Issue 2.4 **Nosokinetics News … August 2005**

Previous issues at http://www2.wmin.ac.uk/coiec/nosokinetics.htm

**In this issue, where designated the full text of articles can be read on the web**



Building a better world

## Measuring bed requirements: skewed data, wrong method, wrong result

*Mark Joy*, Department of mathematics, Kingston University, Surrey (full text)

***"If the Committee was to select a single thread that links all aspects of this inquiry, lack of data would be an obvious choice. It is quite staggering just how little is known about many important aspects of the operation of public hospitals…"*** Crowley Inquiry 2004

The quote above originates from a recent Senate Committee report in Australia however the relevance to the UK should not be underestimated. A simple observation on the parlous state of affairs concerning the use and abuse of statistics seems apt. In order to measure the demand on beds, NHS Trusts have tended to estimate bed requirements over a period of days, thus

$$r = \frac{lp}{d}$$

where $r$ is the number of beds required, $l$ is the mean length of stay, $p$ is the number of patients contracted to be treated in the period and $d$ is the number of days in the period.

Implicit in such advice is the notion that the mean of an empirical distribution will capture its qualitative features! Presumably, in this world all distributions are bell-shaped. In fact, the highly skewed nature of patients' length of stay will cause this equation to underestimate the actual number of beds required.

The presence of simple and complex patients in most services, skews hospital length of stay data to the right.

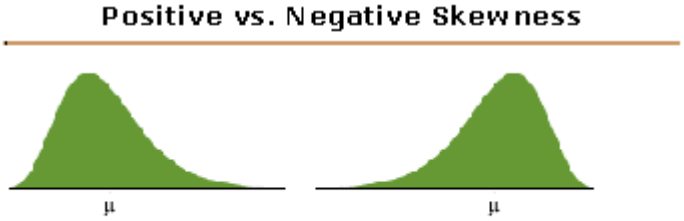


Figure 1 Positive and negative skewed data. Copyright Contingency Analysis http://www.riskglossary.com/

Workshop advice given by the Modernisation Agency for calculating bed requirements for the NHS advocated using this equation, but substituting the 80th percentile of length of stay for $l$-is equally as daft!

## IFORS Conference Hawaii "Quote of the week"

**Prof Gary Harrison: "Millard says the average stay is a bad measure, I prefer to call it incomplete."** Hearing those words, I recognised the error of my ways, emotion not logic rules my heart. To understand why the average stay is incomplete and misleading, see page six "Opening the Black box" a report of an article by Christos Vasilakis and Adele Marshall, JORS (2005) 56,862-869. Also see Nosokinetics News 1.4 page 1 for the percentile distribution data that opened my eyes..

# Problems in the light: look in the dark

*Small numbers make big differences. Using a queuing model and data from the Philadelphia mental health system, Naoru Koizumi PhD research shows how lack of facilities for supported living in the community can cause 'upstream blocking" in acute hospitals.* (full text )

## A queueing network model with blocking: analysis of congested patients flows in mental health systems.

*Naoru Koizumi Ph.D. Assistant Professor, School of Public Policy, George Mason University, Arlington, Virginia, USA.* email

In the USA, downsizing and closing of state mental health institutions has led to an over-utilization of many local mental health facilities. Philadelphia is no exception to this rule. 'Bed-blocking' occurs when patients spend extra, unnecessary, days in intensive facilities, leading to congestion of these facilities.

Using a queuing network model, Naoru's PhD research examines blocking in interrelated mental health facilities, including:

(a) acute hospitals (where patients wait to enter extended acute hospitals),
(b) extended acute hospitals (where patients wait to enter residential facilities), and
(c) residential facilities (where patients wait to enter supported housing).

