Estimating the impact of an improved Healthcare innovation ecosystem in Scotland

Final Report
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Executive summary

i. The Healthcare innovation ecosystem in Scotland is a sizeable and growing sector in the Scottish, UK and wider economy. Scotland has one of the largest Life science clusters in Europe, utilising the triple helix of industry, academia and government. Current Healthcare innovation activity in Scotland spans a range of areas including Digital Health and Digital Healthcare, FemTech, Pharmaceuticals, Precision Medicine and Personal Nutrition.

ii. There is an increasing recognition of the strategic importance of health and well-being for Scotland, not just in terms of the benefits of good health, but also for the economy. There are strong economic arguments for supporting the Health sector and improving the Health and Care innovation ecosystem. Consequently, Scottish Enterprise is seeking to maximise the economic impact of Healthcare innovation in Scotland.

iii. In particular, it is interested in impacts across three domains:

- Direct economic impacts according to standard economic measures, such as job creation, R&D spend, GVA, and so on;
- Indirect economic impact in terms of fiscal savings on Healthcare expenditure, efficiency savings, or a reduction in illness-driven benefit payments; and
- Social impacts including improved health, reduced incidence of illness, improved healthy life expectancy, etc.

iv. The objective of the research was to articulate and model the potential impact of building a world-leading Health and Care innovation ecosystem where increased innovation can drive gains across each of these three impact domains. The primary purpose of modelling is to establish or reinforce the case for continued public sector intervention in health and Healthcare innovation.

v. However, the limited availability of evidence regarding such impacts currently prevents the full modelling of socio-economic impacts arising from Health and Healthcare innovation. The disparate nature of evidence, combined with the particular focus on certain specific and isolated impacts through evaluation of Healthcare innovations and interventions result in a high degree of difficulty in building a coherent, linked model.

vi. Nevertheless, the available evidence, whilst not comprehensive, still allows for a composite overview of impacts to provide an understanding of the likely impacts arising from Healthcare innovation. Thus the study has been able to consider the nature of impacts of innovation within Healthcare in Scotland, and model potential impacts as far as available data allow.

vii. There is a wide range of demonstrable positive impacts arising from the adoption of innovations within Healthcare. In particular, there are strong direct and indirect economic benefits that can be demonstrated through surgical, clinical or medical trials, product, process and service innovations and evaluation of innovation adoption.

viii. Potential impacts that could be realised in Scotland through increased innovation in Healthcare are set out below.

Direct impacts

Matching OECD average spend on Healthcare innovation	**101** additional Life sciences sector businesses **3,000** additional jobs **£537** million additional turnover
Matching leading UK region for Life sciences businesses per capita	**166** additional Life sciences sector businesses **5,000** additional jobs **£884** million additional turnover **£454** million additional GVA
Investment in Health innovation interventions such as the Clinical Entrepreneur Programme	**58** new jobs **8-9** new business start-ups } per intervention **£17** million new investment
Achieving c.50% of benefits arising from London Healthcare accelerator through a £3 million investment	**250** additional Life sciences jobs High levels of additionality **(≥90%)**

Indirect and social impacts

Realising Healthcare expenditure savings through increased innovation	**£2.4-£5.5** billion reduction in Healthcare expenditure
Impacts arising from increased NHS spending (+10%)	Additional **22,900** people economically active **£683.4** million additional wages **£79.6** million additional income tax receipts **£39.6** million additional National Insurance receipts **£242.7** million additional benefits savings
Impacts arising from increased innovation on ill health (-0.7%) and mortality (-1.2%) rates	Uplift in GVA per head of +2.6% to £46,411 **£2.12** billion additional GVA Additional **7,500** people economically active **£223.8** million additional wages **£26.1** million additional income tax receipts **£12.9** million additional National Insurance receipts **£23.3** million additional benefits savings

ix. Consequently, there is a strong rationale for continued investment in Health innovation, and for public sector intervention to stimulate greater collaboration through triple-helix approaches. As such, Healthcare innovation should continue to be a priority for Scottish Enterprise and partners.

x. To progress towards a fuller modelling of impacts arising from Health and Healthcare innovations, an integrated approach that tackles modelling from different angles is required, one that considers top-down approach to modelling impacts combined with an approach to scale up available data to forecast impacts across the three domains.

