Health Record Systems and Medicines Use
A Multi-Scale, Multi-Method Simulation

Rosemarie Sadsad, Geoff McDonnell

Centre for Health Informatics, University of News South Wales, Coogee Campus, Sydney NSW 2052

The Problem

Elderly patients use more medications given the prevalence of co-morbidities, putting them at risk of experiencing medication errors [1].

In the community, 400 000 adverse drug events (ADE) are managed in Australian general practices each year [2] with the elderly attributing to 26.8% of all general practice encounters [3]. The likelihood of experiencing an ADE increased with age to peak in those aged 65 and over [4]. Up to 30% of all hospital admissions for patients aged 70 and over are medication related [5] with 50% of elderly patients taking their medicines incorrectly after leaving the hospital [6].

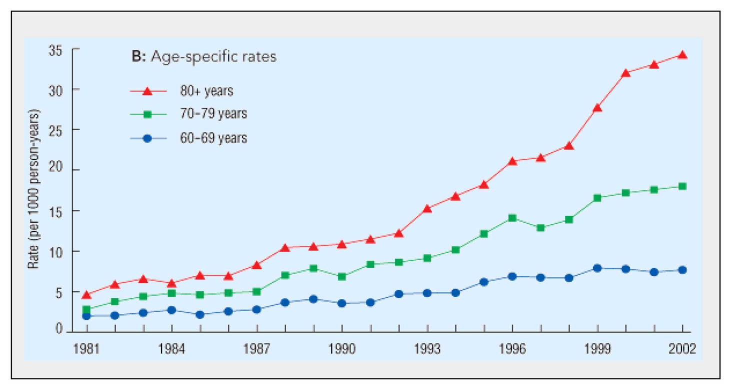


Figure 1: Rate of hospital stays related to adverse drug reactions in people aged 60+ years in Western Australia [7].

A highly anticipated strategy is the implementation of health record solutions, namely a mix of shared electronic health records (SEHR) and personal health records (PHR). SEHRs are managed, stored and shared by health providers whereas PHRs are managed by and kept with the patient. This integrated intervention empowers and provides information to all individuals involved in the medication use system (patients, carers, doctors and pharmacists) enabling more informed decision making throughout the use of medicines use [8].

Aim

This research aims to build a comprehensive model capturing the complexity of the use of medicines by the elderly in the community, across different spatial and temporal scales.

This model can be used to direct the design of an integrated health record solution that takes into consideration contextual factors, its impact on the quality use of medicines, health care cost and accessibility as well as impacts on existing interventions and society.

The Model

Important entities and mechanisms operate simultaneously across varying scales and influence the use of medicines [9].

The context level represented with stock and flow structures, identifies situations that govern and constrain the use of medicines. This aggregate level identifies reinforcing and balancing feedback effects, circular causation, delayed responses and leverage points where strategic decisions and actions towards the use of medicines can be identified [10].

