

Strategic implications of workplace policies on nursing capacity planning

James P. Thompson¹, John P. Ansah, Carmen Y.J. Lee, Robert L. Eberlein

Duke-NUS Graduate Medical School
8 College Road
Singapore 169857

Telephone: +65 6601 1362

¹ james.thompson@duke-nus.edu.sg

Abstract

Human resource requirements planning for nursing capacity has traditionally focused on expected utilization or demand and largely ignored the complex workplace policies. The approach taken in this research emphasizes the interaction of policies affecting compensation, work intensity, task satisfaction and career progression on hiring and retention – the flows that determine the stock of nurses. Based on research conducted with Singapore Ministry of Health, we describe how policy changes influence employment levels at care venues over a strategic time horizon. To answer three research questions posed by experienced planners and managers, we employ a System Dynamics model to test and explain the implications of alternative policy choices.

Introduction

Planning for nursing capacity over a ten or twenty year horizon is becoming more important as countries and regions find that recruiting and retaining nurses is a persistent problem. For the most part such planning follows a pattern of examining near term needs and simply extrapolating those results for several more years.¹ By contrast, we propose a different approach, one that explores fundamental policies that affect the attraction of potential nurses to the profession and retention of nurses in venues. In so doing, the approach explicitly acknowledges that conditions can, and likely will, change over the course of the planning period and provides insight into fast and slow-acting policies. In essence, the approach provides responses to the question of how many nurses will be needed over time, but avoids being hard-wired and fixated on a specific numerical goal.

¹ See for example Roberfroid, D., Leonard, C. & Stordeur, S. 2009. Physician Supply Forecast: Better Than Peering in a Crystal Ball? *Human Resources for Health*, 7(10)., O'brien-Pallas, L., Bauman, A., Donner, G., Murphy, G. T., Lochaas-Gerlach, J. & Luba, M. 2001. Forecasting Models for Human Resources in Health Care. *Journal of Advanced Nursing*, 33(1), 120-129., and Scheffler, R. M., Liu, J. X., Kinfu, Y. & Dal Poz, M. R. 2008. Forecasting the Global Shortage of Physicians: An Economic- and Needs-Based Approach. *Bulletin of the World Health Organization*, 86(7), 516-523..

The work presented here is based on a research project conducted with the Singapore Ministry of Health; however, we believe it has much wider applicability in other countries and regions. Accordingly, it is presented as a policy study rather than a projection. Readers drawn to experiment with the model described here are encouraged to change parameter values to suit their regions. The policy-testing model illustrates nurse capacity system dynamics without reproducing historical results, which may be achieved with model calibration.

The research team met with an Advisory Group composed of Ministry of Health strategic planning personnel, hospital nursing directors and training directors, managers from human resources, and highly experienced nurses from in-hospital settings such as inpatient and emergency care departments. During three half-day working sessions, the team presented a concept model and introduced System Dynamics iconography as described in Andersen and Richardson (1997). The Advisory Group offered comments on the concept model, which was developed to produce increasingly complex dynamics, as described in Lee and Thompson (2011).

Working only with verbal reference modes is not unprecedented, and is documented in Forrester (1974). When several reference modes are offered, a coherent explanation can emerge and its consistency can be tested in simulation. As a result, the analysis points to a useful means for thinking about how workplace policies affect nursing capacity in the long run and provides means for exploring policies for other medical professions.

We begin with a brief description of the approach to thinking about capacity planning from a policy perspective. We then consider several factors that contribute to the relative attractiveness of nursing as a profession in general and at venues with different employment opportunities. Next we present simulated results from selected research questions and conclude with a short summary of implications.

Research Questions

The Advisory Group raised concerns about the adequacy of Nursing Capacity over the next 20 years. In addition to the overall need to meet perceived rising demand, policy changes have appeared to generate confusing results. Three of these questions are explored in this paper:

1. Nursing capacity in long-term care facilities such as nursing homes is below the desired level. In response, a policy of mandatory rotations among all venues is being considered for inexperienced nurses. How do mandatory rotations for nurses affect nursing capacity?

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2. In the past, special budget provisions increased the number of nurse positions at acute hospitals. The goal of the policy is to create a surplus of nurses at existing hospitals so that, when new hospitals come on-stream, there will be a supply of nurses to draw from. The results have been mixed so far, with the special budget creating new positions but the number of nurses leaving the system increases which caused the surplus to be lower than expected. How does a surge in hiring affect employment levels?
3. As noted in (1), nursing capacity shortages in longterm continue, wage adjustment in a prior year failed to correct a perceived disparity between longterm and other venues. Why did a wage adjustment in longterm fail to correct a perceived shortage in staffing?

Description of Model²

Core structure

In its simplest form, nursing capacity can be thought of as a system state or level – number of nurses – that changes with flows of hiring and leaving (Figure 1). Hiring is a function of the nurses available for work and positions available, and leaving positions is a function of the attractiveness of other opportunities. In addition, there is an assumed average time to stay in a career path before leaving or trying to leave a position. This core simulates the comings and goings.

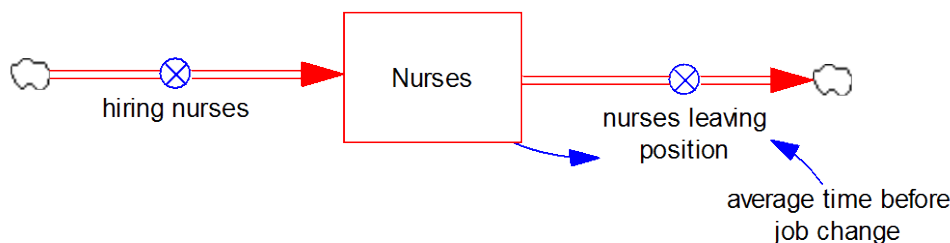


Figure 1: Core structure of nursing capacity

Parallel to the core, the model simulates the average amount of experience accumulated in a position. As described later, this attribute is endogenously simulated and changes in average experience affect promotion opportunities and, hence, the number of experienced nurses in a venue.

