Nosokinetics News

Making the world a smaller place for Health Care Modellers

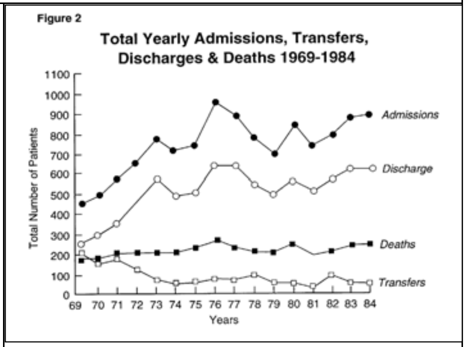
Issue 1.4 http://www2.wmin.ac.uk/coiec/nosokinetics.htm August 2004

In this issue

Building a better world

Pressure and Force or Space, Time and Behaviour: Peter Millard

The world population is ageing. How should health and social care services respond? Current theories are based on Newtonian concepts of pressure and force. So were mine, until one day in 1988 Maggie Barker, my house physician, a graduate entry, previously a medical editor, had the courage to tell me (her professor) that my draft doctoral thesis explaining the rise and fall of admissions to the department was paranoia. To cut a long story short, my ideas changed when I examined the data below.



Length of stay prior to discharge or death of the patients admitted each year to the Department of Geriatric Medicine which served the London Borough of Merton, 1969-1984

		Length of stay in days*					
Year	*No. Admitted*	*Mean*	*25%*	*Median*	*75%*	*95%*	*Max.***
1969	437	178	16	35	99	1041	2946
1970	477	136	16	32	75	785	2443
1971	572	119	15	26	56	605	3492
1972	653	81	15	27	54	279	2146
1973	778	80	11	20	41	271	3419
1974	711	68	11	19	41	230	2468
1975	744	65	12	20	37	176	3130
1976	969	72	12	20	37	200	3328
1977	898	80	11	21	43	283	3046
1978	776	93	12	21	43	361	2864
1979	703	68	11	21	45	242	1583
1980	835	56	12	20	39	176	1920
1981	732	70	11	19	43	307	1735
1982	807	75	13	22	49	396	1367
1983	877	55	13	20	40	183	791
1984	729	51	13	21	40	204	729

* In all years, the minimum length of stay was one day

** The max. stay relates to those who have been discharged-some may still be inpatients

Note that the 50th and 75th percentiles changed between 1969 and 1972, then in 1973, they and the 25th percentile 'flip' to a new stable state. Thereafter admissions increased as long stay beds became acute. And, vice versa, they decreased when acute beds became long stay. If you have data sets that confirm or refute these observations please let us know.

For this issue we thank Peter Hahn for the lead to the website below and Andy Horn for opening our eyes to the reality of electronic records.

GERIATRIC HEALTHCARE TECHNOLOGY SYMPOSIUM PRESENTATIONS AVAILABLE ONLINE

On 4 June, IEEE-USA teamed with Mitretek Systems and Intel Corporation to host a one-day symposium in Falls Church, Va., designed to explore ways that computer, communication and other electronic technologies can improve the quality and cost-efficiency of caring for our nation's aging population. To view the presentations, go to: http://www.ieeeusa.org/conferences/geriatrictech/. It's a fascinating collection with remarkable insights into current thinking on telemedicine and electronic records.

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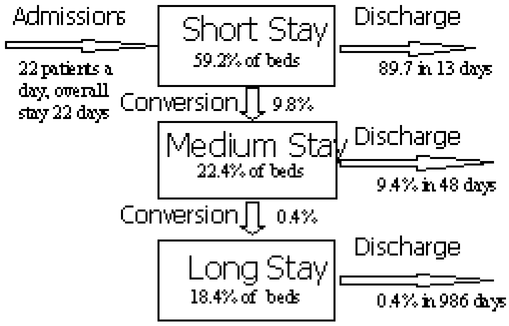
Different approaches in modelling patient flow, Dr. Christos Vasilakis

Lecturer, Health Care Computing Group, University of Westminster, London

Traditionally, patient flow models have been developed from clinical and operational perspectives.[1] The Noso*kinetics* group researches compartmental models of patient flow. It is important to understand the advantages and disadvantages of each approach.

