REAL Centre Working paper

Nurse supply model: overview

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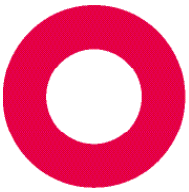

The Health Foundation

About the REAL Centre

The Health Foundation's REAL Centre (research and economic analysis for the long term) provides independent analysis and research to support better long-term decision making in health and social care.

Its aim is to help health and social care leaders and policymakers look beyond the short term to understand the implications of their funding and resourcing decisions over the next 10-15 years. The Centre will work in partnership with leading experts and academics to research and model the future demand for care, and the workforce and other resources needed to respond. The Centre supports the Health Foundation's aim to create a more sustainable health and care system that better meets people's needs now and in the future.

www.health.org.uk/REAL

About DAS

decision analysis services

DAS is an independent management consultancy with offices in the UK and Australia. DAS has expertise in the use of simulation, systems thinking, programme management, investment modelling and data analytics in government and business domains. Coupled with extensive regulatory, operations delivery and engineering experience, this expertise underpins their ability to look deeper into issues, to provide clearer insight and foresight, and to solve critical client challenges. DAS specialises in bridging the gap between strategy and operations, creating effective solutions to uniquely complex issues faced by our clients worldwide. DAS' clients cover the public, private and third sectors who look to us for strategic and operational support for their most critical issues.

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Nurse supply model: overview

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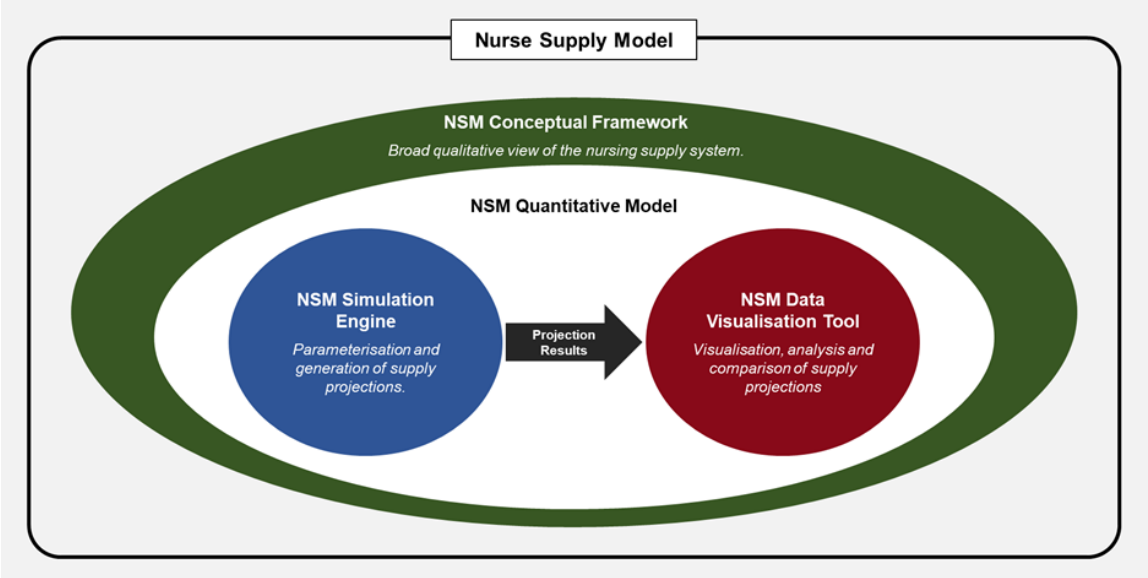
Even before the COVID-19 pandemic, workforce issues were identified as the single biggest challenge for health and social care in England. Nursing, the NHS's single largest staff group with over 300,000 full-time equivalent (FTE) registered nurses in the hospital and community sector, is the key area of workforce shortages, accounting for over 40% of all NHS vacancies. Nursing shortages, measured in terms of the vacancy rate in registered FTE nurse numbers, have been a recurrent theme for the NHS and have grown more prominent in recent years.

High nursing vacancy rates are problematic as NHS trusts are forced to resort to a combination of bank and agency staffing to address shortfalls, which leads to increased costs for the service. One of the main reasons for the shortages in nursing, and in the NHS as a whole, is a lack of long-term planning around staffing levels and a 'boom and bust' approach linked to funding. The lack of high quality, robust and transparent projections of workforce supply and demand is a major factor underlying the lack of long-term planning and a coordinated workforce strategy. Existing modelling tends to take a relatively narrow view of nurse supply, not accounting for system-wide or second order effects.

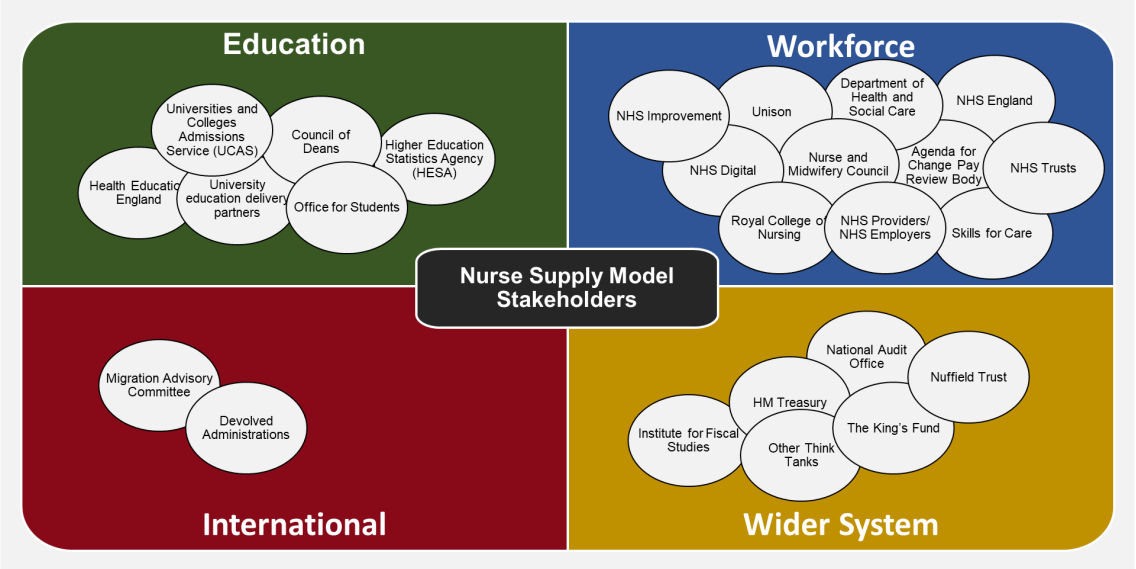
To address this research gap, the Health Foundation's REAL Centre commissioned Decision Analysis Services Ltd (DAS) to develop a nurse supply model (NSM) representing the whole of the nurse supply system. The nurse supply system is a series of interrelated markets with their own demand and supply schedules affected by a 'price' and other factors such as entry requirements to nurse education, nurse workload and immigration rules into UK and for other countries who recognise UK qualified nurses. The NSM will inform policy by enabling projections of future nurse supply in alternative scenarios exploring the impacts of changes in the factors that affect nurse recruitment and retention.

The NSM provides a set of tools that support the appraisal of alternative policies. In particular, it includes a conceptual framework which offers a bird's eye view of the system. This assists people to think about the effect of changes to the nurse supply system on the supply of nurses. It also includes a quantitative model that can be used to assess the impact of changes in policy based on a set of predetermined assumptions. The quantitative model is composed of two key elements: a system dynamics-based simulation engine which uses mathematical modelling to generate nurse supply projections with a 5 to 20-year time horizon and an R-Shiny-based data visualisation tool which enables projections to be viewed through interactive charts and tables and compared for further analysis.

The diagram on the following page illustrates the NSM toolset.



The model was developed in a participatory and iterative manner, involving stakeholders from across the health and social care system as illustrated below.



Model development proceeded through different stages: requirements capture, specification development, model construction, documentation and testing. The development was supported by analysis of the nursing workforce, reviews of the theoretical and empirical literature in nurse labour economics, existing approaches to nurse supply modelling, system mapping exercises and a review of data availability.

The components of the final NSM are described in greater detail below:

NSM conceptual framework	The NSM conceptual framework is a qualitative framework that takes a broad view of the nurse supply system. It captures the key cause-and-effect relationships which influence nurse supply and integrates insights from economic theory and 'stock and flow' perspectives on the nurse supply system. Economics provides a market-based perspective of nurse labour, with price mechanisms helping to regulate supply and demand. Stock and flow analysis is useful in terms of distinguishing between static and dynamic variables (stocks and flows) underpinning the nurse supply system. Flows affect stocks and are themselves influenced by a number of financial and non-financial factors. The conceptual framework was developed using group model building, a participatory approach involving a series of workshops, focus groups and interviews with stakeholders from across the nurse supply system, supplemented by evidence from the literature. The framework can be used to explore different aspects of the nurse supply system such as the implications of changes in policy and the wider economic environment. DAS have used the conceptual framework to explore the potential impact of the COVID-19 pandemic on nurse supply and to consider how a range of economic factors might affect nurse supply.
NSM simulation engine	The NSM simulation engine is the underlying simulation model that is used to generate nurse supply projections. It enables projections to be parameterised, simulated and compared under alternative scenarios. It is a system dynamics-based model developed using Vensim, a system dynamics modelling software tool with an MS Excel simulation control spreadsheet. The simulation control spreadsheet enables scenarios to be defined and executed. The projections themselves are calculated by the Vensim model using system dynamics. The model considers the main flows into and out of the nurse labour market in England, namely through degree education, international recruitment and nurses leaving and rejoining the workforce. It uses adjustment variables to capture the combined effect of various factors that influence each flow in the conceptual framework. This set-up offers substantial flexibility, with all core variables segmented by age, gender, nationality and region to enable analysis of the implications of changes in policy on different subgroups.

NSM data visualisation tool

The NSM data visualisation tool enables the visualisation, analysis and comparison of supply projections produced by the simulation engine. The tool enables libraries of projection scenarios to be analysed and compared. It also facilitates several different data visualisations such as time series plots, bar charts and tables which can be exported for use by other applications or models.

The tool has been developed using R, an open-source statistical programming language. It is based in Shiny, an R package which is commonly used to build interactive web apps that can be used independently or hosted on a webpage.

Data availability

Access to quality data is key to the utility of the NSM. Data sources for the NSM were identified through a review of publicly available sources and engagement with stakeholders from across the nurse supply system. Data were obtained from the following organisations.

- **Universities and Colleges Admissions Service (UCAS):** Data on applications, applicants and acceptances to undergraduate and postgraduate pre-registration nursing courses.
- **Jisc*:** Higher Education Statistics Agency data on enrolled students, graduates and leavers of nursing courses.
- **NHS Digital:** Data on the NHS Hospital and Community Health Service (HCHS), general practice and independent workforces, including staff in post and staff turnover. Some of the NHS Digital data sets were specifically commissioned and provided directly by NHS Digital and other data were obtained from the NHS Digital website†.
- **Skills for Care:** Data on the adult social care workforce, including staff in post and staff turnover.
- **Nursing and Midwifery Council (NMC):** Data on the nurse register, including registrants and joiners and leavers to the register.
- **Office for National Statistics (ONS):** Population data obtained from the ONS website‡.
- **Royal College of Nursing (RCN):** Nurse workforce survey data.

The data collection process identified several data gaps, such as data on the headcount of former nurses and the movement of nurses between sectors. Further, although data

* Jisc provides digital solutions for UK education and research including delivering HESA data analytics services.

† https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics

‡ https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates

on bank and agency nurse staffing and internal NHS nurse job moves are compiled by the NHS, commercial sensitivities led to these data not being available for use in the model. Other data were only partially available (for example on the number of registered nurses who stop working as nurses in a given period), so assumptions had to be made to incorporate these data in the quantitative model.

Looking to the future

The development of the NSM was concluded in September 2021, when the REAL Centre assumed ownership of the model. As the ultimate model owner, the Centre and the Health Foundation will be responsible for any further updates to the model (for example, incorporating updated data when these become available and ongoing model maintenance).

The REAL Centre is keen to engage with stakeholders in policy and academia to facilitate further use of the model. The Centre will undertake extensive quality assurance of all outputs generated by the model. The projections that the model enables will provide useful insights for decision makers and workforce planners with responsibility for and interest in NHS nursing, which continues to be the key workforce shortage area in the NHS hospital and community services sector. In the context of the Health Foundation's repeated calls for a comprehensive longer term workforce strategy that accounts for both health and social care, the model is also likely to prove useful to decision makers in areas other than NHS planning, including social care and general practice.

Decision Analysis Services Ltd and the REAL Centre would like to thank all those involved over the course of the project.

1 Introduction

The nurse supply model was commissioned by the Health Foundation to enable robust projections of future nurse supply in England to be developed and generated, alternative future scenarios to be compared and to test policy options. Nursing, the NHS's single largest staff group with over 300,000 full-time equivalent (FTE) registered nurses in the hospital and community sector, is the key area of workforce shortages, accounting for over 40% of all NHS vacancies. Nursing shortages have been a recurrent theme for the NHS and have become more prominent in recent years. This paper describes context for nurse supply in England and the various components that make up the nurse supply model. This Section introduces the paper and describes its structure.

1.1 Background

The Health Foundation is an independent charity committed to bringing about a healthier population, supported by high quality health care that can be equitably accessed.

The REAL Centre (Research and Economic Analysis for the Long term) is a specialist semi-autonomous centre within the Health Foundation. The REAL Centre focuses on economic research, model development and supporting analysis in health and social care. The Centre was formally launched in October 2020. A key objective of the Centre is to ensure that decisions about the funding, design and delivery of the health and social care system are informed by the best available analysis and evidence and with consideration of the costs and benefits over the long term.

The REAL Centre's major outputs will include a series of projections of the long-term trends affecting the health service and the resources needed to provide a high-quality service in the future. To support this the REAL Centre commissioned Decision Analysis Services Ltd (DAS) to develop a nurse supply model (hereafter, NSM) representing the whole of the nurse supply system in England. DAS is an independent management consultancy with an expertise in the use of simulation, systems thinking, programme management, investment modelling and data analytics in government and business domains. The NSM is required to be able to provide projections of future nurse supply under a range of different scenarios over a 5 to 20-year period. The NSM is a quantitative simulation model set within a conceptual framework that represents the nurse supply system.

1.2 Nurse supply in England

Even before the COVID-19 pandemic, workforce issues were identified as the single biggest challenge for health and social care in England (Gershlick & Charlesworth, 2019). Workforce shortages are a major concern, with NHS full-time equivalent vacancies exceeding 93,000 in June 2021 (NHS Digital, 2021). Nursing is the key shortage area, accounting for close to 39,000 (42%) of these vacancies. Looking further back, while output in NHS trusts increased by over a quarter (27%) between 2010/11 and 2018/19, the number of full-time equivalent nurses increased by just 1% (ONS and

NHS Digital, 2021). Workforce shortages are already having a direct impact on patient care and staff experience (Health Foundation, Nuffield Trust, & The King's Fund, 2019), with a recent RCN survey highlighting nurse perceptions of increases in stress and work hours (Royal College of Nursing, 2020).

One of the main reasons for the shortages in nursing, and in the NHS as a whole, is a lack of long-term planning around staffing levels and a 'boom and bust' approach linked to funding (House of Commons Health Committee, 2007). As the Health Foundation set out in 2016, 'The less costly, reactive and short-term solutions – being used by national and local leaders to tackle current problems – are quick fixes, and will only put a sticking plaster on deep-seated and systemic problems for the NHS.' (Buchan, Seccombe, & Charlesworth, 2016). The lack of high quality, robust, and transparent projections of workforce supply and demand is a major factor underlying the lack of a coordinated workforce strategy. This is partly due to a lack of capacity and capability at both national and local levels, exacerbated by reorganisations of the system architecture (Health Foundation, 2016).

Most nurse supply models described in the literature take a 'stock and flow' approach to modelling the workforce: taking current workforce numbers then applying joiner and leaver rates in order to roll the model forward by 1 year, and repeating this for a given number of years (Ono, Lafortune, & Schoenstein, 2013), (Cave & Willis, 2020), (DAS, 2019b), (Health Foundation, Nuffield Trust, & The King's Fund, 2019), (Health Resources and Services Administration, 2017). The Centre for Workforce Intelligence previously produced and published long-term projections of health care demand and supply, but it has now been dissolved.* The remaining models in use in England tend to focus on specific clinical areas or training pathways, with none providing representation of the whole system: for example no models were identified that provided a cross-sector view (see Section 2.4). This is despite the future supply of nurses being a core determinant of the future sustainability of the NHS.

A comprehensive model of nurse supply rooted in system dynamics that captures not only stock and flow numbers but also considers the factors that drive individual nurse participation decisions, underpinned by academic expertise, is needed now more than ever. It was in this context that the REAL Centre commissioned DAS to lead the development of a nurse supply model.

1.3 Overview of the nurse supply model (NSM)

The NSM is a quantitative simulation model set within a conceptual framework that represents the nurse supply system. DAS has adopted a collaborative approach to developing the NSM that generates long-term nurse supply projections and enables a wide range of forward-looking scenarios and policy levers to be investigated. For the

* See www.gov.uk/government/collections/workforce-planning-for-health-public-health-and-social-care

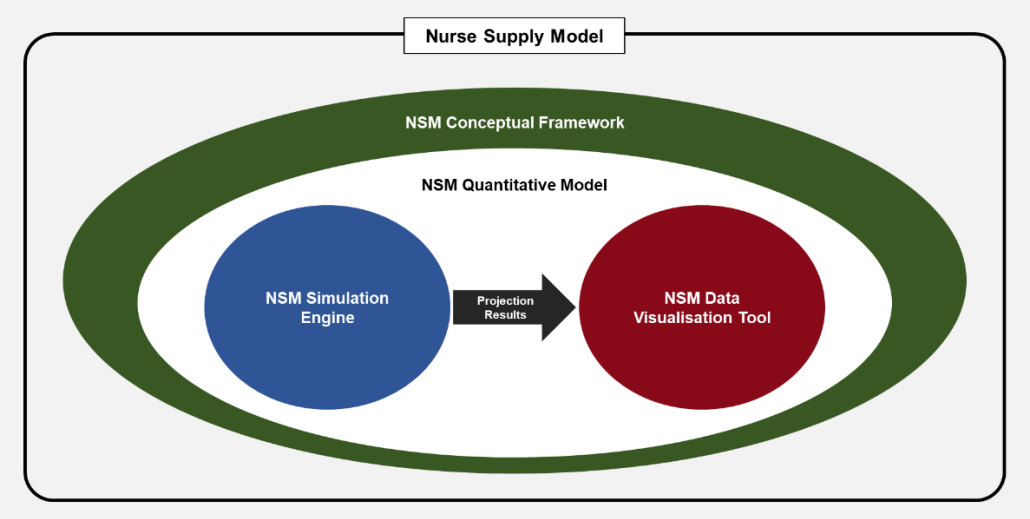
purposes of this project, the 'long term' is a time period up to 20 years. The model has been co-designed with the REAL Centre and stakeholders so that it is widely acknowledged to be valid and fit for purpose. DAS has used the best and most efficient analytical tools based on the available data to ensure a handover of capability to the model's end users (principally the REAL Centre).

The conceptual framework takes a broad view of the nurse supply system and includes variables that are not quantified within the simulation model. For the purposes of this document the NSM is considered to be composed of the nurse education market, the nurse labour market, qualified nurses not working as nurses, the international nurse labour market and the factors affecting these markets. The conceptual framework captures the key cause-and-effect relationships which impact nurse supply and integrates economics and stock and flow perspectives on the nurse supply system. This can be used as a tool to support scenario development and to set research agendas for quantifying relationships in the simulation engine.

The quantitative simulation model is composed of two key components, a simulation engine and a data visualisation tool. The purpose of the NSM simulation engine is to produce projections of nurse supply for England with a time horizon of up to 5 to 20 years. The purpose of the data visualisation tool is to enable the analysis and visualisation of the supply projections produced using the NSM simulation engine.

The simulation engine adopts the system dynamics approach. It represents education/training and workforce pathways. The simulation engine incorporates actionable and meaningful segmentations. The data visualisation tool will enable libraries of projection scenarios to be analysed individually and comparatively using a variety of analysis tools. The simulation engine also produces data exports for use by other applications.

Figure 1-1: A high-level overview of the proposed nurse supply model solution



Source: DAS Ltd

The purpose of this technical paper is to provide a description of the conceptual framework and the quantitative model. The purpose of the paper is not to provide projections of nurse supply, which will form the basis of future publications from the Health Foundation.

1.4 Approach to developing the nurse supply model

A collaborative and participatory approach was adopted to developing the NSM, with representatives from the various organisations in the nurse supply system involved. Initially a series of rapid research tasks were undertaken, including a historic analysis of nurse supply in England (DAS, 2019a), a review of the economics of nurse supply (DAS, 2019e), a review of nurse supply modelling (DAS, 2019b), a review of the nurse supply system and a review of the data landscape. These tasks were undertaken through reviews of the literature and stakeholder workshops.

The nurse supply model review considered 40 workforce projection models from the UK and overseas. This included models used by Health Education England (HEE), the Department of Health and Social Care (DHSC), NHS Wales and the Scottish Government. The review considered how workforce models are applied to strategic planning, identification of common approaches to workforce projection modelling, the pros and cons of available tools and methodology, identification of common issues or constraints and a review of data typically required for a model projecting nurse supply. It was concluded that existing modelling tends to take a relatively narrow view of nurse supply, not accounting for system-wide or second order effects.

This research was followed by the development of the NSM conceptual framework and the quantitative model. DAS developed a delivery plan to design, develop and test the model. An academic advisory panel from the University of Southampton provided oversight and scrutiny throughout the process. The panel was composed of experts in health care modelling and simulation from the University of Southampton: Dr Steffen Bayer, Professor Stephan Onggo and Professor Martin Kunc.

The conceptual framework was used to support two separate research tasks, namely a review of the economic factors that affect nurse supply (DAS, 2021a) and the impact of the first wave of COVID-19 on nurse supply (DAS, 2021c). The quantitative model was tested by the Health Foundation prior to final delivery.

1.5 Structure of the document

Section 2 presents a historic analysis of the nurse labour market, including a discussion around workforce planning and the models that have been used to create nurse supply projections. This provides greater context for the NSM.

