availability

Valente, R., A. Testi, et al. (2009). "A model to prioritize access to elective surgery on the basis of clinical urgency and waiting time." BMC Health Serv Res **9**: 1.

Data from Italian Ministry of Health funded Surgical Waiting List Info System (SWALIS) project, with the aim of experimenting solutions for managing elective surgery waiting lists. SWALIS model allows homogeneous and standardized prioritization, enhancing transparency, efficiency and equity. Due to its applicability, it might represent a pragmatic approach towards surgical waiting lists, useful in both clinical practice and strategic resource management.

2009 Predicting surgical operation time

Dexter, F., R. H. Epstein, et al. (2009). "Automatic updating of times remaining in surgical cases using Bayesian analysis of historical case duration data and "instant messaging" updates from anaesthesia providers." Anesth Analg **108**(3): 929-40

Cases scheduled for 2 hours ongoing for 1.5 hours, the median time remaining is not 0.5 hours but longer,

and time taken differs among procedures. Conditional Bayesian lower prediction bound of a case's duration, conditional on the minutes of elapsed time in the operating room. Uses the posterior predictive distribution of OR times following an exponential of a scaled Student t distribution that depends on the scheduled case.

THEORY

2007 Intensive care: Quality of Life

Hofhuis, J. G., P. E. Spronk, et al. (2007). "Quality of life before intensive care unit admission is a predictor of survival." <u>Crit Care</u> **11**(4): R78.

Patients admitted to ICU surviving longer than 48 hours included in the study. Including measures of pre-admission Quality of Life measures, and mental competence in addition to measures of clinical severity (APACHE score) increased statistical significance of prediction of mortality at six months. 159 of 411 (39%) From the abstract there is little evidence of the value of the conclusion regarding admission avoidance.

2009 Meaningless means: heterogeneity and nonlinearity

Marrie, R. A., N. V. Dawson, et al. (2009). "Quantile regression and restricted cubic splines are useful for exploring relationships between continuous variables." <u>J Clin Epidemiol</u> **62**(5): 511-517.

The mean of a dependent variable may not reveal the true nature of the system under study. Two case studies show heterogeneous relationship between cognition and disease duration in multiple sclerosis, and nonlinearity of the relationship between severity of illness and length of stay in intensive care unit.

2007 Systems engineering concepts and overview

Kopach-Konrad, R., M. Lawley, et al. (2007). "Applying systems engineering principles in improving health care delivery." <u>J Gen Intern Med</u> **22 Suppl 3**: 431-7.

Presents an exploratory, qualitative review of systems engineering concepts and overview of ongoing applications in the areas of hemodialysis, radiation therapy, and patient flow modeling.. Discusses challenges and opportunities for bringing people with systems engineering skills into health care.

2007 Open access out patients

Kopach, R., P. C. DeLaurentis, et al. (2007). "Effects of clinical characteristics on successful open access scheduling." <u>Health Care Manag Sci</u> **10**(2): 111-24.

Considers the fraction of patients being served on open access; the scheduling horizon for patients on longer-term appointment scheduling; provider care groups, and overbooking. Discrete event simulation used to study the effects of the variables on clinic throughput and patient continuity of care. If correctly configured, open access can lead to significant improvements in clinic throughput with little sacrifice in continuity of care.

2009 Forecasting overcrowding sinusoidal and auto regression

Schweigler, L. M., J. S. Desmond, et al. (2009). "Forecasting models of emergency department crowding." <u>Acad Emerg Med</u> **16**(4): 301-8.

Using data from three tertiary care hospitals, hourly emergency department occupancy hospitals was reconstructed. Both a sinusoidal model with autoregression structured error term and a seasonal ARIMA model robustly forecast bed occupancy 4 and 12 hours in advance at three different EDs, without needing data input in the preceding hours.

Filling the gaps: Spreading the word

If you have a referenced paper, which you would like to draw to the attention of the group, to, please send us an email with the reference details and a short four to five line summary of the findings. Preferably, with the reference details in the style of the newsletter—so its simply a matter of cutting and pasting.

Happy days

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Chaver bugs

Ever since the 1970's, when on a wet party afternoon the Cubs played football on our lawn, it has never been beautiful. However its always looked OK. Now, however, disaster has struck. A combination of urban foxes, crows, magpies and jays are creating havoc searching for chafer grubs, and the whole lawn has need to be replaced. However, the grubs, which chew the roots of the grass, have a life cycle of four years until the bugs fly out. So it will be several years before we know whether the treatment will be successful.

'What's that got to do with Nosokinetics - how patients' flow through health and social care systems - I hear you ask? Imagine, heaven forbid, the Chafer grubs as politicians, accountants, economists, managers and clinical researchers. Anyone who only takes a short term interest in the outcome of their decision making. And read on.