The figure shows the three compartments in geriatric medicine, modelled from a one night bed census in Leicestershire District Health Authority.[2]



Geriatric medicine: stable state model

Clinical flow models represent the progression of a patient's or cohorts of patients' health status over time. Since routine data can be used and fine details need not be captured, clinical models are generally easier to develop. They are used in epidemiological and health technology assessment studies where the behaviour of certain patient populations is modelled over a long period of time and the cost effectiveness of different interventions or screening programmes is evaluated (for an example see [3]). As most hospital departments deal with a variety of patients and diseases, such models are unsuitable for micro-level hospital resource allocation and capacity planning.

Operational flow models are very detailed and complex, usually taking the form of simulated queuing networks (for a comprehensive example see [4]). Although capable of providing an accurate picture of the movement of patients through a set of locations in a health care facility, they are costly and time consuming to build and often require input data that is not readily available. So expensive and time-consuming on-site observations are often needed. Furthermore, operational flow models are usually tailor made to the needs of specific health care settings, so the results can neither be easily replicated nor generalised.

Compartmental flow models offer a practical level of simplification and abstraction. An empirical observation led to the first mathematical solution[5]: mixed exponential equations fit the cumulative pattern of occupancy time in midnight bed states (see issue 1.2) The concepts have similarities to models used in pharmacokinetics [For a good online textbook of pharmacology see (http://pharmacy.creighton.edu/pha443/pdf/Default.asp)] Their main advantage is that longer stay patients are included in the various calculations – usually excluded in models based on averages.

As routinely collected administrative data can be used, costly on-site observations can be avoided. Models can be scaled to accommodate departmental, hospital, regional and national levels of analysis. Extending these models however, is not a trivial task. Advanced and sound statistical techniques need to be employed or developed before being linked to decision models from the broad operations research portfolio. Ultimately, these models should provide quick but sound analytical capabilities in aid of decision making at a higher level than current operational models.

1. Cote M.J. (2000) Understanding Patient Flow. *Decision Line* **31:** 8-10
2. Millard P.H., Christodoulou G., Jagger C., Harrison G.W. & McClean S.I. (2001) Modelling hospital and social care bed occupancy and use by elderly people in an English health district. *Health Care Manag Sci* 57-62
3. Davies R., Brailsford S., Roderick P., Canning C. & Crabbe D. (2000) Using simulation modelling for evaluating screening services for diabetic retinopathy. *J Opl Res Soc* **51:** 476-484
4. Altinel I.K. & Ulas E. (1996) Simulation modeling for emergency bed requirement planning. *Ann Oper Res* **67:** 183-210
5. Harrison G.W. & Millard P.H. (1991) Balancing acute and long term care: the mathematics of throughput in departments of geriatric medicine. *Meth Inform Med* **30:** 221-228

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Moving averages: what are they? Mark Mackay

I'm glad you asked! Moving averages make trends in time series data clear. A time series is a sequence of observations, ordered in time (i.e. hours, days, months or years). Moving averages are commonly used to analyse stock price and for quality control in manufacturing and could with benefit be applied to the analysis of bed occupancy trends. Problems in planning are occurring because high-level statistics, such as the average length of stay or total bed days, do not identify the variation in bed occupancy over time. The benefit of using moving averages is that noise or variation in the data is reduced, so trends within the data appear.

Figure 1 shows the pattern of bed occupancy in an Australian acute care service. Clearly, the average bed occupancy is a poor measure of bed occupancy and use. While seasonal trends in bed usage are clear, more beds are occupied in winter than in summer, there is a lot of day-to-day variation that can be distracting.