Not visible in Figure 1, Nurses and associated changes are disaggregated into different venues of care such as acute hospital inpatient, emergency, day surgery, and outpatient clinic departments, nursing homes, community hospitals, physician offices, community-based

² A copy of the model described here is available on request to the authors.

services and the like. To simplify discussion the model presented in this paper includes only acute inpatient hospital care (“acute”) and long-term care such as nursing or convalescent homes (“longterm”).

Attributes of employment

The advisory group discussed a wide range of characteristics of work at each venue – attributes of employment – and four common elements emerged: compensation, work intensity, task satisfaction and career progression.

Compensation

Each venue can be parameterised with reference compensation, which is the average annual compensation per nurse. The relative attractiveness of compensation is a comparison of annual compensation at each venue. In compensation structure, the average compensation at one venue is compared to the average compensation at all venues to compute its relative attractiveness from the perspective of nurses seeking employment.

Work Intensity

In the group advisory sessions, it was mentioned that work intensity varies by venue, with the discussion centring on average how many patients a nurse was responsible to attend to over the course of a time period—say, month. In daily-visit venues such as physician offices, nurses attended to a larger number of patients for a shorter period of time than in the long-term care venues, but the notion of a ratio was consistent. In the model here, the ratio is a comparison of actual staffing versus desired staffing. The question of whether desired staffing is appropriate for patient needs is the matter of other research.

Task Satisfaction

Task satisfaction frequently arose in discussions and included adequacy of training and appropriateness of assignments. One recurrent theme was the adequacy of support services which distilled to a ratio of trained nurses to health care assistants. When nurses are adequately supported by such assistants, the nurses performed essential medical care, and assistance with activities of daily living such as hygiene were the purview of support staff. Thus, from venue to venue, the adequacy of support staff contributed heavily to task satisfaction as viewed by the nursing staff.

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Career Progression

The advisory group discussed in detail how nurses progress throughout their careers. Notably, nurses in understaffed facilities progressed more quickly than nurses in more adequately staffed facilities. It was clear that nurse experience plays a crucial role in determining progression. In facilities in which average experience was above a norm, career progression slowed, and, where average experience was below a norm, promotions were more likely based on performance and achieved in shorter timeframes. Although not entirely fungible, experience gained in one venue transferred with the nurses in a change in position. Thus, career progression bottlenecks changed with new hiring and the average seniority of transfers between venues.

Combined Attributes and Relative attractiveness of venue

The attributes combine to describe the employment conditions at a venue. For example, a venue may offer high work intensity and high compensation. The two do not “cancel out” but can be balanced out; the question is relative to what? Once a group of people have selected nursing as a profession, the group can be observed to be equally, more or less attracted to one venue than another. The model here simulates the attractiveness of venues by comparing one to the other (or all others in a more granular situation) in the form described by Sterman (2000):

$$\text{venue relative attractiveness}[\text{venue}] = \frac{\text{venue attractiveness}[\text{venue}]}{\text{SUM}(\text{venue attractiveness}[\text{venue!}])}$$

where:

$$\begin{aligned} \text{venue attractiveness}[\text{venue}] = & \\ & \text{relative compensation attractiveness}[\text{venue}] \\ & * \text{relative work intensity attractiveness}[\text{venue}] \\ & * \text{relative career progression effect}[\text{venue}] \\ & * \text{relative task satisfaction}[\text{venue}] \end{aligned}$$

and, relative attractiveness of each attribute at one venue is compared to the sum of relative attractiveness of that attribute at all venues.

Demand

Demand created by patient activities is a very different topic from capacity planning. There clearly is a feedback loop between patient demand at one facility or another and the level of nursing capacity: inadequate capacity can have the effect of lessening patient demand (visits), and adequate or even excess capacity can increase realized demand. In the accompanying

model, these feedback loops are not included because they are likely to be more spot situational and thus part of a more detailed operational study than a policy study.

In the subject simulation model, demand is represented as a function of population with a modification for age of the population. That is, population and demand are assumed to be constant unless the demographic values are specifically changed. Overall facility demand can be changed to reflect a shift in population age in which a higher average age demands more acute and long-term care, and a lower average age demands more acute care.

Supply

Supply of trained nurses is generated from two principal sources: domestic nursing schools and hiring of nurses from foreign sources, both of which are presented in the model. The advisory group noted that, in periods of domestic shortage, more foreign nurses were recruited while in periods of adequate nursing school graduates fewer foreign nurses were recruited.

The domestic nursing schools are assumed to be the principal source of supply, an assumption borne out by experience and data. However, the advisory group did not offer a description of how nursing school capacity is determined, and thus assumptions in the model are worth noting. First, there is an equilibrium value for class size that permits a steady state in which

$$\begin{aligned} \text{domestic nurse class size} = & \\ & \text{SMOOTH (historical expected class size ,} \\ & \text{time to change class size)} \\ & * \text{ nurse profession attractiveness} \\ & + \text{ nurse school class size adjustment} \end{aligned}$$

where

SMOOTH is a first-order exponential smooth over time to change class size

weight on extrapolated class size = 0 (default)

historical expected class size is an indicated class size with an information delay of one year,

indicated class size is the sum of open nurse positions to be filled at all venues minus the sum of all nurses seeking new positions in the system times the average time in nursing school (three years) times the sum of 1/ average time in nursing school plus the fraction of students dropping out.