Section 3 describes the conceptual framework which has been created to describe the nurse supply system. This includes the process that has been adopted to create the framework.

Section 4 describes the data landscape in relation to nurse supply in England and relates this to the key stocks, flows and factors contained within the conceptual

framework. This Section also includes a discussion of data availability and critical data gaps which informed the development of the quantitative model.

Section 5 describes the NSM quantitative model. It describes the key components of the model, including the simulation engine and the data visualisation tool. The key model assumptions are discussed.

Section 6 describes how the model can be used, for example access plans.

Section 7 contains a bibliography.

Appendix A provides a glossary of some of the key terms used in this document and defines abbreviations.

Appendix B provides an overview of the costs associated with oversupply and undersupply of nurses and how this could be modelled.

Appendix C provides a larger scale version of the conceptual framework.

2 Historic analysis of the nurse labour market in England, 2010 to 2020

This section gives some background to the nurse workforce planning system in England and provides an analysis of the nurse labour market over the last 10 years*. The nurse workforce planning system comprises the organisations (and their formal/ informal networks) that are responsible for, and have an interest in, the future of nurse supply. This section provides the context for the nurse supply model that is described in subsequent sections and explores where this model differs from previous models.

The initial stages of developing the NSM involved a series of research tasks to improve understanding of the nurse workforce and its context. This Section is a high-level summary of one of those research tasks, namely a historic analysis of the nurse workforce (DAS, 2019a).

2.1 What is a nurse?

The Royal College of Nursing (RCN)† defines nursing as 'the use of clinical judgement in the provision of care to enable people to improve, maintain, or recover health, to cope with health problems, and to achieve the best possible quality of life, whatever their disease or disability, until death'. (Royal College of Nursing, 2003).

A nurse is someone who has successfully completed a recognised education and training programme, has been licensed to practise as a registered nurse by the Nursing and Midwifery Council (NMC) and holds a current and valid registration with that body.

The Nursing and Midwifery Council (NMC) was established in 2002 as the successor to the United Kingdom Central Council for Nursing, Midwifery and Health Visiting, and the core role of the NMC (Sellman & Snelling, 2010) is to:

- Set the education standards professionals must achieve to practise in the United Kingdom.
- Maintain a register of all nurses and midwives who are properly qualified and competent to work in the UK.
- Ensure nurses and midwives keep their skills and knowledge up to date and uphold the standards of their professional code.

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* Appendix B estimates the costs of the persistent nurse shortage that began to emerge in 2013.

† The RCN is a UK-wide professional organisation for nursing that seeks to further the profession of nursing and support its members in their relationship with their employers. The RCN develops professional documents for nursing and lobbies government and other organisations to improve nursing. It is one of the key parties to give evidence to the NHS Pay Review Body on behalf of its membership.

2.2 Nurse labour market

The nurse labour market in England is limited to the hire of registered nurses for work that can only be done by registered nurses. Registered nurses working in occupations other than nursing, or not working at all, are not part of the nurse labour market.

Qualified registered nurses working as nurses represent the existing supply of nurse labour. Qualified nurses not working as nurses form the potential supply, or the qualified 'pool'. They are not part of the actual supply of nurse labour, but could quickly join it, if the right job with the right wage became available.

2.2.1 The number of registered nurses in England and the UK

The size of a workforce is typically measured using the terms headcount (HC) and full-time equivalent (FTE). HC represents the number of people in employment, irrespective of their hours worked. FTE takes into account the number of hours worked per person. Nurses may work either full time or part time and as such the size of the workforce in terms of HC will be greater than that measured in FTE.

There were 534,000 nurses in England (Nursing and Midwifery Council, 2021a) on the NMC register in March 2021 (82% of the UK total and slightly below the England population share at 84%). This is an increase of 23,000 or 4.5% from the figure of 511,000 in March 2017 (Nursing and Midwifery Council, 2021a). There were an additional 10,494 temporary nurse registrants resident in England, 70% of the UK total. The temporary register was established in March 2020 to allow nurses who left the register after 2008 to help with the COVID-19 emergency.

There were an additional 4,340 nursing associates on the NMC register (Nursing and Midwifery Council, 2021b), all of them in England. The nursing associate role was introduced in 2018/19 in response to the Shape of Caring review and sits between health care assistants and registered nurses.* It is meant to be a staging post to qualification as a registered nurse.

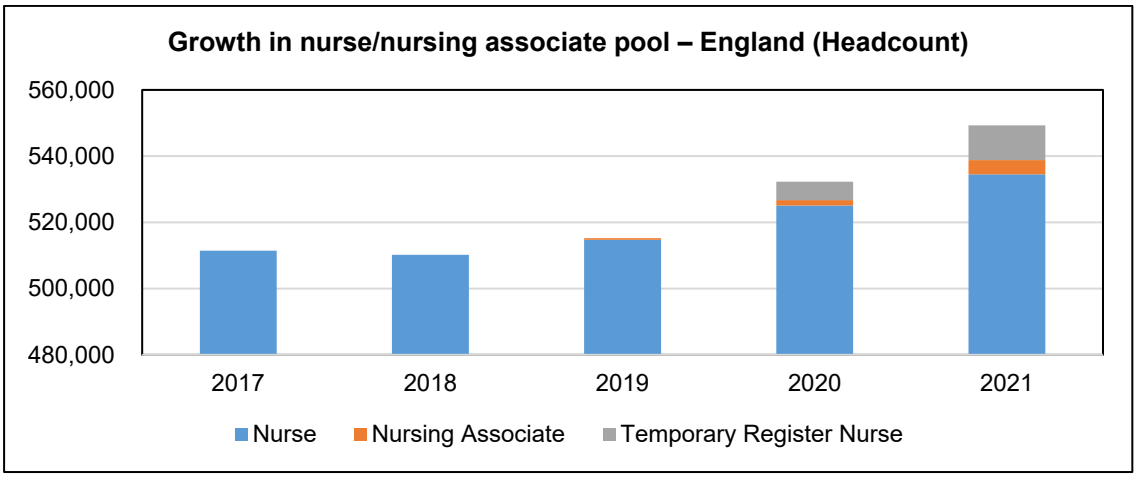
These data are shown in Table 2-1 and Figure 2-2.

Table 2-1: Size of the nurse and nurse associate registers in England (March 2017 to March 2021)

	2017	2018	2019	2020	2021
Nurse	511,437	510,179	514,750	525,073	534,486
Nursing associate	-	-	478	1,676	4,336
Temporary register nurse	-	-	-	5,529	10,495
Total	513,454	512,197	517,247	534,298	551,338

* See: www.hee.nhs.uk/our-work/nursing-associates

Figure 2-1: Growth in the total pool of nurses (including temporary register) and nursing associates on the NMC register in March each year from 2017 to 2021. Headcount



Source: DAS Analysis of NMC published data

By far the largest employer of nurse labour in England and the UK is the NHS, and within that the NHS trusts providing hospital and community health services (HCHS). In England, the 150 acute and specialist hospital trusts, 25 community and 20 mental health trusts directly employ around 310,000 FTE nurses (NHS Digital, 2021). We estimate that a further 26,000 to 28,000 FTE are supplied via bank and agency staffing to fill between 85% and 90% of around 31,000 (10%) vacancies in England.*

Bank and agency nurses are temporary staffing. Bank tend to be NHS or ex-NHS staff working extra shifts and are organised via an NHS trust or group of trusts or NHS Professionals (see below). Agency nurses are supplied by a private company who specialise in supplying nurses to NHS and other employers of nurses. A significant portion of bank nurses and some agency nurses will also be working in permanent jobs in the NHS. Not all of these additional FTE will therefore be additional headcount.

The next three largest employers in England are private nursing homes with around 30,000 FTE, GP surgeries with approximately 16,000 FTE (NHS Digital, 2021) and the private acute sector with around 12,000 FTE. There are thousands of nurses working as nurses in charities (4,500 Macmillan nurses alone) and possibly 3,000 nurses in the prison service and the armed forces.†

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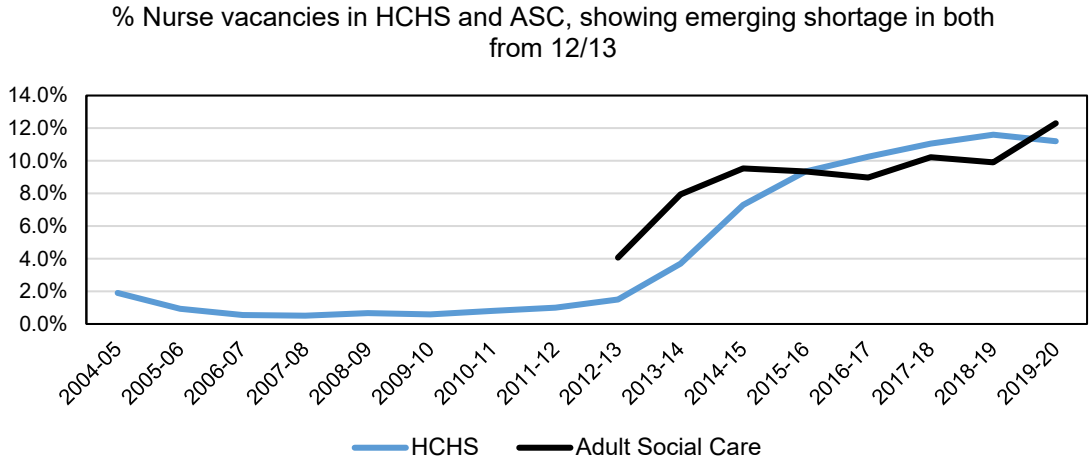
* NHS Improvement annual and quarterly performance reports – which also state that 85% to 90% of vacant shifts are filled by temporary staffing.

† It is difficult to get firm data on charities or 'other government' outside of the NHS. We have estimated from various sources, eg 150 prison service vacancies for nurses combined with a 10% vacancy rate suggests a minimum of 1,500 establishment nurses. With around 220,000 armed forces personnel and an estimated 5 nurses per 1,000 military, we arrive at an approximate figure of 1,100 nurses in the armed forces.

2.3 The current shortage of nurses

This Section describes the evolution of the current shortage of registered nurses in England in terms of the vacancy rate trend over the last decade and a half. Figure 2-2 shows a long run time series on vacancies from various sources for those in HCHS and adult social care (ASC).

Figure 2-2: Registered nurse vacancy rates in NHS hospital and community health services and adult social care in England, 2004/05–2019/20



Source: ASC (The state of adult social care and workforce, 2020). HCHS official NHS vacancies, as % of establishment, 2004/5 to 2010/11, imputed figures for 2011/12 to 2014/15 (derived from analysis of NHS Professions temporary nursing hours requested); 'experimental' vacancy data from NHS Jobs 2015/16 to 2016/17, published by NHS Digital; and NHS Improvement figures published by NHS Digital from 2017–19.

In the period between 2005 and 2010, there was a relative balance between the demand and supply of nurses. The 3-month vacancy rate averaged less than 1% in the HCHS from 2005 to 2010 and was at its lowest in 2010/11 at 0.6% (a total of 1,922 vacancies, 825 of which were in London) (Health Foundation, 2021).

Following the financial crisis of 2008–09, the Department of Health began preparing for a long period of low funding growth. The NHS Quality Innovation Productivity and Prevention (QIPP) programme, introduced in 2009/10, looked to deliver up to £20bn of savings over the next 4 years.

Although the NHS budget continued to grow, it was at a slower pace than in previous years. Budgets rose by a real-terms average of 1.1% between 2009/10 and 2014/15 and 1.5% between 2014/15 and 2018/19, compared to the long-term average growth rate of 3.7% between 1949/50 and 2019/20 (Health Foundation, 2021).

In 2010, the coalition government announced a 2-year pay freeze from 2011/12 (followed by a public sector cap on pay awards of 1% from 2013/14 to 2017/18. (House of Commons Library, 2021). In its 2011 report, the NHS Pay Review Body (PRB) studied the effect of the pay freeze on NHS staff and noted the proposed changes to workforce planning arrangements published in a consultation document on developing the

healthcare workforce in December 2010 (Department of Health, 2010). There was a major restructuring and reorganisation of the NHS and the Department of Health's arm's-length bodies, including changes to the infrastructure around workforce planning.

The PRB noted that (NHS Pay Review Body, 2011):

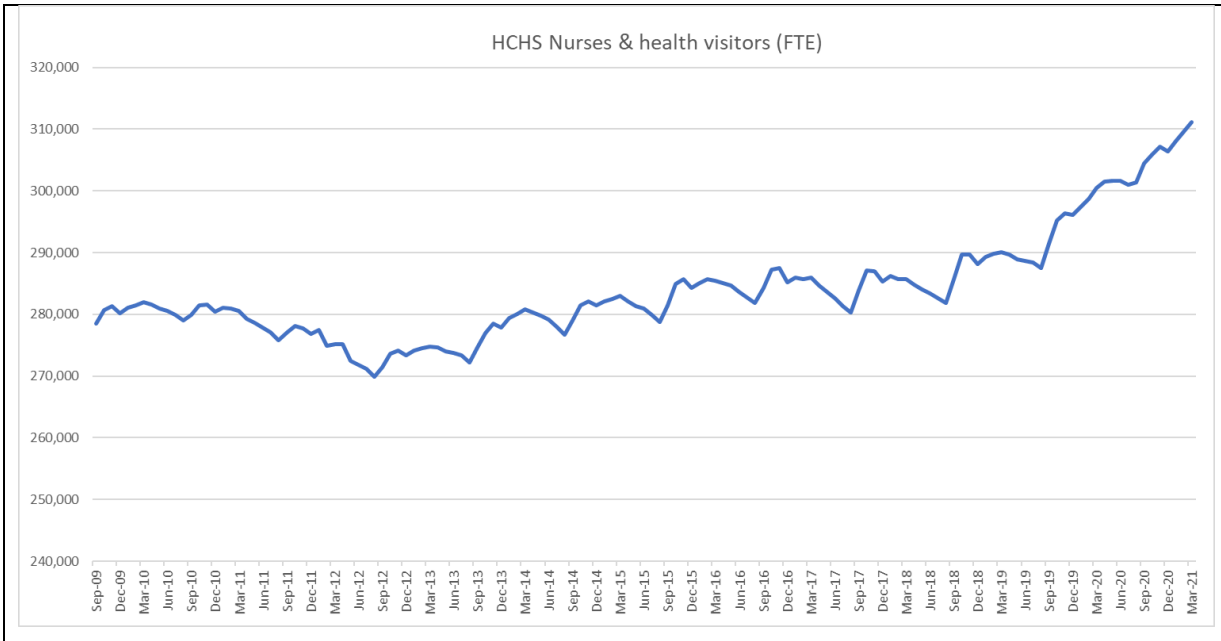
'We consider it important that:

- Wider NHS reforms planned for England… are not allowed to fragment the way in which information on workforce requirements is gathered at a local level, leading to imbalances between demand and supply.
- Individual employers, it could be argued, may be likely to take a short-term view of their own requirements, especially when their own financial plans are typically of between one and three years in length…' (NHS Pay Review Body, 2011)

The PRB would repeat these concerns in various forms in subsequent reports.

Figure 2-3 below shows the historic number of FTE nurses in establishment positions to the HCHS in England, ie it excludes temporary staffing. Based on vacancy rates and supply data, we infer that the demand for nurses was growing more quickly than supply for most of the 2013 to 2020 period.

Figure 2-3: FTE establishment nurses and health visitors working in the NHS HCHS (monthly data, September 2009 to March 2021)



Source: NHS workforce statistics, NHS Digital (NHS Digital, 2021).

Ignoring the seasonality in these data there is a decline of 10,000 FTEs (3.6%) in establishment nurse numbers between September 2010 and September 2012.

Commissions for student nurses taking a qualification in the adult field of nursing in 2010/11 were 13,628, their lowest level for 10 years, and were reduced further in 11/12 and 12/13, falling to 11,933 in that year. These numbers reflect a mindset strongly influenced by the QIPP programme for making significant recurrent savings in NHS expenditure, including from reduced growth in hospital activity and improved labour productivity.

2.3.1 2013 public inquiry (Francis) report on events at Mid Staffordshire NHS Hospital Trust

In February 2013, the report into the failings at Mid Staffordshire NHS Foundation Trust (Her Majesty's Stationery Office, 2013) highlighted the importance of staffing to the quality of care. In June 2014, NICE published *Safe staffing for nursing in adult inpatient wards in acute hospitals* (National Institute for Health and Care Excellence, 2014). Shortly afterwards acute hospital trusts estimated they would need 24,000 more nursing staff than they had forecast 2 years earlier in 2012.

As we can see from Table 2-2 there was growth in nurse numbers of around 20,000 FTEs from December 2013 to December 2019 (1% per annum) but this could not keep pace with the demand for nurses. Over the same period vacancies – one measure of the gap between supply and demand – rose from 3.7% in 2013/14 to 11.3% in 2019/20 (NHS Digital data), equivalent to excess demand of around 22,000 FTE.

Nurse training commissions were increased from 2013/14 and in subsequent years to reach 14,417 commissions for adult nursing and 20,741 for all fields of nursing by 2016/17.

Table 2-2: Nursing commissions 2010–2016, England

	Strategic health authority commissioning				HEE workforce plans		
Nursing specialism	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**
Adults	13,628	11,930	11,416	12,134	13,228	14,160	14,417
Children	2,095	2,045	2,159	2,151	2,182	2,343	2,343
Learning disability	681	599	606	628	653	664	638
Mental health	3,500	3,253	3,083	3,096	3,143	3,243	3,343
Total nursing commissions	**19,904**	**17,827**	**17,264**	**18,009**	**19,206**	**20,410**	**20,741**

Source: Health Education England Commissioning and Investment Plan 2016/17 (Health Education England, 2016)

Despite the broad consensus on the need to increase domestic training the number of acceptances onto nurse degree courses remained more or less static from 2016 to 2019 (UCAS, 2019). This was almost certainly the result of the change from a student bursary and free tuition to a student loan system in 2017.

2.3.2 Impact of COVID-19

Figure 2-3 shows that from March 2020, the start of the COVID-19 pandemic, the number of FTE nurses in the NHS has grown quite quickly, and the seasonal pattern has been less marked. There are several possible causes, including the implementation of the NMC temporary register and lower leaver rates (NHS, 2021) over the period. This might be due to increased economic uncertainty during the pandemic, or as stated by Fernandez (Fernandez, et al., 2020) it may be due to the increased sense of professional duty of nurses to work during a pandemic.

The impact of COVID-19 on the nursing workforce is further discussed in Section 3.8 and in our previous report (Nurse supply model: exploring the impact of COVID-19 (DAS, 2021c)).*

2.3.3 Gap between demand and supply

There were no official nurse vacancy rates published in England from 2011 to 2015/16, making understanding the position at the time (and subsequently) difficult. We have used data from NHS Professionals to attempt to plug this gap. NHS Professionals Ltd is a company wholly owned by the secretary of state for health that acts as the supplier of bank nurses for 30% of NHS trusts in England.

The National Audit Office reported (NAO, 2016) that the number of nursing hours requested per month from NHS Professionals doubled between April 2012 and April 2015, from 800,000 hours per calendar month (pcm) to 1,600,000 pcm (5,300 to 10,600 FTEs). NHS Professionals runs a bank service for 62 acute, mental health and community trusts (30% of total). Extrapolating from NHS Professionals data suggests a national 17,500 FTE shortfall from 2012 to 2016/17 being met from the bank.

An agency nurse works on a temporary (or 'locum') basis through an agency† in a variety of settings rather than in a permanent role in one fixed place. Agency spend in the NHS rose from £2.6bn in 2013/14 to £3.7bn in 2015/16, when NHS Improvement imposed a price and volume cap on agency staffing. Combined bank and agency spend increased from £3.6bn in 2013/14 to over £6bn in 2019/20. An agency nurse is different to a bank nurse. The bank is a pool of nursing staff within a trust or group of trusts who wish to work additional hours. It is open to retired employees who may work solely through the bank.

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* www.health.org.uk/publications/nurse-supply-model-exploring-the-impact-of-covid-19

† Nursing agencies are private companies which supply nursing staff to trusts. Agencies keep a number of qualified nurses on their books and cover several employer organisations in a geographical area. They charge the ultimate employer for the labour they provide, deduct a fee and pay their contracted nurses for each session worked, usually at a higher rate than that which would be paid to establishment staff.

Vacancy data collected on a consistent basis from individual trusts and published by NHS Digital suggest that the registered FTE nursing rate in the NHS was 12.1% in September 2018 and September 2019, but fell to 10.1% in September 2020, at the end of the first wave of the COVID-19 pandemic, and stood at 10.5% in September 2021.

2.4 Workforce planning

A key purpose of workforce planning is to avoid or mitigate expensive shortages or surpluses of the staff groups of interest (NAO, 2016), and this calls for the following:

1. Projections of demand for particular staff based on the predicted level and pattern of demand for health care.
2. Understanding the actual supply of the workforce of interest and how this might change in the future.
3. Comparison of workforce demand and supply under alternative scenarios based on different assumptions of interest and how any imbalance might be reduced with various 'gap-close' measures.
4. Persuading those who control resources to redeploy them based on projections, predictions and assumptions.

The fourth step is noted by Buchan, among others, as 'the critical issue in determining its impact on policy and service delivery. [Most] important is the extent to which the planning process connects with and influences decisions on funding'. (Buchan, Seccombe, & Smith, 1998)

2.4.1 Why is the fourth step in workforce planning – engagement with decision makers – so difficult?

Workforce planning for health care services is essential because of long lead times in training key staff groups, followed by a typical working life in a particular health care profession. For example, nurses take 3–4 years to train, compared to 7–11 for doctors. Once qualified a nurse might expect to work over 25 years as a nurse, spread over a 40-year working life. Career gaps could result from professional career breaks for training or family caring responsibilities. A decision on the appropriate number of nurses to train now requires some confidence in the future demand for nurses 5, 10 and 20 years into the future and the labour market participation decisions of nurses who have already qualified.

