Using system dynamics to inform future pharmacist student intake in England until 2040

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Abstract

This paper describes the use of system dynamics in a major piece of work supporting the Department of Health, Health Education England and wider Government policy. The Centre for Workforce Intelligence (CfWI) carried out an in-depth review of the pharmacist workforce in England, projecting and analysing the future supply of and demand for pharmacists between 2012 and 2040. The purpose of the review was to inform future pharmacist student intake at university level and was driven by the need to provide sustainable, high-quality pharmacy services in a complex and evolving environment. The work was set in the context of recent increases in the number of students studying pharmacy at university and proposes for training reform.

System dynamics modelling was extensively used to produce a range of supply and demand projections across challenging and uncertain scenarios. This enabled potential policy interventions to be tested for robustness, with uncertainties and sensitivities fully recognised. The methodology and framework used allowed the CfWI to work transparently with pharmacy system professionals and stakeholders, eliciting knowledge of those closest to the system.

The review, its findings and suggestions are currently being used to support major discussions regarding the future pharmacist workforce and training environment in England.

Key Words: System dynamics, workforce planning, pharmacy, healthcare, health policy, higher education planning

1 Introduction

This paper describes the use of system dynamics as part of a strategic review of the pharmacist workforce in England. The project was carried out by the Centre for Workforce Intelligence (CfWI) throughout 2013 and was commissioned by the Department of Health (DH) to support Health Education England (HEE) and wider Government policy. The project aim was to forecast and analyse the future supply of and demand for pharmacists in England between 2012 and 2040 with the purpose of informing future pharmacist student intake at university level.

The review, its findings and suggestions are currently being used to support major discussions and decisions regarding the future pharmacist workforce and training environment in England.

The CfWI used the robust workforce planning framework (CfWI, 2014a) previously developed for use in its medical and dental student intakes review (CfWI, 2012). The robust workforce planning framework is a scenario-based methodology for examining both the supply of and demand for a given workforce within the context of an intrinsically uncertain future. It is a combination of recognised methodologies consisting of, but not limited to, horizon scanning, scenario generation, workforce modelling and policy analysis. Across all stages of the framework there is a focus on working and collaborating with system stakeholders and eliciting their knowledge to drive the review in progress.

System dynamics (SD) modelling is an essential part of the approach. The models developed as part of the framework allow the impact and robustness of policy options under consideration to be tested to support workforce planners' decisions.

This paper describes the robust workforce planning framework, its implementation in the pharmacist in-depth review and the SD model designed and developed as part of it.

The CfWI is an independent agency working on specific projects for the Department of Health and is an operating unit within Mouchel Management Consulting Limited. The CfWI is the UK's national authority on workforce planning and development, providing advice and information to the health and social care system. The aim of the CfWI is to produce quality intelligence to inform better workforce planning, in order to improve people's lives. The CfWI was supported by Decision Analysis Services Ltd (DAS) who provide specialist system dynamics consultancy. DAS is a team with a shared vision of solving strategic challenges facing government and industry decision makers using systems modelling and simulation methods. The Department of Health is responsible for Government policy for health, social care and the National Health Service (NHS) in England.

1.1 Contents

Section 2 describes the challenges facing the pharmacist workforce in England and the necessity for effective workforce planning.

Section 3 introduces the robust workforce planning framework and describes its use in the CfWI's in-depth review of the pharmacist workforce.

Section 4 describes the development process of the pharmacist workforce SD model developed as part of the robust workforce planning framework.

Section 5 describes the pharmacist workforce SD model developed to support the CfWI's in-depth review of the pharmacist workforce.

Section 6 describes the in-depth review's results and findings from the system dynamic model simulations and the subsequent analysis of the future supply of and demand for the pharmacist workforce as well as the options considered for policy intervention.

Section 7 concludes this report.

2 Contextualising the review

This section describes the challenges facing the pharmacist workforce in England and the necessity for effective workforce planning.

2.1 What is workforce planning?

Workforce planning is the process of ensuring that a business or organisation has 'the right people with the right skills in the right places at the right time' (Taylor, 2005, p.78). Nowhere is the importance of meeting this paradigm more vital than in health and social care environments where service users demand and deserve a safe and effective service. When planning is poor, people suffer; both those that depend on the service as well as those who deliver it.

For workforces that rely on highly skilled and qualified staff with long training pathways, it can take a significant amount of time before adjustments to the system can be felt. Patients cannot afford to face supply and demand imbalances as they may suffer. Likewise, system stakeholders cannot wait to react to supply or demand imbalances; they must be proactive. As such, effective planners must have foresight of the key issues likely to affect their workforces in order to adapt the system where necessary and mitigate risk and challenges in the future.

2.2 The pharmacist workforce

In order to register in England as a qualified pharmacist, one must attain a master's degree in pharmacy, the four-year MPharm degree, followed by successful attainment and completion of a minimum of 12 months of work-based pre-registration training.

Over the last decade there has been rapid expansion in the number of students opting to study pharmacy at university. As noted by MEE (2011, p.6) 'Between 1999 and 2009, the number of schools of pharmacy in England increased from 12 to 21 and the number of students more than doubled from 4,200 to 9,800'. As of 2013 'in England there is no link between Mpharm student numbers accepted into schools of pharmacy and the commissioning of pre-registration trainee pharmacist placements' (CfWI, 2013a, p.10). While historically the number of pre-registration places available has always matched the number of Mpharm students, the British Pharmaceutical Students' Association (2012, p.14) found 'funding for pre-registration training cannot continue to increase at the current rate' and states the 'current level of pre-registration training numbers is likely to remain the same or decrease'.

Therefore, should Mpharm courses continue to expand at the current rate, there could be a future shortage of pre-registration places. In the absence of effective planning, the British Pharmaceutical Students' Association warns that this could result in an 'increase [in the] number of pharmacy graduates who are unable to complete their training to become registered pharmacists' (2012, p.12).

Alongside the increasing number of students, the number of practicing pharmacists registered in England has also increased from 33,274 in 2008 (Hassel, 2012) to 38,867 in 2013 (GPhC, 2013). The size of the workforce makes effective planning complex as does the speed with which it is expanding. This is compounded by the complexity of the profession itself. There are multiple sectors a pharmacist can work in, each with different demand drivers and issues that must be accounted for separately. Additionally it is not uncommon for a pharmacist to work across more than one sector or less than full-time hours (RPSGB, 2009) which adds further complexity for those considering planning for the pharmacist workforce.