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Nurse school class size adjustment is the average difference between nurses graduating and hired in the previous years. A surplus reduces and a deficit increases subsequent class sizes.

The variable, nurse profession attractiveness, is discussed next.

The advisory group reported that the nursing profession in Singapore declined in popularity over the past ten or so years and that nursing schools were finding it more difficult to attract students. In addition, the advisory group agreed that the number of nurses permanently leaving the profession was increasing. No measured data were provided to support these assertions, but the assertions were considered sufficiently firm to simulate.

Compensation levels were considered most likely contributors to the changing condition; that is, nursing profession compensation may not be keeping pace with other fields such as independent pharmaceuticals firms and even the financial industry. Again, lacking data to discern how nursing compensation compares with other professional opportunities, an entirely endogenous argument was proposed. The proposition is that foreign nurses are paid at lower rate than domestically-sourced nurses, and, as the proportion of foreign nurses increases, the nursing profession is perceived as less attractive than competing professions in which foreign labour is either not a factor or is compensated at rates similar to domestically-sourced labour.

Foreign additions to nursing capacity is determined as

$$\begin{aligned} \text{additional foreign trained nurses entering hiring pool} = \\ \text{SMOOTH} (\text{MAX} (0, \text{deficit in nurses by venue summed}) , \\ \text{time to recruit foreign trained nurses}) \end{aligned}$$

When there is a deficit in aggregate nurses measured by subtracting the sum of nurses at all venues from target nurses, this formulation adds capacity from foreign sources, delayed by the time to recruit foreign trained nurses.

Target Nursing Capacity

To simplify discussion, this paper considers two venues of care—acute care hospitals and long-term care facilities such as nursing homes. Ratios of patients to nurses set desired nurses, and the target is a result of desired nurses multiplied by venue attractiveness. In essence, the number of nurses desired is an ideal staffing situation while the target is the result of actual conditions. In addition, there is a function that relates nursing experience to effectiveness that is set to null. That is, average experience level does not affect desired capacity for this research, but the subject model can be adjusted to simulate its effect.

Open Nurse Positions

Open nurse positions are simply the difference between the target nurse capacity and available nurses plus replacements for nurses leaving positions.

Hiring Pool

The hiring pool is the sum of nurses seeking employment: newly graduated students, experienced nurses seeking new positions and foreign-trained nurses entering the system. As noted above, nursing schools are simulated to produce graduates over a three-year curriculum. Deficits in expected graduates are supplemented with recruitment of experienced foreign nurses. Given a system in use, the largest group of nurses seeking new positions comes from turnover – nurses leaving existing positions.

Nurses available for hiring is the sum of nurses seeking employment:

$$\begin{aligned} \text{nurses available for hiring} = & \\ & \text{experienced nurses seeking new positions} \\ & + \text{graduating} \\ & + \text{expected surge in nurses available for hire} \end{aligned}$$

where

$$\begin{aligned} \text{experienced nurses seeking new positions} = & \\ & \text{SUM (nurses seeking new positions[venue!])} \\ & + \text{additional foreign trained nurses entering hiring pool} \\ \text{graduating} = & \\ & \text{Nursing School} \\ & / \text{average time in nursing school} \end{aligned}$$

It can be noted here that the core capacity diagram (Figure 1) describes nurses leaving position as a function of Nurses and average time before job change, which is the average time nurses are in one venue before attempting to find positions in another venue, quitting the nursing profession or retiring. This average time is set to the advisory group's observation that nurses tend to stay in positions for five years (a reference average time), adjusted for the effect of the concentration of foreign nurses and the attractiveness of other venues.

While not unique to Singapore, the concentration of foreign nurses is meaningful because foreign nurses are employed for fixed work visa periods which are, on average, shorter than the reference average time before job change. Thus, as the concentration increases, the turnover in positions increases. The attractiveness of other venues clearly affects turnover rates, too, because more attractive venues are expected to have higher retention rates than less attractive venues.

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The average time before job change does not equate to career length. This is represented as fraction of nurses leaving profession. Leaving the profession can occur for a wide variety of causes in the real world, e.g. starting a family, providing informal care for family or friends, or finding employment outside the sector. We assume that the normal fraction of nurses leaving the profession is 20% times the turnover, which results in an average career length of 25 years. Anecdotal information from the advisory group guided the parameter choice.

Allocation of Nurses Seeking New Positions

The model discussed in this paper was developed in Vensim[®] which is an application environment designed for System Dynamics model development. The software includes built-in capability for numerous common formulations such as exponential smoothing of data as mentioned above. In addition to such common formulations, the software contains several useful functions for chores such as allocation of scarce supply based on either the demand or attractiveness. The research model includes the use of one such function – ALLOCATE AVAILABLE – which mimics the selection of available nurses by either “free market” choice in which the relative attractiveness of offerings dominates position selections or “mandated placement” in which open positions are filled in proportion to the total need. This allocation formulation can be varied with an elasticity constant that shifts emphasis from “free market” to “mandated placement” depending on the strength of observed effect. In the simulations discussed below, the allocation function is set to mimic free market choice unless otherwise indicated as a free market is characteristic of the observed system.

Discussion

Policy-testing models are designed to create an environment in which individual policy choices can be observed without the noisy real world data to obscure outcomes (Forrester (1961) and Simon (1989)). To accomplish this idealised environment, the model is constructed to simulate in steady state equilibrium until disturbed. So when a policy choice is implemented in simulation, the contributions to change can be traced and analysed. The following three sections address findings from exploration of the Research Questions, but again the lack of measured time-series data limits estimation of real world effects.