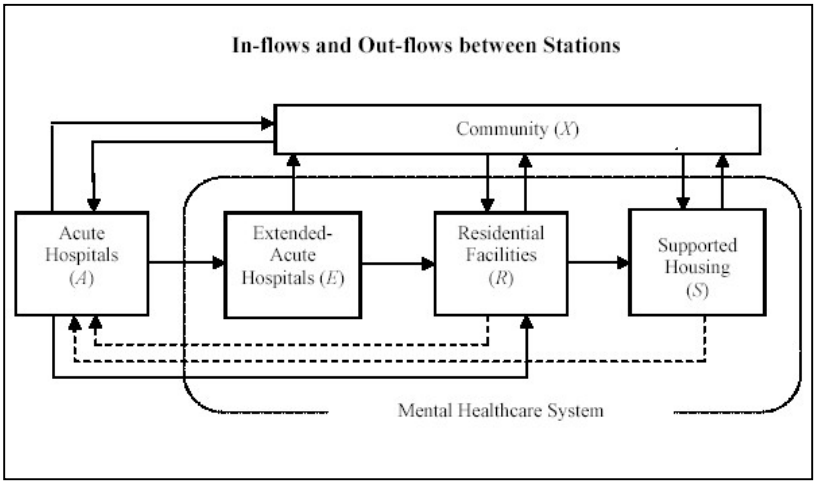


Figure 1. Open queuing network model with blocking used to analyse congestion in the Philadelphia health care system

In the theoretical portion of this study, a queuing network model of the Philadelphia system is constructed and analysed both in terms of steady-state behaviour and transient behaviour via numerical simulations. These theoretical results are then compared with the observed congestion levels in Philadelphia.

The single most important finding is that, in contrast to popular perception, system congestion is not always a simple cumulative effect of shortages across all facility types.

(full text )
Online dissertation

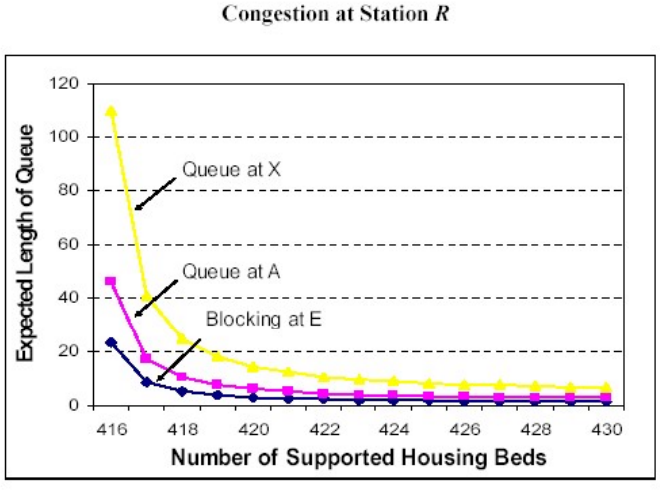


Figure 2. Impact of small changes in the number of supported housing beds on queue length in the community (X), acute hospitals (A), and extended acute hospitals

## Modeling "Rate of Admission" for Treatment and Bed Queues in an Emergency Department.

Leon K. Au University of Melbourne and Melbourne Health

Our article in Nosokinetics News (June, 2005) established that the distribution of the number of patients waiting for treatment or a bed and their waiting times are vastly different. So the question of interest is whether the hospital responds differently in terms of rate of admission (number of patients per hour) depending on the length of the queue and the day of the week?

Using the method of survival regression analysis (see "Analysis of Failure and Survival Data" by Peter J Smith), we estimated effects of both queue length and time of week (Figures 1 & 2). Note that the rate of admission steadily increases then appears to level off when there are more than 16 patients waiting for a bed. This suggests the capacity of the hospital to respond to increased demand is exhausted by this point.