xi. This would require:

- Broad macro-economic forecasting at the national and/or global level to provide greater detail on current and future trends in Healthcare;
- Clear evidence of results and outputs from Health innovation projects, which considers impacts across the three domains in question; and
- A detailed understanding of the socio-economic context(s) in which Health innovation impacts are realised, to better model the influence of external factors.

xii. Fully understanding the extent to which outcomes can be attributed to interventions will always require a number of assumptions. Any future model should acknowledge that it would be demonstrating impacts that have been contributed to by innovations, rather than these having been solely responsible for.

xiii. It is recognised that data collection at the scale required to inform a full model is the single largest challenge for fully understanding and demonstrating the potential impact of Healthcare innovation in Scotland.

1 Introduction

Overview

1.1 There is an increasing recognition of the strategic importance of health and well-being for Scotland, not just in terms of the benefits of good health (which are multiple for the individual and for society) but also for the economy. There are strong economic arguments for supporting the Health sector and improving the Health and Care innovation ecosystem, both in terms of the direct economic contribution of Scottish businesses involved in Healthcare products, processes and services, but also in terms of the indirect economic benefits in terms of the exchequer savings of a healthy population, and the cost saving and productivity benefits of healthy employees.

1.2 Recent programmes of activity implemented by the Scottish Government and its enterprise and skills agencies acknowledge the value of good health (and a good Healthcare sector) for Scotland.[1] Similarly, the UK Government's Medical Technology Strategy[2] (and prior to this, the Ageing Society mission of the previous Industrial Strategy[3]) along with the Plan for Health and Social Care through *Build Back Better: Our plan for Growth*[4] aim to improve access to and application of innovative technologies and approaches to deliver improved outcomes for patients. This includes projects in Scotland such as iCAIRD (the Industrial Centre for Artificial Intelligence Research in Digital Diagnostics).[5]

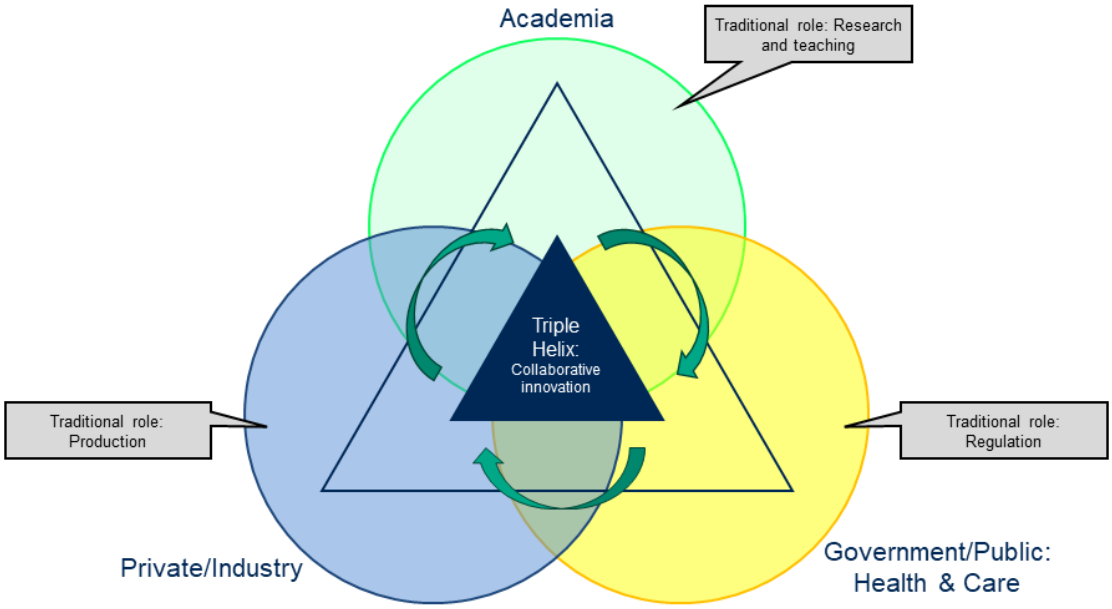
1.3 These have been delivered to support ambitions for Scotland to become a world-class Health and Care economy, one where innovation flourishes and citizens live longer and healthier lives.