Considering the above, the key challenges planners need to consider are:

- the rapid expansion in university student numbers
- the disconnect between university student numbers and commissioned pre-registration training places
- the potential future pool of graduates unable to secure pre-registration training places
- the workforce size and complexity
- the long training period of a minimum of five years.

2.3 The purpose of the CfWI's in-depth review

The purpose of the CfWI's strategic review of the pharmacist workforce was to inform future pharmacist student intake at university level. The review was driven by the need to 'provide sustainable, high-quality pharmacy services in a complex and evolving environment' (CfWI, 2013a, p.3). In light of the challenges detailed above, along with recently proposed recommendations for graduate training reform (MEE, 2011), the CfWI's remit was to 'provide the evidence base for sustainable improvements in planning for the pharmacist workforce of the future', looking ahead to 2040 (CfWI, 2013a, p.3).

3 Methodology

This section introduces the robust workforce planning framework and describes its use in the CfWI's in-depth review of the pharmacist workforce.

3.1 The robust workforce planning framework

A risk to the success of workforce planning is the failure to recognise that the future is intrinsically unknowable. When focusing on shorter-term planning, it can be acceptable to plan for the future as one expects it to unfold. However, when planning with longer-term consideration, unexpected system influences may disrupt expected futures and surprise those focusing on a narrow range of potential outcomes, regardless of how likely they seem. Where possible, it is better to consider the range of uncertainty that could be faced in the future.

To support decisions that impact further into the future and enable the provision of suitable information, the CfWI has developed an approach: the robust workforce planning framework. The framework enables longer-term planning and supports more robust decision-making, taking into account the uncertainties of the future rather than attempting to predict the future.

The process was originally developed for the CfWI's medical and dental student intake review and was used again in the pharmacist in-depth review. The approach is flexible to any given workforce. In both reviews it has been used to inform decision-making as far forward as 2040. Use of the methodology within the medical and dental project led to a 2 per cent reduction in medical school intakes introduced in 2013 (DH, 2012, p.7). It has also been used in a follow-up dental project and projects considering the GP and psychiatrist workforces. The high-level framework is illustrated in Figure 1 and described in depth following it.

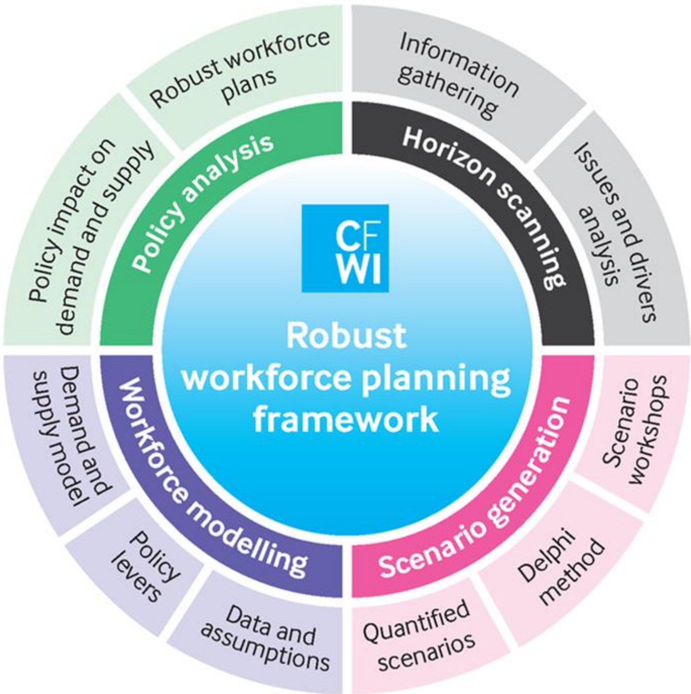

Figure 1 – Robust Workforce Planning framework (CfWI, 2014a)

3.2 Horizon scanning

The process begins with horizon scanning, which is 'the systematic examination of potential threats, opportunities and likely developments including but not restricted to those at the margins of current thinking and planning'[i]. This exploration focuses on the technological, economic, environmental, political, social and ethical (TEEPSE) influences on an unfolding future. This process provides a contextual basis for considering the possibilities that may emerge in the future with regard to the workforce under review. It is useful as it encourages not just consideration of the more expected and predetermined influences (such as the ageing population) but also the more uncertain influences that may not be at the forefront of current expectation.

For the pharmacist review, approximately 50 stakeholders and experts identified the TEEPSE factors influencing the future pharmacist workforce via telephone interview with CfWI analysts (49 participants) and a workshop (four participants). The factors were recorded and used as the foundation for the next stage in the process, scenario generation. Later, the findings of the horizon scanning activities were published as a supplementary tool alongside the CfWI's full review (CfWI, 2013b).

3.3 Scenario generation

When planning for the future, one can plan for what is perceived to be the single most likely future. However, where possible, it is better to understand the most appropriate range of uncertainty affecting a chosen system and assess the opportunities and risk available across this range. Developing distinct quantifiable scenarios allows for the creation of multiple supply and demand projections across the widest appropriate range of uncertainty. Any desirable policies or potential interventions of interest can then be simulated and tested across each of the scenarios, enabling a level of robustness to be measured.

The scenarios used in the pharmacist review were built in January 2013 during a workshop involving a group of 24 system stakeholders. The stakeholders invited represented multiple sectors of the pharmacist workforce and people across different stages of their careers. Development of the scenarios focused on the highest impact and most uncertain driving forces derived from the horizon scanning process. This resulted in four extreme scenarios. Careful consideration was given to ensure that, while extreme, the scenarios were consistent and plausible. A plausible scenario is defined as one that is 'logically self-consistent in the sense that each postulated event follows from those that come before' (Lempert et al, 2003, p.30).

The scenarios are written descriptions of how the future may unfold. These narrative scenarios are powerful tools in themselves and can be useful in provoking thought and consideration of the wider possibilities and threats facing a workforce's future. However, in order for the qualitative scenarios to feed into the subsequent stages of the framework they had to be quantified.

The CfWI utilised a Delphi process (Dalkey and Helmer, 1963) to quantify the variables that had been identified as key descriptors of the scenarios and representative of their differences. Thirteen stakeholders representing a cross-section of the pharmacy system participated in the process, providing quantitative values for the required variables via a two-round process which saw a consensus answer achieved for each variable.

3.4 Workforce modelling

As part of the CfWI's robust workforce planning approach, system dynamics models are developed to project the supply of and demand for workforces across the range of plausible but challenging futures, as developed by the scenario generation and Delphi process. System dynamics modelling is used, since it is 'most appropriate to complex systems with feedback, like health and social care workforce planning, and can be easily extended or revised to address additional issues as they arise' (CfWI, 2014a).