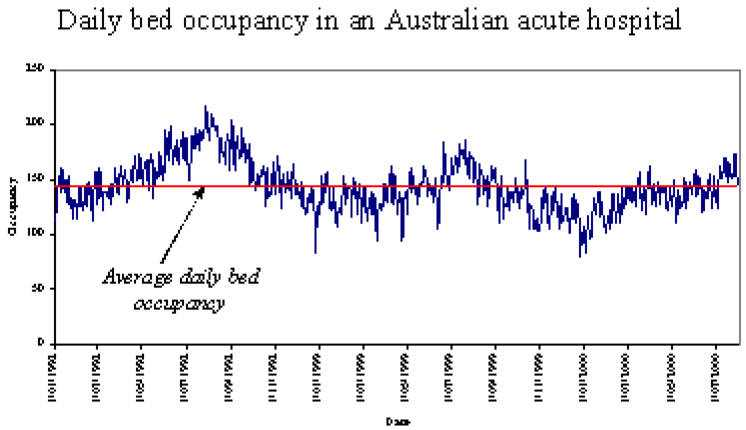

Figure 1. Bed usage 1st January 1998 to 30th July 2002

Figure 2 shows the trends revealed in the data. The seven-day moving average removes a lot of the variation over a short period of time (e.g. 1-2 years); 30 days highlights monthly trends, and 90 days highlights seasonal trends. Usually three moving averages would not be shown on the one graph.

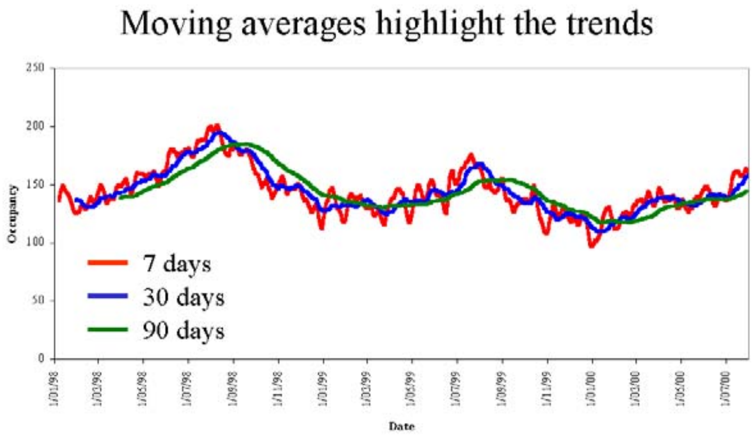

Figure 2. Smoothing occupancy with moving averages

The same technique can be used to look at subsets of data. This can be a powerful way to highlight differences, e.g., between short and long stay patients and different age groups.

Problems

The Slutsky-Yule effect occurs when, as a consequence of the data, a non-existent cyclic trend is observed even where there are no trends (Kohler, 1984). Weekly and seasonal trends are clearly evident in Figure 1, so there can be certainty about the existence of the trends, thus the Slutsky-Yule effect does not apply. Other weaknesses include sensitivity to extreme values and prolongment of trends: clearly, the 90 day moving average in Figure 2 prolongs the trend. Providing that you do not link peaks and troughs in moving average cycles to specific dates, but rather align the cycles with the appropriate seasonal (or other) variation (e.g. winter or summer) this is not an issue.

(continued on page 4)

Moving averages: (continued)

Exponential smoothing

Exponential smoothing may reduce sensitivity to extreme values (Kohler, 1984). Extreme values, particularly periods of high bed occupancy, are important in the analysis of bed occupancy and patient flow issues, as the management of beds involves consideration of peaks and troughs to ensure that beds are available to avoid the likelihood of unnecessarily long delays in patient admission. Thus, the need for exponential smoothing is unlikely.

Calculating moving averages (Spiegel, 1972 pg 284).

"Given a set of numbers Y_1, Y_2, Y_3, ….. we define a moving average of order N to be given by the sequence of arithmetic means,

$$\frac{Y_1 + Y_2 + Y_3 \ldots + Y_N}{N}, \quad \frac{Y_2 + Y_3 + Y_4 \ldots + Y_{N+1}}{N}, \quad \frac{Y_3 + Y_4 \ldots + Y_{N+2}}{N}, \ \ldots\ldots"$$

Don't worry if you're not mathematical – the ubiquitous MS Excel enables you to add a moving average to a graph easily (right click the mouse on the bed occupancy line) select "add trend line" and then select "moving average". Using a statistical package (e.g. SPSS) moving averages are usually found in the time series analysis section.

