Developing a policy simulator at the acute–aged care interface

Leonard C Gray, Gerald A Broe, Stephen J Duckett, Diane M Gibson, Catherine Travers and Geoff McDonnell

Abstract

This paper describes the development of a computer simulation of the interactions between the acute and aged care systems in Australia, using system dynamics modeling enhanced by agent-based techniques. National and regional simulations will be developed, enabling the impact of a variety of policy scenarios to be forecast over the next 10 years. The paper includes a description of the relevant policy environment and some of the associated key policy issues.

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What is known about the topic?

Computer simulations offer an inexpensive, low risk method to test the impact of policy options in health care.

What does this paper add?

The paper describes a combined method of two simulation techniques to test policy scenarios at the acute–aged care system interface in the Australian context.

What are the implications for practitioners?

The simulation model described in this paper provides a method of conducting policy experiments at low risk and low cost with instant results. While the outcomes will not necessarily be precise, the development process and interactions with stakeholders are likely to raise the quality of the debate on the acute–aged interface. ◆

THE INTERACTION OF the acute and aged care systems is a contemporary issue for health planners, administrators and clinicians.[1] Persons awaiting residential care placement and frail older people admitted from residential care facilities or from the community, with seemingly "minor" medical or "social" problems, are perceived to reduce capacity and to contribute to "access block" in acute care hospitals.[2] A recent Australian study concluded that up to 20% of bed-days utilised by older patients in acute care public hospital beds are non-acute — the largest single proportion utilised awaiting permanent residential care.[3] These groups have become a target of policymakers and health administrators, suggesting the need for methods to analyse the impact of various policy options.

The policy context

Australia's population structure is ageing. Over the next 20 years, it is anticipated that the number of older people (65+) will increase by about 2 million and that the proportion of the total population that is aged 65 years and over will increase by 92%, from 13% in 2004 to 20%

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in 2024.[4] Increasing age is associated with higher rates of disability and service utilisation within the acute and aged care sectors.[5,6] For example, hospital separation rates in 2001–02 in Australia were 876 per 1000 for the population aged 65 years and older compared with 251 per 1000 for the population aged less than 65 years.[5]

The provision of aged care in Australia

Aged care generally refers to a range of services which address the needs of those older people with chronic illness and disability who are continuously in need of help from others for basic day-to-day activities. Services include residential, community and hospital services.

In Australia, long-term residential care for older persons is provided in government-licensed subsidised facilities. In 1986, following a period of unrestrained growth, the government moved to control provision of these services, based on the observation that many people were living in nursing homes who could be provided with suitable care in alternative, less intensive care environments, or the community. Planning ratios of 40 nursing home places (beds) per 1000 population aged 70 years and older (per 1000 70+) (compared with the then provision of 67 per 1000 70+) and hostel places of 60 per 1000 70+ (compared with 33 per 1000 70+) were established.[7] At the same time, a sustained commitment to accelerated investment in community care through the Home and Community Care program commenced.

A national Aged Care Assessment Program was established in 1984. Regional services fulfil the dual roles of advisers to frail elderly people and their carers, and gatekeepers to expensive programs including residential care and Community Aged Care Packages (CAPs). Subsequently, the relative provision of residential aged care places declined progressively (although the absolute number of places increased), primarily as a result of aged population growth, to the 2004 levels of 84.2 per 1000 70+.[8] In 1992, a process of substitution of hostel places with CAPs commenced, in which funding about equivalent to the average cost of care in hostel settings was made available to provide individualised care in the community.[6] The provision of these places became incorporated into the overall residential care planning framework, which in its most recent iteration prescribed 40 nursing home, 48 hostel and 20 CAPs per 1000 70+.[8]

In 1997 a raft of reforms underpinned by the *Aged Care Act 1997* (Cwlth) included a consolidated casemix system for nursing homes and hostels, in which funding was based on annually assessed care requirements regardless of the style of facility. The terms nursing home and hostel were replaced by "high" and "low" care. Low-care facilities (hostels) were able to provide ongoing care in many cases where the resident's care requirements exceeded those traditionally offered at that level. This "ageing in place" resulted in a growing proportion of low-care facility residents being classified as "high care", most recently reported at 65.6% of all residents.[8]

Because of vast historical variation in supply of residential places at a regional level before 1986, there remains considerable disparity today.[9] For example, in 2001 provision of high-care places ranged from 25 to 88 places per 1000 70+ among regions.