A system dynamics model representing the pharmacist training pathway and workforce system was developed by a CfWI modeller for use in the in-depth review. This model, both its development and design, are described in more detail in Section 4 and Section 5 of this report.

3.5 Policy analysis

Policy analysis builds on the workforce modelling and focuses on analysing the future impact of specific policy options and interventions across the range of scenarios. The strength of producing and modelling over multiple futures is that it allows for robustness of interventions to be tested, not just a policies success or failure across one future, but across many. The system may react differently to specific policies in different scenarios. As such, it is important the consequences of any action are assessed across a wider range of uncertainty. This allows risk to be more widely acknowledged where apparent.

The SD pharmacist model developed as part of the workforce modelling stage was used as a tool to quantify the impact of various policies options on the pharmacist workforce. The policies examined are described in more detail in Section 6 of this report.

3.6 Stakeholder Engagement

While not a distinct stage or phase of the process, the high degree of stakeholder and expert input and involvement throughout is a key benefit of the approach. At each stage there are opportunities and activities in which the knowledge of those closest to the system under review is elicited. For example, the visual nature of SD modelling allows non-modellers with expert system knowledge to be involved in the process as they are able to understand the model structure even if they don't understand the underlying technical and mathematical foundation. This benefits the work in two ways:

1. it takes advantage of a wide range of knowledge and means the information that drives the work comes directly from the system stakeholders
2. it means that the system stakeholders and decision-makers are close to the work, with the project as transparent as possible and their understanding ensured.

This second point is vital as, ultimately, the purpose of this type of work is to provide stakeholders and decision-makers with an evidence base to support their decision-making process. The greater their understanding of the work, the more useful the evidence base provided becomes.

4 The model development

This section describes the development process of the pharmacist workforce system dynamics model developed as part of the robust workforce planning framework for the CfWI's in-depth review. The development approach is based on the CfWI's formalised best practise guide (CfWI, 2014b). The process is consistent with previous development methods presented by authors such as Sterman (2000), Keating (1999), Randers (1980) and Forrester (1961). The approach is also consistent with the recommendations of the MacPherson review of Government analytical models (MacPherson, 2013). The model development process is shown below.

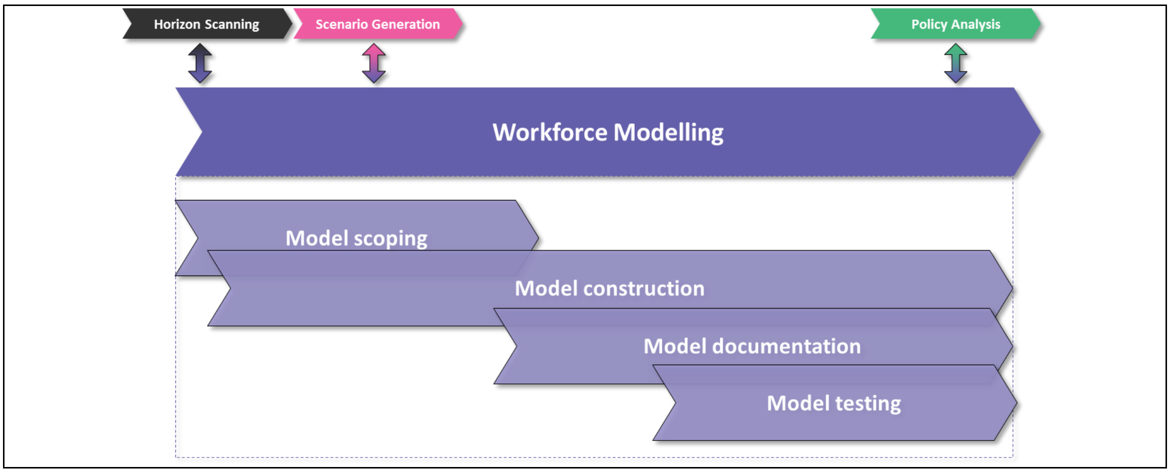

Figure 2 – Overview of the CfWI model development process (CfWI, 2014b)

4.1 Model scoping

The first part of the model development process was the model scoping and the formalisation of the model specification. The purpose of model scoping was to clearly define the purpose of the project, what was required of the model and equally importantly, what was out of scope. The specification document defined the model that the CfWI would develop to meet these criteria. It contained the model purpose, model requirements and a high-level design specification.

As the specification was developed it was shared with stakeholders and system experts for review. Their input was encouraged in order to ensure that what we were designing would be appropriate and fit for purpose as defined by the project scope and model requirements. Together, the pharmacist system's training and career pathways were mapped out and initial data sources were considered.

Upon completion and agreement on the specification, model construction began.

4.2 Construction

The model was developed in house by a member of the CfWI data modelling team with support from DAS Ltd.

The CfWI chose Vensim DSS© as the software to use in the modelling process as it was able to handle the complexity of the system and allowed multiple levels of data and calculation segmentation across each stock and flow, including but not limited to age and gender. It also allowed for sophisticated sensitivity and uncertainty analysis which, along with the CfWI's formal testing procedure and model validation, allowed for appropriate levels of reliability to be assessed.

4.3 Documentation

Prior to analysis the model was documented. Two documents were produced: one providing an in-depth description of the model's structure and another providing an in-depth description of the data used and any assumptions made. Both documents were reviewed by a Technical Advisory Group (TAG) consisting of pharmacy workforce experts outside the CfWI for an independent evaluation and critique. Following implementation of suggested improvements the TAG agreed that the model as documented and including these updates was fit for purpose and met the requirements and objectives as outlined in the original model specification.

4.4 Testing

Testing consisted of a formal process which ensured that the model was accurate and adequately error free as well as appropriate given the original purpose and specification. A test specification was developed to check that the model did as the model documentation (both of the TAG documents and the original specification) stated. The test specification detailed all the tests to be carried out on the model, and included tests of the model structure, formulation and behaviour. The test specification ensured that the testing was carried out methodically, and that all areas and substructures of the model were tested fully.

The testing was carried out by a modeller independent of the model development. All errors and failed tests were logged and returned to the CfWI modeller to rectify. Following correction the tests that led to errors and failures were repeated by the model tester to check if the correction was satisfactorily implemented and that the correction didn't have wider implications on the model. This process was repeated until the model tester was satisfied that the model was fit for purpose as defined by the scope, the specification and the documentation.

5 The model

This section describes the pharmacist workforce SD model developed to support the CfWI's in-depth review of the pharmacist workforce.