Conclusion

Moving averages should be in the toolkit of anyone working on bed management problems. Providing that the raw underlying data is presented; any disadvantages should be ameliorated. Some trends will not emerge unless analysis at the subgroup level occurs. Moving averages do not enable managers to understand and manipulate the drivers of the occupancy profile, namely patient numbers and length of stay – that's a role for compartment flow modelling and other techniques. Finally, while moving averages can be used for forecasting, I don't suggest that they are used for forecasting bed occupancy (that's a topic for another time).

For those wanting to learn more:

There are plenty of websites dealing with moving averages. Using the Google search engine and typing moving averages there were approximately 6.8 million hits. However, narrowing the search helped – adding health achieves 1.7 million hits! Most statistics text, particularly business related ones, have information on moving averages e.g.

Kohler H (1984). *Statistics for business and economics*. Scott Foreman and Company. USA.
Spiegel MR (1972). *Theory and Problems of Statistics in SI Units*. McGraw-Hill International, New York, pg 284.

Patient Flow: No man is an island

Articles in Frontiers of Management Science (Summer 2004; 20, 4) consider the management of patients in transition through the acute patient setting (Zimmerman, R pages 33-38). Haraden and Resar (pages 3-15) report methods used to change acute care by the Institute for Healthcare Improvement . Hospital departments are interdependent systems: beneficial actions taken in one service can have detrimental impact elsewhere. Specific areas of concern are smoothing flow in elective surgery, reducing waiting times from accident and emergency, achieving timely and efficient transfer from intensive care and improving flow to long-term care.

Henderson, Dempsey and Appleby (report successful changes in a tertiary hospital in Missouri. And Brideau Fache (pages 47-50) questions why health care has retained its "cottage industry" approach. Barriers to success are failure to recognize the importance of flow, the organizational structure of hospitals and political and cultural barriers: especially the *fervently held value of physician autonomy (my italics).*

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Electronic Patient Records: Response to John Cummins comment in last newsletter

"The entire area of computerised medical records and the exchange of information between primary care and secondary care is currently a nightmare. There is not even common agreement on anything as basic as systems to be used or universal Read codes." John Cummins, Chairman of the Standing Committee of General Practitioners.

Editor,
A similar long running debate in the USA indicates that it is driven by resistance to change, rather than clinical expedience. Reticence stems from an awareness of a fundamental change to professional status concomitant with e-records systems.

Sociologically, a "Professional" is an agent of social control, inferring that the individual is to some degree subservient to professional direction. The imbalance of power varies, depending upon profession and environment: e.g Law, Church, Army in peace or war. The avuncular culture of the medical profession has always predicated a marginal imbalance, but this has become increasingly tipped, as society has moved generally towards empowerment of the individual, especially post Bristol babies and Alder Hey.

Electronic records *inter alia* make medical cases more portable, enabling individuals to tout between clinicians in search of personal optima. This dis-empowers the professional: e.g. Delaying hip replacement for the patient's greater long term benefit, by waiting list manipulation according to on-going out-patient follow up, is undermined by permitted migration between hospital waiting lists in search of short term patient satisfaction. The surgeon becomes a technician, a status that is not likely to be voluntarily embraced throughout.

Risk averse senior NHS management, seeks no power to make use of e-records mandatory, which would transfer medical liability borne of its failures. Lower management stands to be made redundant by it, and shares no allegiance. Given the profession need only acquiesce in order to preserve its status, it is clear why fatuous debate rages *ad infinitum*, but not why management spent £6bn: After all, only patients stand to gain, and they are a minority stakeholder!

David Horn
Consultant in healthcare business change strategy

Editor's comment: Let the debate continue after all someone else also expects to gain:

President George W. Bush, State of the Union Address, January 20, 2004.

"By computerizing health records, we can avoid dangerous medical mistakes, reduce costs, and improve care."

And the whole process is not without its costs: *The bill for e-enabling 1 million staff will be more than £13bn over six years. "It's a major piece of public infrastructure, like roads, rail, electricity, fuel supply. It's on that scale,"* Gwyn Thomas, chief executive of the NHS Information Authority (NHSIA), the organisation charged with making it happen.