Community care, other than that provided in the form of CAPs, is provided through a variety of programs, the largest of which is the Home and Community Care program (HACC). The prescriptive planning arrangements for residential care are notably absent in this and related programs. The HACC program is jointly funded on a 60 : 40 basis,[10] with the larger federal allocation dependent on the state contribution, and an upper limit set by the Australian Government. Not all states take up the full federal offer. Distribution of resources at a regional level vary considerably and in most states do not follow a strict formula. The overall effect is that there is wide variation in the distribution of community-care resources among regions.[11]

Acute care and associated subacute programs are administered by state governments. Hospital facilities provide general acute medical services, and specific geriatric assessment and rehabilitation programs. Acute care hospitals are relevant to

the recipients of the residential and community aged care programs as:

- Acute care hospitals are often the entry point to aged care services, when acute illness is associated with newly acquired permanent disability (eg, stroke and fractured hip).[12]
- The majority of residential care entrants at the high-care level are admitted from hospitals.[12,13] These individuals usually await a permanent place for care in an acute care setting.
- When recipients of community or residential care services become ill, they often require admission to acute care hospitals. Management of the acute illness is complicated by the pre-existing chronic illnesses and disability.
- Recovery from disabling acute illnesses often draws on the resources of geriatric assessment and rehabilitation units.

Throughout the 1990s, hospital bed provision progressively declined in absolute terms by around 3% per annum.[14] The provision of inpatient specialist geriatric hospital programs varies widely among state and regional jurisdictions.[9] In 2001, the provision of dedicated geriatric assessment and rehabilitation beds varied from 3.01 beds per 1000 70+ in Western Australia to 0.48 per 1000 70+ in Tasmania. Many large hospitals or health regions do not offer such services in any form.

In 2001–02, persons aged 75 years and older constituted 18% of admissions to hospitals in Australia, and utilised 31% of available bed-days.[5] Over the decade to 2002, the rate of admissions among this group increased by 42% compared with declines of 2% and 4% in the < 65 years and 65–74 years age groups, respectively. However, the proportion of beds utilised by the 75+ population remained stable, primarily due to substantial reductions in length of stay.

A large proportion of recommendations to nursing home (or high-level residential) care are made in the context of an acute hospital admission, whereas the majority of applications to low care are made by individuals located in their "usual" domiciliary setting.[12] A cross-sectional study of bed occupancy conducted in April 2002 demonstrated that 1926 of 16 104 overnight inpatients aged 65 years and older in Australian public hospital beds (12%) were considered by treating staff to be more appropriately cared for in a residential aged care facility.[3] Of these, 1306 were reported to have a current active ACAT recommendation for residential care, of which the majority were for high care. The study concluded that up to 20% of elderly overnight patients in acute care hospitals were not receiving the form of care that best met their care needs.

In 2004, the federal Minister for Ageing announced the establishment of "up to 2000 transition care places over the next three years to help older people after a stay in hospital."[15] These places are designed to support people upon discharge from acute care hospitals who are on the threshold of requiring permanent residential care. If successful, the program will provide a more "appropriate" rehabilitative setting than hospital and will, if successful, ultimately allow some frail older people to return to live in the community. This initiative might reduce the pressure on the hospital system by decreasing the number of elderly people waiting in an acute care hospital setting for a bed in a residential care facility. It might also reduce the demand for residential care beds by delaying or altogether avoiding some admissions.

In summary, the relative provision of hospital and residential care places has declined over the past decade or more, whereas the investment in community care has increased in excess of inflation. In the late 1990s, acute care hospital "access block" emerged as a critical issue, and a potential solution is perceived to be to reduce the number of frail older people using hospital beds, particularly those awaiting a permanent place in residential care.