The full model consists of a Vensim system dynamics model as well as a Microsoft Excel user interface. Both the supply calculation structure and the demand calculation structure are contained within the SD model. The user operates and interacts with the

SD model from within the Microsoft Excel based user interface. This architecture is shown in Figure 3 below.

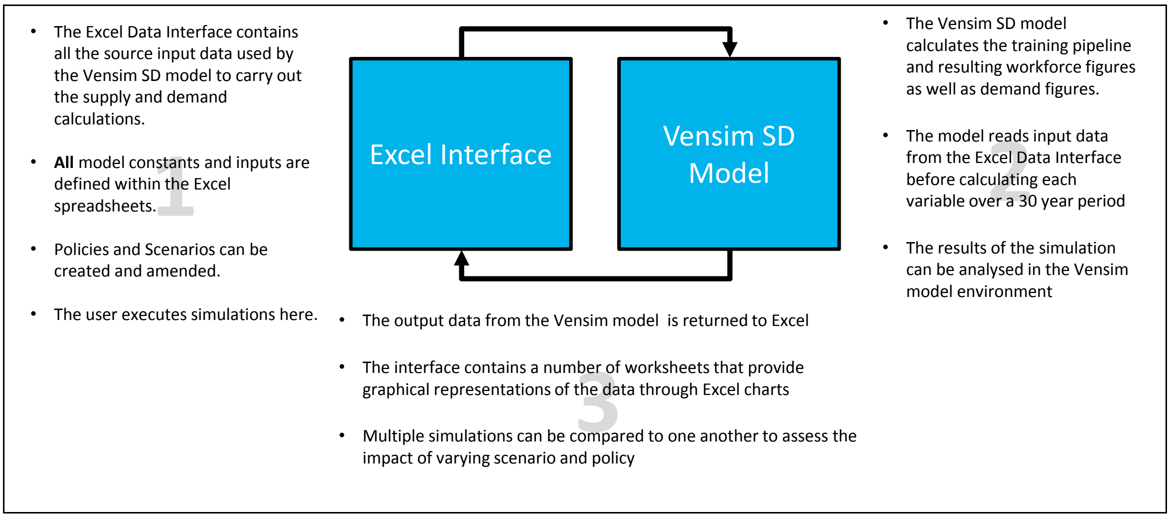

Figure 3 – The system dynamics model architecture

5.1 Supply

The supply section of the SD model calculates the future supply of pharmacists from 2012 until 2040 across the six pharmacy sectors defined below.

- community pharmacy
- hospital pharmacy
- primary care pharmacy
- industrial pharmacy
- academic pharmacy
- 'other[1]' pharmacy.

Its output reports both head count (HC) projections and full time equivalent (FTE) projections. The main stock-and-flow diagram from the supply model is given below.

[1] The Centre for Pharmacy Workforce Studies defines the 'other' category as including 'pharmacy-related posts which fall outside the five main categories' with 3.8 per cent of registered pharmacists working in 2008 accounted to this categorisation (Seston and Hassel, 2009, p.20).

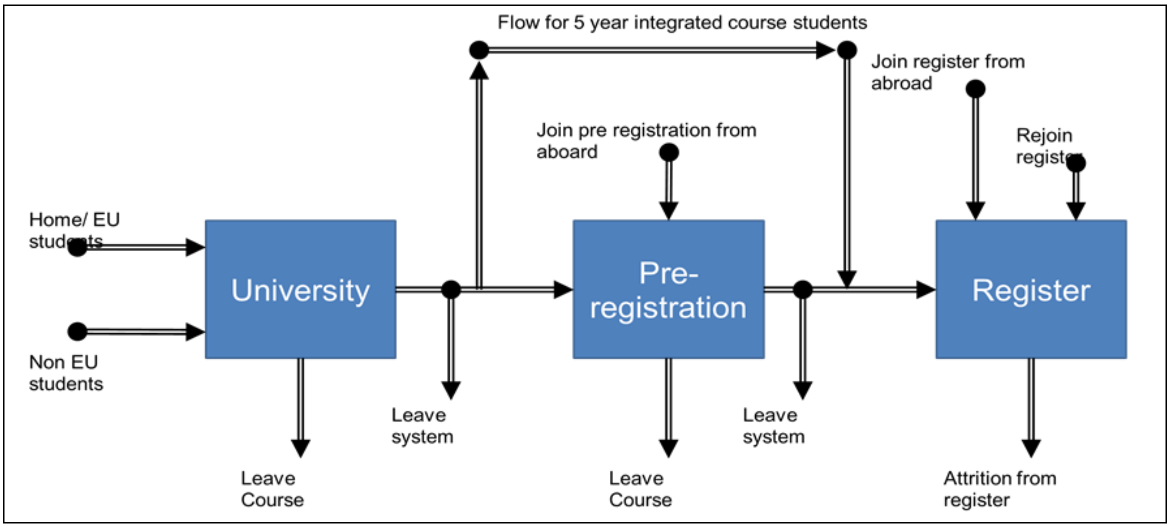

Figure 4 – High-level diagram of the pharmacist supply model

The full model consists of a number of stocks that make up the university, pre-registration and workforce sections of the system. The model includes flows between the stocks that represent progression through the system as well as additional flows not shown above representing system attrition, system exits, additional system entries, re-sits etc.

The model contains a significant use of segmentation, both across the entire model as well as some sub-structure specific segmentation. Segmentations are referred to as subscripts in the Vensim model. The full segmentation is listed and described below:

- **Age** – The model is segmented by age (from 15 to 85 years old). The students, trainees and workforce numbers used in the model are based on historical data which is apportioned in one-year age bands at the earliest point at which they enter the system. Every year, the population is aged by being moved up one age subscript element, representing one year. This occurs at the start of the year. This segmentation enabled age-specific system impacts to be calculated, such as participation rate and attrition.
- **Gender** – The full model was segmented by gender, enabling gender-specific system impacts to be measured.
- **Workforce sector** – The workforce substructure was segmented to measure the variations based on the sector in which a pharmacist may work. This segmentation is not required prior to the workforce substructure, as training is not sector specific. As such, upon entry to the workforce substructure, flows are apportioned between sectors.
- **MPharm course structure** – This is used to differentiate between whether the university students training pathway was set as it is at present (MPharm followed by pre-registration) or set as a hypothetical structure where the pre-registration year was part of the university course (a five-year course that allows direct joining to the registered workforce upon completion). The inclusion of

this segmentation allowed the testing of implementing the course change, while tracking a system that, for a brief overlap, would contain students from both course structures.