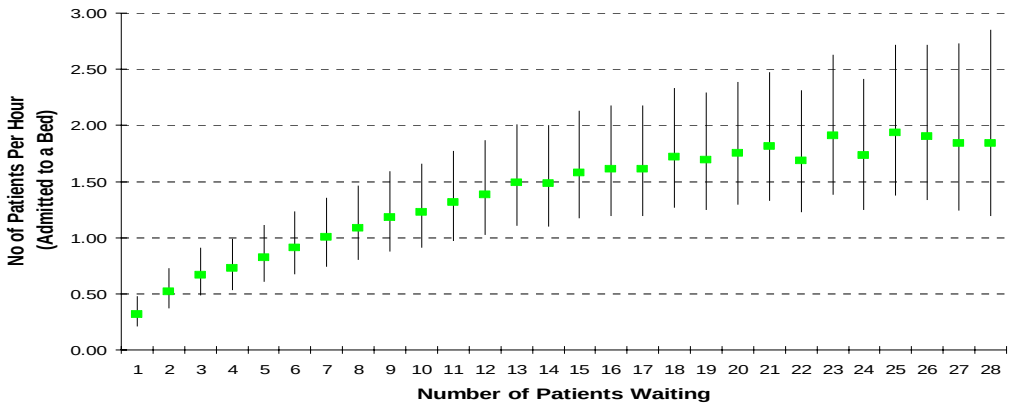


Figure 1: Rate of admission versus the number of patient waiting for a bed, with 95% confidence intervals.

Figure 2 shows that relatively more admissions occur in early afternoon and late evening of weekdays. The pattern is highly consistent throughout the working week, while there is less variation on weekends.

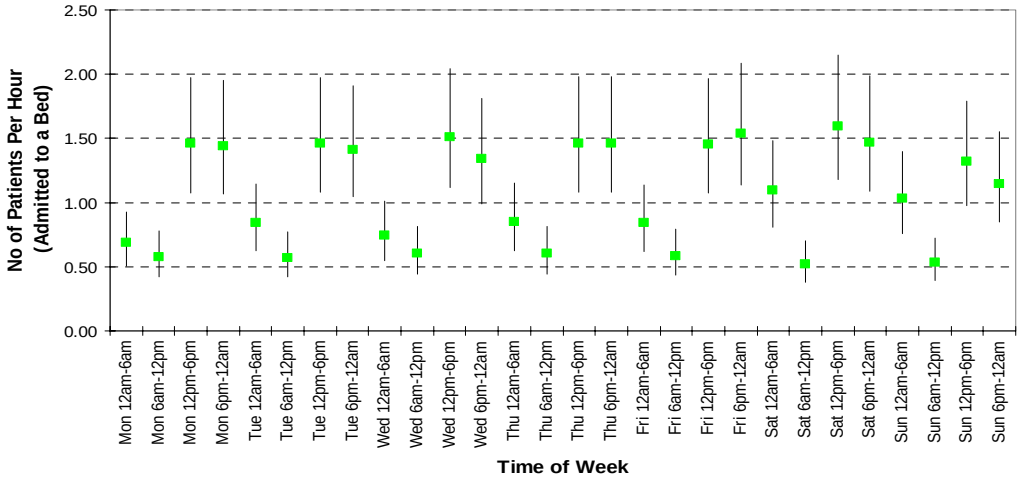


Figure 2: Rate of admission versus the day of the week for patient waiting for a bed, with 95% confidence intervals.

Similar patterns are observed for the number of patients awaiting treatment, as shown in Figures 3 & 4. Note the scale of Figure 3 is larger, as most of those waiting for treatment will be discharged directly from the ED. Also the maximum queue length is shorter, as suggested in our previous article.