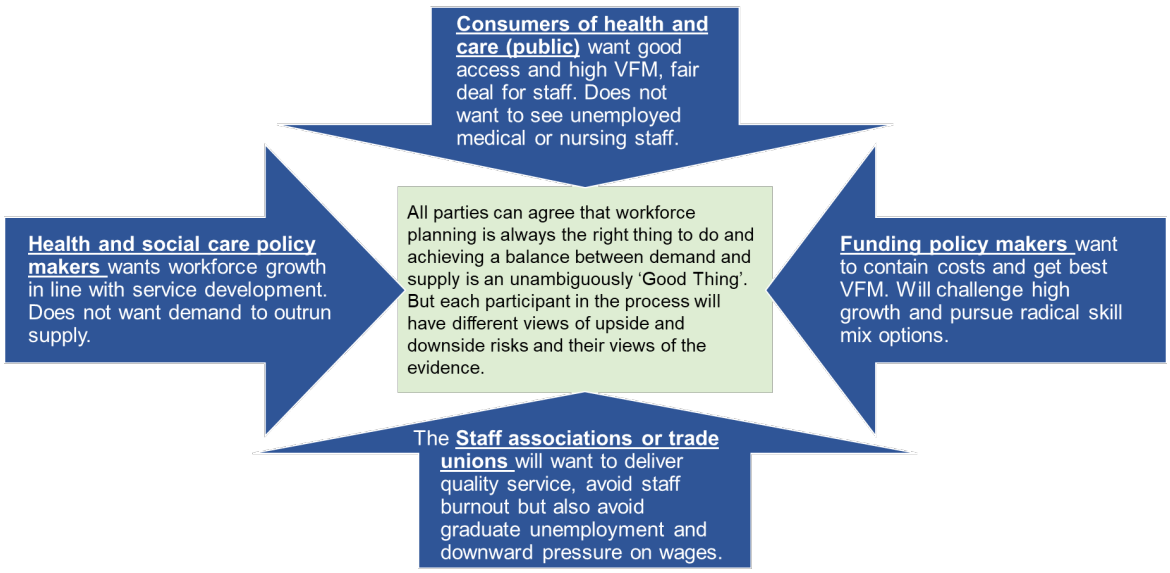
The actions arising from workforce planning usually require making adjustments and changes to current plans. That requires a reallocation from 'current consumption' (eg the affordability of nurses working on the front line) towards an increased 'investment' in training places. 'Spend more now on training to insure against the risk of future undersupply' is generally not an attractive proposition for politicians, and service managers.

There could, of course, be unusual instances where planning might point to a need to correct for past investment decisions to prevent a future surplus. But either type of adjustment will result in winners and losers in the short term and a change in future

risk perception. This 'winners and losers' element of workforce planning decisions makes it difficult for all parties to be entirely objective and draw the same conclusions from the same evidence.

All agents* in the health and care system (eg ministers, professions, managers, service providers, higher education institutions, health and care staff, and the general public and their representatives) will unanimously agree that achieving a balance between workforce supply and demand is an unambiguous 'good thing', but each will view the problem from their own perspective, as shown in Figure 2-5.

Figure 2-5 Different agents have asymmetric view of risks



Source: Decision Analysis Services Ltd

To get to the right decision based on the balance of available evidence requires significant engagement and trust between the workforce planners, educators, professional associations and the people who actually allocate resources. Such levels

* The agents in the system are decision makers, whose decisions have impacts on the nurse supply system in the short and long run. At one level we can think of the potential/would-be nurses, qualified nurses and former nurses as individual agents whose decisions on career choices and job roles help to determine the supply of qualified nurse labour in the short and long run. Other agents include the employers of nurse labour (mainly NHS and social care providers) and providers of nurse education. Government and its agencies are also agents that seek to influence the level and quality of health and care service provided and ensure adequate supply of nurse labour (and other inputs). They can do this by changing the factors that affect nurse supply (eg funding for nurse training) or by changing regulations (eg by introducing a new licensed profession of nursing associates).

of trust are best built up over time through a continuous, and preferably consistent, process of evidence gathering, review and decision making.

A workforce planning system that is in a state of flux is less likely to diagnose the need for adjustments early enough and might lack the credibility to persuade decision makers to reallocate resources. As noted in the Health Foundation ITT for this project (Health Foundation, 2019), 'There have been more than a dozen significant structural changes in the national workforce policy and planning architecture since 2000.'

A 'stop-go' workforce planning process is less likely to get traction or build a sufficiently solid reputation to influence decision makers.

2.4.2 Solutions

The *Closing the gap* report (Health Foundation, Nuffield Trust, & The King's Fund, 2019) recommends that to resolve the workforce shortages in the NHS, more effective workforce planning must be carried out.

One of the main reasons for the shortages in nursing, and in the NHS as a whole, is a lack of long-term planning around staffing levels and a 'boom and bust' approach linked to funding (House of Commons Health Committee, 2007).

As *Closing the gap* concludes:

- Historically, the NHS workforce has not been a policy priority for the Department of Health.
- Responsibility for workforce planning in England is fragmented.
- The information the NHS needs to understand and plan the workforce is poor.
- Government views education and training as an overhead cost that should be minimised.

The government's pledge for 50,000 more nurses in England by 2025, in its 2019 election manifesto, was also criticised by the Health Foundation as being 'insufficient to meet growing demand, especially in the wake of the coronavirus pandemic' (Health Foundation, 2020). They suggest a shift away 'from single top-down targets to a sustainable, long-term approach… starting with robust, independent projections of the future demand for, and potential supply of nurses'.

2.4.3 The role of projection models of demand and supply

As noted above, workforce planning requires projections of demand for particular staff and an understanding of future supply. Therefore, the lack of high quality, robust, and transparent projections of workforce supply and demand is a major factor underlying the lack of workforce planning and a coordinated workforce strategy.

Projection models are commonly used within the overall workforce planning process to enable organisations, in health and beyond, to develop estimates of future demand and supply. This enables organisations to plan for the future and understand how the evolving needs for services will affect the numbers and types of staff required.

A review carried out by DAS in January 2019 (DAS, 2019b) found that there have been several techniques successfully applied in workforce supply projection modelling, most commonly MS Excel based stock and flow models but also some applied simulation methods such as system dynamics and microsimulation. In England, the most commonly used technique is MS Excel modelling, used by HEE and the Health Foundation. The Department of Health and Social Care (DHSC) uses system dynamics to model nurse supply for secondary care.

The review found that modelling of the English nurse workforce predominantly focuses on secondary care due to a lack of reliable data in the primary, social care and private or independent sectors. None of the models reviewed that are currently in use in England captured a whole system view or considered the rest of the UK.

Similarly, models that were identified to model the nursing workforce in Scotland and Wales, developed by the Scottish Government and Health Education and Improvement Wales, only considered nurses in the individual country.

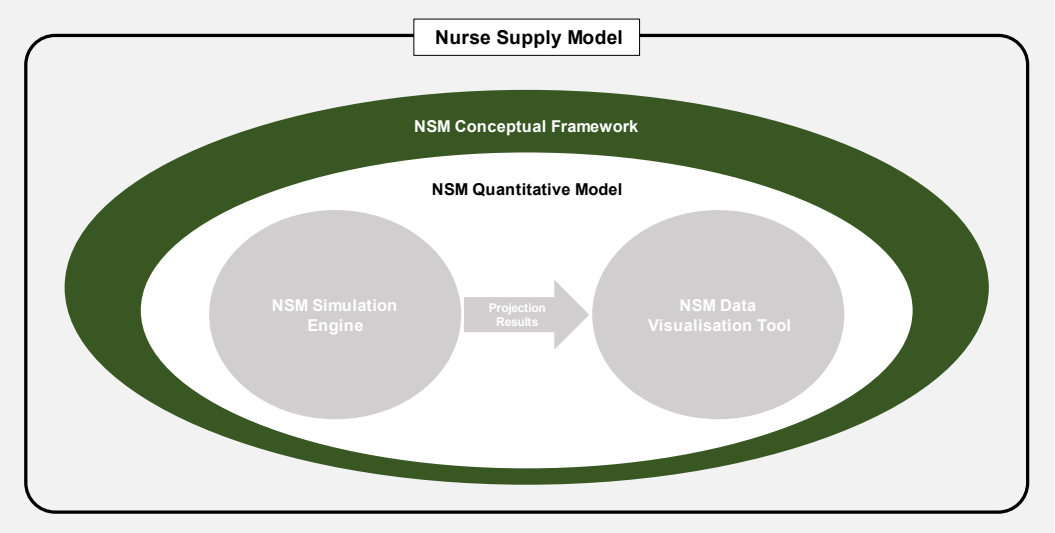
No examples of models in the UK were found to consider the influences underlying inflows in and outflows from the workforce, for example the environmental or individual specific factors driving the career choices made by nurses, such as why they chose to start training or why they choose to leave the workforce.

3 Nurse supply model: conceptual framework

The conceptual framework takes a broad view of the nursing supply system and includes variables that are not quantified in the simulation engine. It captures the key cause-and-effect relationships which influence nurse supply and integrates insights from economic theory and stock and flow perspectives on the nurse supply system. This Section describes how the conceptual framework was developed and provides an overview of its key building blocks. It also provides two examples of its use to explore the nurse supply system.

The diagram below illustrated the position of the conceptual framework within the NSM as a whole:

Figure 3-1: Highlighting the position of the conceptual framework in the NSM



Source: DAS Ltd

3.1 Developing the NSM conceptual framework

A participatory and iterative approach was adopted to developing the conceptual framework. Stakeholder groups involved with its development included:

- Council of Deans of Health
- Department of Health and Social Care (DHSC)
- Health Education England
- Institute for Fiscal Studies (IFS)
- King's College London
- National Audit Office (NAO)
- NHS Digital
- NHS Employers
- NHS England
- NHS Improvement
- NHS X

- Nuffield Trust
- Nursing and Midwifery Council (NMC)
- Office for Students
- Royal College of Nursing (RCN)
- Skills for Care (SfC)
- Staffordshire University
- The Health Foundation
- Unison
- University of Kent
- University of Sheffield
- University of Southampton
- University of Surrey

A group model building (GMB) approach was adopted. GMB is a participatory approach, whereby those involved in a system or problem system actively contribute to the construction and validation of qualitative and/or quantitative models. Facilitated processes such as structured interviews, focus groups and workshops were used. In addition, the available literature and data were analysed to support the GMB process and develop initial hypotheses for challenge and debate and to validate outputs.

In addition to many interviews with stakeholders from across the system, the following major workshops were used to take people through aspects of the GMB process:

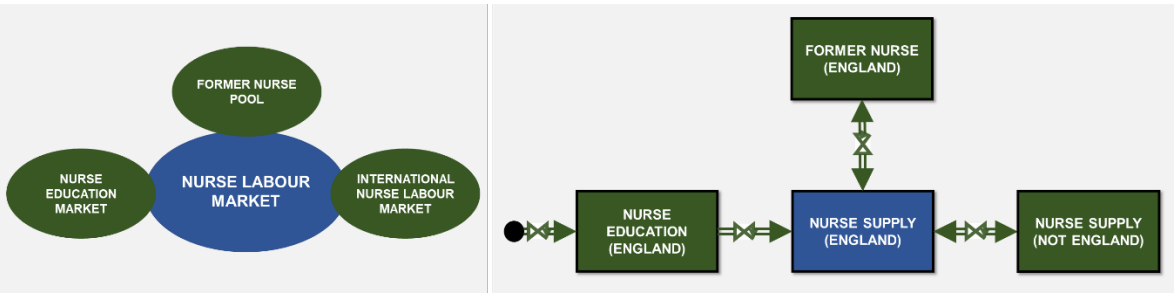
1. The nurse employment system: training and career pathways mapping – November 2019
2. The nurse economics system: policy and behavioural mapping - November 2019
3. Exploring the NSM conceptual framework – June 2020
4. Using the conceptual framework to explore the impact of COVID-19 – November 2020
5. Nurse education deep dive – March 2021

The first two workshops were held in person, and all subsequent workshops were held online due to COVID-19 restrictions. Each of the workshops included a range of activities, for example diagramming, brainstorming and voting to gather contributions from participants. Sample outputs included system maps, lists of factors that affect nurse supply and impact weightings. Over 110 separate factors were identified as influential within the nurse supply system, and their degree of influence assessed.

Throughout the process, two main perspectives were used to support the conceptualisation of the nurse supply system. The first perspective was through taking an economics framed viewpoint and considering the nurse supply system as a set of interrelated markets (DAS, 2019e). Each market may be viewed as having its own demand and supply schedules that are affected by a 'price' and other factors such as entry requirements to nurse education, nurse workload and immigration rules into UK and for other countries who recognise UK qualified nurses.

The second perspective was a stock and flow perspective, whereby the key stocks in the system were considered,* including the flows into and out of the stocks and the factors that affected those flows. These alternative views on the nurse supply system are illustrated in Figure 3-2. DAS combined these two perspectives and incorporated the output from the GMB exercises along with the various factors that had been identified from the literature to develop the overarching NSM conceptual framework.

Figure 3-2: Comparison of market level and stock and flow views of nurse supply system



Source: DAS Ltd (DAS, 2020)

The following Sections give more detail, including definitions, for the core building blocks of the conceptual framework, ie markets, stocks and flows and factors (pecuniary and non-pecuniary) that act in combination to influence the flows into and out of the nurse supply system. All the diagrams in the following Sections were created with input from, and validated by, numerous stakeholders within the nurse supply system.

3.2 Markets

Markets are systems where a product or service is supplied (sold) by one set of agents (see Section 2.4.1) and demanded (purchased) by another set. The exchange between supplier and consumer (or employee and employer) is made using a price (or wage). The nurse supply system has been conceptualised as a set of markets.

The conceptual model is framed within a set of three core markets and the pool of former nurses. Together these form the nurse supply system in England:

- **England nurse labour market:** the nurse labour market is concerned with the labour supply of qualified nurses in jobs that can only be done by a qualified nurse in England (note these jobs may be within the NHS, other government departments, charities, social care and private health care providers).

* See Section 3.3. In summary, a stock is a representation of the accumulation of resources in a system, such as the total number of qualified nurses or the total number of former nurses whose registration with the NMC has lapsed. A flow is the representation of the rate at which resources flow in and out of a stock.

- **International nurse labour market:** acts as a potential pool of qualified nurse labour supply into England and as a destination for UK qualified nurses to work abroad, subject to immigration rules into the UK and importing countries' (eg New Zealand and Saudi Arabia) immigration rules. There are also flows of qualified nurses working between the four nations of the UK that are not subject to any immigration rules.
- **Nurse education market:** the market for nurse education in England. The nurse education market supplies nurse education to student nurses, return to practice (RTP) courses to former nurses with lapsed registration and postgraduate qualification or dual registration to qualified nurses.

The former nurse pool comprises nurses in England who are no longer working in nurse jobs but are able to return to the nurse labour market either because they are still registered or, if their registration has lapsed, are able to re-register via an RTP course. The duration of the RTP course and its opportunity costs for the nurse depend on the length of time the nurse has been off the register. These qualified nurses not working as nurses form a potential supply. They are not part of the actual supply of nurse labour but could join it, if the 'right job' became available.

We need to differentiate former nurses from the general population because they can add to nurse supply in a relatively short period, even if their registration has lapsed.

In the England nurse labour market (hereafter, the 'nurse labour market'), the price is the nurse wage, and it will simultaneously affect the quantity of nurse labour that is supplied by registered nurses and demanded by health and care employers. Additional factors can increase or reduce the levels of demand and supply at a given price. For example, a fall in the overall unemployment rate may reduce the supply of nurse labour at a given wage as nurses have more opportunities to work outside of nursing, while a drive to improve patient safety is likely to increase the demand for nurse labour at a given wage.

The three markets of the nurse supply system are interrelated in three ways:

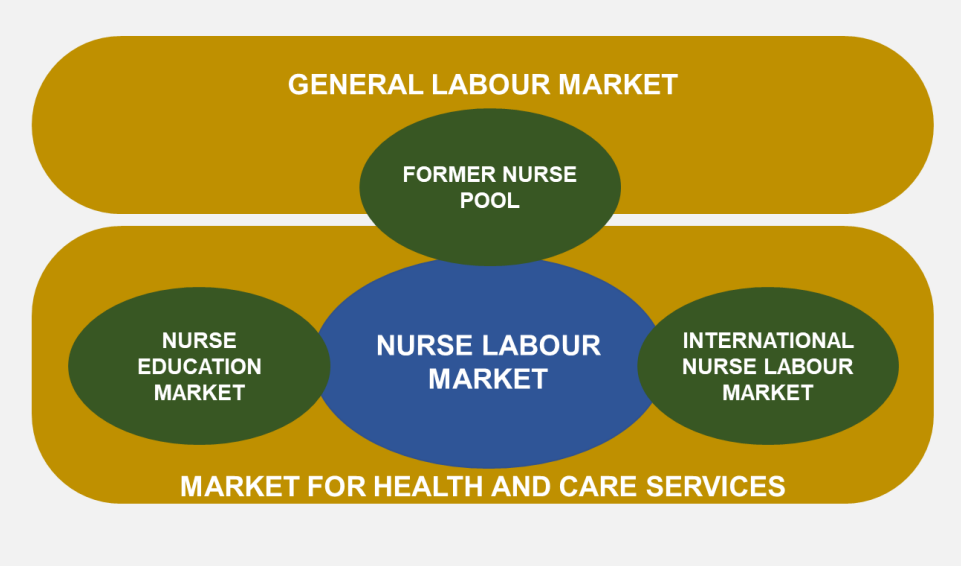
1. People and information flow between them. For example, student nurses may enter the nurse labour market on graduation and the level of nurse satisfaction may affect whether someone wishes to train to be a nurse.
2. The factors that affect one market will often affect another. For example, the level of nurse renumeration may affect whether a nurse wants to carry on working as a nurse and whether undertaking a nursing degree is attractive.
3. Conditions in one market can affect conditions in the other markets. For example, the quality of nurse education will subsequently affect the quality of graduate nurses arriving in the nurse labour market.

The conceptual model has been developed to explore and help represent these interrelationships.

3.2.1 Other markets

Two other markets exist outside of the nurse supply system – the general labour market and the market for health and care services, as shown in the diagram below.

Figure 3-3: Exogenous and endogenous market view



Source: DAS Ltd (DAS, 2020)

These markets exert a powerful influence on the nurse supply system and the flows within it, but they are not influenced by it, ie they are considered as exogenous to the boundary of the nurse supply system. These two markets influence the nurse supply market in a range of ways:

- **The general labour market** provides a range of alternative employment opportunities for potential student nurses, qualified nurses and former nurses, including those with lapsed registrations, but the nurse labour market does not affect the general labour market of 32.3 million employed persons in the UK (including 15.4 million women)*. Some of the nurses in the former nurse pool will sit within the general labour market, however their influence on the general labour market will be insignificant.
- **The market for health and care services** generates the derived demand for nurse labour and other labour and non-labour inputs, such as doctors and MRI scanners. This demand for nurse labour can vary significantly by geography and branch of nursing and, to some extent, by grade and experience. Where demand exceeds supply, and wages do not adjust to restore equilibrium, excess

* Values for April to June 2021 from: www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/fulltimeparttimeandtemporaryworkersseasonallyadjustedemp01sa

demand will lead to a rise in overtime work and bank and agency staffing and potentially an increase in the use of skill substitution where possible (such as increased recruitment of health care assistants).

The size and some of the complexity of nurse demand can be illustrated by considering the current scale of the registered nurse workforce by sector, as shown in Table 3-1.

Table 3-1: Employment of registered nurses by sector FTE and HC England 2017

	HCHS[1]	Primary[1]	Bank[2]	Agency[2]	Adult social care[4]	Private[1]	Total[5]
Numbers in 000s FTEs	305	15	(24)[3]	(12)[3]	30	12	375
Headcount (HC)	343	24			42	14	450

Notes: **(1)** The FTE figures taken from RCN Market Review 2018. HC calculated from NHS Digital ratio FTE to Headcount. (Primary HC figure based on 54% FTE and 26k working an average 2 days per week.) **(2)** Estimate based on NHS I bank and agency used to fill 36,000 vacancies (90% of total) in 2017. **(3)** Sum of sectors is less than given total as majority of bank staff and some agency already employed either by NHS. **(4)** The size and structure of the adult social care sector and workforce in England, Skills for Health 2018. **(5)** Significant numbers of nurses also work in charities, local authorities, prisons, for the armed forces. These (approximately 18,000 headcount) are not included in the above figures.

Section 2 of this report provides more information regarding the size of these markets and how they have changed over time.

3.3 Stocks and flows

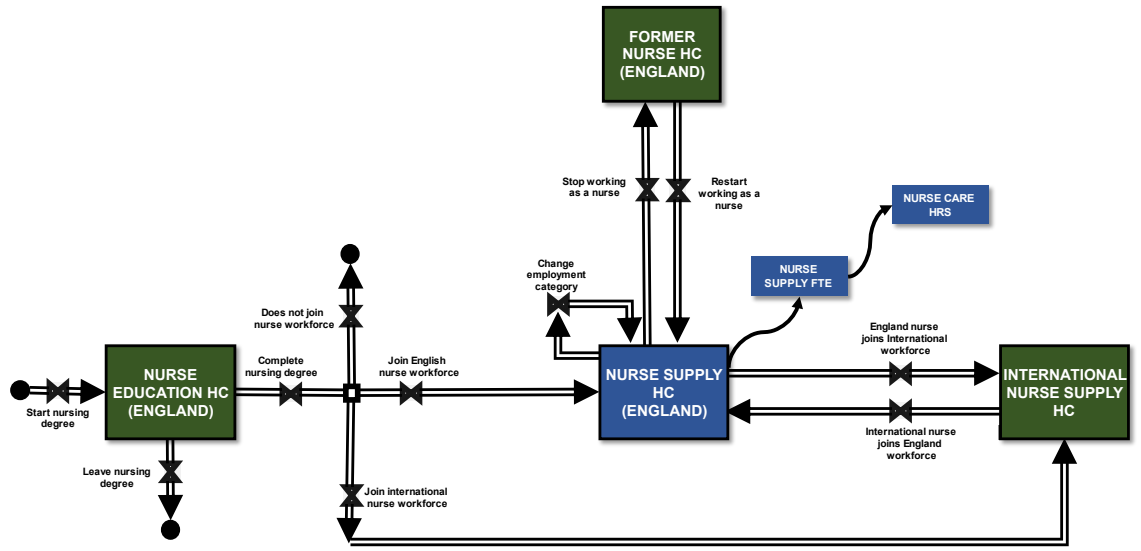
A stock is a representation of the accumulation of resources in a system, such as the total number of qualified nurses or the total number of former nurses whose registration with the NMC has lapsed.