- **MPharm degree length** – The MPharm degree is a four-year undergraduate course. However, students do not always complete the course in this time frame. The model was designed to account for delays in completion of the course and tracks how long students have remaining in university at all points during the simulation.
- **Pre-registration application attempts** – To meet the GPhC's registration criteria, graduates on average have roughly four years in order to complete their pre-registration training. Pre-registration takes a minimum of one year to complete. The model allows for a capacity constraint to be placed on the number of pre-registration places available. Should the number of graduates seeking pre-registration exceed the number of places, the excess graduates will be placed in a holding stock and added to the pool of new graduates seeking places the following year. The model tracks the number of attempts taken to get into pre-registration. As one must register within a rough four-year period, any trainees unsuccessful in gaining a pre-registration place over three times are removed from the system.
- **Pre-registration cohort** – This tracks whether someone starts their pre-registration year in the summer or winter, which in turn affects which registry exam a trainee can sit (June or September). Which exam trainees sit can greatly affect the time taken to move from commencing training to joining the register, an issue compounded for trainees who fail their exam and choose to resit. Those who fail the September exam have roughly nine months to wait before they have the opportunity to sit a second exam in June, whereas those who fail the June exam have only a few months to wait to resit in September.

The model allows for quick addition of new segmentation should future work determine it necessary and valid data become available for use. For example, additional segmentation by nationality or ethnicity was not required for this project, but may be of interest in the future.

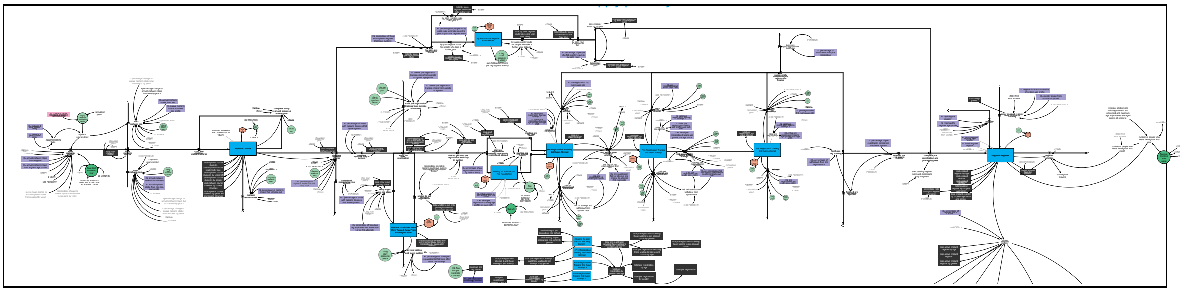

Figure 5 – Detailed system dynamics pharmacist supply model.

5.2 Demand

The demand model calculates the future FTE demand for pharmacists across the six sectors defined from 2012 until 2040. A high-level diagram representing the demand model is given below.

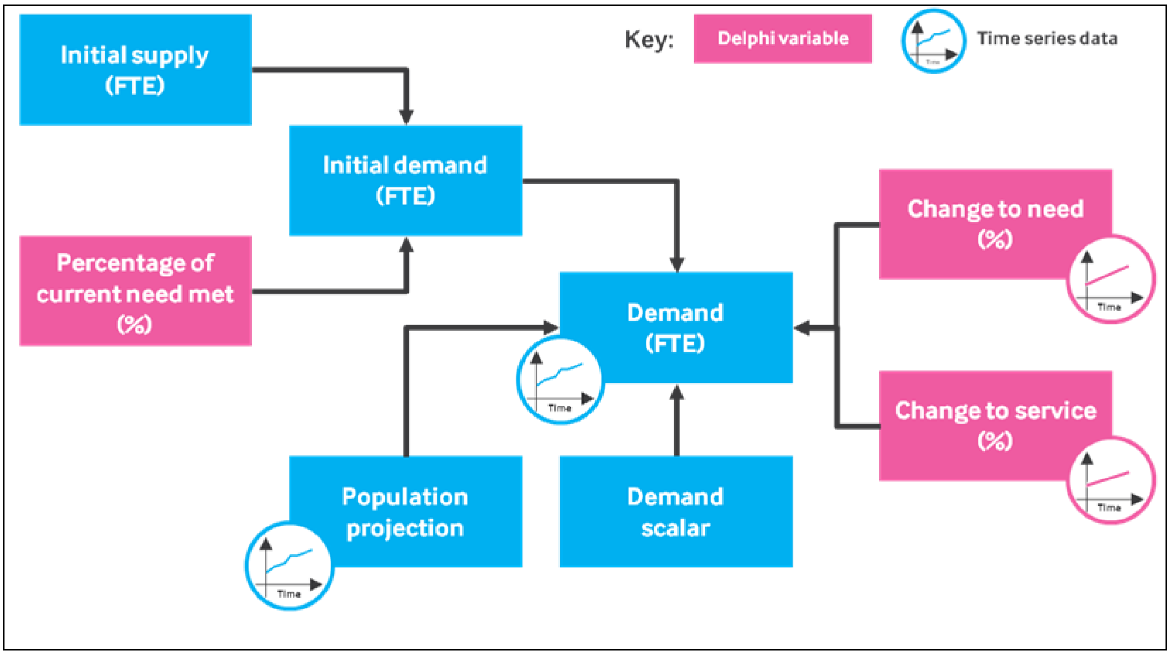

Figure 6 – The demand calculation structure

The framework used to calculate future demand is adapted from work by the Canadian research programme on health human resources (Birch et al, 2011) and was also used as the basis for the CfWI's demand calculations for the medical and dental students intakes project for which the Robust Workforce Planning approach was first developed. The same demand calculation structure has since been used on further reviews of the GP workforce and psychiatrist workforce.

Current demand is calculated by measuring current supply and assessing what proportion of current need this meets. The proportion of current need met is one of the variables gathered during the Delphi process. The CfWI then considers how current demand may change due to changes to demographics, changes to the average service user's level of need and changes to the service itself as defined by the future scenarios under consideration.

The English population is increasing, as is the proportion of elderly people in this total population. The CfWI quantifies expected percentage change in the population size using the Office for National Statistics future population projections (ONS, 2013).

However, as changes in the size of different age bands are likely to have proportionately different impacts on changes in demand, the ONS projections are weighted by age group such that changes to those age groups that have a greater demand for pharmacists have more impact on the changing level of demand. Inpatient and outpatient data from the Health and Social Care Information Centre as well as data from the Mental Health Minimum Data Set was used to calculate an appropriate weighting system by both age and gender of the growing population.