Issues at the interface

There are several key stakeholder groups that hold different perspectives. Older people are likely to desire prompt access to acute hospital care when they are ill and, when a decision to seek permanent residential care is required, to wait in a setting where suitable care is available and where sufficient time is available to make an informed choice

of a residential care facility. Hospital administrators, in the face of demand pressures, seek to minimise the number of "non-acute" patients in their care, particularly if reimbursement is based on episodes of care (eg, diagnosis related groups). Similarly, state governments, which administer hospitals in Australia, seek to ensure that the demand for hospital beds by the elderly is minimised — ultimately to constrain costs, but also, in the short term, to avoid political damage from emergency access block and burgeoning elective surgical waiting lists.

Aged care providers operate with tight budgets, workforce pressures and limited availability of skilled health professionals (eg, nurses in low care facilities, medical staff after hours). Consequently, the threshold for transfer to acute care settings when residents become ill may be falling. The federal government is responsible for residential care facilities, and seeks to constrain costs by capping places and subsidies. State and federal governments share responsibility for community care. Investment in community care may be driven by a variety of influences, including a view that greater investment reduces demand on institutional care, which in turn may drive down overall aged care outlays.

The next section of the paper describes the use of computer systems simulation to test a variety of actual and potential policy initiatives related to interactions between the acute and aged care systems.

Systems simulation

Health systems simulation is the application of computer simulation to explore, understand and improve the interaction between structure and action in health care and policy. Computer simulation is now a mature and powerful tool for modeling the health system to test how different factors may improve efficiency, effectiveness and equity in situations where it is not possible to conduct real-world experiments (such as expanding the number of residential care places). Important advantages are low cost and low risk. Real world experiments can be extremely expensive and irreversible for decades, because they often require significant capital investment and workforce realignment.

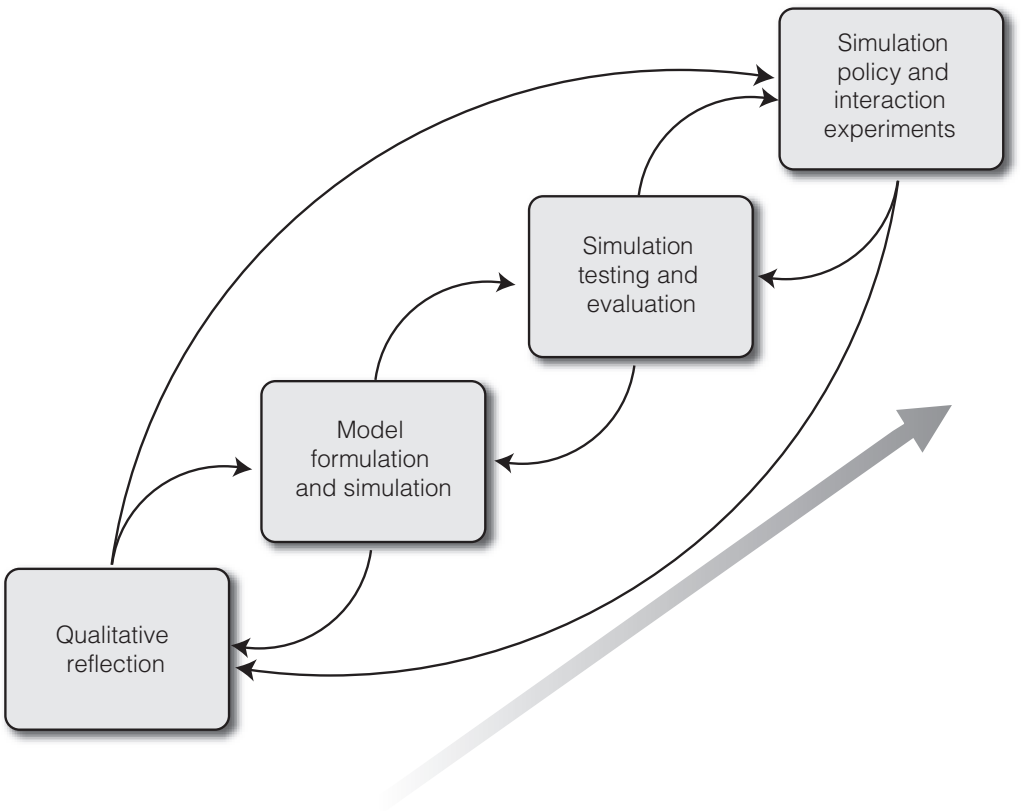
After 50 years of learning how to apply computer simulation to help solve complex real world problems, the techniques are now powerful and flexible enough to provide a comprehensive integrating framework for tackling "messy" or complicated real-world health system problems. The decision sciences and systems engineering disciplines have addressed such problems in other areas by increasingly turning to modeling and computer simulation. Their use has accelerated over the past decade, with the advent of powerful desktop PCs and software with user-friendly interfaces which have dramatically reduced the time needed to build models to weeks, and simulation runs to seconds. This has resulted in wider use and popularisation beyond the traditional quantitative modeling community.[16]