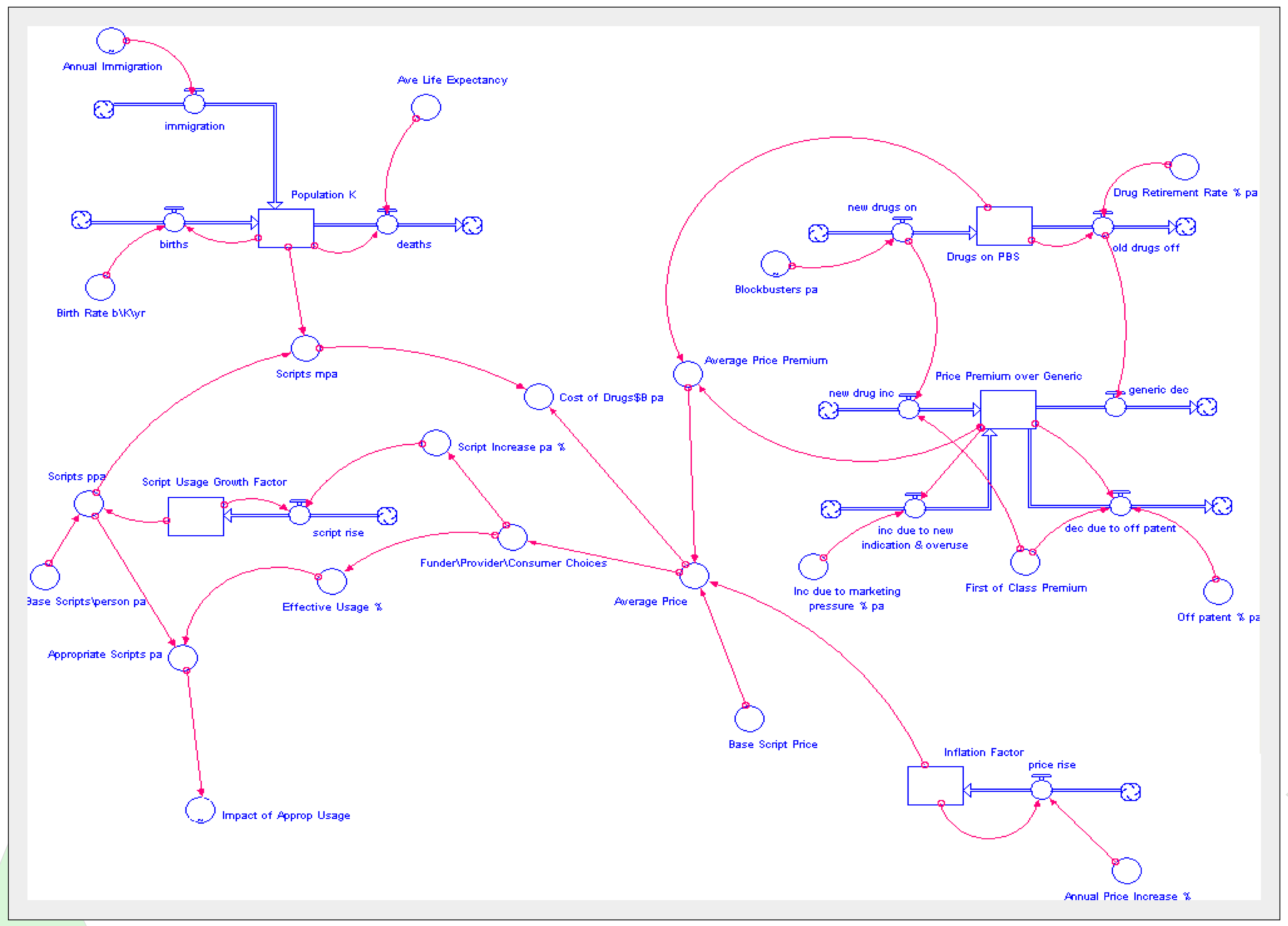


Figure 2: The National Medicines Use System [11].
The population is growing and ageing. The elderly are more susceptible to medication errors, thus have a large impact on the quality use of medicines. The increase in prescriptions written implies people are using more drugs increasing the chance of experiencing a medication error. Drug cost inflation and price premiums due to the development of new drugs affects the purchase of drugs by individuals, if the prices are too high, required medication may not be taken.

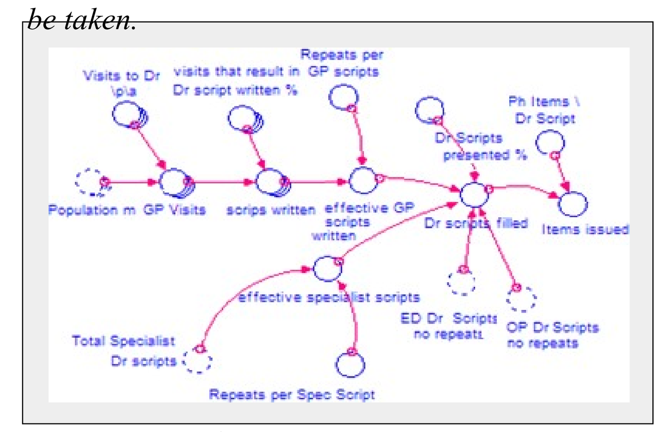
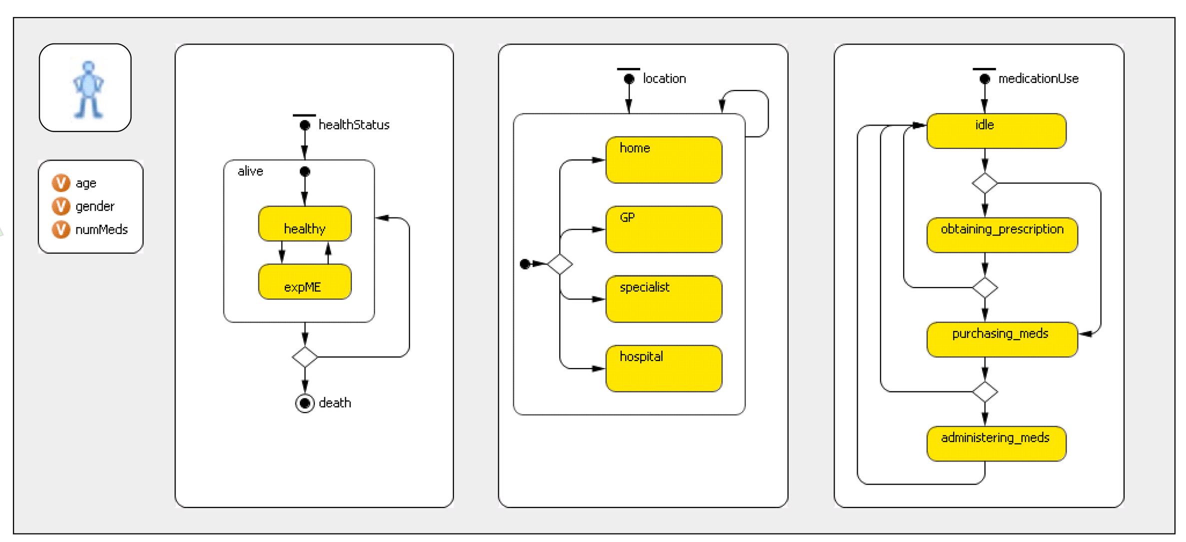