Question 1: How does a surge in hiring affect employment levels?

The advisory group conjectured that a recent surge in nursing capacity was lost in part to the private sector. Several members of the advisory group noted that more nurses left the profession to take up private sector jobs as the surge was absorbed. To make a complete exploration of the question, one would need more information about employment market conditions, but the model at hand can help to develop an endogenous explanation of an elaborated question: What caused a surge in nursing school class size and graduates and new hiring to result in fewer experienced nurses than indicated by historical experience?

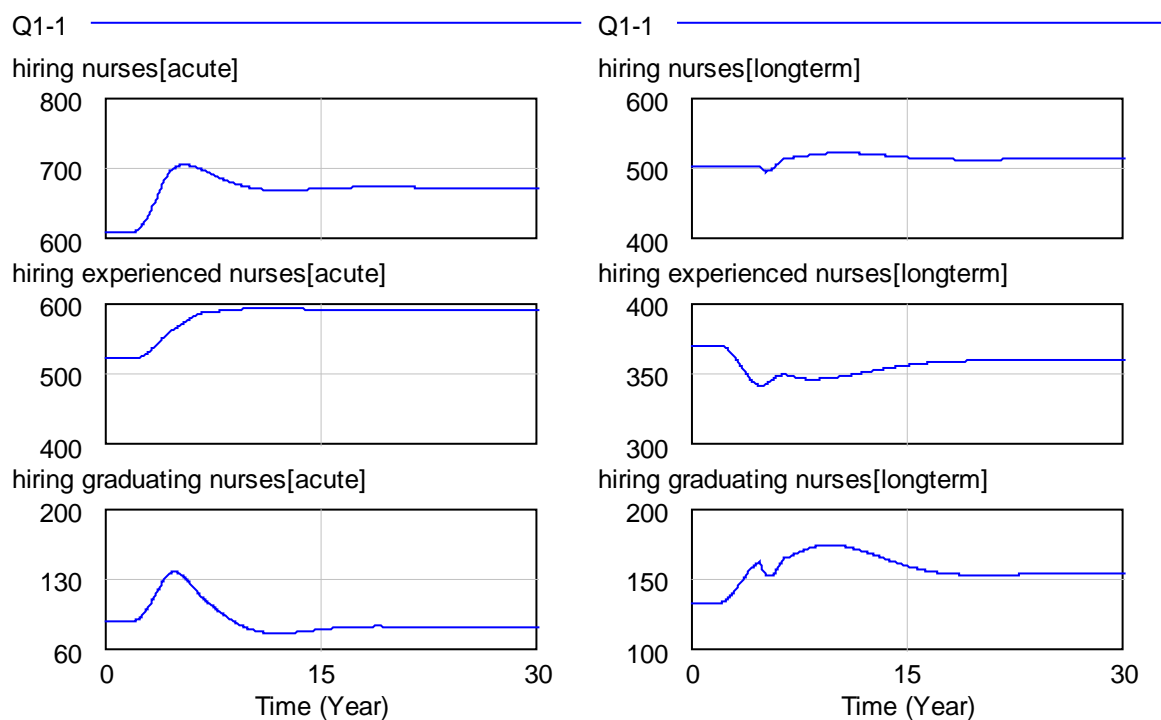


Figure 2: Hiring of experienced and inexperienced nurses in acute and longterm as consequence of training surge

A first test was developed in which nursing class size is doubled for two years and new positions are made available in the acute venue to absorb the graduates. No change was made in facility capacity, which closely matches the notion of creating a capacity surplus in a venue that will be taken up by expanding that venue at some later time. The surge conditions set off shifts in experience levels between acute and longterm that continue for six years (Figure 2).

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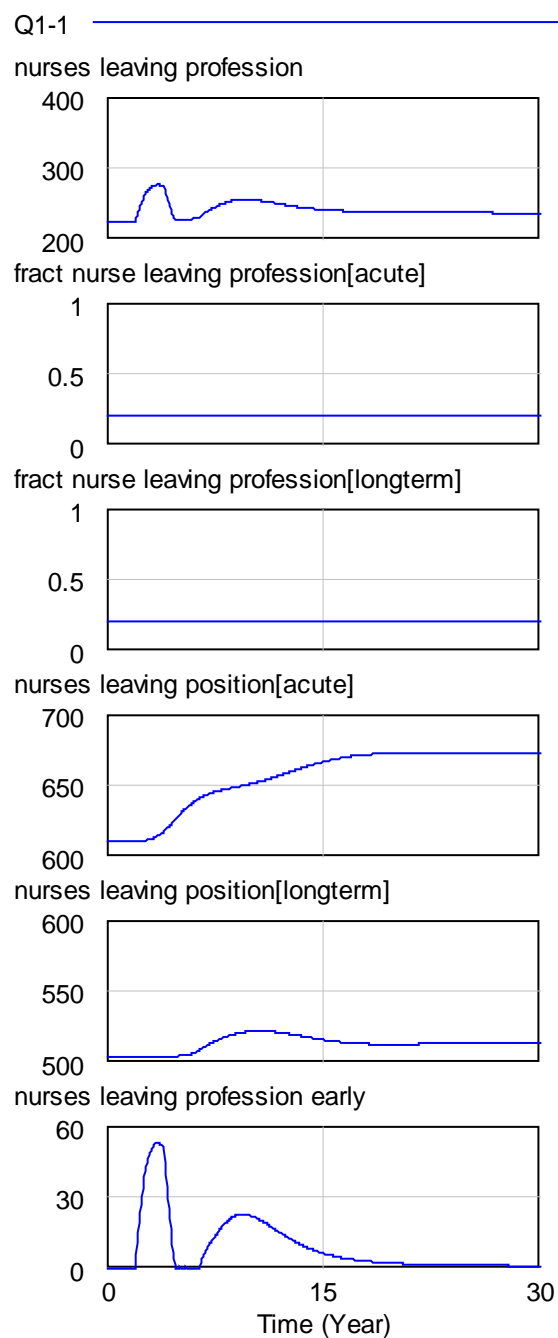