Whole system approaches using computer simulation originated as quantitative system dynamics, and are now being extended using multi-level, multi-method approaches that depict individual, sectoral and system behaviours and interactions over both time and space. System dynamics modeling was developed by Forrester in 1956 as "a way of combining personal experience with computer simulation to yield a better understanding of social systems, combining traditional management, feedback theory and computer simulation."[17]

System dynamics usually develops a high level aggregate view of the "forest" of relevant stocks, flows and feedback interactions that are relevant to the system problem of interest. The simulation plays out the overall pattern of system behaviour over time by solving difference equations, including non-linear effects. Agent-based approaches focus on the "trees" — the interactions of individuals with each other and the environment. They handle distributional and subgroup effects well, but the system-level behaviour is less clear since it "emerges" from the lower levels of interaction.

In the current project we plan a blended approach which employs system dynamics and

Schematic representation of the simulation development process



agent-based simulation, made possible through the existence of a single commercial software package called "AnyLogic" (XJ Technologies, St. Petersburg, Russian Federation). This object-oriented Java-based software can integrate multiple simulation methods (including discrete event), support multiple levels of aggregation and interact with users through web browsers using advanced animations of distribution over space and time. This joint methodology has been successfully employed by one of the authors (G M) and his colleagues in commercial engineering and health care projects in Australia. (see www.anysims.com and www.healthsims.com.au)

The approach involves a sequence of activities to build and test the model, before applying the desired policy questions (Box).

Qualitative reflection

This stage consists of identifying and defining the problem as a series of key questions, and conceptualising the subsequent model needed to answer these key questions. In complex problems the key questions may be refined progressively as the project proceeds, and a deeper understanding emerges during subsequent analysis. Typical policy questions about the future are: What are current and future challenges? What are the key policy levers? What are the key measures of performance? What are the probable alternative futures?

Model formulation and simulation

Initially an aggregated top-down view is adopted using system dynamics methods, then bottom up agent-based approaches if required for more

detailed conceptualisation, or if specific detailed datasets are available. This combination of multi-level, multi-method approaches is possible due to the object architecture of the simulation software.[18]

The top-down methods involve mapping the context using stocks and flows of key items of interest in a system using a process view, together with the relevant connecting information feedbacks and delays. This produces a graphical, logical structure (wiring) diagram. The mathematical relationships among each of the components in the logical structure are added or estimated from available data or best opinion. The behaviour of the system over time is then displayed graphically by the computer simulation engine solving a set of difference equations, using integration approximation and other numerical analysis techniques.

Technically, the agent-based simulation uses mainstream software object-oriented design methods to define and describe the detail of classes of interest and related functions, standard unified modeling language (UML) statecharts to describe their dynamic behaviour, and timers and messaging to specify coordination and interaction. The authors' current practice is to first develop a traditional system dynamics model using "ithink" software (isee systems, inc., Lebanon, NH, USA). Subsequently, this model is tranferred to AnyLogic as sector objects and, where required, some sectors are elaborated as interacting agents.