A flow is the representation of the rate at which resources flow in and out of a stock. There is either a flow into a stock (eg the number of new qualifiers each year, causing the stock value to increase) or out of a stock (eg the numbers falling off the register, causing the stock value to decrease). The size of a stock can only be changed by the action of a flow.

Stocks and flows can be segmented to capture population characteristics. Characteristics can for example be based on the attributes of individuals (eg age, gender, nationality, household composition, etc) or their employment (eg sector, setting, job role and level etc).

Figure 3-2 above provided a high-level view of the key stocks in the nurse supply system. The diagram below provides a more detailed view of the stocks and flows and includes additional flows that are significant to policy actions. This diagram defines the key stocks and flows that form the basis for this document and the NSM.

Figure 3-4: More detailed stock and flow diagram of nurse supply system



Source: DAS Ltd

3.3.1 Permanent exits

To maintain a mutually exclusive and collectively exhaustive view of stocks and flows, it is important to consider permanent exits from the system. This might be, for example, due to chronic sickness, death, malpractice, lack of competence, old age or disillusion with nursing work, leading to permanent withdrawal from the profession or a move to another role within or outside the health and care sector.

Further, a significant number of nursing degree students leave their course without completing it and smaller numbers are believed to graduate but not practise nursing. The former (student attrition) represents a major outflow from the system. For instance, nursing student attrition in England stood at 25% in 2020 (Nursing Standard, 2020), suggesting that 1 in 4 student nurses left their degree programme prior to completion.

3.4 Factors, flows, policy instruments and flow adjustments

Each flow in the nurse supply system is influenced by a variety of factors, some of which are common to multiple flows and others unique to a particular flow. We may categorise them as pecuniary (financial) and non-pecuniary (non-financial) factors. Pecuniary factors relate to monetary and economic variables, such as the opportunity cost of nurse education, lifetime earnings, costs of living in different parts of the country and promotion prospects.

Non-pecuniary factors relate to important non-monetary aspects of working as a nurse. These include helping sick people to get better and being part of a strong team, on the upside, and poor work environment, high workload and stress on the downside.

There are also 'regulatory policies and instruments' made by government departments and their arm's length bodies that will impact on the nurse supply system. The policies may not be aimed at the nurse supply system but may have an impact anyway, or they may be aimed at the nurse supply system and either achieve their desired effect or something different. An example would be policies designed to make a particular career (teaching, social work) more attractive and attract potential nursing students away from a nursing degree. Many regulatory policies and instruments will impact on the nurse supply system via their influence on the factors discussed in this paper (eg changing the financial support for student nurses and funding more clinical placements for students). Other policies may not affect the factors we discuss but can have a direct impact on nurse supply or demand. Obvious examples are immigration policy on the supply side and health and care quality and access standards on the demand side. In this technical paper we focus on the factors rather than the potential regulatory policies.

The impacts of pecuniary and non-pecuniary factors will vary depending on the flows they affect and the characteristics of the people in those flows. For example, high workload and stress in the England nurse labour market are more likely to affect flows out, to the former nurse pool, than flows in from the international nurse labour market. Younger, more recently qualified nurses may be more sensitive to stress, but also more responsive to opportunities to work longer hours.

The pecuniary and non-pecuniary factors are discussed and can then be combined in a single statement or 'equation' that uses available data to measure the factors. The overall impact of pecuniary and non-pecuniary factors is captured in the model as an 'adjustment affecting a flow or critical system variable' as shown in Figure 3-5.

In summary: nurse supply flows in the nurse supply system are regulated by flow adjustments.[*] The adjustments represent combinations of pecuniary and non-pecuniary factors that influence nurse supply.[†]

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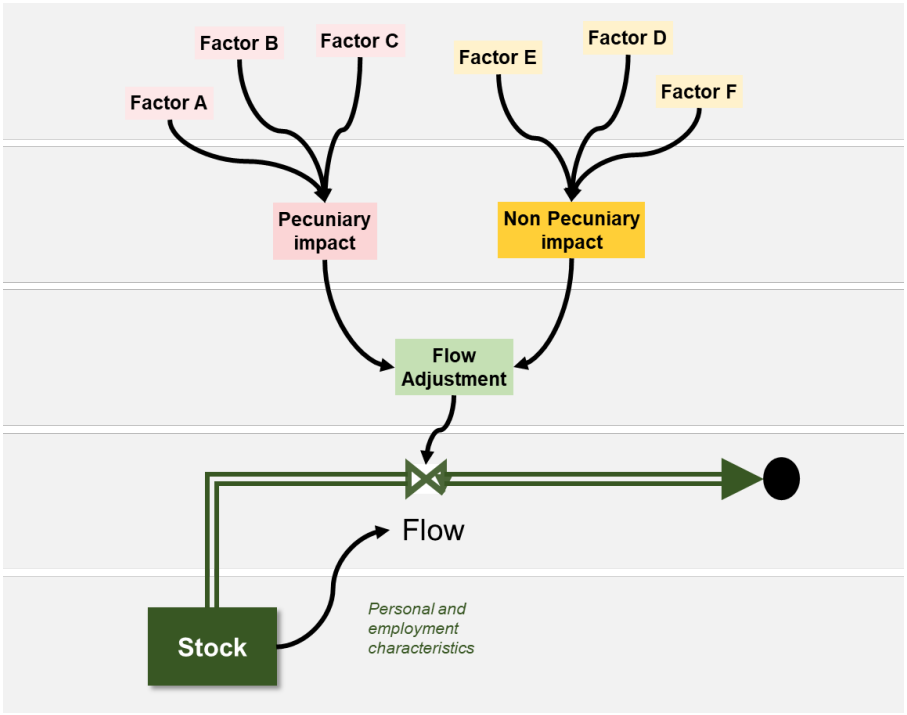
[*] These are also called adjustment variables through this document as they affect significant parameters in the system other than flows, for example the conversion of headcount to FTE.

[†] The focus of this paper is on the factors affecting the flows. The conceptual model (DAS, 2020) also considers system delays and constraints. Delays (sometimes called lags) indicate that a process takes a period of time from start to finish, for example time to undertake a degree. Constraint limits the flow to a maximum value, for example the number of degree places or student placements.

Figure 3-5: The flows in the system are affected by factors, the impacts of which are combined to give the overall adjustment



Source: DAS Ltd

In the quantitative model the adjustment variables can be defined directly, or potentially calculated in response to changing values of individual factors where suitable evidence exists of the relationship (λ) between factors and flows.

11 principal strategic adjustment variables have been identified based on an analysis of the conceptual model. The flows they affect and the market in which they are discussed in this document are shown in Table 3-2:

Table 3-2: The 11 principal strategic adjustment variables in the nurse supply system

	Adjustment variables	Affected flows	Source market/pool
1	**Number of applicants and acceptances[1] to a nursing degree**	Start nursing degree	Nurse education market
2	**Percentage of students who leave nursing degree prior to completion**	Leave before completion of degree / Complete nursing degree	Nurse education market

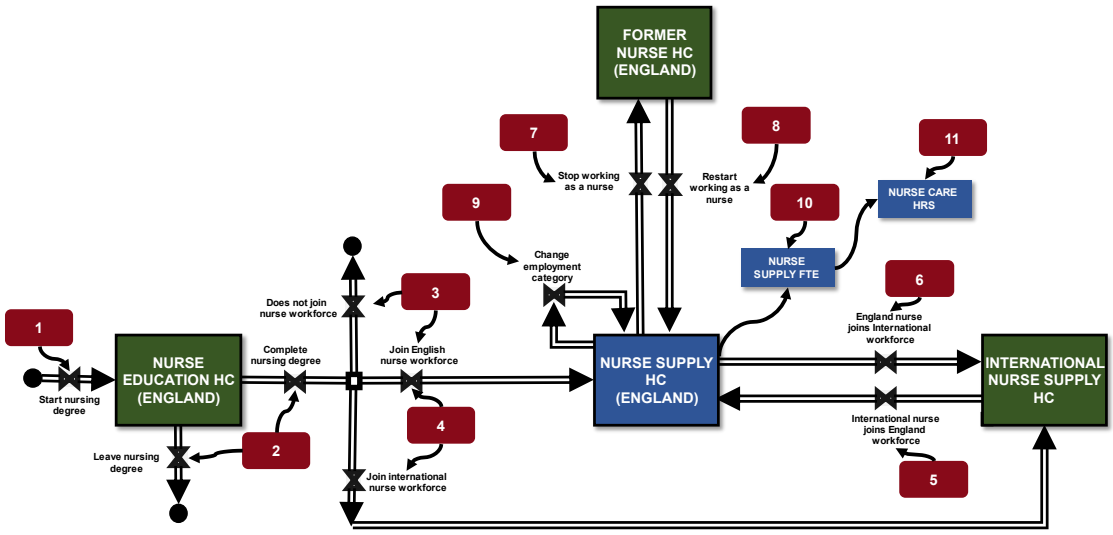
	Adjustment variables	Affected flows	Source market/pool
3	**Percentage of students that complete degree but do not join nurse workforce**	New nurse joins/does not join nurse workforce	Nurse education market
4	**Percentage of students that complete degree and join international nurse workforce**	New nurse joins international nurse workforce	Nurse education market
5	**International nurse joins England nurse supply**	International nurse joins England nurse supply	International nurse labour market
6	**Percentage of nurses joining the international nurse supply**	Nurse joins international nurse supply	Nurse labour market
7	**Percentage of nurses who stop working as a nurse**	Stop working as a nurse	Nurse labour market
8	**Percentage of former nurses who restart working as a nurse**	Restart working as a nurse	Former nurse pool
9	**Percentage of nurses that move between employment categories**[2]	Change nurse employment category	Nurse labour market
10	**Hours worked per week**	Nurse supply FTE	Nurse labour market
11	**Care hours delivered per FTE nurse**	Nurse care hours delivered	Nurse labour market

Source: DAS Ltd

Notes: **(1)** The size of, and the quality and commitment of the applicant pool, and how effective HEIs are at selecting the most able and dedicated, will be a major determinant of future supply, since it will define the number who graduate and how long they practise. **(2)** A transition matrix can be used to represent the probability of switching between categories, eg from working in one sector to another such as nurses moving across care settings, regions, grades or working patterns but remaining in the nurse workforce.

Figure 3-6 below relates the adjustment variables in Table 3-2 to the summary stock and flow diagram.

Figure 3-6: Strategic adjustment variables linked to system flows

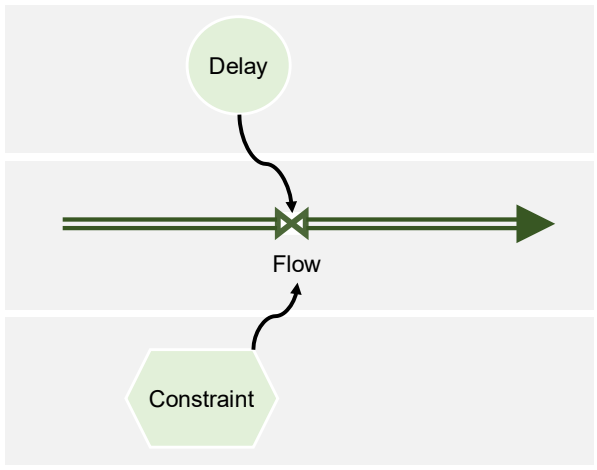


Source: DAS Ltd

3.5 Delays and capacity constraints

The final elements of the conceptual framework are delays and capacity constraints, which are illustrated in the framework as shown in Figure 3-7.

Figure 3-7: Delays and capacity constraints



(1) Delays indicate that a process takes a period of time from start to finish, for example time to undertake a degree. May also be called lags.

(2) Constraints limit flows to maximum values, for example the number of degree places or the number of available jobs.

Source: DAS Ltd

A classic area where delays and constraints can be considered is in nurse education. The delay associated with undertaking a nursing degree is based on the time it takes to

complete, which would take into account aspects such as resits and part-time study. The constraint on nurse degree education is based on the number of places available, which could again be constrained by the capacity of HEIs to offer nurse degree education.

3.6 Regulatory policies and instruments

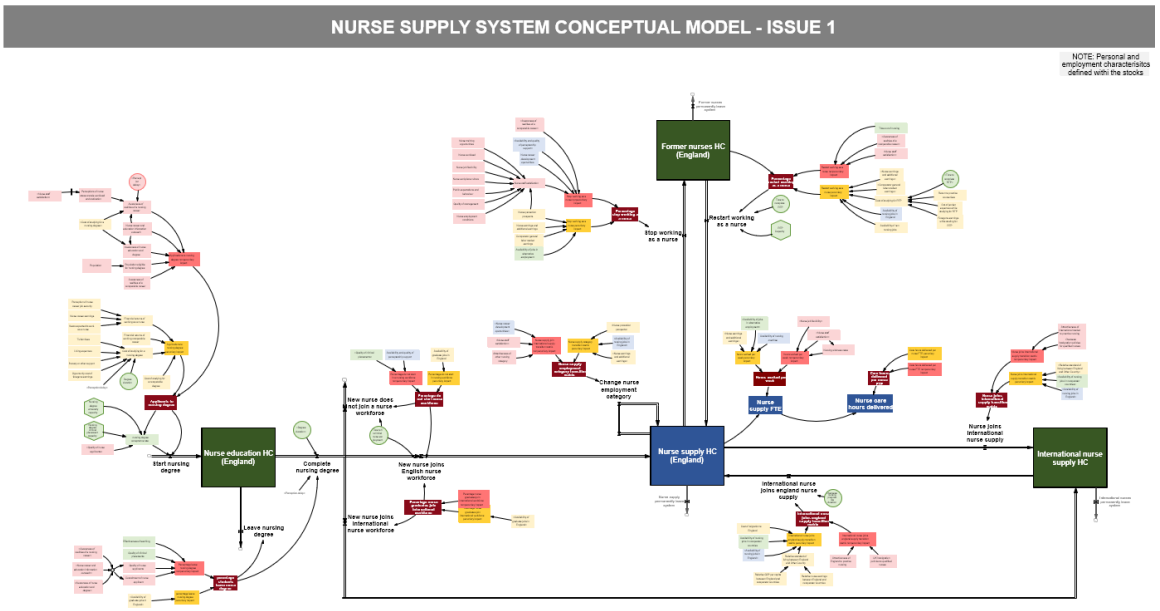
The conceptual framework has been developed to be neutral of regulatory policies and instruments. Regulatory policies and instruments can be described through their impact on one or a combination of the factors, delays and constraints in the nurse supply system. The conceptual model does not focus on specific/potential regulatory policies and instruments, but does identify the various potential factors, delays and constraints that could be elements of those policies and instruments.

3.7 Detailed view of the NSM conceptual framework

It is important to note that the NSM conceptual framework is not actually a single diagram but a range of diagrams and perspectives on the nurse supply system that use a consistent language and set of definitions. This can be used to better articulate the nurse supply system and how the system can be affected to alter nurse supply.

At its most detailed level a diagram has been created that combines the various factors that were identified from the literature and from the GMB workshops to provide a broad view of the nurse supply system, as shown in Figure 3-8 and Annex C. Figure 3-8 illustrates the general structure of the diagram, the full detail can be seen in Annex C.

Figure 3-8: Conceptual model of the nurse supply system (large reprint in Annex C)



Source: DAS Ltd (DAS, 2020)

This diagram combines all the key elements of the conceptual model described thus far, ie the markets, stocks and flows, and factors (pecuniary and non-pecuniary) that act in combination to influence nurse supply. A full description of the conceptual model has been developed (DAS, 2020).

This detailed diagram exists in the form of a Vensim model, which is a system dynamics model development tool. Each of the variables that exist in this diagram have underlying definitions, and Vensim enables cause-and-effect linkages to be created to assist in identifying how different variables affect other variables in the system.

DAS has used the conceptual framework as a tool to explore aspects associated with nurse supply in England, namely the potential impact of COVID-19 on nurse supply and the impact of various economic factors on nurse supply. These two case studies are described briefly below.

3.8 Conceptual framework application 1: Considering the impact of COVID-19 on nurse supply

Research question: What is the potential impact of COVID-19 on future nurse supply?

Full details of this research are provided in Nurse supply model: exploring the impact of COVID-19 (DAS, 2021c).

The World Health Organization (WHO) declared the COVID-19 outbreak as a Public Health Emergency of International Concern on 30 January 2020 and a pandemic on 11 March 2020. The pandemic had a significant impact on the workload, emotional and organisational demands on nurses, and how they deliver care. A number of emergency measures were implemented to temporarily increase nurse supply during the pandemic and there was a change in how nurses are perceived by the general public, potentially prompting nurses to reflect on the importance and value of what they contribute to society. There is potential that each of these changes will influence the career decisions of current and future nurses and have long-term consequences on nurse supply.

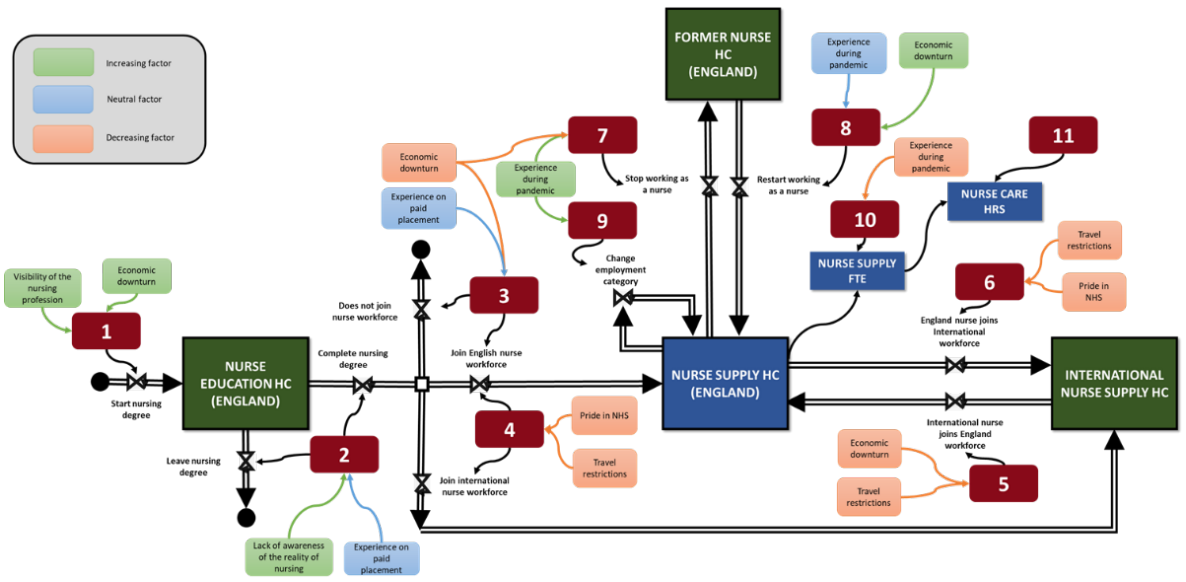
In light of this DAS used the NSM Conceptual Framework to support the exploration of the impact and implications of the first wave of the COVID-19 pandemic on the future supply of nurses in England.

Research activities, including stakeholder interviews and a literature review, identified the changes introduced in response to COVID-19 and gathered insights on the potential long-term impacts resulting from the changes, including what part of the nurse supply system would be impacted and how the impact would differ for different cohorts. This information was validated at a stakeholder workshop, attended by representatives from across the nurse supply system, focusing on elicitation exercises to gain insight on how each of the adjustment variables in the conceptual model would be impacted.

The key changes and associated insights gained were mapped to the conceptual framework, in particular the adjustment variables, to understand where and how they

would impact the stocks and flows in the nurse supply system. This is shown in Figure 3-9.

Figure 3-9: Impact of the COVID-19 pandemic on nurse supply adjustment variables



Source: DAS Ltd (DAS, 2021c)

The research concluded that the impact COVID-19 will have on nurse supply is very uncertain and there are several external factors that should also be considered (eg Brexit and the government's 50,000 nurse pledge). However, it did show that the pandemic will have a very different impact on individuals and their career decisions depending on factors such as their experience during the pandemic, personal circumstances, age and ethnicity. Further, the research demonstrated differences between parts of the system. For example, while the pandemic shone a positive light on the NHS, it exposed existing issues in the social care sector. So it cannot be expected that the impact on future nurse supply will be consistent across the system.

The conceptual framework enabled the impact of the changes to be considered methodologically across the system, as well as exploring how the changes impact different individuals based on characteristics such as age, gender, sector etc. In addition, data sets that will indicate the nature of emerging effects were identified and linked to the conceptual framework.

3.8.1 Benefits of using the conceptual framework to undertake the assessment

Using the conceptual framework provided the following benefits:

- Ensured the whole of the nurse supply system was considered including all sectors and cohorts.
- Enabled the varying impacts across different cohorts of nurses, student nurses and former nurses to be considered.
- Enabled gaps in available data to be identified.

- Resulted in a visual map of the factors affecting supply and the potential extent of their impact that could be readily understood by stakeholders.
- Good communication tool to provide a visual narrative of the impacts.

3.9 Conceptual framework application 2: Assessing the impact of the economic factors on the adjustment variables

Research question: What are the economic factors that affect nurse supply in England? And what evidence and data exist to quantify their impact?

Full details of this research are provided in A review of economic factors affecting nurse supply (DAS, 2021a).

For the purposes of this research task, 'economic factors' are considered to be the subset of factors that can be usefully studied using economic theory, literature and available data. It is accepted that economic factors have a significant effect on the supply of nurses now and in the future. However, the evidence of their impact in terms of their scale, direction and magnitude is diffuse and sparse. The purpose of this research was to undertake a comprehensive review of the available literature to ascertain to what extent the available evidence could be used to better understand and quantify their impact.