Changes to the service provision will cause changes in the level of demand for a service. As such we consider changes to the efficiency and productivity of the pharmacist workforce in the future. We quantified future percentage change to the service levels of the workforce via a Delphi process.

Similarly changes to the average service user's level of need will cause changes in the level of demand for the workforce. Again via Delphi, estimates for this change were estimated and quantified.

Each of the factors used to determine future changes to demand are mutually exclusive. As such they can each be multiplied by current demand to calculate future demand. Changes to the average service user's level of need, and changes to the service provision are dependent on scenario. We asked Delphi participants to quantify both factors in relation to the four distinct scenarios defined.

5.3 User interface

To enable rapid simulation and facilitate the use of 5,000 distinct variables (of which 4,900 are time dependent, i.e. not constant) the Vensim SD model is operated via an Excel user interface. The Excel interface contains all the input data used by the Vensim model, including all data references and a complete data audit trail. No data is defined or stored within the Vensim model. VBA and Macros enable SD projections to be initialised from within Excel with future supply and demand projections then returned, saved and stored within the Excel workbook. This enables comparison between scenarios and projections using Excel's built-in graph and chart tools and compatibility with the other Microsoft office programs. Before commencing each run, the scenario and policy (if any) under review are chosen for simulation. Alongside the results of every simulation, a record of the scenarios and policies chosen is saved in order to provide an audit trail for future reference.

5.4 Data

All data used in the simulations (both supply and demand side) is stored in the Excel user interface.

The data the model consists of can be split into three categories:

- scenario dependent parameters
- policy defining controls
- general data applicable across all scenarios and policies.

The sources of the data sets used include:

- Centre for Pharmacy Workforce Studies
- General Pharmaceutical Council
- Health & Social Care Information Centre
- Higher Education Statistics Agency
- Pharmaceutical Journal
- Royal Pharmaceutical Society
- The Department of Health
- The NHS Pharmacy Education and Development Committee
- The Office for National Statistics.

A full list of the data sources and individual variables used is included in the full pharmacy report (CfWI, 2013a).

The scenario specific data was defined via the Delphi process. The key variables determined to describe the scenarios and vary across them were determined to be:

Supply variables include:

- change to the average participation rate of pharmacists in 2040
- change to the percentage of pharmacists leaving the workforce for non-retirements reasons in 2040
- changes to the average retirement age in 2040.

Demand variables include:

- percentage change in the overall need of the average service user at 2040
- percentage change in the overall level of service provided by pharmacists at 2040 (as a result of productivity and efficiency change)
- percentage of current need met by the workforce.

As each Delphi-quantified variable was only quantified at 2040 (to ask at every time interval would have overburdened Delphi participants and led to weaker results) the CfWI had to assume these variables followed linear trends from 2012 until 2040.

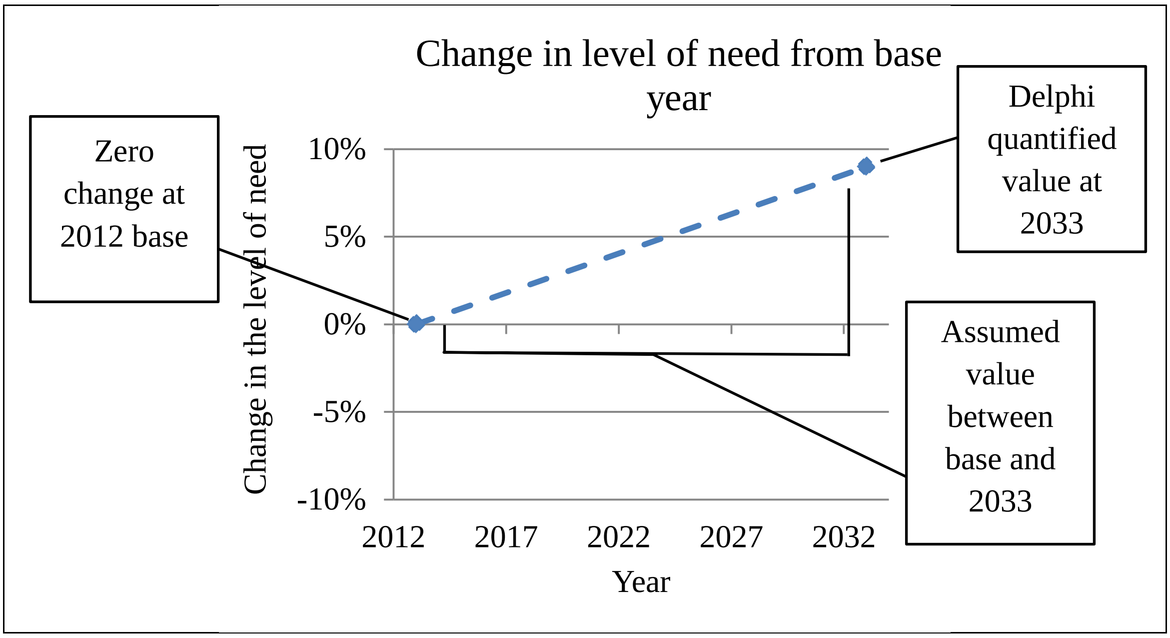

Figure 7 – The linear extrapolation of Delphi variables

5.5 Sensitivity and uncertainty

The models developed are tools used to provide decision-makers with relevant information and evidence to support and enable effective decision-making. As such, it is important to not only provide them with the results of the simulations but also an understanding of the sensitivity and uncertainty of them.

Given 5,000 rows of input data, there are varying levels of confidence associated with each source or assumption that maps the data to our model. Sensitivity analysis was executed to assess the impact of each variable in comparison to the strength of the data it consists of. It is critical that the more impactful variables are the ones we have the high confidence in. The diagram below shows the impact of this sensitivity analysis for the pharmacy model's supply calculation. The two pieces of data which were perceived to be of low quality did not have large impacts on the model output. In an ideal world all data used would be of very high quality, but in reality the data available was deemed acceptable given each variables impact in respect to its quality level.