1.4 To achieve this, Healthcare systems globally, not just within Scotland, must improve in terms of their sustainability and effectiveness. Supporting and nurturing Health and Care innovation ecosystems is a critical component of this – including opening access to the NHS and private Healthcare markets for Scottish businesses, for the benefit of patients.

1.5 Scottish Enterprise (SE), as an enterprise agency, is seeking to maximise the economic impact of Health and Care innovation in Scotland by working with the full range of partners: industry, academia and government (the Triple Helix), in order to develop the products and processes that will underpin global Health and Care systems. The diagram below neatly shows the Triple Helix and space for collaborative innovation at its heart. In addition, the Quadruple Helix approach can be used to engage patients or civic society/community groups, and can therefore be an effective means of engaging charitable organisations, which form a large part of the Health innovation ecosystem (the Quadruple Helix is discussed more in Chapter 3).

[1] Such as the Health for Wealth Programme (HfW)
[2] https://www.gov.uk/government/publications/medical-technology-strategy
[3] https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions
[4] https://www.gov.uk/government/publications/build-back-better-our-plan-for-growth
[5] https://www.woshealthinnovation.scot/exemplar-projects/icaird/

Figure 1.1: A triple helix for collaborative innovation



Source: Adapted from Etzkowitz and Leydesdorff, 1995

1.6 Consequently, SE has commissioned extensive research in this space, in order to better communicate the potential economic impact that realising the two strategic aims noted above could have on the Scottish economy. A strong thread through these commissions is the focus on the P4 Medicine approach, one that is: predictive, preventive, personalized and participatory. This approach plays to a number of Scotland's strengths and assets, not least in Data Science and Artificial Intelligence (AI), allied to Health research. This is an area where area where Scotland has some particular strengths and experience, supported by policy and some very active organisations, not least the Digital Health & Care Innovation Centre (DHI). Fully exploiting the potential of digital technologies and data to transform Healthcare is a key element of building a world leading Health and Care innovation ecosystem that optimally links the triple helix of NHS, academia, and industry.

1.7 Recent research has also demonstrated the strong supporting role of Scottish Government's Chief Scientists Office (e.g. through innovation test beds) and the Scottish Health and Industry Partnership (SHIP).[6] The studies completed to date also show the strong role of other players in research and innovation, notably other Innovation Centres such as The Data Lab and university departments (where there are strengths in Data Science/AI, Life sciences, Health Analytics, manufacturing/wearables etc.).

Research objectives

1.8 At the outset of the commission, the objective of the research was to articulate and model the potential impact of building a world-leading Health and Care innovation ecosystem that optimally links the triple helix of NHS, academia, and industry, and fully exploiting the potential of digital technologies and data to transform health, and to set this out according to a three-fold model of economic impacts arising from economic development interventions:

- **Direct economic impact**: 'standard' measures of economic impact, such as jobs created, increased gross value added (GVA), level of business expenditure on research and development (BERD), increased exports, increased (inward) investment, growth in start-

[6] e.g. ekosgen and Context Economics, for SE (2023) FemTech Economic Opportunity for Scotland; Available at: https://www.evaluationsonline.org.uk/evaluations/Search.do?ui=basic&action=show&id=802. See also Additional Research with Context Economics, Addspecialists, Open Cities and IBP Strategy & Research, for Scottish Government (2023) Innovation Centres Programme Evaluation.

ups/company formation, etc. For example, these may arise from increased industry collaboration with NHS Scotland or social care providers, where this activity stimulated higher levels of R&D or employment, from increased industry sales to Scottish, UK or global markets, or from increased spinouts from academia or the NHS.

- **Indirect economic impact**: fiscal impacts arising from innovation adoption, such as savings in terms of NHS expenditure, including from greater efficiency (which may in turn be reinvested in innovation); reduced workforce absence, due to a decreased need for patients to be treated as inpatients; or a reduction in the number of illness-driven benefit payments required.
- **Social impact**: benefits gained at the individual patient or community level, i.e. a due to patients in receipt of innovative treatments or procedures being in better health, and thus reduction in illnesses or ill-health, along with those benefits associated with healthier citizens or happier citizens. For example, an increase in the disability free life expectancy of citizens, a reduction in hospital waiting times, or an increase in persons able to live more active lives.