The first phase of the research was to use the detailed conceptual framework diagram (Figure 3-8) to generate a long list of the factors understood to impact supply and where in the nurse supply system their impact would show. This was based on stakeholder experience, including DAS' own experience of workforce planning and policy developments in health care, and the relevant literature. This long list was refined to a higher level, more aggregate list of 13 key factors (Table 3-2) which were identified as:

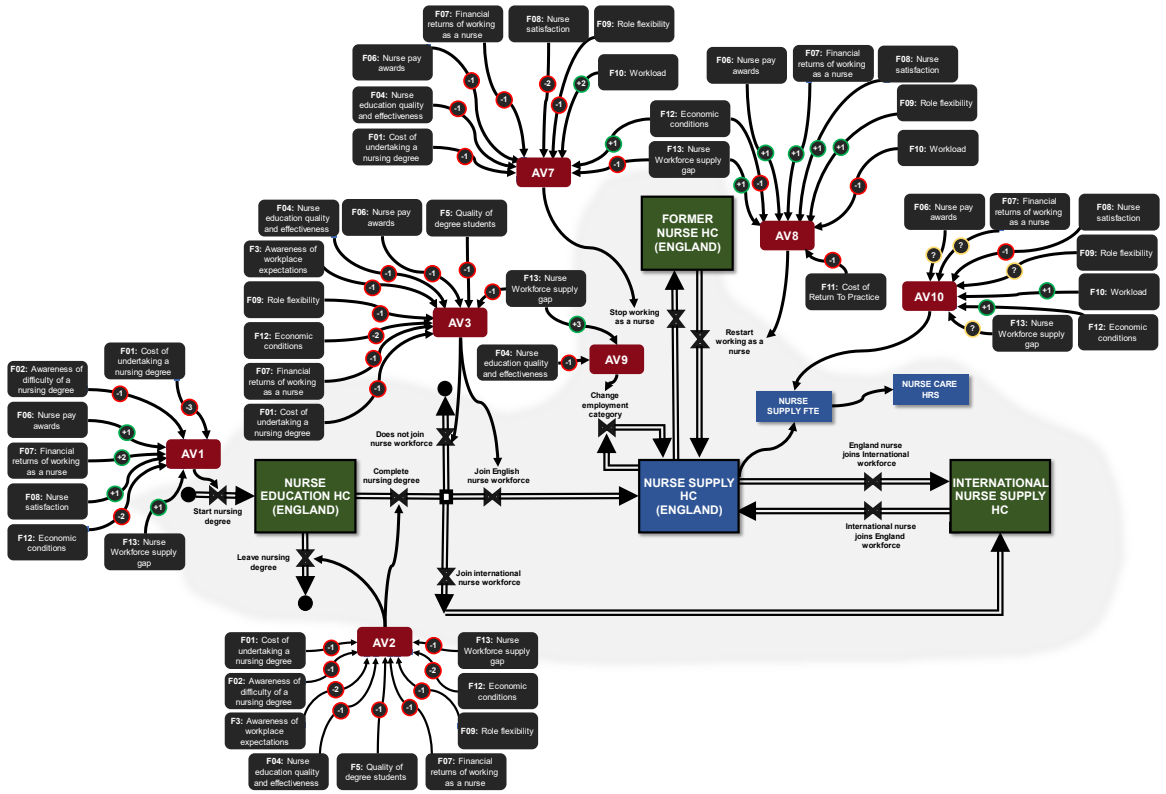
1. Cost of undertaking a nursing degree
2. Awareness of difficulty of a nursing degree
3. Awareness of workplace expectations
4. Nurse education quality and effectiveness
5. Quality of degree students
6. Nurse Pay awards
7. Financial returns of working as a nurse
8. Nurse satisfaction
9. Role flexibility
10. Workload
11. Cost of return to practice
12. Economic conditions
13. Nurse workforce supply gap

This identification and mapping of the high-level factors and adjustment variables provided an important means to relate stakeholder views to the subsequent literature review and data analysis. Following the analysis, each of the relationships was scored

in terms of the extent of the available evidence, the magnitude and direction of the impact and the potential lag between a change in the factor and the impact showing up on the adjustment variable. This information enables the priority areas for further research to be identified based on the most impactful variables.

Figure 3-10 illustrates how the conceptual framework diagram in Figure 3-6 was amended to include the economic factors and the potential magnitude of their impact on the adjustment variables. This provides a visual summary of the research.

Figure 3-10: Integrating the factors into the conceptual model



Source: DAS Ltd

3.9.1 Benefits of using the conceptual framework to undertake the assessment

Using the conceptual framework provided the following benefits:

- It provided a framework for research related to nurse supply as all the key areas are identified based on the literature and stakeholder reviews.
- The detailed diagram provided a summary of the detailed factors that affect supply which could be aggregated to give a top-level view
- The framework provided a mechanism to create a visual map of the factors affecting supply and the potential extent of their impact.

3.10 What is next for the NSM conceptual framework?

The NSM conceptual framework is a tool that takes a whole system approach and integrates a variety of perspectives on nurse supply in England. It provides a coherent view of the nurse supply system and, as demonstrated in the examples above, can be applied to provide a robust research structure, ensuring all elements of the system are captured and considered. Further, the framework provides an easy to digest visual narrative, making it a valuable tool to communicate assumptions, changes in the system or impacts of potential policies to a wide and varied audience.

It is also important to note that although designed to be flexible and scalable, the framework is a snapshot of the current views of the wider stakeholder community and the literature that has been reviewed. No system stays the same forever, however the conceptual framework is designed to be flexible enough to enable changes in terms of the important factors to be included.

Future analysis that could be undertaken building on the conceptual framework includes:

- Use the framework to compare the nurse supply system and drivers of supply with the other home nations and other countries.
- Apply the principles of the conceptual framework to create similar frameworks for other workforce groups within and outside of the health and care system.
- Identify areas of impact and qualitatively assess the impacts of potential policy changes.

4 The English nurse supply data landscape

The NSM conceptual framework provides a series of system maps that describe the English nurse supply system. It does this by describing nurse supply via a set of interconnected variables. In order to take this qualitative representation of nurse supply and produce a quantitative simulation model it is necessary to understand the data landscape, since data availability is a significant constraint in developing robust models. This Section describes the data landscape, including the identification of the key data custodians, and maps the availability of data to the conceptual framework.

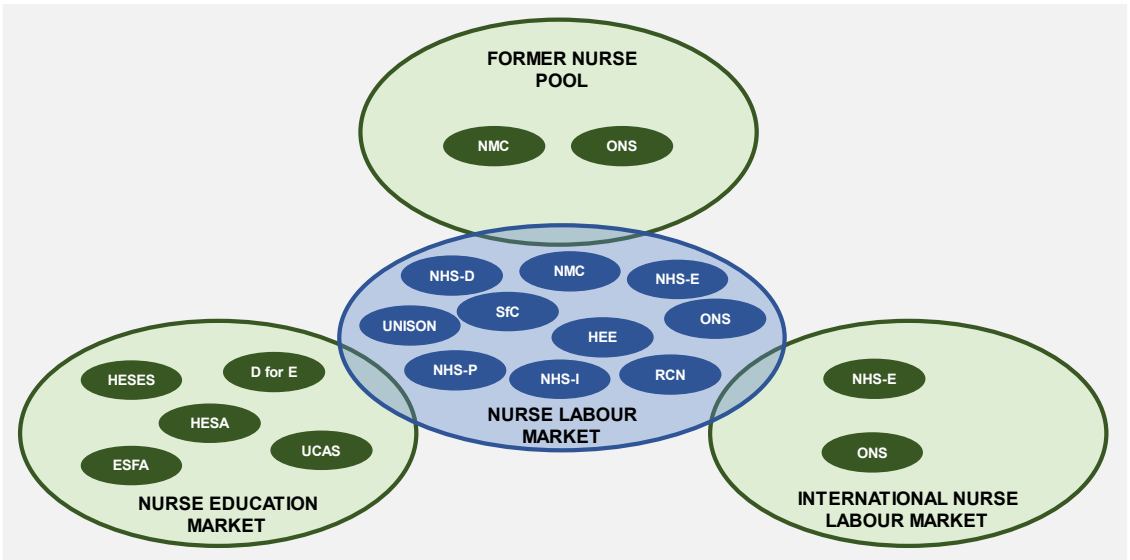
4.1 Data review process

A comprehensive review of the data landscape was undertaken during the initial stages of the NSM development process (DAS, 2019d) (not published). This review was based on:

- a review of publicly available data sources
- interviews with stakeholders from across the nurse supply system
- insights from the various workshops organised during the project (see Section 3.1). This included asking participants to consider system maps and identify potential data sets for the various variables.

The identification process was focused on those organisations that might potentially maintain data related to the system stocks, flows and factors. Figure 4-1 uses the market view of the nurse supply system to illustrate where the potential data custodians sit in terms of labour markets (see Figure 3-2) and thus which elements of a supply system they might be able to supply data for.

Figure 4-1: Nurse supply system stakeholder map based on the four nurse supply markets



Source: DAS Ltd

Figure 4-1 highlights that the data landscape is diverse and composed of many organisations that could be contacted for data for a quantitative model of nurse supply. Of the organisations identified, where applicable, DAS went on to identify the data available, which are listed in Table 4-1.

Table 4-1: Data identified

Data custodian	Description	Data identified
Universities and Colleges Admissions Service (UCAS)	UK-based organisation whose main role is to operate the application process for British universities. www.ucas.com/	Annual applications and placements to UK university courses.
Higher Education Statistics Agency (HESA)	Official agency for the collection, analysis and dissemination of quantitative information about higher education in the United Kingdom. www.hesa.ac.uk/	Annual reports of enrolled students, qualifiers and leavers by nursing field, year of study, and location.
Student Loans Company	Public body providing student loans within the UK and owned by the Department for Education. www.gov.uk/government/organisations/student-loans-company	None identified.
Department for Education	Information on the number of apprenticeship starts, achievements, and participation, and additional traineeship measures. www.gov.uk/government/organisations/department-for-education	None identified.
Education and Skills Funding Agency (ESFA)	Brings together the former responsibilities of the Education Funding Agency (EFA) and Skills Funding Agency (SFA) to create a single agency accountable for funding education and skills for children, young people and adults. www.gov.uk/government/organisations/education-and-skills-funding-agency	None identified.
Higher Education Students Early Statistics (HESES)	The data collected in HESES19 provides an early indication of the number of higher education students studying in 2019–20. www.officeforstudents.org.uk/data-and-analysis/data-collection/heses/	None identified.
Health Education England (HEE)	Executive non-departmental body sponsored by Department of Health and Social Care	Aggregated ESR data segmented by field, geography,

Data custodian	Description	Data identified
	(DHSC) for education, training and workforce development in the health sector. www.hee.nhs.uk/	age, gender and nationality for NHS staff.
Nursing and Midwifery Council (NMC)	Nursing and midwifery regulator for England, Wales, Scotland and Northern Ireland. www.nmc.org.uk/	Nurse and midwifery register – 6-monthly updated register of all nurses, associates and midwives with segmentation over UK/EEA/NON-EEA, age and field. All practising nurses appear on the register. Suspension data – list of nurses, midwives, and nursing associates who have had suspension orders placed on them from 2013–20 including name, pin, field, date imposed, date last reviewed and review outcome.
NHS Digital	Trading name of the Health and Social Care Information Centre, which is the national provider of information, data and IT systems for commissioners, analysts and clinicians in health and social care in England, particularly those involved with the NHS. https://digital.nhs.uk/	ESR – National Workforce Data set – transactional data set of NHS staff with many segmentation options including leavers and joiners. Data on general practice and independent workforces.
Skills for Care	Strategic body for workforce development in adult social care in England. Skills for Care is an independent registered charity. www.skillsforcare.org.uk/Home.aspx	Comprehensive data set covering workforce in the adult social care sector, including workforce demographics, turnover rates and more.
NHS Improvement (NHS-I)	https://improvement.nhs.uk/	Data on bank and agency workforce. Experimental publication of NHS vacancy statistics created from administrative data related to published vacancy adverts obtained from NHS Jobs.
NHE Employers (NHS-E)	Organisation which acts on behalf of NHS trusts in the NHS in England and Wales. It was formed in 2004, is part of the NHS Confederation, and negotiates contracts with healthcare staff on behalf of the government. www.nhsemployers.org/	None identified.

Data custodian	Description	Data identified
Unison	Largest trade union in the United Kingdom with almost 1.4 million members. www.unison.org.uk/	None identified.
Royal College of Nursing	Membership organisation of over 435,000 registered nurses, midwives, health care assistants and nursing students. www.rcn.org.uk/	The RCN carry out annual surveys of approximately 1% of the nursing workforce relating to workload, pay and career satisfaction with detailed segmentation.
Office for National Statistics (ONS)	UK's largest independent producer of official statistics and the recognised national statistical institute of the UK. www.ons.gov.uk/	Official measures of employment and unemployment from ONS for each nursing sector (NHS, charity, private, other), full/part time, EU/non-EU, age and gender.

Following identification of potential data sets, DAS engaged with data custodians and further explored data sets in the public domain to determine which were available and most suitable for the quantitative NSM model. This process was significantly impacted by COVID-19, with data custodians needing to use their available resources to support the pandemic. Nevertheless, all data custodians supported DAS requests for data to the best of their ability.

Data from the following sources was obtained for use in the NSM:

- **Universities and Colleges Admissions Service (UCAS):** Data on applications, applicants and acceptances to undergraduate and postgraduate pre-registration nursing courses provided by UCAS.
- **Jisc*:** Higher Education Statistics Agency data on enrolled students, graduates and leavers of nursing courses provided by Jisc.
- **NHS Digital:** Data on the NHS hospital and community health service (HCHS), primary care and private sector workforces, including staff in post and turnover. Some of the NHS Digital data sets were specifically commissioned and provided directly by NHS Digital and other data were obtained from their website†.
- **Skills for Care:** Data on the adult social care workforce, including staff in post and turnover.

* Jisc provides digital solutions for UK education and research including delivering HESA data analytics services.

† https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics

- **Nursing and Midwifery Council (NMC):** Data on the nurse register, including registrants and joiners and leavers to the register provided by the NMC.
- **Office for National Statistics (ONS):** Population data obtained from the ONS website*.
- **Royal College of Nursing (RCN):** Survey data provided by the RCN.

The received data was then preprocessed, visualised and analysed using R.† This resulted in a dialogue between DAS and the data custodians in order to refine data requests. The purpose of this analysis was to initially determine the utility of the data for the quantitative model, and then process the data such that it could be used in the quantitative model. The type of preprocessing that was required included:

- cleaning the data to remove irrelevant values and duplication, correct typos and handle missing data
- filtering the data to only data relevant to the NSM
- mapping the segmentation of the data onto the segmentation in the NSM (NSM definition)
- Introducing assumptions for estimating values for any suppressed data (some source data was suppressed due to data protection policies).

The data files and data processing assumptions were fully documented (DAS, 2021b) (not published).

4.2 Mapping the data sets used by the quantitative model onto the conceptual framework

The previous Section has described how the data were selected and made available for use in the quantitative model. Figure 4-2 illustrates how the data relate to the conceptual model.

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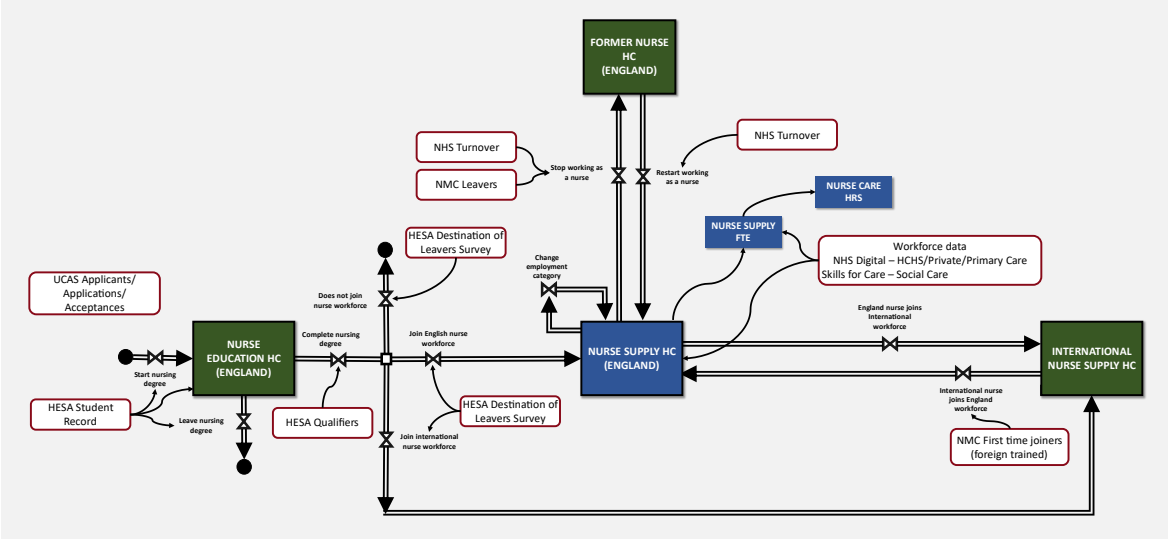
* www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates

† R is a programming language and free software environment for statistical computing and graphics. www.r-project.org/about.html

Figure 4-2: Mapping the selected data sets onto the conceptual framework



Source: DAS Ltd

Figure 4-2 shows only data that were identified, obtained and used in the NSM. Mapping data availability to the conceptual framework ensured that data were sought for all stocks, flows and factors and illustrated gaps that existed in the availability of data. As shown in Figure 4-2, areas where data could not be identified included England nurses joining the international workforce, the headcount of former nurses and the movement of nurses between sectors. Data sets identified capturing data on nurses stopping working as a nurse and former nurses restarting work as a nurse were only partial. Data were identified for NHS leavers and those who undertake RTP courses, therefore assumptions were made to scale the available data to the full system. Finally, although NHS England and Improvement was identified to have data on bank and agency nurses and NHS Digital had more detail on internal moves within the NHS, DAS was not able to obtain either data set for use in the model due to commercial and data sensitivites.

Through our data review, we identified gaps in meaningful and comparable measures of nurse attrition in training and identified no systematic tracking of newly qualified nurses into the workforce. In some cases, such as reasons for leaving the NHS, although there was scope to collect the data, the collection or completion of the data was free text and at individual trusts' discretion, which resulted in large gaps in the data or unmeaningful responses.

Where data were available and accessible, varying levels of segmentation or granularity were available. This was due to several reasons including limitations of source data, resource burden in generating or collecting data, and data protection policies introducing suppression. The data associated with the core stocks and flows in the NSM quantiative model are segmented at least by age, gender, nationality and region, with further segmentation being driven by the availablity of robust data.

4.3 Data availability

- High-level data on the NMC register and NHS and adult social care nurse workforces are available in the public domain but held at a more granular level within the relevant data provider organisations.
- Not all identified data were accessible outside of the data owner organisation.
- Due to data sharing policies, data from some organisations, including UCAS and NHS Digital, were only available in a suppressed format.
- Robust data on nurse attrition from training were not identified.
- No organisation or data set was identified to be capturing data on the number of former nurses who are either still registered but not working as a nurse or have let their NMC registration lapse.
- No data was identified on the 'other'* workforce and limited data on the private workforce were identified.
- NHS I was identified to have data on bank and agency nurses, including spend data, but DAS was not able to access these data.
- Data sets from different organisations are not linked, making it impossible to track nurses' movements between sectors. Data on movement within sectors are also limited.
- The level of data segmentation varied across organisations and was driven by the source data collected and data protection policies.

The quantitative model has been designed to take into account the available data.

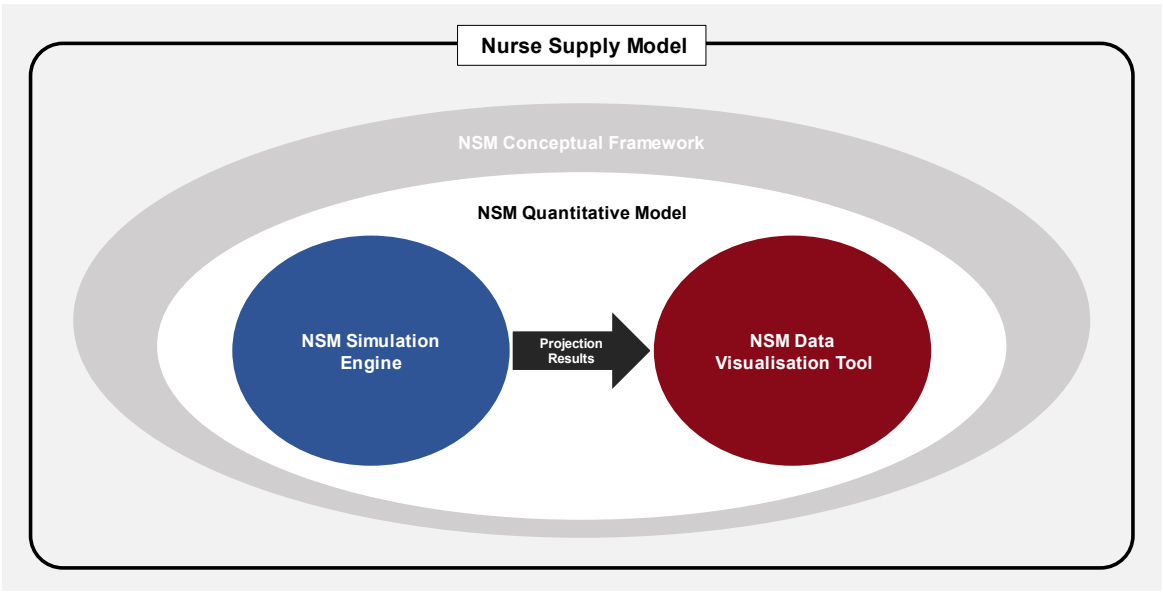
* For example, nurses working for charities.

5 Nurse supply model: quantitative model

The quantitative model is based on those elements of the conceptual framework that can be quantified. It enables nurse supply projections to be parameterised, simulated and compared under alternative scenarios. Understanding the data landscape was critical in understanding the boundaries of the quantification. The quantitative model itself is composed of two key elements, the system dynamics-based simulation engine and the R-Shiny-based data visualisation tool. This Section provides an overview of these components.

The diagram below illustrates the position of the NSM quantitative model within the NSM as a whole.

Figure 5-1: Highlighting the position of the quantitative model within the NSM



Source: DAS Ltd

5.1 Overview of the NSM quantitative model

The purpose of the NSM quantitative model is to enable projections of future nurse supply to be parameterised, simulated and compared. This is to:

- Help policymakers and planners make informed decisions and understand the range of uncertainty around policy outcomes.
- Enable testing of complex and multiple (phased and/or concurrent) policy options over time and in different economic environments, for example changes in immigration policy or changes in nursing student attrition.
- 'Paint a picture' of the nursing workforce now and into the future.