Simulation testing and evaluation

The simulation model is evaluated by assessing whether it is fit for its intended purpose. During this phase the model is progressively refined over multiple iterations with domain experts although review of the model and modification can occur at any stage of model development. Differences between the predicted and observed historical behaviours are detected and reconciled. Sterman states that: "The real test is whether the model helps make better decisions. Therefore we must assess the overall suitability of the model for its purpose, its conformance to fundamental formulation principles, the sensitivity of results to uncertainty in assumptions, and the integrity of the modelling process."[19] A series of questions are posed which address conceptual validity (can the model answer the questions asked?), structural and behavioural verification, simulation verification and the pragmatics and politics of model use.

Simulation policy and interaction experiments

Policy design ranges from changing parameter values to creating entirely new strategies, structures and decision rules. These include changing time delays and the flow and quality of information available at key decision points, or fundamentally re-inventing the decision processes of the actors in the system.[20]

The policy design approach in service industries involves representing the common service demand patterns: describing how information about demand and capacity are used, how resourcing goals and staffing levels are set and how discrepancies between goals and actuals are corrected.

The computer simulation is presented to users in the style of a "flight simulator", with a variety of dials and levers available for manipulation to modify the context of the experiment or to prescribe policy interventions. It can be made available on a PC platform or as a web-based application.

There are several approaches to deploying simulations in policy experiments. They can be used as a single-user simulation or as computer simulation games with multiple players locally or across the Internet. They can also be converted into board games, with players rotating through different decision-making roles to enhance group learning. Computer and board-game simulation participants can be subjected to controlled experiments to observe why they make specific decisions in simulated conditions.

Evaluating performance of the system

In designing the model, we have selected a set of key performance indicators (KPI) against which to assess the "performance" of the acute and aged

care systems at the interface. The primary KPI is the number of people awaiting permanent residential care in an acute care hospital setting. This phenomenon is considered to best reflect alignment of interactions between the sectors, as it is placed at an interface where there is a constant flow of individuals between the systems. Other important KPIs include:

- the average waiting time to placement from acute care;
- the number of people waiting for residential care placement in the community;
- the number of high-care residents in low-care settings (reflecting a mismatch of supply and demand of high-care places); and
- the total system cost (acute and aged care systems).

The policy scenarios

A series of policy scenarios have been compiled to be submitted to the simulation. They have been refined through a series of workshops of the project investigators and their colleagues and will be presented to a wide range of stakeholders for comment and refinement in the course of the project.

The model will be used to assess a variety of scenarios, and the impact will be observed over a 10-year time frame to 2016, although the simulation can be run over any time period. The scenarios are:

1. *No change from the current policy framework.* Current planning ratios for residential places are preserved. Investment in community care continues in line with increases over the past 10 years.
2. *The provision of high-care places is increased.* This scenario represents a direct attempt to reduce unmet demand by increasing available places for those individuals most likely to be awaiting residential care in hospital.
3. *Transition (or interim) care places are increased* to house queues of people awaiting residential care.
4. *The provision of community places is increased* (for example, by expanding the CAP program) in an attempt to reduce demand for permanent residential care.
5. *The provision of subacute-care places is increased.* This intervention represents an attempt to attenuate demand for permanent residential care. Of all of the available interventions, geriatric assessment and rehabilitation units probably are associated with the strongest evidence base to influence outcomes.[21]
6. *Investment in effective preventive strategies is increased.* The prevention of the major illnesses and disabilities that drive the demand for residential care results in either deferral of morbidity with increased life expectancy, or compression of morbidity without life extension.

Two models will be constructed. A national model will provide a broad perspective to assist in scrutiny of the wider policy framework, whereas a regional model will assist local planners to examine policy options in a more local context. The latter will enable detailing, with actual resource stocks available in the region built into the model.

As the simulation is constructed it will be presented to an increasingly wider audience, through live presentations and a web-based version. Ultimately, the computer model will be presented as a "policy flight simulator" where users can test their own policy adjustments, load their own data and explore the impacts of possible scenarios.

Conclusion

The interactions between the acute and aged care systems are complex, involving people of different backgrounds and disciplines with different views of the world. Systems simulation integrates these views in a logical, consistent way to build consensus and participation as groups in asking "what-if" questions about this complex world.