1.9 As the brief noted, this is a difficult question to answer: there is a considerable range of hypotheticals to consider, as well as a number of (inter)dependencies. These include (but are not limited to) the rate of innovation adoption within the Health and Care sector, the extent and nature of industry:academia collaboration, the size of the market opportunities within and outwith Scotland in particular sub-sectors, and of course the extent of public sector funding. Barriers to realising market opportunity will also be a significant influencing factor.

1.10 However, a number of issues with regard to availability of evidence concerning impacts, and specifically the focus of such impacts (or indeed the focus of supporting evidence), has impacted on the ability to develop a working model of socio-economic impacts. Many evaluations of Health innovations and clinical trials focus on the effectiveness of novel treatments, procedures or processes, with some consideration given to cost effectiveness versus standard treatment approaches. Further, much of the available evidence is disparate or focused on very specific innovations, precluding the ability to build a bottom-up picture of impacts on Healthcare or indeed shedding any light on how a top-down model may be rationalised. This is discussed more fully in the report.

1.11 Consequently, in agreement with the SE client team the study set out to consider the nature of impacts of innovation within Healthcare in Scotland, and to model potential impacts across the direct, indirect and social domains based as far as available evidence allowed, and on a case-by-case basis.

Approach

1.12 The study methodology has consisted of the following elements:

- Scoping of the Healthcare ecosystem in Scotland, including consideration of key Healthcare subsectors such as digital health;
- A desk review of evidence related to Healthcare innovation and associated impacts, including SE-commissioned research reports; identifying data gaps, limitations, and tangible economic opportunities;
- Establishment of metrics and measurements for modelling, drawing from standard sources like Scottish Annual Business Statistics (SABS) and Scotland's Business Enterprise Research and Development (BERD) expenditure, and proxy measures where appropriate/relevant.
- Development of a logic chain and draft impact model, plus refinement of the model based on feedback from the SE client team.

- Assessment on modelling of potential/anticipated impacts in Scotland across three domains: direct impacts, indirect impacts; and social impacts, including consideration of the extent to which such impacts could be attributed to potential innovations and interventions.

2 The Health innovation context in Scotland

Introduction

2.1 Health innovation in Scotland is an increasingly important component of the Scottish economy. Based on secondary desk research, this chapter provides a summary of Health innovation in Scotland. It presents an overview of the health and Healthcare innovation ecosystem, along with current Healthcare innovation activity across a number of sub-sectors and areas of Healthcare activity. The chapter also presents some international examples of Healthcare innovation for reference.

The Health and Healthcare innovation ecosystem in Scotland

2.2 The Healthcare innovation ecosystem in Scotland is a sizeable and growing sector in the Scottish, UK and wider economy. Digital Health comprises a substantial part of Healthcare innovation activity. Scotland has one of the largest life science clusters in Europe, utilising the triple helix of industry, academia and government. The Campbell Report's overview of the sector highlights a healthy ecosystem with over 200 medical technologies companies, 150 pharma services companies and over 700 organisations overall employing 40,000 people.[7]

2.3 Health and Life sciences is still a relatively small sector in terms of direct employment, but it makes a disproportionately larger contribution to the Scottish economy in terms of productivity, innovation and wages. This pattern has been replicated and built upon year after year, with sustained growth in GVA, GVA per head and total turnover. The total turnover generated by Scottish Life sciences companies grew from £3.6bn in 2010 to £7.3bn in 2020.[8] At £38,156, GVA per head is over 64% larger than the Scottish average of c.£23,200 in 2020. This growth has also been seen in the 21% increase in life science enterprises in Scotland between 2010 and 2020.[9] This success has been supported by and supports the position of Scotland being an important cluster at both a UK wide and global level, remaining the top UK location outside London for foreign direct investment. Within Scotland, Edinburgh and Glasgow remain the top two regions for life science start-ups in the UK, whilst simultaneously being the fastest growing.