Figure 3: Nurses leaving the profession

Of note in Figure 3 is that the policy generates more immediate hiring of graduates into both venues but sustained graduates hiring in longterm. The acute venue's superior attractiveness draws more experienced nurses into the new open positions. Then, as more experienced nurses fill the open positions, the other variables affecting attractiveness affect system performance as explained in more detail following.

At first new positions created at acute cause experienced nurses to flow from longterm to acute as experienced nurses are attracted by better career progression, higher compensation, and reduced work intensity.

The effect of the surge on task satisfaction is interesting because the effect is less obvious. As the surge of nurses flows into acute, nurses who were hired to perform medical services find themselves performing tasks that do not utilize medical training, and task satisfaction decreases. Over a short period this may be tolerable, but the surge itself lasts two years and its effects are felt for several years after the initial surge. This effect on task satisfaction does not subside until the surplus of nurses is absorbed, with the

greatest effect noted about midway through the five-year cycle.

In a second test of the effects of a surge, we considered a whether a surge was necessary to correct for an anticipated insufficiency in the nursing corps. To simulate the effect of an anticipated insufficiency, we relaxed the assumption of a stable population and allowed population to grow at 2% per year, which is roughly the case in Singapore. To keep the changed assumptions simple, we did not assume a change in demographics such as ageing, and

so demand grows at the same rate as population. Finally, we assumed no changes in staffing levels other than those organically generated by increasing demand.

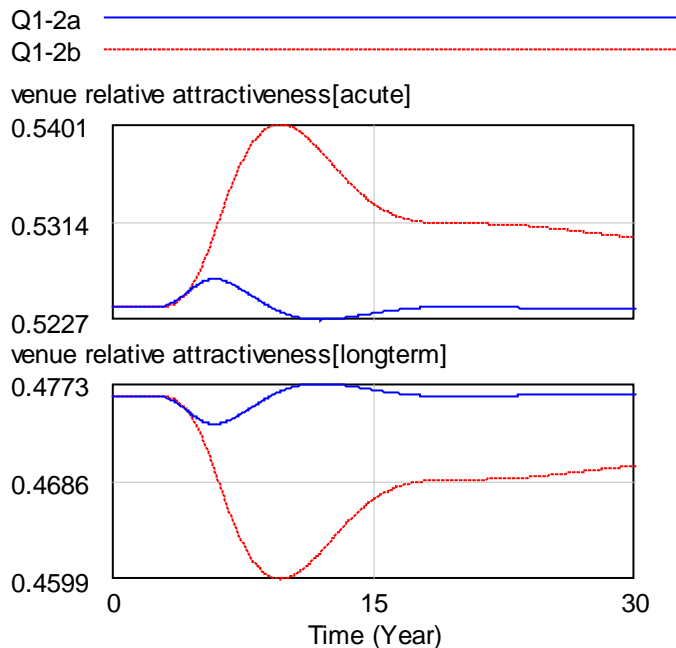


Figure 4: Venue relative attractiveness in growth scenarios without surge (2a) and with surge (2b)

Growing demand magnifies the relative attractiveness of the acute venue (Figure 4). As demand grows in proportion to the population more graduates and more opportunities for promotion arise in acute relative to longterm, and experienced nurses are drawn from longterm. Although not visible in Figure 4, there is some diminution in task satisfaction and work intensity at acute, but it is not enough to offset the enhanced promotion opportunities.

It is worth noting the effect of having of having two venues in this model: other than leaving the profession, there are no alternatives other than acute or longterm. In the real world, there are more than two venues of care, and there are alternative opportunities in the private sector, other countries and even other professions so the effect is plausible but not fully captured. The important point is that a policy cannot be applied in total isolation, and, if nurses are permitted to choose between venues, they will choose the more attractive venue over the less attractive options. Question 3 considers mandatory rotations as a policy to mitigate undesired effects.

Question 2: How do mandatory rotations for nurses affect nursing capacity?

In the present system, nurses seek open positions in the most attractive venues. It is assumed that the hiring venues select experienced nurses first and graduate nurses to fill remaining available positions. This assumption does not imply that a venue will attract only experienced nurses, but it does mean that each venue will first select experienced nurses and then select

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inexperienced nurses to fill available positions. (It should be noted that the model is configurable and that the selection process can be varied to put more or less weight on experience.)

To create a capacity deficit and test the effect of mandatory rotations, we use the same assumptions as for Question 1, viz. that there is a two-year increase in nurse school enrolment and an increase in new positions at acute. However, Question 2 assumes that there is a ‘free market’ allocation in which nurses fill available positions based on the relative attractiveness of the venue, and for Question 2 the allocation of nurses seeking new positions is changed to place priority on greatest need, which approximates the effect of mandatory rotations. In Q2, nurses are hired in proportion to the number of available positions. In Q1, nurses are hired in proportion to the attractiveness of each venue.