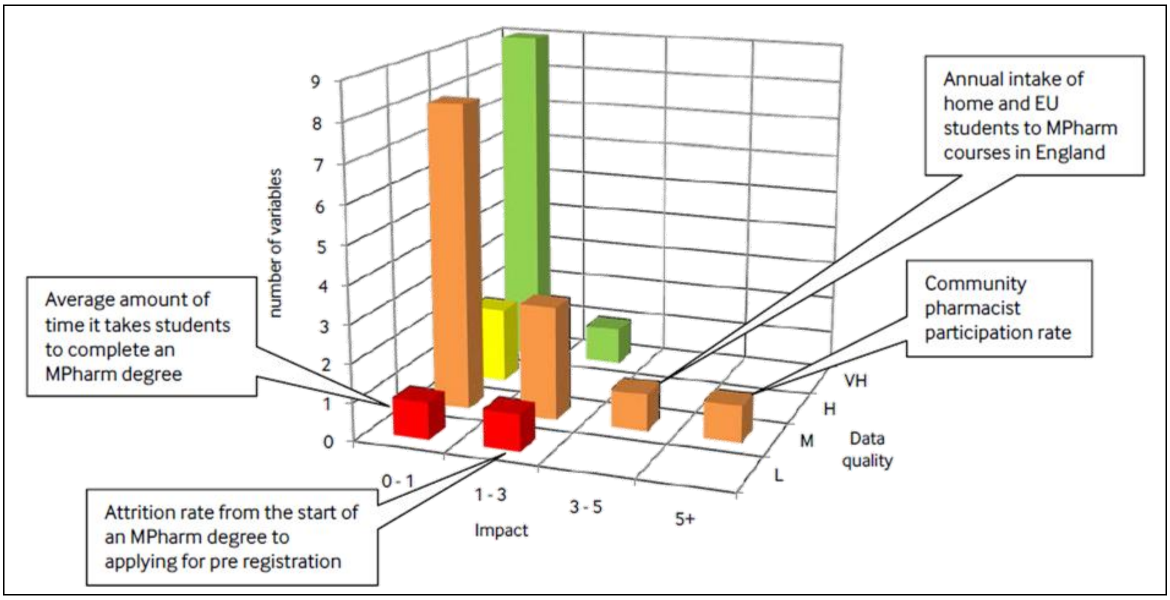

Figure 8 – Sensitivity analysis of the pharmacy model supply data (CfWI, 2013a)

As well a sensitivity analysis we also consider the level of uncertainty through the use of Monte Carlo simulation via Vensim's sensitivity functions. For each scenario, the key uncertain variables (mostly being, but not limited to, those defined in the Delphi process and those considering factors further in the future) are randomised from a defined distribution and the model re-run multiple times with the output recorded each time to provide a probability distribution for supply and demand across each scenario.

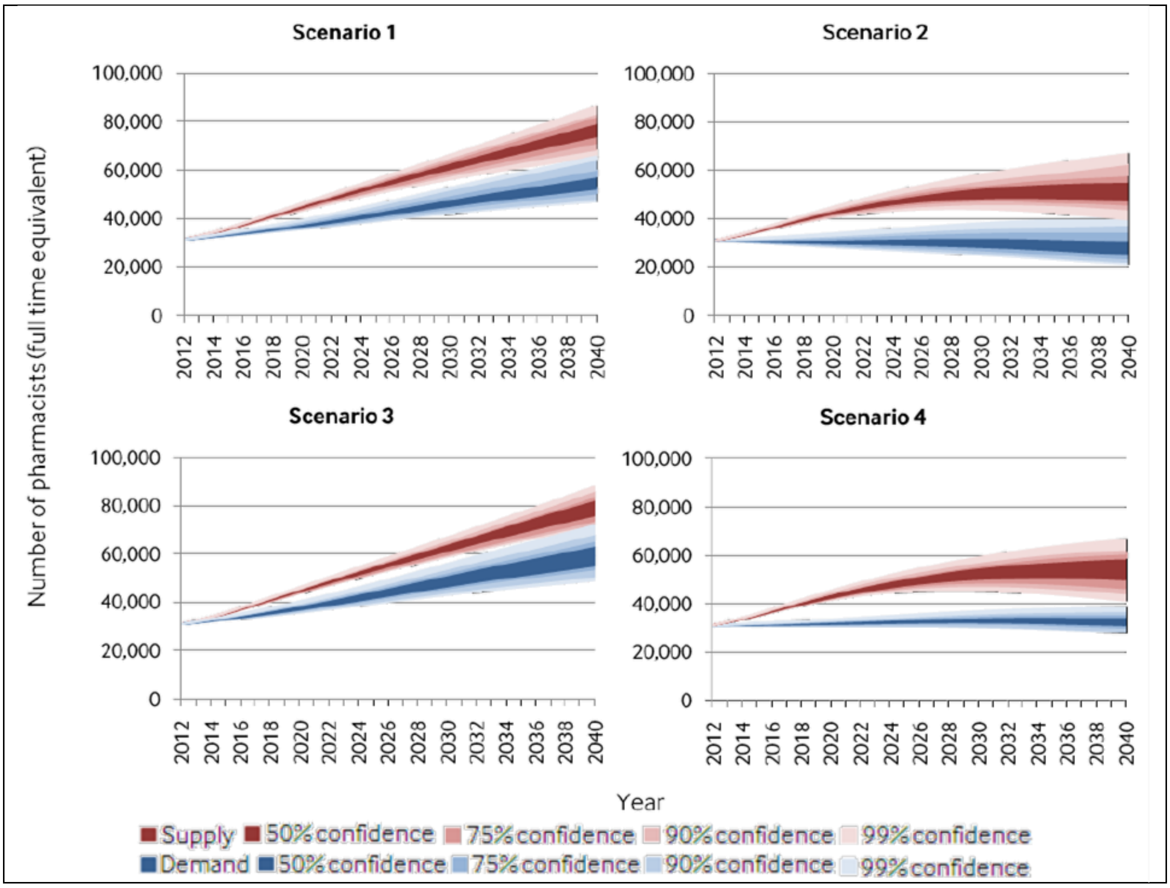

Figure 9 – Uncertainty analysis of the pharmacist supply and demand projections for each of the four scenarios (CfWI, 2013a)

6 Analysis and review

The pharmacist SD model was used during the CfWI's in-depth review of the pharmacist workforce to project supply for and demand of pharmacists across four distinct scenarios up until 2040. In this section the results of these simulations and the subsequent analysis is described in detail.

Across each scenario the model produced projections depicting an overall oversupply of pharmacists across the full range of uncertainty (see Figure 9). For the simulations, the number of students entering pharmacy training each year was held at the 2012 level throughout. Given the substantial increase in the number of pharmacy students over the last 10 years and recognising that more pharmacy courses are likely to be offered in the near future, there is expected to be a continued increase in pharmacy student numbers. This means that the supply levels produced by the model are likely to be underestimates of the actual future. Therefore, the supply-demand charts shown below are probably conservative estimates of future supply-demand imbalance.