2.4 As per the Scottish Health Research and Innovation Ecosystem (SHRIE) directory[10] as of March 2023, there are 156 organisations that are described as "expert groups" that form the Scottish Health Research and Innovation Ecosystem. These organisations are further categorised by three different metrics – by development stage, by technology type and by therapeutic area. The largest stage of development is the "Develop" stage, with around 96% of organisations having a role in this development stage. The largest technology type is with regards to "Diagnostics," with 46.8% of organisations involved in this type of technology, compared to 4% of organisations involved in the "Lasers and Microwave" technology type. The largest therapeutic areas are in "General Medicine" and "Genetics & Rare Diseases, Ageing, Regenerative Medicine and Metabolic" which each share around 30% of organisations, compared to "Primary Care and Public Health" which has a share of 14% of organisations. When filtering the SHRIE directory to "Digital health/Telehealth" technology type, there are 25 organisations (16% of the total on the directory) that are listed as expert groups.

[7] https://www.gov.scot/publications/campbell-report-roadmap-investment-health-innovation-life-sciences-healthtech-scotland/pages/2/
[8] https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2019/07/growth-sector-statistics/documents/life-sciences-cluster/life-sciences-cluster/govscot%3Adocument/Life%2Bsciences%2Bcluster.xlsx
[9] Ibid.
[10] https://health.directories.scot/

2.5 However, it is understood that this only presents part of the picture in focusing on mainly public sector organisations. When factoring in private sector entities and the wider innovation supply chain, the ecosystem is understandably much larger, as demonstrated above. Total employment across Scottish Life sciences was around 31,400 in 2020; when considering Life sciences employment in Higher Education Institutions in Scotland, this rises to c.42,500.[11]

Current Healthcare innovation activity in Scotland

Digital Health and Digital Healthcare

2.6 In broad terms, Digital Health and Digital Healthcare can be defined as the application of technology and digital processes, typically involving the use of computing platforms, connectivity, software, and sensors, etc., for Healthcare and related uses.[12] Digital Health applications consist of elements including wireless devices, hardware and software sensors, microprocessors and integrated circuits, the internet, social networking, mobile and body area networks, Health IT, genomics and personal genetic information. Because of the varied nature of these elements the term Digital Health forms an umbrella term for the application of the following to Healthcare provision[13]:

- Big data;
- Cloud computing;
- Connected health;
- eHealth, medical informatics and ePatients;
- Medical and Healthcare gamification;
- Health 2.0;
- Health Information Technology;
- Mobile health (mHealth), telehealth, wireless health and telemedicine; and
- Quantified self (patient self-tracking).

2.7 Digital Healthcare is a critical means to improve Healthcare provision and health outcomes, reduce inefficiencies in Health and Care delivery, make Healthcare more person-centred and personalised, and also help to realise socio-economic benefits elsewhere.

2.8 Importantly, it is important to note that Digital Health or Digital Healthcare is both a subsector (like wellness) and also a trend. Better access to patient data, for example, is digital innovation/improvement that enables even non-digital medicines or interventions to be better targeted.

2.9 There have been significant steps taken with regards to the development of Digital Healthcare and Healthcare innovation over the last decade. However it should be noted that there was a step change as a result of the COVID-19 pandemic – with health providers rapidly switching to the use of digital technologies in order to reduce contact, thereby reducing the chances of transmission and therefore hospitalisation.[14]

2.10 The response to the COVID-19 pandemic resulted in the rapid development of several products and services that heavily involved the development of data and digital solutions including: Test and Protect as a programme for contact tracing; the Protect Scotland App

[11] https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2019/07/growth-sector-statistics/documents/life-sciences-cluster/life-sciences-cluster/govscot%3Adocument/Life%2Bsciences%2Bcluster.xlsx
[12] https://www.fda.gov/medical-devices/digital-health-center-excellence/what-digital-health
[13] https://www.dhi-scotland.com/about/what-is-digital-health-and-care/
[14] https://www.gov.scot/binaries/content/documents/govscot/publications/progress-report/2021/11/scotlands-digital-health-care-response-covid-19-2021-update2/documents/scotlands-digital-health-care-response-covid-19-2021-update/scotlands-digital-health-care-response-covid-19-2021-update/govscot%3Adocument/scotlands-digital-health-care-response-covid-19-2021-update.pdf

which supplemented manual contact tracing for individuals that were in close proximity; the NHS24 Symptom Checker App; and the Flu Vaccines and COVID-19 Vaccinations Delivery programme.