The results of the two policies differ significantly in that the mandatory rotations produce a relatively smooth response to the increased hiring, and the deficit created is shared by acute and longterm venues while the free market approach (without mandatory rotations) changes the promotion opportunities, work intensity and task satisfaction, which shift as experienced staff move between venues (Figure 5).

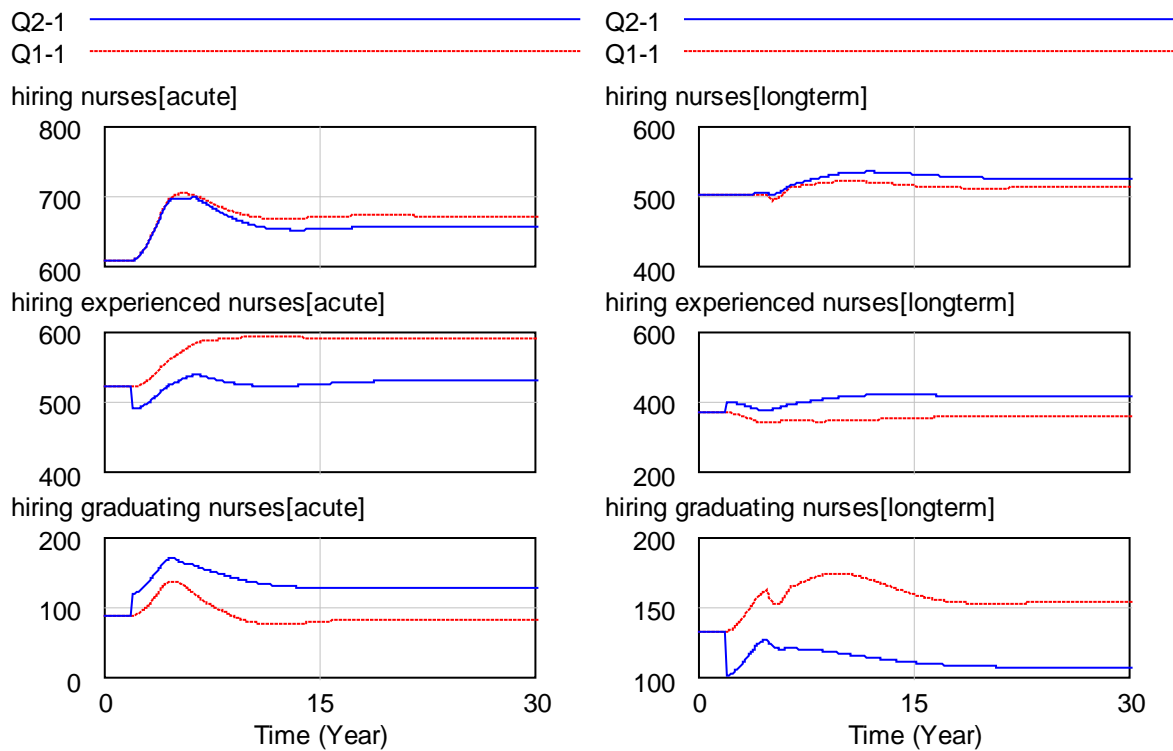


Figure 5: Nurse hiring with hiring surge and 10% increase in demand at acute

Perhaps as revealing is the source of nurses to meet the increased need. Whether or not mandatory rotations are invoked, the sudden increase in deficit is not met by the nurse training capacity but rather is met by increased foreign nurse recruiting. Over time, the domestic nurse training capacity increases to meet the need, peaking at Year 10 and then gradually dissipates to match the new level of demand 15 years later (Figure 6).

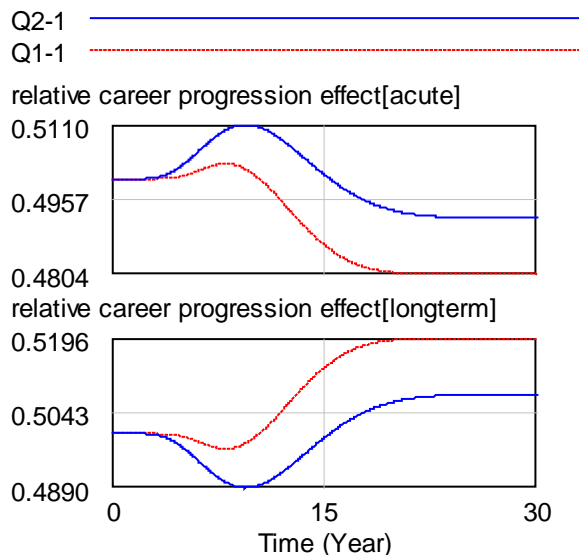


Figure 6: Effect of mandatory rotations on career progression

Work intensity and task satisfaction affect the results: the extra nurses at acute reduce work intensity but task satisfaction decreases because the surplus in nurses is not accompanied by an increase in support staff. The changes to the pattern of hiring graduates and experienced nurses affect career promotion prospects differently in the two scenarios. In both scenarios more graduates flow to acute, followed by a stable distribution of experienced nurses and graduates (Figure 7). However, with mandatory rotations the effect is more pronounced.