The model was required to consider two key measures:

- **Headcount (HC)** – the number of nurses in terms of the number of people irrespective of their hours worked.
- **Full-time equivalents (FTE)** – a measure of the nurse workforce size, taking into account the number of hours worked per person.

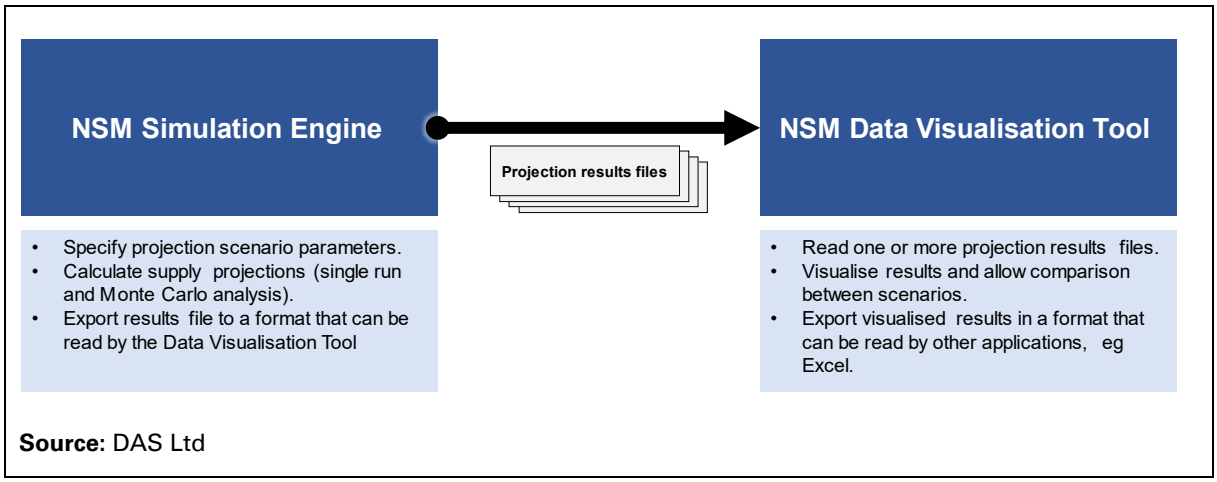
It is important to note that the quantitative model is intended to occupy a 'projection' space rather than a 'forecasting' space. Projections provide an indication of the values for a measure over time based on a series of assumptions for a particular scenario, with a policy analysis considering numerous possible scenarios. Although the model projects future supply in terms of headcount and full-time equivalents, the differences between the projections of alternative scenarios are of more importance for policy analysis than the absolute values in a given scenario. It is also important to note that as with any projection model, uncertainty increases with longer time horizons.

As shown in Figure 5-1, the quantitative model is composed of two key components:

- **The NSM simulation engine (NSM SE)** produces projections of nurse supply for England with a time horizon of up to 20 years. The simulation engine has been developed using MS Excel and Vensim, a system dynamics modelling software tool.
- **The NSM data visualisation tool (NSM DVT)** is an R/Shiny app which enables the nurse supply projections produced by the NSM simulation engine to be visualised, shared, compared and analysed.

The key functionality of the NSM quantitative model components is illustrated below.

Figure 5-2: Quantitative model architecture



Source: DAS Ltd

The NSM simulation engine and the NSM data visualisation tool are described in greater detail in the following Sections. During the development process a model specification document was created (DAS, 2019c) (not published) which listed all the requirements of the quantitative model, all of which are met in the final model.

5.2 NSM simulation engine

Projections of nurse supply are calculated using the simulation engine which is composed of a Vensim system dynamics (SD) model and an MS Excel simulation control spreadsheet. The simulation control spreadsheet enables scenarios to be defined and executed. The projections themselves are calculated by the Vensim model.

The SD model is the underlying model that is used to generate the nurse supply projections. SD is a modelling approach that helps an analyst comprehend complex systems through mapping and simulation of those systems. SD is a 'flow' based methodology that uses concepts from control engineering. The approach involves the identification of key components of the system and the relationships between them. The process results in a diagrammatic description of the system which, when coded, can be simulated for quantitative analysis. Further detail on SD can be found in Section 5.2.1.

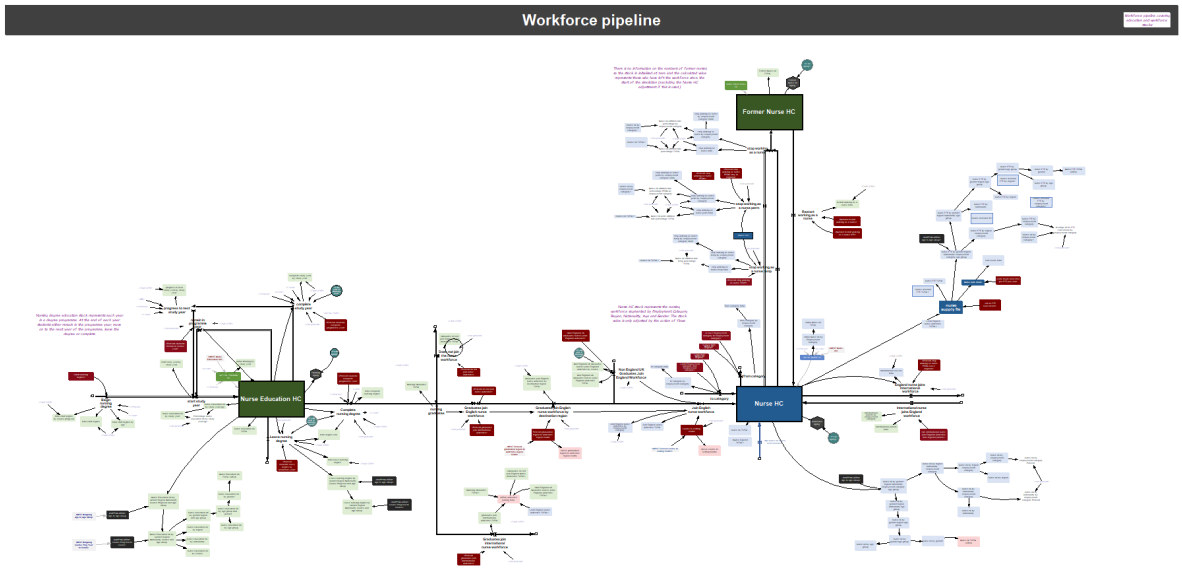
The SD tool that has been selected for developing the NSM SE is Vensim DSS. Vensim DSS is produced by Ventana Systems Inc (www.vensim.com). Other SD packages exist that are based on similar principles, with slight differences in presentation and model development tools. However, in this instance Vensim was selected as it has the required level of functionality to produce the NSM SE. A complete description of how to use Vensim is given in the online Vensim documentation (www.vensim.com/documentation/index.html).

The parameters used by the model to generate the forecast are read in from the MS Excel user interface and from a historic data file. Over the course of a simulation each of the variables in the SD model is calculated over time. The results of these calculations are saved to results files. If the model is simulated from the model control spreadsheet then selected variable results are also exported to a specially formatted text file that can be read by the NSM DVT.

5.2.1 Overview of system dynamics models

System dynamics enables complex systems to be better understood and their behaviour over time to be projected using computer simulation. SD models are constructed around the production of model diagrams. These can be referred to by several names, for example, stock and flow diagrams (SFD), influence diagrams (ID) or causal loop diagrams (CLD). These model diagrams are graphical representations of the cause-and-effect relationships captured in the model. Arrows are used to denote the cause-and-effect relationships between different variables and these relationships are quantified using an equation editor in Vensim. An example is provided in Figure 5-3, which illustrates the nursing workforce as a 'pipeline' system encompassing nurse education and training, the existing nurse supply including domestic and international recruitment channels, and the former nurse pool.

Figure 5-3: Example diagram from the NSM SD model – workforce pipeline



Source: DAS Ltd

Each variable in a Vensim model will have an associated equation. When a simulation is executed the value of each variable is calculated over time, and the results viewed using the Vensim analytical toolset.

5.2.2 Overview of the NSM system dynamics model

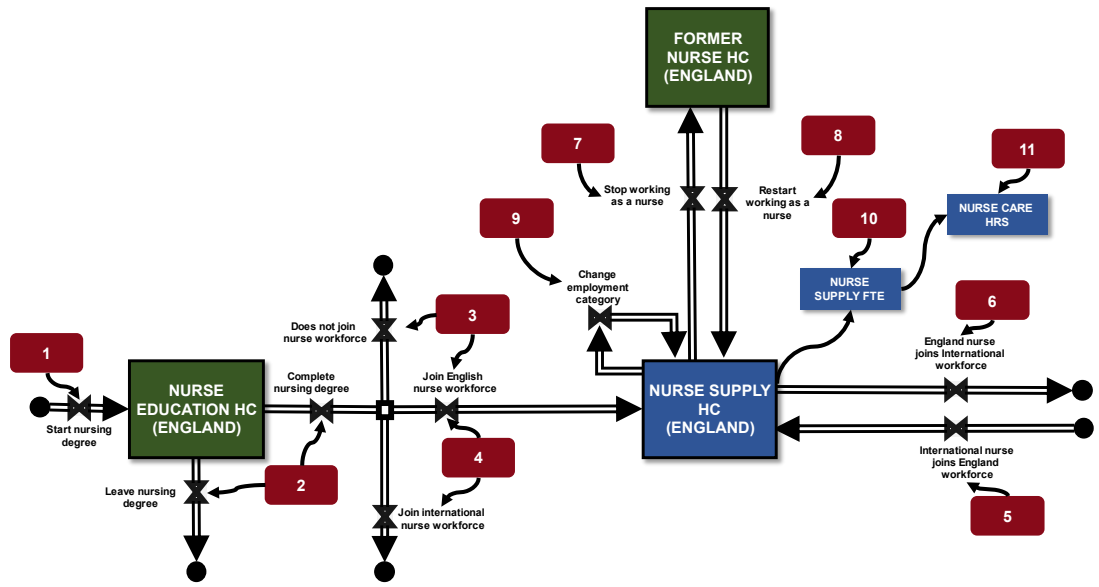
The NSM system dynamics model considers the main flows into and out of the nurse labour market, namely through degree education, international inflows and outflows and nurses leaving and rejoining the workforce, as illustrated in Figure 3-4. It also includes some of the structures illustrated in the detailed conceptual framework (see Figure 3-8).

The model is heavily segmented (see Section 5.2.4), with all the core stocks and flows representing age, gender, nationality and region. The level of detail represented by the model is restricted by the availability of robust data, as discussed in Section 4. The model contains a series of 'scenario input' variables which are used to configure alternative scenarios based on the adjustment variables illustrated in Figure 3-6. For example, a potential policy could be increasing the nursing student intake by 50% against current values for 3 years, followed by a 25% increase in the student intake thereafter combined with reducing student attrition by 1% a year for the next 5 years. It is in this way that the impact of alternative regulatory policies and instruments (see Section 3.6) can be assessed.

The SD model also includes numerous 'checks and balances' to maintain model robustness, eg system-wide mass balances and warnings if values exceed expected limits. Unless otherwise stated, all stocks and flows are initialised based on historic data.

The key structures in the SD model are illustrated in Figure 5-4 and described below.*

Figure 5-4: Key SD model stocks and flows



Source: DAS Ltd

5.2.3 NSM SE model structures

Nurse degree education

The model contains a stock that calculates the number of students undertaking different degree programmes. Each year of each of the degree programmes is represented, with students moving up through the programme years. The model represents the students that successfully complete degree programme years and remain in the same year of their programme and those that leave their programme.

The student intake is based on historic intake and course acceptance levels and adjusts in proportion to changes in population.

Nurse workforce

The model contains a stock that represents the number of nurses currently employed as a nurse across different employment categories. This stock is increased by students

* The SD model is supported by a detailed technical document which describes each of the underlying model structures and the model assumptions in detail (DAS, 2021d). In addition, the definition of each variable in the Vensim model contains a description, units, and key assumptions. Further, the diagrams include a brief description of the structures and key assumptions.

graduating and joining the workforce, former nurses rejoining the workforce and nurses joining the workforce from outside England. The workforce stock is reduced by nurses leaving the workforce and leaving to work outside England. There are transition flows into and out of the workforce stock that consider nurses moving between employment categories and regions.

The workforce stock calculates the number of nurses in terms of headcount. This is converted to FTEs and number of care hours delivered. The model control spreadsheet enables demand projections to be included as part of the model inputs, allowing supply-and-demand analysis to be undertaken.

The model calculates the number of nurses that have left the workforce since the start of the simulation run. This is not initialised with a value at the start of the simulation as there is no reliable data on the number of former nurses. Similarly, there is no stock of the number of nurses in the international market.

Nurse register

The model contains a stock that represents the nurse register, calculating the number of nurses by each of the four main fields and those who are dual registered. The flows into and out of this stock mirror the flows into and out of the nurse workforce stock.

Adjustment variables

The red boxes in Figure 5-4 illustrate the adjustment variables which can be specified in the model as separately alterable time series in order to specify alternative scenarios or policy changes. These are specified in the simulation control spreadsheet. In general terms, the adjustment variables can be altered as follows:

- replaced with new values
- increased/decreased by a defined value
- multiplied by a chosen factor (eg 0.95 multiplied by the values that a variable would otherwise have taken).

In addition, non-linear relationships can be defined that affect the adjustment variables by the factors described in Section 3.9.

Finally, the model can be configured for the changes to the adjustment variables to be made stochastically using a uniform or triangular distribution. This enables Monte Carlo simulations to be configured and the outputs presented in terms of ranges of uncertainty.

Cost structures

The model contains various structures that calculate costs, as described in Annex B. It should be noted that although costs can be calculated, as identified in Section 4,

relevant data are sparse. It should also be noted that the NSM quantitative model is not a detailed cost model nor was this an aim of the project, rather the costing structures are intended to enhance high-level understanding and are not for in-depth policy analysis.

5.2.4 NSM SE model segmentation

The NSM simulation engine is heavily segmented through the use of subscripts. Subscripts are used in Vensim to allow data and variables to be segmented or grouped under different subheadings, so that a single variable can be used to represent multiple dimensions (effectively creating a variable array). Variables in Vensim can have multiple dimensions (ie they can be arrayed by more than one subscript). This is useful as it enables the same model structure and logic to be used, while keeping track of separate groups. For example, in the NSM SE model, the stock representing the number of people undertaking a nursing degree is segmented by multiple courses.

The subscripts and subranges used in the system dynamics model are described in Table 5-1:

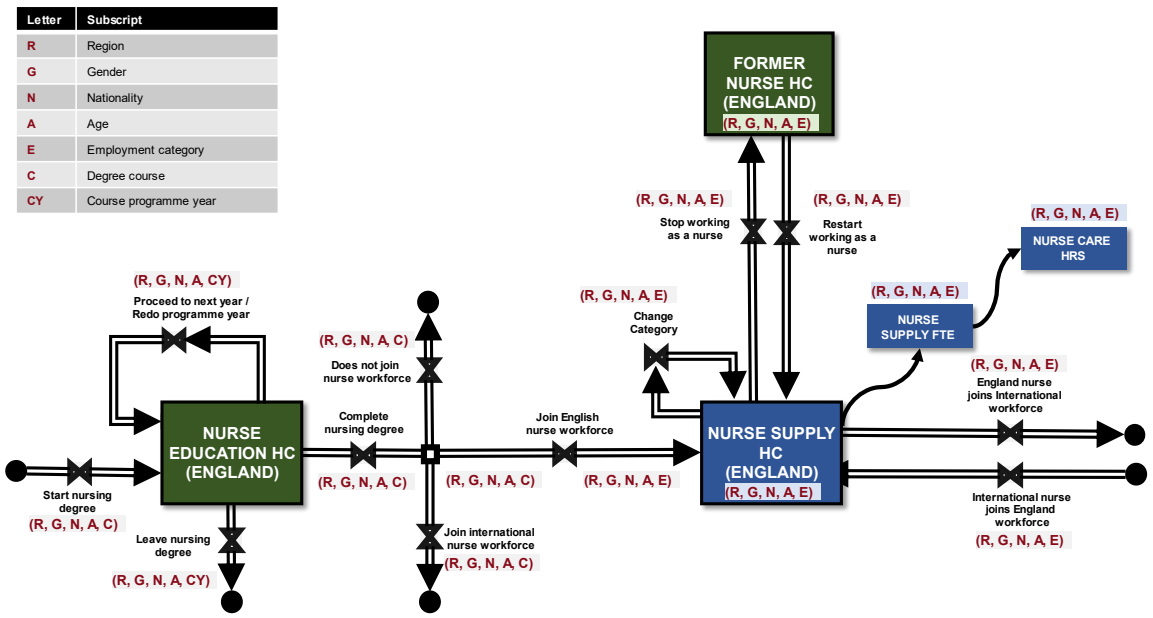
Table 5-1: Subscripts

Name	Description
Adj Var	List of adjustment variables, used in the calculation of the impact of the factors on the adjustment variables in the model.
Age	Single year age bands.
Age group	Age bands. Used for importing and export results at a more granular level in terms of age.
Course	Nurse degree courses
Course ProgYear	Programme years within a nursing degree course.
Employment Category	Mutually exclusive employment categories.
Factors	List of factors used in the calculation of the impact of factors on separate adjustment variables.
Field	Field (or branch) of nursing.
Gender	Gender of the nurse.
Nationality	Nationality of the nurse defined by the location of training.
Region	England regions.

The elements within each of the arrays are defined in the model control spreadsheet. This means that the simulation engine is extremally flexible, for example new courses and employment categories can be added.

To illustrate this high level of model segmentation, Figure 5-5 shows the level of segmentation for the main education and workforce pipeline.

Figure 5-5: Segmentation of the main workforce pipeline

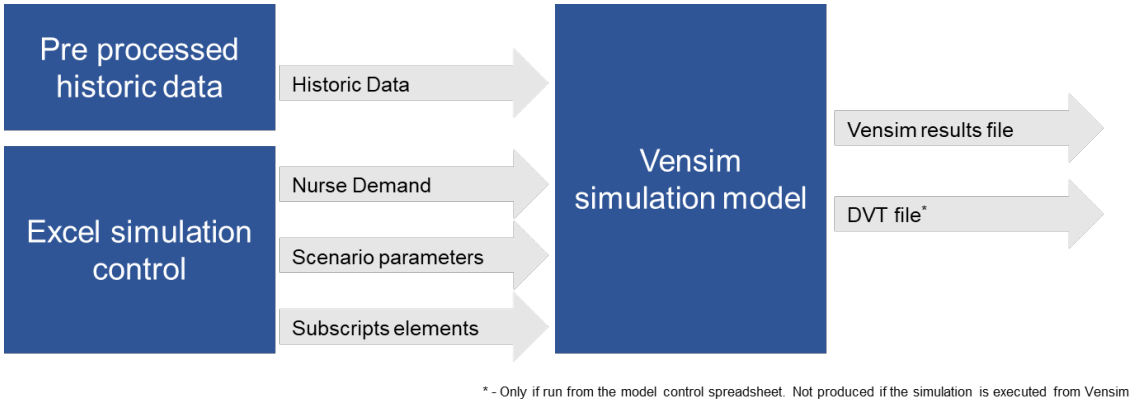


Source: DAS Ltd

5.2.5 Data inputs and outputs

The NSM simulation engine uses several different data sets to initialise the model and produces a range of data sets on completing a simulation.

Figure 5-6: NSM simulation engine data flows



Source: DAS Ltd

Input – Historic data

A core input for the Vensim simulation engine comes from preprocessed historic data files, which initialise the core model stocks and flows. Raw data, provided by data custodians such as NHS Digital and the NMC, are cleaned and processed into a consistent format using R scripts developed by DAS. The processed data are combined into a single Excel/CSV file that can be imported directly into Vensim. The historic data processed is detailed in Section 4.2, and the full set of assumptions applied during processing is described in a separate technical document (DAS, 2021b) (not published).

Input – Nurse Demand

The Health Foundation has undertaken analysis that projects the future demand for nurses (FTE) by region and employment category over time. These can be imported into the NSM simulation control spreadsheet and specific demand projections selected for a scenario.

Input – Scenario parameters

Scenario data files are created by the simulation control spreadsheet based on predefined scenarios. The scenario data files contain time series that alter the baseline values for the adjustment variables, along with scenario set-up parameters such as the projection duration.

Output – Vensim results file

Every time a projection is simulated, a Vensim results file is created which contains the values for each variable over time. Vensim results files can be explored in Vensim using Vensim's extensive range of analytical tools.

Output – DVT results files

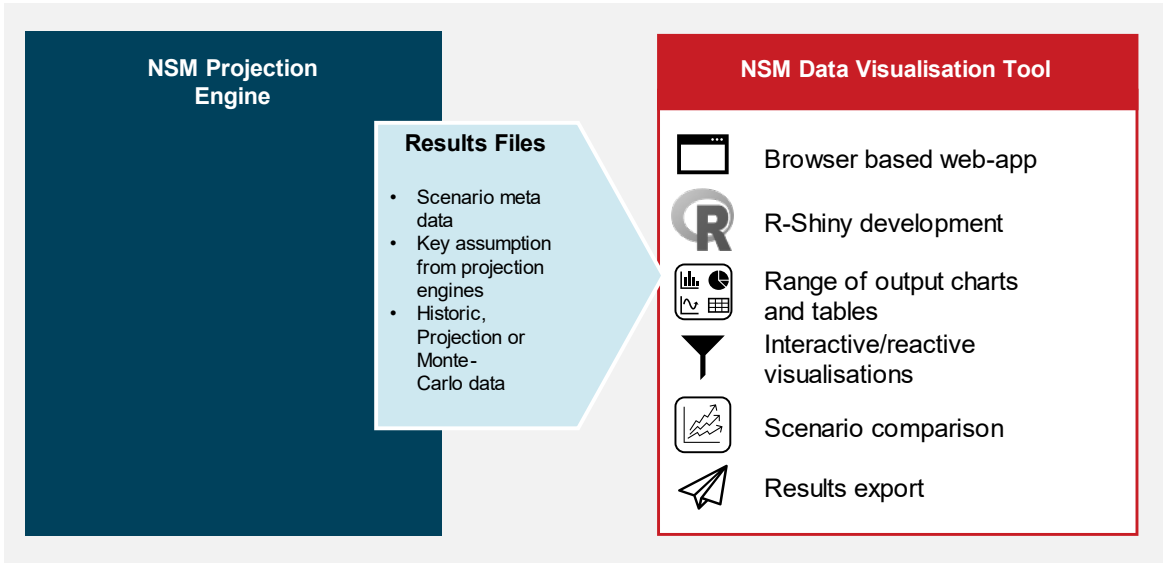
Every time a projection is executed from the simulation control spreadsheet, a text file is created which can be read by the NSM data visualisation tool. The DVT results files contain a reduced set of variables compared to the full model results file.