2.11 With regards to continuity of regular services during the pandemic, digitally enabled services were provided across: Remote health monitoring through the Remote Health Pathways programme; Mental health, through the development and scaling up of services such as computerised Cognitive Behavioural Therapy (cCBT) and internet-enabled CBT (ieCBT) services; Social care, through the introduction of the Connecting Scotland programme; and Care at home to support vulnerable individuals that were required to be shielding throughout the pandemic.

2.12 As such, the rapid mobilisation of the Digital Health sector in Scotland and these innovations in continuity care (beyond the special services established for COVID-19 purposes) are expected to be lasting. Key learning has underlined the importance of consistent, high quality aggregated and anonymised data that can be analysed and interpreted to review effectiveness to better inform clinical decisions around care, prevention, prescriptions, the value of interventions, as well as enhancing innovations in improving drug discovery, design and manufacture.

2.13 As the largest employer in the broader Life sciences sector, the HealthTech sector in the UK (covering medical devices, diagnostics and digital health technologies) currently employs 131,800 people in 4,060 companies, with a combined turnover of £25.6bn, and has enjoyed annual growth of around 5% in recent years.[15] UK Office for Life sciences statistics indicate that there are over 500 businesses in Biopharmaceuticals and Medical Technologies in Scotland, employing more than 18,600 people, and with a turnover of almost £7 billion in 2021/22.[16]

2.14 The UK represents approximately 5% of the global industry, and Digital Health and Healthcare innovation is set to remain a key driver of economic growth in the UK, and is an industry both the UK and Scottish governments have committed to supporting.[17,18]

2.15 In Scotland, there is a heavy emphasis on the economic opportunity of digital technology in Healthcare. It is noted within the Scottish Government's updated Digital Health and Care Strategy that a priority in the design and delivery of digitally innovative services should be focused on both improving wellbeing and economic benefits.[19]

2.16 In practice, actions around the improvement of health and economic outcomes through digital innovation can be seen in the Cancer Medicines Outcomes Programme, which linked nationally-held datasets with prescribing data in order to describe patient characteristics (such as age, gender, diagnosis and fitness for treatment) of the Scottish population who received immunotherapy treatments, in order to ensure supported Healthcare professionals can understand the outcomes of cancer medicines, enhancing the information available for patients and for the clinicians making treatment decisions.[20]

[15] https://www.abhi.org.uk/media/3184/making-it-happen-delivering-future-innovation-in-healthtech.pdf
[16] https://www.gov.uk/government/statistics/bioscience-and-health-technology-sector-statistics-2021-to-2022
[17] https://www.gov.uk/government/publications/a-plan-for-digital-health-and-social-care/a-plan-for-digital-health-and-social-care
[18] https://www.gov.scot/publications/scotlands-digital-health-care-strategy/
[19] https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2021/10/scotlands-digital-health-care-strategy/documents/enabling-connecting-empowering-care-digital-age/enabling-connecting-empowering-care-digital-age/govscot%3Adocument/enabling-connecting-empowering-care-digital-age.pdf
[20] https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/02/data-strategy-health-social-care-2/documents/greater-access-better-insight-improved-outcomes-strategy-data-driven-care-digital-age/greater-access-better-insight-improved-outcomes-strategy-data-driven-care-digital-age/govscot%3Adocument/greater-access-better-insight-improved-outcomes-strategy-data-driven-care-digital-age.pdf

2.17 There is evidence to suggest that there is an economic cost to not pursuing wider Health innovations and improving health outcomes. In research that was conducted with respect to the Northern Powerhouse in England, it was found that an increase of 10% to the NHS budget in Northern Powerhouse health board areas would decrease the economic inactivity rates in the region by three percentage points, and that decreasing rates of ill health by 1.2% and decreasing mortality rates by 0.7% would reduce the gap in gross value added (GVA) per capita between the Northern Powerhouse and the rest of England by 10%.[21] As such, productivity is intrinsically linked to improving health outcomes, and therefore any innovations in Healthcare that lead to better health outcomes would help to aid productivity and further boost the economy.