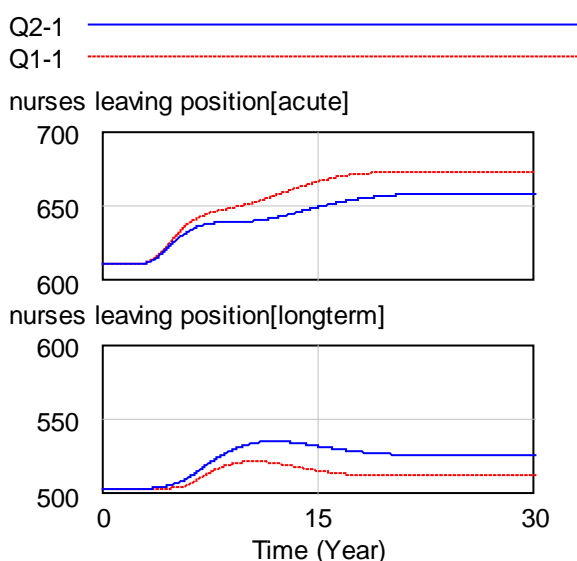


Figure 7: Venue turnover (nurses leaving positions)

In both scenarios, the deficit in nurses is small (<80 nurses) and occurs only in acute. In summary, mandatory rotations change the mix of experienced.

The effect on nurses leaving the profession is somewhat surprising, however, in that mandatory allocation by open position (rotations) affect venues differently but not the total. Turnover at acute decreases and turnover at longterm increases, but in neither case is the pattern or rate

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of change significantly different. So mandatory rotations would improve retention at acute, which could give the impression that the policy is ‘partially effective’. On balance, it moves the effect from one venue to another.

Question 3: Why did a wage adjustment in longterm fail to correct a perceived shortage in staffing?

The model developed for this study includes variables that allow test inputs to change compensation at a venue and observe how a change in compensation at one venue ripples through nurse capacity. We assume that average annual compensation at the acute venue is initially 10% higher than average compensation at longterm.

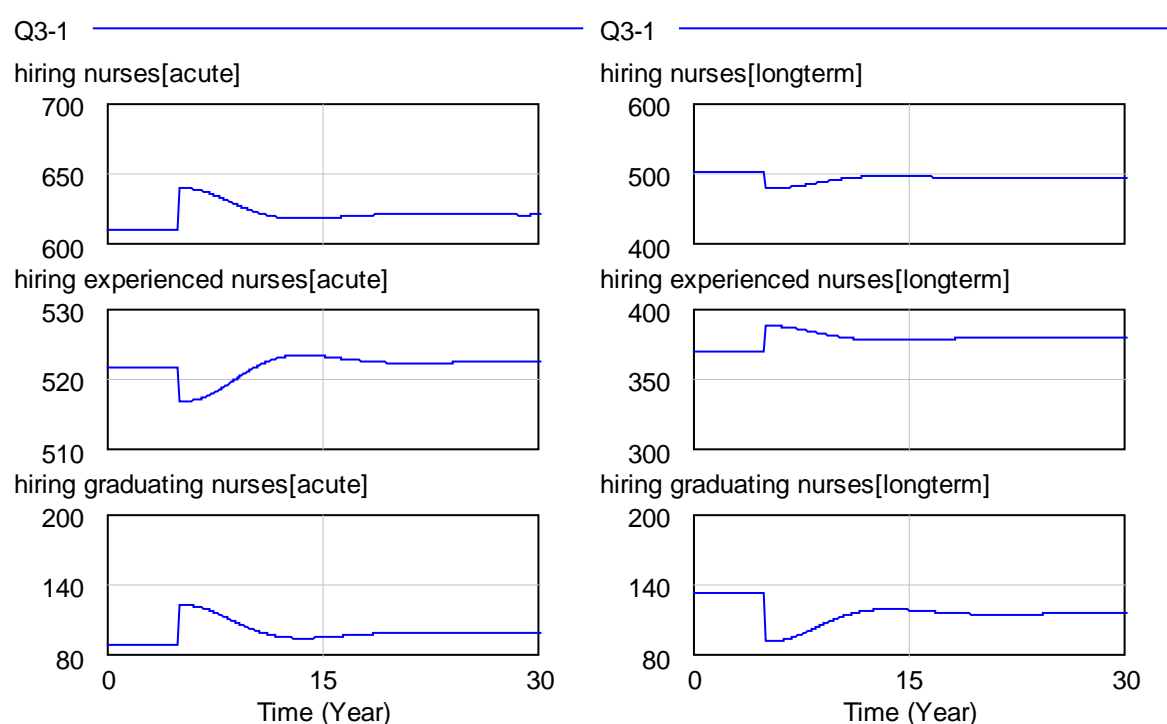


Figure 8: Hiring patterns for experienced and graduating nurses when compensation increased 10% at longterm

For the test, compensation is increased by 10% in longterm at year 5 to bring longterm compensation into line with compensation at acute. The increased compensation rate at longterm draws experienced nurses from the acute venue to the longterm venue, which changes the average experience at both venues driven by career (e.g. promotion) opportunities, and experienced nurses shift from acute to longterm (Figure 8).

Over time, the movement of experienced nurses from acute to longterm causes career prospects to improve in acute and the flow reverses. A new steady state is achieved at approximately year 18. In summary, the one-time compensation adjustment affects changes in experience levels for more than 12 years (Figure 9), but has not effect on actual staffing levels which are determined

by the target number of nurses. So, although compensation plays a role, one of the other attributes may have a stronger effect on the attractiveness of longterm. For example, the Advisory Group mentioned that the nursing support staffs at longterm were inadequate, and this also affects attractiveness.