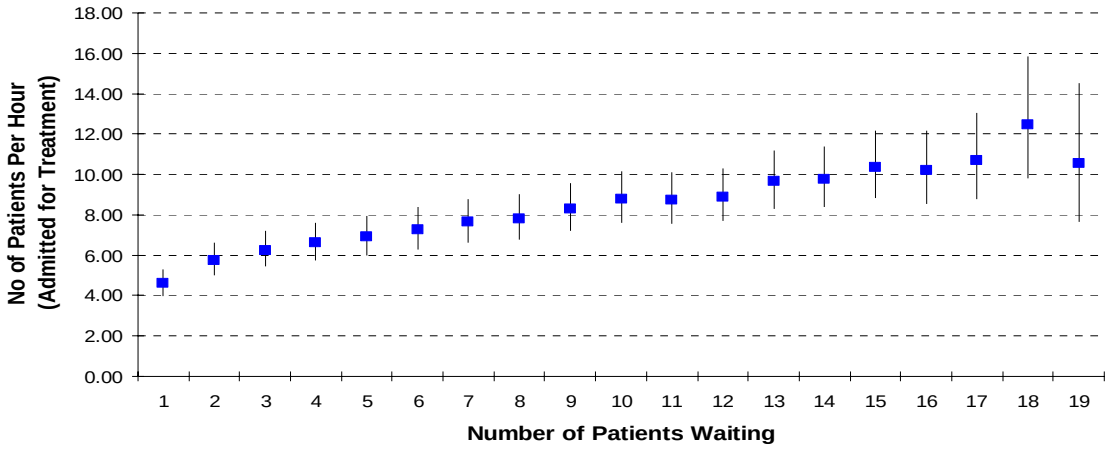


Figure 3: Rate of admission versus the number of patient waiting for treatment, with 95% confidence intervals.

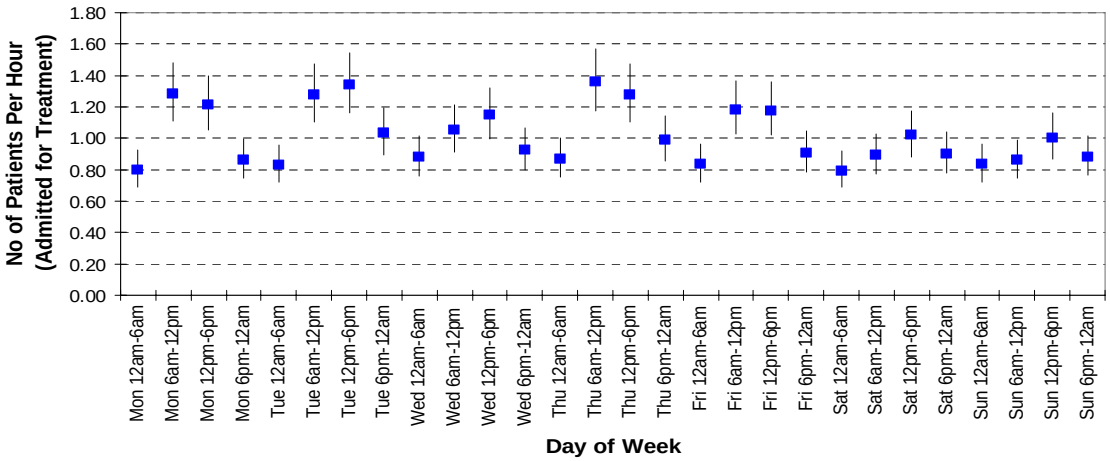


Figure 4: Rate of admission versus the day of the week for patient waiting for treatment.

We plan next to investigate differences between treatment queues for patients who will subsequently be admitted, and those discharged from the ED. We will present our next results in a future edition of Nosokinetics News. Additional information is available by contacting Leon Au at leon@ms.unimelb.edu.au.

**Nosokinetics News: Web Archive sponsored by IMS.** Thanks to Paul Cooper, Roy Johnston is developing an article archive for us. To ease our task, articles and tables should be submitted in Word, with pictures and files in jpeg or GIF, 600 pixels in size.

## Nursing Workload, Skill mix and Outcomes Research

Professor Christine Duffield, Prof of Nursing Studies at the Centre for Health Services Management at the University of Technology, Sydney (full report)

**Background**: In 2003 NSW Health funded the Centre for Health Services Management at the University of Technology, Sydney to conduct an innovative three-year research project, to extend the current knowledge of factors that explain variations in nursing costs and workload, and client, nurse, and system outcomes of care.

**Significance of the study:** This is the first large scale work of its kind in Australia with unique methodological challenges combining retrospective and prospective data collection. It is anticipated that the findings will provide policy makers with insight into the characteristics of patients that influence nursing service utilisation, workload and quality patient outcomes with a particular focus on unit-level activity.