2.18 It has been acknowledged that the status quo also has significant social costs. Many patients and service users receive sub-optimal health & social care due to poor quality, inconsistent, or unshared data, leading to lower levels of happiness and wellbeing, higher levels of health inequalities, lower levels of household wealth and income as a result of economic inactivity from chronic and long-term ill health, and a poorer quality of life as a result.[22]

2.19 As such, the social opportunity of good quality data about patient health and patients' lived experiences and quality of life can enrich, expand and personalise the information which health and social care professionals can draw on to deliver better care. Data also enhances prevention and prescribing capabilities, and therefore can lead to treatments being more effective.

Wellness

2.20 The Wellness economy is a collection of industries that enable consumers to incorporate wellness activities and lifestyles into their daily lives, providing products and services targeted at physical and mental health and wellbeing. The Global Wellness Institute (GWI), a leading body representing wellness related industries and practitioners, defines wellness as "the active pursuit of activities, choices and lifestyles that lead to a state of holistic health".[23] Ultimately, when considering a wellness economy, this refers to businesses and industries that provide products and services that incorporate wellness activities into their daily lives. Though the Wellness economy includes products and services that could be considered Healthcare, it also includes activities and services that are not – for example spa treatments, personal care and beauty, etc. Thus Wellness should not be conflated with a wellbeing economy which commonly refers to public sector strategy relating to community welfare.

2.21 The Global Wellness Institute further defines the wellness economy as expenditure across 11 core sectors[24], namely:

- Mental wellness support and activity
- Physical activity for sports, leisure and recreation
- Wellness real estate: construction, operation and management of residential and commercial/institutional properties for Wellness activities
- Workplace wellness: programmes, services, activities and equipment by employers aimed at improving their employees' health and wellbeing
- Wellness tourism
- Spa economy: spa facilities and related activities that support and enable spa businesses
- Thermal/mineral springs, and related recreational and therapeutic uses of water

[21] https://eprints.whiterose.ac.uk/146595/1/NHSA_REPORT_FINAL.pdf
[22] https://www.scdi.org.uk/wp-content/uploads/Mind-the-Gap-SCDI-2021-1.pdf
[23] https://globalwellnessinstitute.org/what-is-wellness/
[24] https://globalwellnessinstitute.org/what-is-wellness/what-is-the-wellness-economy/

- Healthy eating, nutrition and weight loss, including vitamins and supplements, fortified/functional foods and nutraceuticals, nutrition and dietary services, and weight loss/management products and services;
- Personal care and beauty: beauty and salon services (excluding spas); skin, hair and nail care services and products; cosmetics, toiletries and other personal care products; dermatology; and prescription pharmaceuticals for skin care (including age-related health and appearance issues and conditions)
- Preventive and personalised medicine and public health: medical services that focus on treating "well" people, preventing disease, or detecting risk factors
- Traditional and complementary medicine: diverse medical, holistic, and mentally or spiritually-based systems, services and products that are not generally considered to be part of conventional medicine or the dominant Healthcare system (e.g. homeopathy).

2.22 The global wellness economy is currently estimated at around £3.3 trillion globally with predictions that it will grow to between £4.5 and £5.2 trillion within the next five years. The confidence in this sector has sustained throughout the COVID-19 Pandemic and has resulted in the sectors positioning as an answer to jobs, wealth and health and wellbeing targets and objectives. This has been replicated in Scotland, where its sector has flourished.

2.23 The wellness sector is an important and growing part of the Scottish economy. Despite there being challenges in mapping wellness activities to existing industrial classifications, recent estimates have stated that £6.6 billion is spent on wellness in Scotland, making up 3.9% of the total economy. This total spend is further supported by the estimated £5.7 billion generated in GVA, which is expected to rise to around £7.0 billion by 2030[25]. This increase is important when placed within the context of the wider Scottish economy, as estimates have suggested that a 5% increase to the wellness economy by 2030 would see the generation of an additional £284 million. When it comes to employment, research has found that there are 96,982 employees across the Scottish Wellbeing activities, relating to 6,683 businesses.[26]

FemTech

2.24 The FemTech sector is an emerging sub-sector of the Scottish Healthcare sector that has a wide range of specialisms and areas of innovation. The FemTech sector is the software, diagnostics, products and services that use technology to focus on women's health and wellness. This is a relatively broad sectoral definition, encompassing longevity, fertility and period, pregnancy and nursing, diagnostics and PharmTech, general Healthcare, sexual Healthcare and wellbeing, and beauty.