5.3 NSM data visualisation tool

The NSM DVT enables the visualisation, analysis and comparison of supply projections produced using the NSM simulation engine. The DVT enables libraries of projection scenarios to be analysed, comparatively or using deep dive drill throughs. This is realised through a variety of different data visualisations, such as time series plots, bar charts and tables. The DVT enables results to be exported for use by other applications/models. The DVT has been developed using R-Shiny, an open-source statistical programming language.

Figure 5-7 demonstrates the architecture of the DVT.

Figure 5-7: NSM DVT architecture



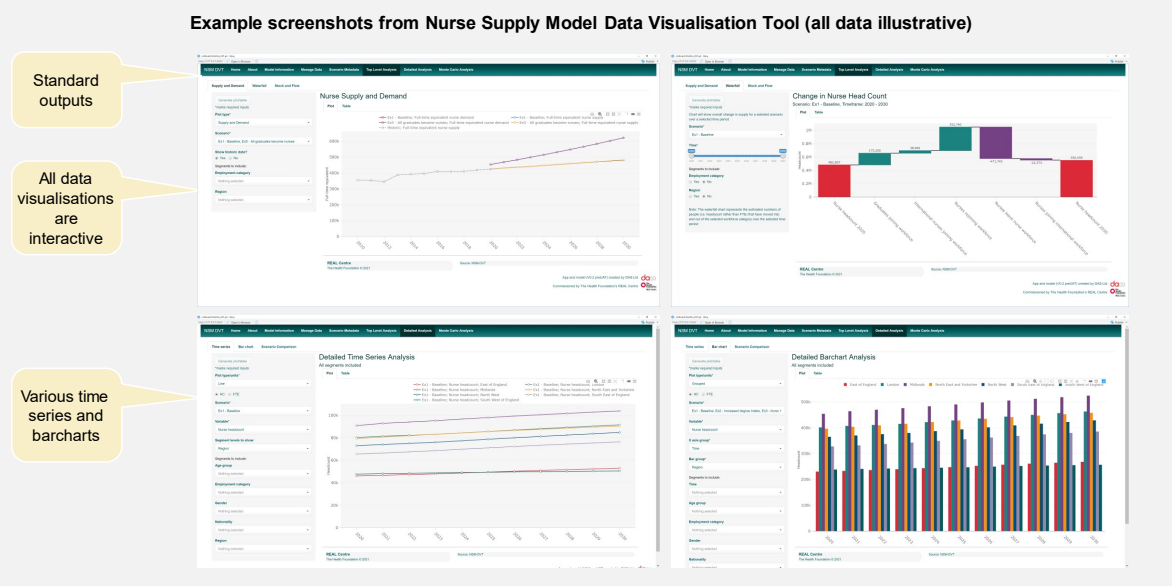
Source: DAS Ltd

The DVT allows the user to explore projections of nurse supply under alternative scenarios through different visualisations:

- supply and demand charts which can also include historic data
- waterfall charts showing the overall change in supply over a specific time period by key supply channels
- stock and flow charts providing a graphical representation of key elements of nurse supply.

It also provides customisable time series and bar charts for further analysis.

Figure 5-8: NSM DVT screenshots



Source: DAS Ltd

All outputs are available in graphical and tabular form and can be exported in various forms, for example table data can be exported as CSV, Excel or PDF.

To illustrate the uncertainty that is inherent in projections, Monte-Carlo results files can be created and loaded into the DVT. Outputs available in the DVT include fan charts showing uncertainty in projections over time and cumulative distribution charts showing uncertainty at a point in time.

6 Using the nurse supply model to support analysis

The nurse supply model is a quantitative simulation model set within a conceptual framework that represents the nurse supply system. This Section describes how the NSM can be used to support policy and analysis, and how the Health Foundation will work with system stakeholders to support the policy analysis process.

6.1 Policy analysis process

For the purpose of this document, policy analysis is defined as follows (CDC, 2021):

> Policy analysis is the process of identifying potential policy options that could address your problem and then comparing those options to choose the most effective, efficient, and feasible one. Conducting a policy analysis ensures you have gone through a systematic process to choose the policy option that may be best for your situation.

It is common to consider the following aspects when evaluating policies (Prime Minister's Strategy Unit, 2004).

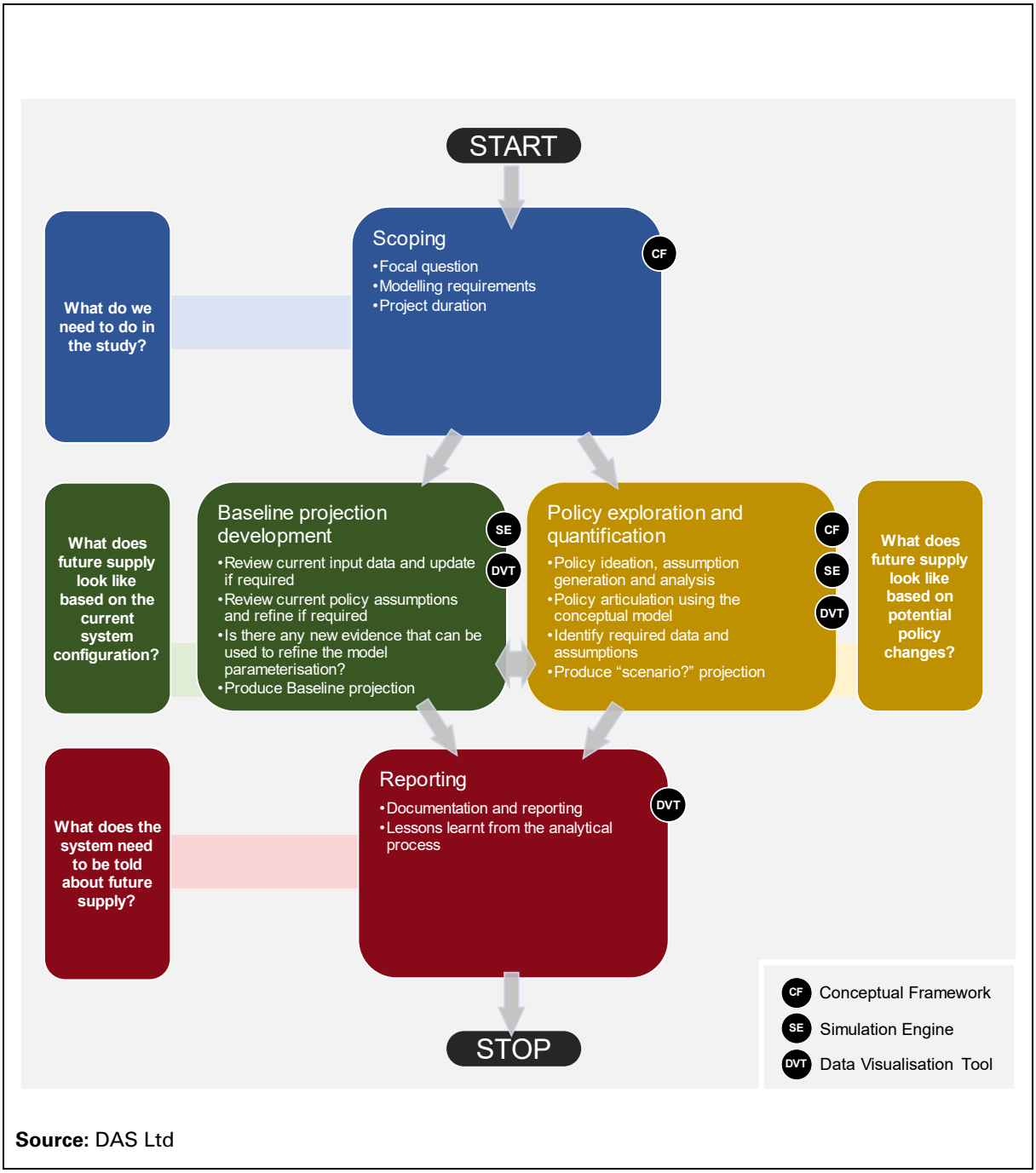
1. **Suitability:** Will the option address the key issues and will it be able to deliver desired outcomes?
   - **Rationale:** Is there a clear case for government action?
   - **Proportionality:** Is the (cost of the) policy option proportionate to the (cost of the) problem?
   - **Effectiveness:** How well will the option address the issue or problem? Impact – are there any unintended consequences? Are costs and benefits equitably distributed?

2. **Feasibility:** Is the option a realistic and practical possibility?
   - **Capability:** Will it be possible to implement and manage the option?
   - **Accountability:** Can clear accountabilities be established and aligned with incentives?
   - **Affordability:** Is there the money, and is it value for money against alternatives?
   - **Risk:** Can risks be identified and either mitigated or allocated and managed?
   - **Control:** Are there clear success measures and mechanisms for prompt feedback and learning?

3. **Acceptability:** Is the option supported by those with the authority and influence to legitimise action?
   - **Participation:** Has there been sufficient public participation and consultation in policy design?
   - **Buy-in:** Is there sufficient support from both internal and external stakeholders?

The NSM provides a set of tools that support the appraisal of alternative policies: principally the conceptual framework can be used to explore policy and understand where in the system it may impact; the simulation engine to create quantitative supply projections; and the data visualisation tool to share projection assumptions and results. Figure 6-1 illustrates where in a typical policy analysis process the NSM components could be used, noting that the quantitative model was not intended for the scenarios to be developed and simulated with the decision maker, so there is not a necessity for rapid projection execution as part of the policy analysis approach.

Figure 6-1: Analysis approach

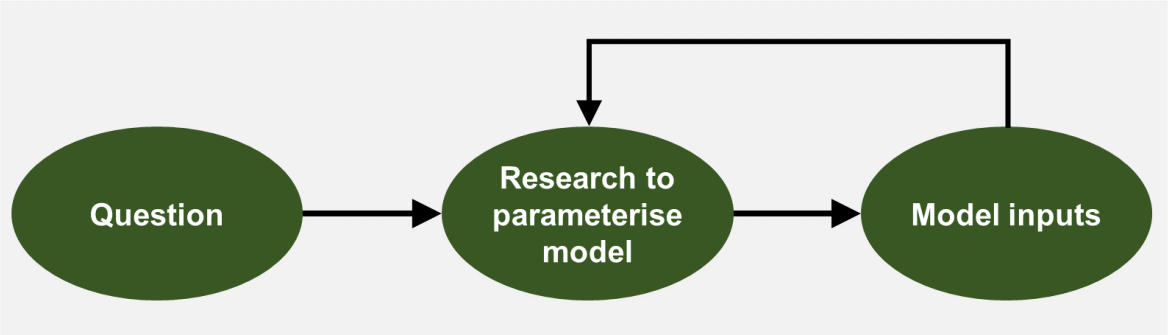


Source: DAS Ltd

6.1.1 Model parameterisation

In summary terms, the nurse supply model enables nurse supply projections to be generated based on changing the variables that affect various key flows and variables in the nurse supply system. When a complex or novel nurse supply question arises, research will need to be carried out to determine what values should be used for the model inputs. Previous research (DAS, 2021a) has identified that the evidence base is sparse, and so either expert judgement will be required to facilitate the parameterisation of the model or alternatively research could be commissioned to parameterise the identified relationships, as per Figure 6-2. The model has been designed in such a way as to facilitate new research evidence and new initiatives to be factored into key model parameters (see Section 5.2.2).

Figure 6-2: Research approach



Source: DAS Ltd

6.2 How the Health Foundation will support the analysis of nurse supply policies

The development of the nurse supply model was concluded in September 2021, when the REAL Centre assumed ownership of the model. As the ultimate model owner, the Centre and the Health Foundation will be responsible for any further updates to the model (for example, incorporating updated data when these become available).

The REAL Centre is keen to engage with stakeholders in policy and academia to facilitate further use of the model. The Centre will undertake extensive quality assurance of all outputs generated by the model. The projections that the model enables will provide useful insights for decision makers and workforce planners with responsibility for and interest in NHS nursing, which continues to be the key workforce shortage area in the NHS hospital and community services sector. In the context of the Health Foundation's repeated calls for a comprehensive longer term workforce strategy that accounts for both health and social care, the model is also likely to prove useful to decision makers in areas other than NHS planning, including social care and general practice.

The different components of the model can be used to support analysis and consideration of the impacts of alternative future policy scenarios. The conceptual

framework provides a lens for qualitative analysis and scenario development. The simulation engine and the data visualisation tool can apply insights from such qualitative thinking to the available data, to clearly specified assumptions, in order to generate well-founded projections of future nurse supply.

To promote awareness of the model and its potential usefulness among the stakeholder community, the REAL Centre and DAS held a stakeholder workshop in September 2021. The REAL Centre plan to engage further with interested parties in the coming months to discuss how the model might best be used to support workforce policy and planning. The Centre will use the model to generate nursing workforce projections in upcoming work, including a workforce projections report in 2022 that will analyse supply issues in the nursing and general practice workforces in England. As such, the completion of this project is not an 'ending', but rather the beginning of a new phase in which the nurse supply model yields rich qualitative and quantitative insights in a long-standing research area.

Appendix A: Glossary, abbreviations and notation

Glossary

The table below lists some of the key terms used in this document.

Term	Definitions
Data visualisation tool	An R/Shiny app which enables the nurse supply projections produced by the NSM simulation engine to be visualised, shared, compared and analysed.
England nurse labour market	The nurse labour market in the England is limited to the hire of registered nurses for work that can only be done by registered nurses. Registered nurses working in occupations other than nursing, or not working at all, are not part of the nurse labour market.
Flow	A rate of change variable affecting a stock, such as trainees flowing into a workforce or attrition of trainees flowing out.
Former nurse pool	Nurses in England who are no longer working in nurse jobs but are able to return to the nurse labour market either because they are still registered or, if their registration has lapsed, are able to reregister via an RTP course.
General labour market	A range of alternative employment opportunities for potential student nurses, qualified nurses, and former nurses, including those with lapsed registrations.
International nurse labour market	Potential pool of qualified nurse labour supply into England and as a destination for UK qualified nurses to work abroad, subject to immigration rules into the UK and, importing countries' (such as New Zealand and Saudi Arabia) immigration rules. There are also flows of qualified nurses working between the four nations of the UK that are not subject to any immigration rules.
Stock	An accumulation or state variable, such as the size of the workforce.
Nurse education market	The market for nurse education in England. The nurse education market supplies nurse education to student nurses, return to practice (RTP) courses to former nurses with lapsed registration and postgraduate qualification or dual registration to qualified nurses.
Nurse supply system	Series of interrelated markets with their own demand and supply schedules affected by a 'price' and other factors such as entry requirements to nurse education, nurse workload and immigration rules into UK and for other countries who recognise UK qualified nurses.
Nurse workforce planning system	The nurse workforce planning system is the formal and informal organisations that are responsible or have an interest in future of nurse supply.
Simulation engine	System dynamics model that produces projections of nurse supply for England with a time horizon of up to 20 years.
Full-time equivalents (FTE)	A measure of the workforce size, taking into account the number of hours worked per person.
Headcount (HC)	A measure of the workforce size. The number of people in employment, irrespective of their hours worked.
System dynamics	A modelling approach that enables complex systems to be better understood and their behaviour over time to be projected using computer simulation.
Workforce demand	The workforce required by an organisation, whether in terms of workforce size (headcount and FTE), skills, composition,

Term	Definitions
	etc.
Workforce planning	The practice of determining the demand that will be placed on the workforce of an enterprise at some time in the future, in terms of required effort, and hence the number, skills, and proportion of people required. Following this, determining how those demands will be met through developing workforce or human resources (HR) plans.
Workforce supply	The workforce delivered by the organisation to meet the workface demand.

Abbreviations

Abbreviation	Definition
ALB	Arm's-length bodies
ASC	Adult social care
CLD	Causal loop diagram
DAS	Decision Analysis Services Ltd
DHSC	Department of Health and Social Care
DVT	Data visualisation tool
ESR	Electronic staff record
FTE	Full-time equivalent
GLM	General Labour Market
GMB	Group model building
HC	Headcount
HCHS	Hospital and community health services
HEE	Health Education England
HEI	Higher Education Institution
ID	Influence diagram
IFS	Institute for Fiscal Studies
NAO	National Audit Office
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NMC	Nursing and Midwifery Council
NSM	Nurse supply model
ONS	Office for National Statistics
pcm	Per calendar month
PRB	Pay Review Body
QIPP	Quality Innovation Productivity and Prevention
RTP	Return to practice
SD	System dynamics
SE	Simulation engine
SFD	Stock and flow diagram

Appendix B: Calculating the costs of nurse supply surplus and shortage

This Appendix highlights the lack of good data on the nurse labour market in England (especially outside the hospital and community health services (HCHS)) and estimates the costs of a shortage using the data that are available, supplemented with assumptions.

For the purposes of this document, costs are limited to financial costs borne by the NHS. Costs arising from poorer quality care and reduced treatment capacity, or psychological harms from 'burnout' in times of shortage and not being able to find a job in times of surplus, are out of scope of this analysis.

Direct costs arising to the pay bill from overtime, 'drift', bank and agency spend are combined with indirect costs arising from higher than normal levels of turnover and attrition. The cost estimates are limited to the HCHS sector – which employs around three-quarters of all nurses who are working as nurses (Institute of Employment Studies, 2017).

We estimate the pay bill costs of the current shortage in the HCHS at £1.2bn with an additional £600m recurrent cost of training more nurses to replace those who leave nursing (exit the NMC register early) because of high workload and stress. Both costs are net additional over and above the cost of employing extra establishment nurses at current terms and conditions.

Definitions of shortages and surpluses

Describing the current nurse labour market position would be straightforward if we had consistent data on vacancies, turnover, total earnings, bank and agency spend and number of shifts, workload and staff satisfaction.

- Shortages will be characterised by high vacancy rates, greater reliance on bank and agency, high staff turnover, grade drift, higher workload, rising nurse dissatisfaction with the quality of care they can provide and upward pressure on total nurse earnings.
- Equilibrium will be marked by low vacancy rates, modest and efficient levels of bank and agency spend, and moderate staff turnover.
- Surpluses will be marked by most temporary staffing being filled by bank rather than agency staff. Turnover will be low, and more nurses will emigrate. There will be low vacancy rates, with more applicants per post and fewer promotions. The headcount to FTE ratio will be high.
- Note that good quality data on all of these would be very helpful to workforce planners to help avoid future shortages and surpluses. Unfortunately, as noted

by most NHS PRB reports since 2011, 'there are long run problems with all of these data'.*

The costs of a surplus

The costs of a surplus of nurses to the NHS (3-month vacancy rates below 1% in HCHS) are likely to be negligible or negative:

- Despite the introduction £5,000 cost of living grant for all nurses (with a further £3,000 for some specialisms and in some regions) the majority cost of overtraining, under current student financing arrangements, will be borne by student nurses themselves.
- Plus, any Exchequer cost will be offset by lower pay pressures and by temporary staffing being at an optimal level and met from cheaper bank staff, rather than through more expensive agency staff.

The role of basic pay in balancing nurse supply and demand in the HCHS

Nurse wages in the HCHS are centrally determined by the Agenda for Change Pay Review Body (PRB). In market equilibrium, we would expect PRB uplifts to follow pay increases in the general labour market (GLM), maintaining nurse income relative to other workers.

NHS PRB uplifts also appear to follow the business cycle with periods of high general unemployment (and poor government finances) being marked by pay restraint, and periods of lower unemployment and (better government finances) marked by an element of catch-up.

During times of nurse shortages there will be market pressure to increase wages faster, but the 'affordability' criteria of the PRB remit limits scope for pay growth until government injects more money into the NHS, making headroom for affordable pay awards.

However, pay restraint does not translate fully into savings, because trusts have flexibilities to pay additional earnings, promote staff and employ bank and agency staff. When basic pay is held down below the 'going rate', the pay bill per worker will tend to rise to help retain and recruit more nurses.

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* Source (1) NHS PRB 28th report: 'We support the concerns raised by the Joint Staff Side and Unison about the need for improved and consistent data collection on vacancy and attrition levels to enable effective workforce planning. This has been a concern for us since 2011.' And in the 30th report in 2017, 'The lack of reliable vacancy data in England continues to be a serious barrier to the Review Body fulfilling its remit.'

This approach is viable because of the monopsony power of the NHS and the cartel behaviour of NHS trusts who do not use Agenda for Change flexibilities to increase wages, but channel money into specific areas where the return is more immediate and certain (bank and agency staffing and promotions).

Because nurse supply is inelastic in the short run, this approach is cheaper than a general pay increase.

Potential costs of a shortage

The table below lists four possible strategies adopted by trusts in the HCHS to manage nurse numbers, highlighting one possible indirect effect of shortages on staff turnover and attrition.