Upside down and downside up: mirror images

Australia vice versa UK

Commenting on a recent report of the Australian Health and Hospital Reform Commission, Dr Saffut considered that they had missed the point. The good thing in the report was the need for the Federal government to boost the beds by 15%. However, that is expensive and simply throwing money at the problem. Rather what Dr Saffut would like the commission to have done ''… *is to have really addressed the issue of the rising* bureaucracy *and the cutting of beds. Unless we get reforms that are going to address those problems, I don't think the crisis is going to be solved any time soon.*

Population ageing, and preventive policies won't work. There are too few beds to meet demand and 100% bed occupancy. Compared to OECD countries, Australia has only two-thirds of the number of hospital beds. And in the 25 years since Medicare came in a third of the hospital beds have been shut.

For a brief interlude and déjàs vue, click on this http://www.abc.net.au/am/content/2009/s2638151.htm for

a transcript of an Australian broadcast by Dr Jeremy Saffut author of The Centre for Independent Studies' report, Why Public Hospitals Are Overcrowded: Ten Points For Policymakers.

UK vice versa Australia

What can we say but: 'Amen, Amen to that'. During a similar time period, in the UK, following the market reforms, the needs based geriatric and psycho-geriatric related clinical services to meet the needs of ill and dependent old people have collapsed. It's not the Roman Empire, but like Nero fiddling when Rome burns, following the American dream, UK politicians have 'little by little and bit by bit' destroyed the goose that gave the golden egg.

No one is saying bring out your dead, but the modernisation agenda, throwing money at the problem without a coherent plan, is just like pouring petrol on a bonfire. Week by week, day-by-day new initiatives are proposed and the discussion on the way forward to provide sustainable services to meet the health and social care needs of the ageing population has turned into a slanging match. Yah! Boo! We're better than you.

However, there is one commonality: All political parties agree:

"WE CANNOT AFFORD IT"

If one of the richest countries in the world cannot afford "IT' what hope is there for third world countries. Hang on a minute. And settle down and ask:

WHAT IS IT?

As far as I can see, in the UK, not since the blue print for the National Health Service was laid down has any parliamentary or professional body laid down, a blue print of what IT—a Nationwide Health and Social Care System to meet the needs of dependent citizens should and could be like. The problem is that its an altruistic solution. Far and away from the me, me, me, society we currently have. For the truth is, so long as we start now it could be twenty years before we could really see the results of our actions.

IMA HEALTH 2010

The 6th IMA International Conference on Quantitative Modelling in Management of Healthcare, 29-31 March 2010, London, UK.
Call is now open. http://www.ima.org.uk/Conferences/health2010/call_for_papers.html

Submit abstracts of 300-500 words online at http://online.ima.org.uk/ or to Amy.Marsh@ima.org.uk by **20 December 2009**

Summer school (Biomedical and Health Informatics) in Samos Island, Greece
> 19-24 July, 2010, in the next Nosokinetics newsletter?
> The corresponding link is:> > http://www.ineag.gr/summerschool/index.php

2nd International Conference on Computer Supported Education
> CSEDU 2010, to be held in Valencia, Spain (7 - 10 April, 2010) (http://www.csedu.org)

1st International Workshop on Applications of Machine Learning Techniques in Medicine and Biology,MLMB 2010
> February 10-15, 2010 - St. Maarten, Netherlands Antilles.
> MLMB 2010: http://www.iaria.org/conferences2010/MLMB.html
> eTELEMED 2010: http://www.iaria.org/conferences2010/eTELEMED10.html

5th International Conference on Software and Data Technologies - ICSOFT 2010
> July 22 - 24, 2010 Athens, Greece Website: http://www.icsoft.org

7th International Joint Conference on e-Business and Telecommunications - ICETE 2010
> July 26 - 28, 2010 Athens, Greece >   http://www.icete.org

Modelling in the NHS — web link

You won't find any mathematical models here, but you can see what is being used. http://www.institute.nhs.uk/quality_and_service_improvement_tools/quality_and_service_improvement_tools/modelling_and_simulation.html

View the 'Milestones' Special Issue of JORS for free, a fascinating collection of articles published to celebrate the 50th Anniversary of The OR Society. Go to: http://links.ealert.nature.com/ctt?kn=63&m=34299825&r=MjA3NDU5MDI3NwS2&b=2&j=NTk3MzE0NzcS1&mt=1&rt=0

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/

To receive a personal copy follow the instructions at

http://www.jiscmail.ac.uk/lists/NOSOKINETICS-NEWSLETTER.html

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