The CfWI identified that future supply could be bought in line with demand should trainee numbers be assessed and limited. The CfWI highlighted that the impact of a cap at the pre-registration stage would lead to ‘an increased risk of future MPharm holders [being] unable to register and practice as a pharmacist’ (CfWI, 2013a, p.28). The CfWI instead presented options for a reduction in the available places at universities for studying on the MPharm course.

The SD model allowed for testing of reductions by various amounts and at different times. The model enabled consideration of large one-off changes or more gradual staged changes. The CfWI found ‘a staged change approach provides greater flexibility in managing the balancing of supply and demand’ whereas a ‘large change can lead to unintended consequences’ (2013a, p.27).

The CfWI presented three options for reduction of pharmacy student numbers: reductions by **5**, **10** and **15** per cent between 2015/16 and 2019/20 followed by a 3 per cent yearly increase until 2030/31. The results of running the simulation across each of these three policy options for each scenario are shown below. The CfWI recommended a ‘staged approach to balancing supply and demand’ (CfWI, 2013a, p.28).

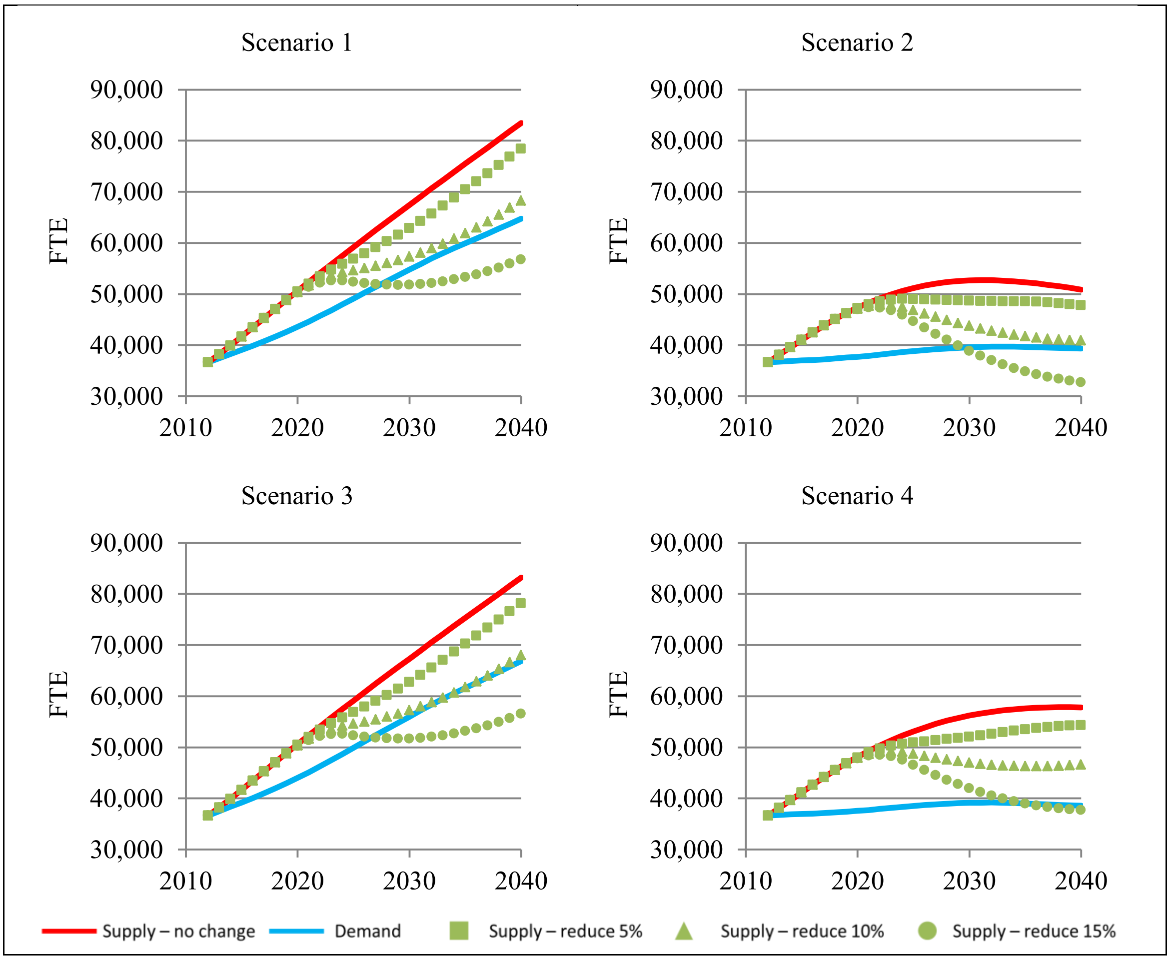

Figure 10 - The pharmacist supply and demand reduction policy projections (CfWI, 2013a)

7 Conclusion

This paper has described the development and use of a system dynamics model to support the CfWI's in-depth review of the pharmacist workforce following the methodology set by the CfWI robust workforce planning framework. The review was commissioned by the Department of Health with the aim to forecast and analyse the future supply of and demand for pharmacists in England between 2012 and 2040 for the purpose of informing future pharmacist student intake at university level.

System dynamics was used to enable the provision of multiple projections across a number of challenging scenarios. This enabled a level of robustness to be ascertained for the policy options under review as well as the levels of uncertainty and sensitivity of the modelling to be fully recognised. The use of system dynamics as part of the CfWI robust workforce planning framework allowed a level of transparency to be maintained throughout the project, meaning the knowledge and expertise of key stakeholders could be used and capitalised on.

The projections produced by the model indicated a future in which pharmacist supply was likely to exceed demand. The CfWI acknowledged that the risk of imposing no active intervention would 'almost certainly lead to unemployment of qualified and registered pharmacists in the short-to-medium term" (CfWI, 2013a, p.29). The CfWI also acknowledged the likely discrepancy between graduates and available pre-registration training places should no change be implemented.

Through the policy testing enabled by the system dynamics model the CfWI presented three options for reduction of pharmacy student numbers. The review, its findings and suggestions are currently being used to support major discussions regarding the pharmacist workforce and training environment in England.

The model developed for this project has proven to be flexible and expandable, and will be used to monitor future changes in the pharmacist workforce, and to inform subsequent reviews where appropriate.

In addition, the system dynamics approach is being used by the CfWI to develop supply and demand models for other workforces across the UK health and social care systems, including psychiatrists and general practitioners.

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[i] This is a widely cited definition of horizon scanning for which, as noted by Miles and Saritas (2012), the original document is difficult to locate. A representative citation is on p.37 of the Government Office for Science (2011).

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