**Data being collected:**

| | |
|---|---|
| **Unit / Hospital Characteristics** | |
| A. Predominant Care Delivery Model<br>B. Revised Nurse Work Index Scale<br>C. Nurse Demographic And Work Environment | These three instruments comprise the nurse survey, which will be administered once to each nurse in the sampled units (approx. 20 minutes) |
| D. The Daily Unit Staffing Form | Completed **daily** by the UTS data collector or the Nurse Unit Manager |
| E. The Hospital And Unit Profile | Completed **once** by the UTS Data Collector with assistance from the NUM |
| **Patient Characteristics and Outcomes** | |
| **F** Patient Data Form | Completed **per patient** by the UTS Data Collector using medical records |
| G. Health Records Data | Completed **per patient** from the NSW HIE |
| **Nursing Workload** | |
| H. PRN Workload Measurement | Completed **daily** by the UTS Data Collector |
| I. The Environmental Complexity Measure | Completed **once each shift** by each nurse in the sampled units (approx. 1-2 minutes) |

**Progress to date**

The first round of prospective data collection has been completed at 19 randomly selected hospitals in what are now eight Area Health Services (12 of previous 17 AHS). Eighty acute medical / surgical wards were randomly selected and data collected on each ward for a seven-day period. In addition data will be collected on up to 50% of the first sample, again randomly selected. Data collection is complete on 17 of these units. The inter-rater reliability overall is 87.1 %. Thus far:

- 1976 nurses have been surveyed and 2100 nurses are expected to participate by the completion of the study with an average response rate of 72% thus far,
- 5610 Environmental Complexity Forms have been completed and 6400 are expected,
- 4580 patient files have been accessed and it is expected that this will increase to 5050,
- Information has been collected on 17650 patient days and this is likely to increase to 20250 patient days.

The Nursing Workload, Skillmix and Outcomes Study is due for completion in 2006. For more information and updates, http://www.chsm.uts.edu.au/ or contact Professor Christine Duffield on Christine.Duffield@uts.edu.au

## Quantitative Modelling of Patient Flow in Acute Care

A workshop to present and discuss information on patient flow in acute care was recently held at the Royal Melbourne Hospital in Melbourne, Australia. The Clinical Epidemiology and Health Service Evaluation Unit (Royal Melbourne Hospital), Melbourne Health and The University of Melbourne sponsored the workshop. The workshop featured two presentations, followed by a panel discussion. Work place redesign featured strongly in the discussions. Details about the workshop, including the presentations, can be accessed at: http://mh1.mh.org.au/ClinicalEpidemiology/New_files/Workshopmodelling.htm

- ***Forecasting Demand and Modelling Patient Flows*** by David Sier, CSIRO, Southern Health,
- ***Complexity Modelling and Hospital Beds:Progress of Research*** by Mark MacKay, Department of Psychology, University of Adelaide
- **Three approaches to modelling hospital patient flows** by Dept of Mathematics & Statistics, University of Melbourne and CSIRO
- ***Challenges in Scheduling the Operating Theatre*** by Damian Armour, Barwon Health
- ***A Whole of Hospital Simulation*** by Phil Cooper, Iridium Consulting, Donald Campbell & Christopher Bain, Melbourne Health

**Lean thinking** Institute of Health Care download on Lean thinking
http://www.ihi.org/IHI/Products/WhitePapers/GoingLeaninHealthCare.htm

**"Priority Medicines and the Elderly"** CoverAGE, briefing English version
http://www.age-platform.org/AGE/IMG/pdf/CoverAGE_June2005_EN.pdf

**NEW! Masters in Science in Medical Informatics & Biostatistics** in Romania
http://www.umfcv.ro/MIB

"Healthcare Quality Improvement and Implementation Science."To be published by BioMed Central, the new journal will focus on the study of methods to accelerate the implementation of evidence-based clinical practices in routine healthcare settings

Gaming in A&E. *BMJ* (21st May) 2005; 330: 1188-9
One in eight patients admitted from A&E moved out of the department in the final 20 minutes of the four hour target period; UK data: 83 departments, 428593 patients, 22% admitted.