Dynamic systems simulation provides a method of conducting policy experiments at low risk and cost with instant results. While the outcomes will not necessarily be precise, the development process and interactions with stakeholders, with the opportunity for users to conduct their own experiments, are likely to raise the quality of the debate around futures for the acute–aged care system.

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Competing interests

The authors declare that they have no competing interests.

References

1 Flicker L. Clinical issues in aged care: managing the interface between acute, subacute, community and residential care. *Aust Health Rev* 2002; 25(5): 136-9. Available at: http://www.aushealthreview.com.au/publications/articles/issues/ahr_25_5_171002/ahr_25_5_136-139.asp (accessed Aug 2006).

2 Cameron PA, Campbell DA. Access block: problems and progress. *Med J Aust* 2003; 178: 99-100.

3 AHMAC Working Group on the Care of Older Australians. Examination of length of stay for older persons in acute and sub-acute sectors. Final report. Adelaide: Aged Care Evaluation and Management Advisors, 2003. Available at: http://www.health.gov.au/internet/wcms/publishing.nsf/Content/health-minconf.htm (accessed Aug 2006).

4 Australian Bureau of Statistics. Population projections, Australia, 2002-2101. Canberra: ABS, 2003.

5 Gray L, Yeo M, Duckett S. Trends in the use of hospital beds by older people in Australia: 1993–2002. *Med J Aust* 2004; 181: 478-81.

6 Australian Institute of Health and Welfare. Australia's welfare 2003. Canberra: AIHW, 2003.

7 Department of Community Services. Nursing homes and hostels review. Canberra: Australian Government Publishing Service, 1986.

8 Australian Institute of Health and Welfare. Residential aged care in Australia 2003–04: a statistical overview. Aged Care Statistics Series No. 20. Canberra: AIHW, 2005. (AIHW Cat. No. AGE 43.)

9 Gray L, Dorevitch M, Smith R, et al. Service provision for older people in the acute–aged care system. Final report. Melbourne: National Ageing Research Institute and Centre for Applied Gerontology, 2002.

10 Australian Institute of Health and Welfare. Australia's welfare 2005. Australian Government: Canberra, 2005. (AIHW Cat. No. AUS 65.)

11 Gibson D, Braun P, Liu Z. Spatial equity in the distribution of aged care services in Australia. *Australas J Ageing* 2002; 21(2): 80-6.

12 Gray L, Dorevitch M, Farish S. A population-based study of nursing home applicants to long-term nursing home care. *J Am Geriatr Soc* 1992; 40: 596-600.

13 Gibson D. The interface between hospital and residential aged care. *Aust Health Rev* 2002; 25(5): 132-5. Available at: http://www.aushealthreview.com.au/publications/articles/issues/ahr_25_5_171002/ahr_25_5_132-135.asp (accessed Aug 2006).

14 Australian Institute of Health and Welfare. Australia's health 2002. Australia's Health No. 8. Canberra: AIHW, 2002. (AIHW Cat. No. AUS 25.)

15 Bishop J. Investing in Australia's aged care: more places, better care. Canberra: Commonwealth Government, 2004.

16 Reid PP, Compton WD, Grossman JH, Fanjiang G, editors, Committee on Engineering and the Health Care System, National Academy of Engineering, Institute of Medicine. Building a better delivery system: a new engineering/health care partnership. Washington, DC: National Academies Press, 2005.

17 Forrester JW. Industrial dynamics. Cambridge, MA: Productivity Press, 1961.

18 Borshchev A, Filippov A. From system dynamics and discrete event to practical agent based modeling: reasons, techniques, tools. Proceedings of the 22nd International Conference of the System Dynamics Society; 2004 July 25-29; Oxford, England, UK: System Dynamics Society, 2004.

19 Sterman J. Business dynamics: systems thinking and modeling for a complex world. USA: McGraw-Hill/Irwin, 2000.

20 Sterman J. System dynamics modeling: tools for learning in a complex world. *Calif Manage Rev* 2001; 43(4): 8-25.

21 Stuck AE, Siu AL, Wieland GD, et al. Comprehensive geriatric assessment: a meta-analysis of controlled trials. *Lancet* 1993; 342: 1032-6.

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