Figure 3: This describes how prescriptions are written and filled.

Other contextual factors not described here include: patient referrals to other health practitioners or hospital, aggregate medication error rates, medical workforce, available drug information as well as health record intervention infrastructure, implementation, costs and adoption

The interaction level represented with agent based modelling, identifies the individuals central to the use of medicines, namely the patient and medication prescribers. These individuals play a role in the prescribing, dispensing, administering and monitoring of medications, with each stage susceptible to error. Local repetitive and competitive interactions, according to an individuals internal rules, occur between individuals and the environment [12, 13]. As the service of care changes with the introduction of new health record interventions, these individuals learn, adapt and self-organise to maintain order [16].

Figure 4: Each elderly patient holds attributes such as age and gender, number of medications. Their current health status, health services they may visit and medicines use status can be described using statecharts.



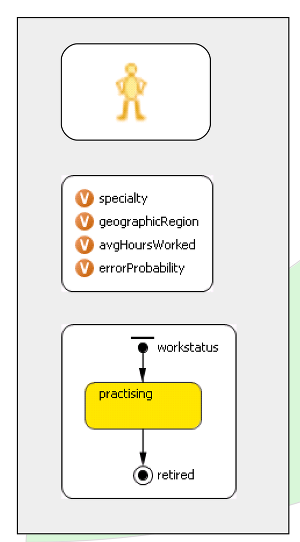


Figure 5: Each doctor holds attributes such as their specialty (general practitioner, specialist, hospital specialist, hospital non-specialist), the geographic region where they practise, their average weekly hours and the probability the doctor will encounter a medication error. Doctors leave the medicines use system once they stop practising.

Multi-Scale Modelling

Multi-scale modelling and simulation can represent different spatial and temporal resolutions [14] of the use of medicines by the elderly in the community. It recognises that mechanisms and entities from different scales interact and influence each other (as depicted by the green arrows).

For example, the introduction of health record interventions will change the pattern of care. The adaptation of individuals to this change is captured at the local level and will influence the structures such as funding system described at the aggregate level. The cost of drugs managed at the strategic level will influence discrete decisions made by individuals locally such as medicine purchasing or prescribing behaviours.

Multi-scale modelling visualises how a policy developed at the aggregate level is applied at the operational level. This modelling technique has the ability to adaptively switch between different levels of abstraction during real-time simulation [14] providing a translation between conceptual and highly descriptive representations of the system.

Multi-scale modelling can be achieved by combining aggregate and disaggregate modelling methodologies. I will be using a combination of System Dynamics and Agent-Based modelling methods, a task that has been simplified with the AnyLogic6 simulation platform [15].

In conclusion, designing health record interventions becomes a difficult task when factoring in the complexity and scale inherent of the use of medicines. Multi-scale simulation provides a logical and consistent framework for dynamic analysis and a means to design and test health record policies to cover a range of possible futures in a risk-free environment.

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