Hospital in the nursing home: Gold Coast Hospital, Queensland, Australia.
The Gold Coast emergency department piloted this innovative model of care that has a focus on keeping elderly patients in an environment they are familiar with and avoiding admission to hospital. The program has demonstrated improved outcomes for the patients, the nursing homes and the hospital. A copy of the presentation for the 2004 International Conference on Emergency Medicine can be found below.
**Hospital in the Nursing Home: an emergency department based model of care**

**"Modelling nationwide hospital length of stay: opening the black box." Vasilakis, C. and Marshall, (2005) Journal of the Operational Research Society 56: 862-869.**

Christos and Adele compare and contrast alternative methods of analysing and modelling length of stay data. Statistical methods - survival analysis, mixed exponential and phase-type distributions - and decision modelling techniques - compartmental and simulation models are explained. Stroke illness is used as an exemplar, for by its very nature, it has short, medium and long stay patients.

The table shows the statistics. Note that the average stay is 14 days. Coxian phase type distributions of discharges and exponential analysis of occupancy time gave similar results: Coxian, 92.3% of discharges left in 10.8 days, 7.5% in 40 days and 0.2% in 667 days; Exponential 90.2%, 10.8 days; 8.9%, 36.7 days and 0.9%, 653 days. However, note the min-max distribution in the data is 0-4906 days, so analysis of discharge data alone masks the use of beds by longer stay patients.

Basic Statistics English HES Stroke Patients
1 April 94-31st March 95

No of Discharges 105 765

| Descriptive statistics LOS (days) | |
|---|---|
| Mean | 14.3 |
| 25th Percentile | 3 |
| Median | 7 |
| 75th Percentile | 15 |
| Min – max | 0 -4906 |
| Std. Deviation | 52.04 |
| Skewness | 42.19 |
| Kurtosis … | 2609.21 |

## Forthcoming conferences: also see http://www2.wmin.ac.uk/coiec/nosokinetics.htm

**International Conference on Health and Social Care Modelling and Applications (HSCM 2006), will be held at the University of Adelaide, Adelaide, South Australia, 19 – 21 April, 2006.** Information will be mailed during early August.
Important dates: Invited session submission October 2005; Deadline for abstract submission: 15 November 2005; Notification of acceptance: 8 December 2005.

**The First East European Conference on Health Care Modelling and Computation (HCMC 2005) Craiova, Romania: 31 August to 2nd of September 2005. Conference organisers** Florin Gorunescu **and** Elia ElDarzi

**OR Society Conference, University College Chester, 13th - 15th September 2005**. Chris Sherlaw-Johnson (c.sherlaw-johnson@ucl.ac.uk) or Gillian Mould (g.i.mould@stir.ac.uk)

**MASHnet launch Tues 20th September 2005 12.00 – 5.00pm** hosted by West Midlands Operational Research Society in the new building at Warwick Business School. MASH net is an EPSRC network for modelling and simulation in health care. Further information contact Martin Pitt

**Congratulations to Barry Shaw from Adele's Group and Kevin Xie from Thierry's group.**

Barry won a presentation prize at the Eighteenth IEEE Symposium on Computer-Based Medical Systems conference in Dublin 23-24th June 2005. A contribution from Barry will be in the next issue. Kevin Xie and Barry have also been invited to contribute their papers to a special issue arising from the conference. Photo of Barry by Kevin.

Nosokinetics News is mailed individually to supporters and collaborators interested in developing a scientifically valid approach to measuring and modeling health and social care systems. To be added to / removed from the mailing list email nosokinetics. For contributions, correspondence mail Editor: Prof Peter H Millard. For earlier editions http://www2.wmin.ac.uk/coiec/nosokinetics.htm.