Table B-1: The hypotheses of the source of increased cost of nurse shortages

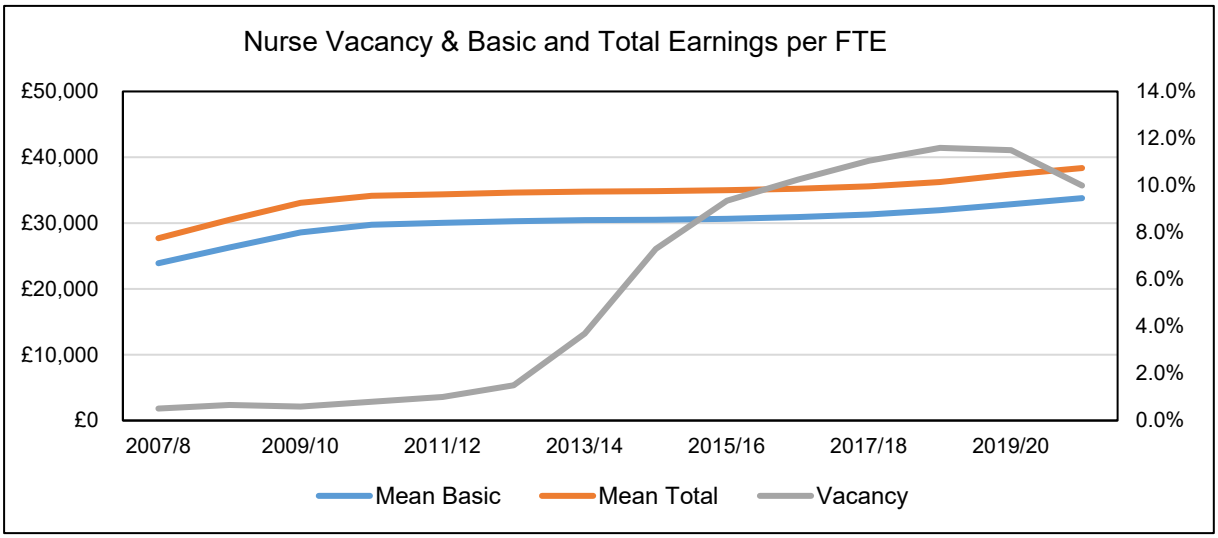
Hypotheses	The direct costs of employing nurses in the HCHS will rise as long-term vacancies increase beyond ~~4%~~
1	Establishment nurses will be encouraged to work longer hours, including through overtime. Rates for overtime will rise, less time off in lieu, as shortages persist.
2	There will be greater use of bank staff, including bank staff not employed by the hospital. Bank rates will rise.
3	There will be greater use of agency staff and higher rates of pay per shift.
4	Trusts may regrade posts to make them more attractive to existing or new staff.
5	A tight nurse labour market will generate excessive turnover or 'churn' that is expensive.

These hypotheses are tested against available data in the next five subsections.

Overtime and other payments

As can be seen from Figure B-1 there is no evidence of nurse shortages as measured by vacancy rates inflating earnings. It also shows there has been no increase in the total average earnings as an uplift to nurses' basic earnings despite vacancies rising from 1% to 11%.

Figure B-1: Nurse vacancy rate in HCHS plotted alongside basic and total average earnings of nurses (2007/08–2020/21).



Source: NHS Digital Staff Earnings Estimates*

The high wage increases between 2007 and 2010 were due to a 3-year settlement negotiated before the 2008–10 financial crash. It provided a cushion (alongside high levels of general unemployment) for a prolonged period of nurse pay restraint, which persisted even after the demand for nurses (as reflected in vacancy rates) rose in 2013.

This is because the AfC PRB remit includes an affordability criterion, alongside recruitment, retention and motivation of staff when recommending pay awards. Given the low NHS-wide settlements, it is not surprising that there was little increase in nurses' average pay between 2013 and 2017, despite rising demand. A new 3-year pay deal, with real terms pay increases, was negotiated in 2017/18.

More surprisingly than basic pay remaining relatively stagnant is that nurses' 'additional earnings' remained at a constant 13–14% of basic pay for the period 2007/08–2020/21. There are two reasons for this.

- 80% of 'other earnings' are composed of shift allowances and geographic allowances for high cost of living in London and the south east. 60% of staff receive some shift allowances and 20% a geographic allowance, but the amounts are centrally determined and rise in line with base pay.
- There is a marked reluctance among trusts to use pay flexibilities to encourage staff to work more hours. Only 8%, 6% and 3% of nursing staff receive overtime, pay for extra activity or on-call, respectively. These payments would need to increase by 6% to the subset of staff receiving them to register as a 1% increase in 'other earnings'.

* http://digital.nhs.uk/pubs/staffearnsep19prov

The preferred mechanism for getting extra hours from establishment staff is to use the staff 'bank'. This has the twin advantages of being in the currency of extra shifts rather than extra working hours and bank rates being driven primarily by conditions in the local temporary nurse labour market.

Bank and agency staff

Essential data to establish the relationship between nurse shortages and bank and agency spend (on nurses) are time series (preferably at regional level) of nurse vacancies and nurse bank and agency staff volume and costs. Data on agency and bank staff spend and volumes are collected centrally but were not made available for the purposes of this analysis.

The data that are available from disparate sources are shown below. The spend data presented for agency and bank staff cover all staff from 2013–14 to 2019–20 and are from NHS Improvement annual and quarterly performance reports – which also state that 85% to 90% of vacant shifts are filled by temporary staffing[*].

Vacancy data and bank and agency spend figures are from NHS Improvement. Nurses account for just under 30% of HCHS staff and 41% of all vacancies (Q1 2021/22). The spend data for bank and agency for nurses in 2017/18 is extrapolated from a freedom of information request to trusts and is likely to be an underestimate[†].[3]

Table B-2: Agency and bank data

	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20
All agency - all staff[1]	2,600	3,300	3,700	2,930	2,400	2,400	2400
All bank - all staff[1]	1,000	1,400	1,768	2,510	2,970	3,440	3800
Nurse vacancy	3.70%	7.30%	9.35%	10.25%	11.05%	11.60%	11.50%
All staff vacancy					8.30%	7.90%	8.10%
Agency + bank nurse					2,400[*]		

Source: (1) Bank and Agency Spend from NHS Improvement quarterly performance of the NHS provider sector publication series; the last 3 years' figures are also validated from an answer to a parliamentary question from Jonathan Ashcroft. In reply, the social care minister said, 'Prior to 2017–18, total expenditure costs for agency and bank staff were not separately identifiable by the Department.'

With these data, we can only estimate the spend on nurse agency and bank staff by making some assumptions.

- Assumption 1 is that 50% of the spend on bank and agency staff is on nurses (as nurses account for close to 50% of all HCHS vacancies) and that level of

[*] NHS England » Financial performance reports

[†] Open University 2018: 61% of trusts responded to an FOI request but high spenders on bank and agency would probably be less likely to file a return.

expenditure fills an average of 85% of all vacancies (based on the NHS Improvement data discussed above).

- Assumption 2 has a fill rate of 90% rather than 85% (also based on the NHS Improvement data discussed above).

This generates estimated costs of bank and agency staffing over and above the costs of filling posts with establishment nurses.

Table B-3: Bank and agency staff spend estimates

Assumption	2016–17	2017–18	2018–19	2019–20
1	1,586	1,452	1,593	1,709
2	1,520	1,380	1,515	1,627

6.2.1 Grade drift

The theory underpinning hypothesis 4 is that trusts faced with rising vacancies, but limited desire and resource to increase pay for all nurses, will be more likely to upgrade posts than would happen under a less competitive nurse labour market.

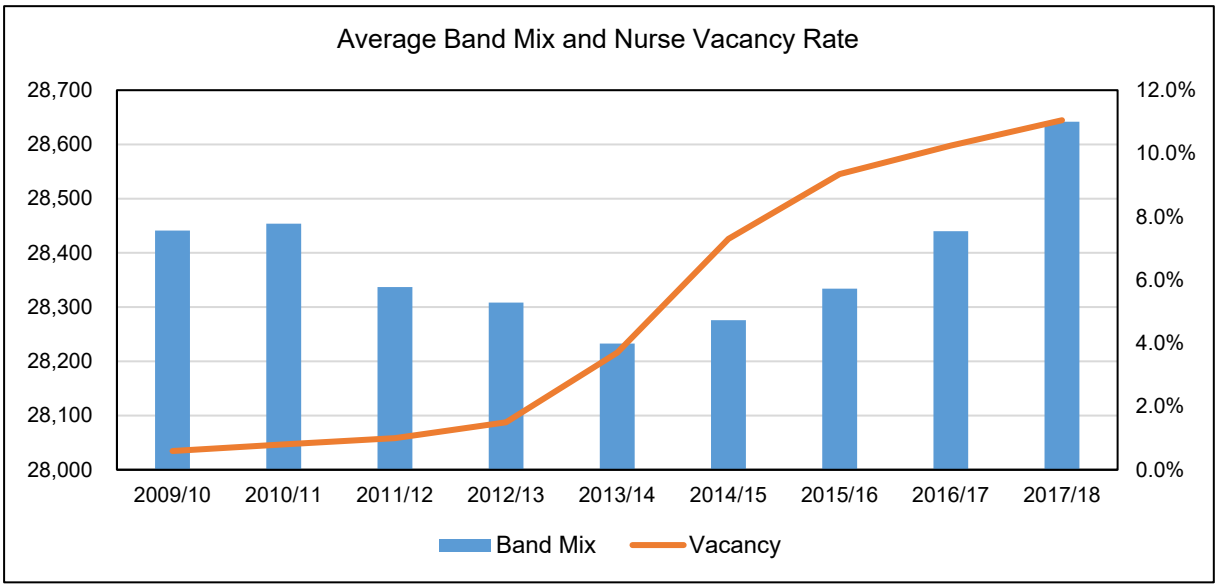
The theory is supported by recent research from the IFS which found 'that promotions are an important channel by which trusts can increase pay for nurses, and are being actively used for such a purpose'.* The study found that:

- trusts in high cost of living areas have higher promotion rates
- The vast majority of 'pay increases' in areas with above-average increases in cost of living (and consequently greater pressure on retention) result from an increased probability of promotion.

The theory is strongly supported by NHS Digital data on the changing grade mix.

* *Cost of Living and the Nursing Workforce in NHS Hospitals*. IFS, 2021.

Figure B-2: Average costs of a FTE in 2009/10–2017/18 prices based on the grade composition of all staff



Source: NHS Digital Staff numbers data, NHS PRB pay bands from 2017/18 PRB.

There was negative nurse grade drift in the four years before 2013/14 and positive drift afterwards. Based on these data we estimate a cost of pay drift of 0.4% per annum when vacancies are above 3%.

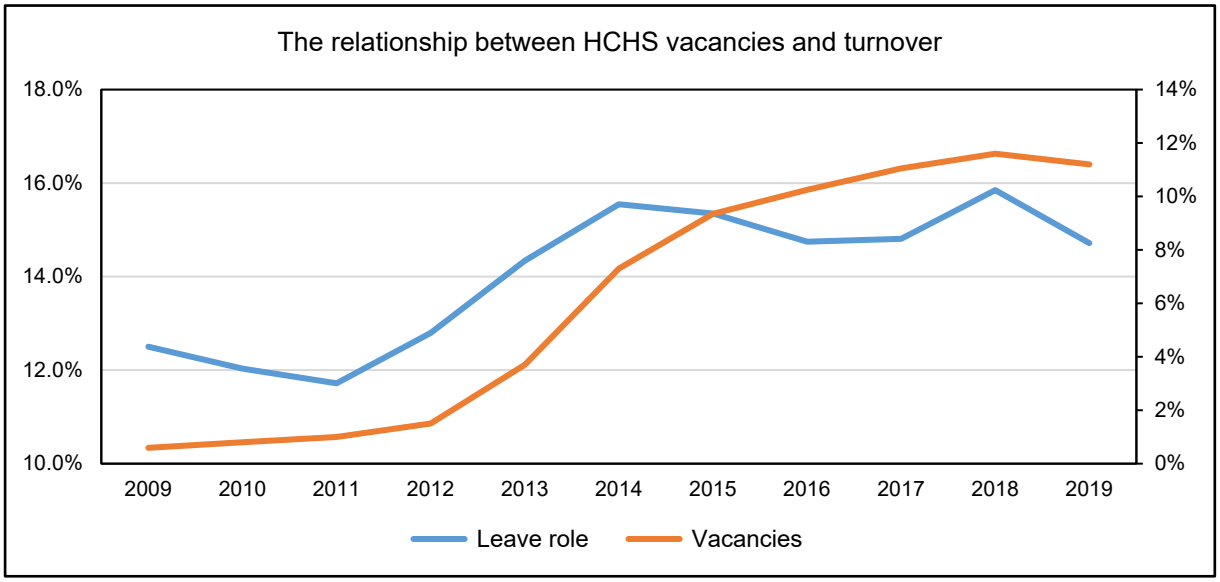
Turnover

A review of the literature on nurse staff turnover (Drennan V. , et al., 2015) found that higher turnover rates were associated with higher levels of nurse job dissatisfaction and 'tighter' nurse labour markets. The latter, with unfilled vacancies, offered both more promotion opportunities and more level transfers to less demanding roles.

There is some literature on the costs of nurse turnover. The costs are high (estimated between 50% and 80% of salary in a 2019 USA National Health Care Retention and RN Staffing report from 2019) including the administrative cost of finding a replacement, plus short-term backfill costs and lower productivity during the period of backfill and training the new staff.

For 2009/10 to 2012/13, when HCHS nurse vacancies averaged 1%, the average rate of internal NHS moves was 12.3%. From 2013/14 to 2019/20, when vacancies averaged 9.2%, internal moves averaged 15.1%. The correlation between HCHS vacancies and HCHS turnover at the regional level is 0.89.

Figure B-3: The relationship between vacancies and turnover over time



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We have used simple linear regression to find an equation that explains 79% of the increasing turnover rate as an increasing function of vacancies. The equation suggests that each % increase in the vacancy rate adds 0.3% to turnover above a fixed element of turnover at 12.3%. So an increase in the vacancy rate from 1% to 11% would increase turnover from 12.3% to approximately 15.3%.

If we assume the cost of backfill and finding and training up replacements is 50% of salary, then each percentage point increase in vacancy rates adds 0.15% of salary costs via increased turnover (0.003 * 0.5 or around £25m).

Conclusions

These estimates of the costs of a shortage are summarised in the Table below:

Table B-4: Summary of evidence to support hypotheses for additional nurse costs

Hypothesis	Evidence/data currently available	Estimate of cost expressed as a function of vacancy rates * pay bill
Other earnings	There was no evidence that nurses' 'other earnings' (non-basic pay) increased from 13–14% of basic pay during the period of rising vacancies from 2013.	There is no evidence of shortages translating into higher non-basic payments (such as overtime pay and local area supplements) over time.
Bank and agency	Obtaining good data on bank and agency spend and volume is difficult. We therefore make conservative assumptions about the data we have.	For every 1 percentage point vacancy rise above 3%, gross costs increase by 1.75% of pay bill (a net extra cost of 0.75% = £120m).
Grade drift	There was negative nurse grade drift in the four years before 2013/14 and strongly positive drift from 2013/14 to 2017/18.	Based on data on drift before and after 2013/14 we estimate a cost of £50m p.a. whenever vacancies are above 3%. This is a net recurrent cumulative additional cost of 0.3% of pay bill.

Turnover	There is a strong relationship between internal churn in the HCHS and vacancy rates. The data suggests a fixed component of 12% and a 0.3 elasticity of higher turnover for each percentage point increase in vacancies.	If we assume the cost of backfill and finding and training up replacements is 50% of salary, each percentage point increase in vacancy rates adds 0.15% of salary costs via increased turnover (0.003 * 0.5 or around £25m).

Modelling surpluses and shortages

The NSM quantitative model calculates the key costs associated with the HCHS nurse workforce at a national level. The calculation structure is implemented at a high level due to data restrictions. It is important to note that the model is not a detailed cost model, and the results of these calculations should be used to consider key cost differences between scenarios rather than to produce detailed cost projections. The model calculates the costs associated with employee supply costs, combined agency and bank supply costs, turnover costs, intervention costs, and an estimate of the cost to meet the gap between supply and demand through training. The calculations are fully described in the system dynamics model technical description (DAS, 2021d) (not published).

The calculations are based on the assumptions described below. For context, initial inputs are included in brackets which can be easily updated in the model control spreadsheet.

HCHS supply, demand and agency/bank gap filling

The supply of agency/bank nurses in HCHS is based on the gap between HCHS supply and demand in FTE. The FTE potentially available is based on the projected size of the register multiplied by the peak capacity percentage (90%), an estimate of the maximum available capacity based on the size of the nurse register. The maximum gap that can be filled is based on the estimated proportion of vacancies which are met through agency/bank staffing (87.5%).[*]

National-level HCHS cost calculation

HCHS employee supply cost is calculated from the HCHS FTE supply multiplied by HCHS supply cost per FTE.

HCHS supply cost per FTE is based on the value at the start of the simulation (£38,360 in 2020)[†] escalated each year by percentage change in annual supply cost. This cost includes total costs to the employer, for example pension, salary etc.

[*] 85% to 90% of vacant shifts are filled by temp staffing - NHS Improvement quarterly performance of the NHS provider sector publication series.

[†] Figures from NHS Digital. Value for total earnings.

The percentage increase to supply cost is based on two components. The first is the standard annual uplift (NHS Pay Review Body Award) (2%/year) which can be defined as a time series. The second is an additional increment due to grade drift, ie more people move into higher grades when vacancy rates are high. This is assumed to add an additional percentage (0.3%) to the annual increment if a vacancy threshold is reached (4%). The vacancy rate is based on the percentage gap between demand and supply.

HCHS agency bank supply cost is calculated by multiplying the HCHS agency bank supply FTE by the HCHS agency bank supply cost per FTE. The HCHS agency bank supply cost per FTE is calculated by multiplying the HCHS employee supply cost by an agency bank cost factor (1.67).

HCHS turnover cost represents the additional costs associated with filling vacancies and is calculated by multiplying the HCHS employee supply cost by the percentage turnover cost. The percentage turnover cost is determined based on a lookup based on the % gap between HCHS supply and demand (a gap of between 0 and 4% results in a 0.15% turnover cost which increases by 0.15% for each additional percentage supply gap up to 12%, after which the turnover cost percentage remains at 1.35%).

Intervention costs

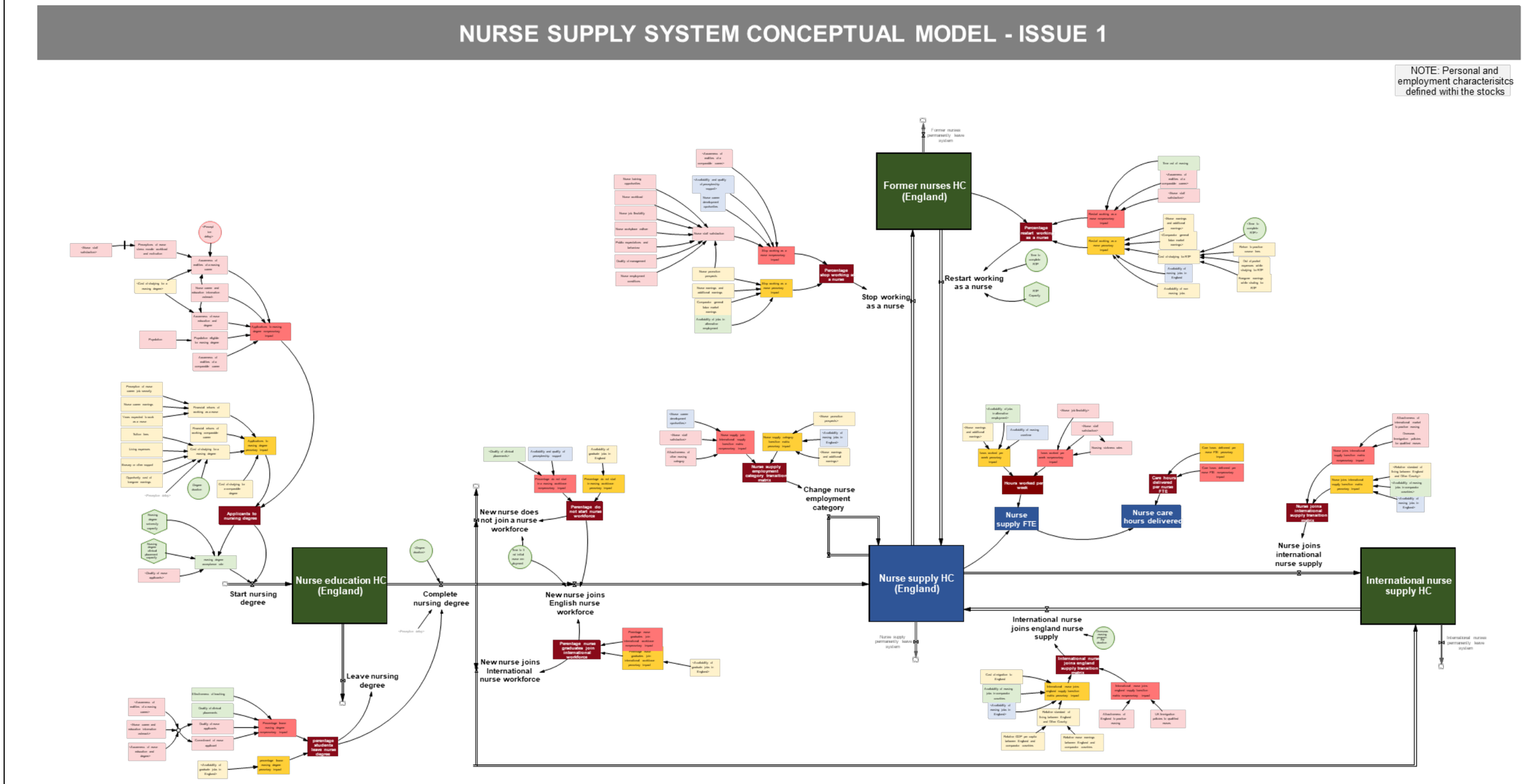
An annual **intervention cost** can be defined as a time series based scenario input.

Training costs

HCHS gap cost training is the estimated cost associated with filling the gap between supply and demand excluding any agency/bank supply. The cost is calculated based on the difference between FTE HCHS supply and demand converted to HC by taking into account the current HCHS FTE and HC values multiplied by the average nursing degree training cost (initial estimate = £20,000 per person). It should be noted that this value presents an estimated snapshot value based on the current gap and does not accumulate over time.

Appendix C: Conceptual model

Figure C-1: Conceptual model of the nurse supply system (DAS, 2020)



Source: DAS Ltd

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About the Health Foundation

The Health Foundation is an independent charity committed to bringing about better health and health care for people in the UK.

Our aim is a healthier population, supported by high quality health care that can be equitably accessed. We learn what works to make people's lives healthier and improve the health care system. From giving grants to those working at the front line to carrying out research and policy analysis, we shine a light on how to make successful change happen.

We make links between the knowledge we gain from working with those delivering health and health care and our research and analysis. Our aspiration is to create a virtuous circle, using what we know works on the ground to inform effective policymaking and vice versa.

We believe good health and health care are key to a flourishing society. Through sharing what we learn, collaborating with others and building people's skills and knowledge, we aim to make a difference and contribute to a healthier population.

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