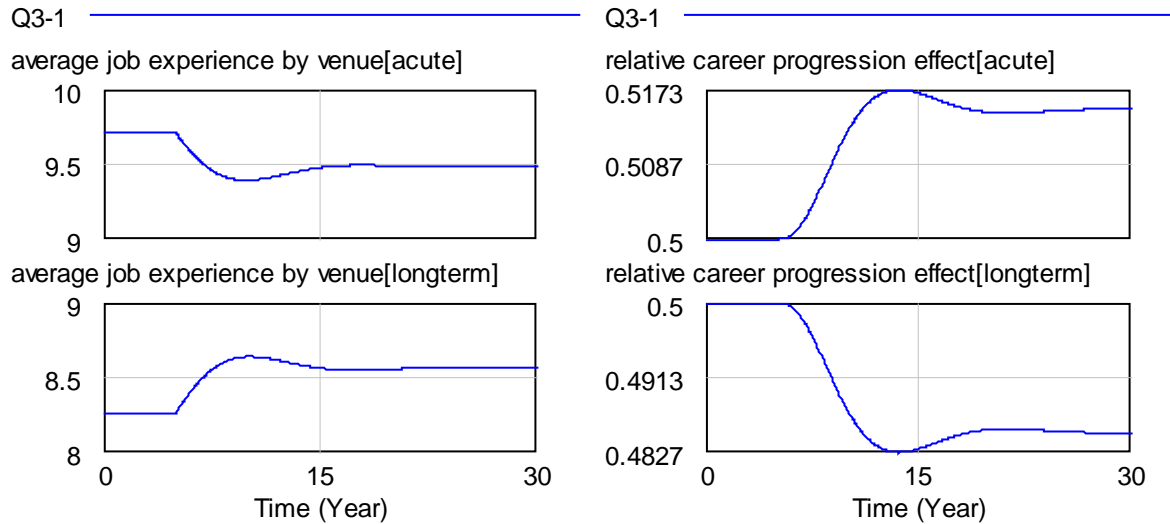


Figure 9: Changes in average job experience with one-time 10% compensation increase at longterm

These observations raise a question: was the lower average compensation at longterm due to lower average experience or was the lower average experience due to lower compensation? This question cannot be answered without data, but clearly these two attributes are linked.

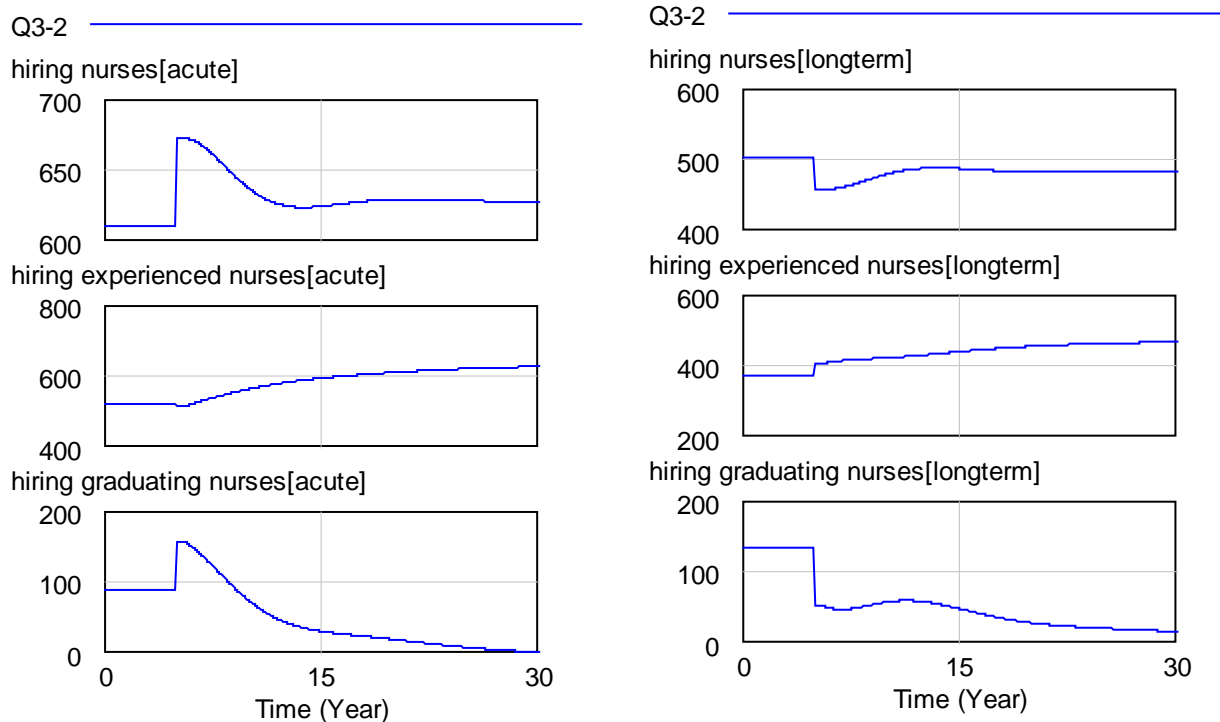


Figure 10: Effect of wage competition with initial 5% increase at one venue

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A second test was conducted in which the venues adjust their compensation levels to match the highest compensation they observe. That is, compensation increases in one venue (longterm in the test) by 5% and that venue attracts more experienced nurses than it otherwise would. However, the other venue adjusts compensation to the highest observed, and the effective advantage gradually erodes (Figure 10).

Summary

In this work, emphasis is on the strategic effect of workplace policies on hiring, retention and attrition. Exploring policy effects one at a time in only two venues simplifies tracing the movement of nurses from venue to venue. However, this sets the stage for more detailed complexity, and as confidence in the policy analysis tool increases, more venues and policy combinations can be tried. The implications are both familiar and worth repeating: (1) a change in one venue affects all venues, and well-intentioned changes can lead to less desirable results elsewhere; and (2) policy changes have different short-term and long-term effects.

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