Research papers

Marshall, A. H., S. I. McClean, and P. H. Millard, 2004, Addressing bed costs for the elderly: a new methodology for modelling patient outcomes and length of stay: Health Care Management Science; 7: 27-33.

Conditional phase type and Coxian survival distributions show how dependency on admission (Barthel grade) and discharge destination influence duration of stay. By integrating Bayesian Networks and Coxian survival distributions, a model is developed that explains differences in outcome and could be used to predict costs, Data concerns 4722 discharges from an English geriatric medical service: 99.6% leave within the first group (average stay 25 days); transferred patients stay longer than those who die or who are discharged. Further information
mailto:a.h.marshall@Queens-Belfast.AC.UK

Anecdote: Forty percent of U.S. bankruptcies are attributed to medical bills sunable to pay. BMJ 2000;320:1295 quoted in Goodness and Mercy by Donald W. Light

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Brailsford, S. A., V. A. Lattimer, et al. 2004, Emergency and on-demand health care: modelling a large complex system: Journal of the Operational Research Society; 55:. 34-42.

Describes a system dynamics stock-flow model (STELLA) used to simulate patient flows and to identify system bottlenecks as a central part of a whole-system review of emergency and on-demand health care in Nottingham, England. The 'conceptual map" based on 30 interviews showed potential patient pathways. Modelling indicated a range of undesirable outcomes associated with continued growth in demand for emergency care, but also considerable potential to intervene to alleviate these problems, in particular by increasing the care options available in the community.

Shactman, D, Altman, S., et al. 2003. The Outlook for Hospital Spending: rapid growth is likely to persist. Health Affairs 22(6):12-26.

Hospital use and spending greatly increased in 2001 and 2002 in US, reversing a long-term trend. Spending on baby boomers grew more rapidly than that of the elderly. If current trends continue, real hospital spending per capita will increase 75 percent between 2002 and 2012: demand for hospital beds will increase considerably. Changing technology is likely to continue to raise costs.

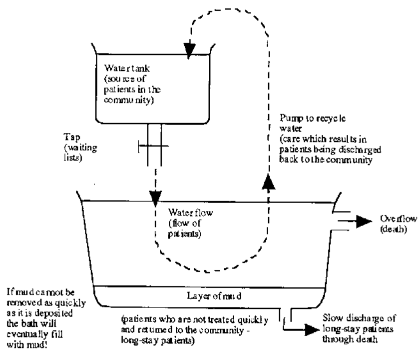
The muddy bottom theory of geriatric medicine

Imagine a bath in which there is a species of fish, specially trained to stop objects (patients) leaving through the overflow (acute death). At first, the fish had limited therapeutic skills (bed rest); mobile survivors returned to the water tank (the community), while bed-bound survivors sank slowly to the bottom of the bath (long-term care), where, eventually they left, via the plughole (chronic death).

Swimming in the clear waters, the number and happiness of the fish increased, as new methods of treatment were developed.

Then rehabilitation began in the long stay wards. Slowly at first, then rapidly, like a stick in the pond, the clear waters became muddy. Then one winter's day the bath began to overflow.

Figure 3 : The 'muddy bottom theory'



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The British Journal of Healthcare Computing & Information Management

Warren, L.Bed-use system shows St. George's to be no stick in the mud: British Journal of Healthcare Computing, 1992; July: 8.

And the cries went up: "Turn off the tap" "Prevent admissions" "Speed up discharge" "Fine social services" "More long-stay beds" and no-one stopped to think that the world had changed.

Historical Note. The Muddy Bottom Theory was developed in the 1970's with Drs. Richard Bailey, Ian Hastie, Jo Oram and John Varney (deceased) when they were training with me at St. George's

Good News

The two sessions organised by Elia ElDarzi at the Brunel and Beirut conferences attracted a strong health care representation. Following the Beirut conference Algeria, Egypt, Kuwait, Lebanon, Saudi Arabia and Thailand have been added to countries receiving the newsletter. Six months after the launch we have 196 recipients in 21 countries. Problems with individual mail out should now have been overcome. Our aim is 500 at the end of the year. Together we could make it happen.