2.25 The evidence from the research is that size of the prize in FemTech is considerable. The estimated value of Scotland's FemTech sector is currently £123m in GVA and 1,350 jobs.[27] Quantifying the existing FemTech sector is challenging given limited data, and the baseline estimate this assumes existing companies are involved in FemTech, an assumption that needs to be tested further. However, if matching global growth rates, and taking the estimated baseline, the FemTech market in Scotland will be £469m by 2031. Matching global growth, which is driven by the US market, would be a considerable achievement, requiring a strong, supportive government policy environment to stimulate the necessary growth. Even a medium growth scenario for Scotland, of 150% growth over 10 years, would add £185m in GVA and 2,035 jobs to the FemTech sector[28].

[25] Additional Research (2021) The Economic Opportunity of the Wellness Economy for Scotland for Scottish Enterprise
[26] Unfortunately, no disaggregation or granularity is available according to the 11 core sectors discussed above.
[27] https://www.femtech.health/interactive-charts
[28] ekosgen and Context Economics, for SE (2023) FemTech Economic Opportunity for Scotland; Available at: https://www.evaluationsonline.org.uk/evaluations/Search.do?ui=basic&action=show&id=802

Pharmaceutical sector

2.26 The Pharmaceutical industry is an important sub-sector of the Scottish Healthcare sector, and one in which innovation is well supported. Crucially for the wider Scottish economy, the pharmaceutical sector creates jobs and economic output throughout the supply chain, generating a greater impact. Directly, the pharmaceutical sector employs 5,600 jobs in Scotland and supports a wider total of 15,250 FTE jobs across the UK[29]. Estimates state that this supports a total of around £2.5bn output within the Scottish economy and contributes a wider £1.8bn to Scottish GVA.

2.27 However, as previously stated, the manufacturing component of the pharmaceutical industry cannot be discounted from its total economic impact. Therefore, the sector employs an additional 3,850 FTE jobs directly in Scotland and 11,530 FTE jobs are supported across Scotland. This wider look at the sector attributes a further £2.1bn in Scottish output and £1.8bn in national GVA.

Precision medicine

2.28 Precision Medicine is defined as delivery of the right treatment at the right time to the right patient.[30] It involves:

> *"the tailoring of medical treatment to the individual characteristics of each patient… to classify individuals into subpopulations that differ in their susceptibility to a particular disease or their response to a specific treatment… allowing preventative or therapeutic interventions to be concentrated on those who will benefit, sparing expense and side effects for those who will not".*[31]

2.29 Scotland has a well-established ecosystem for Precision Medicine, centred around the Precision Medicine Innovation Centre (previously the Stratified Medicine Scotland Innovation Centre (SMS-IC). As identified by the Scotland's key strengths in Precision Medicine Science and Innovation Audit[32], Scotland's key strengths with regard to Precision Medicine include:

- Queen Elizabeth University Hospital (QEUH), the largest acute hospital in the UK with major specialist services such as renal medicine, transplantation and vascular surgery;
- The Imaging Centre of Excellence (ICE);
- A world-leading electronic health record system;
- World-class universities and research centres led by key figures in Precision Medicine;
- A reputation as one the best locations for the development and clinical trials of treatments and therapies; and
- In excess of 230 companies undertaking Precision Medicine-related activity.
- In addition, in 2020 the Living Laboratory for Precision Medicine at the QEUH was one of seven successful bids in Wave 1 of the UK Research and Innovation Strength in Places Fund.[33]

2.30 Previous market estimates had forecast the Precision Medicine market globally to reach $134bn by 2025, and may reach $175.6bn by 2030.[34] To capture some of this market value, the Precision Medicine Alliance Scotland (PMAS) was established. PMAS was a Programme for Government commitment to support research in Precision Medicine. It aimed to stimulate research and delivery in the NHS of Precision Medicine through specific programmes of work

[29] Fraser of Allander Institute (2021). The Economic Contribution of the Pharmaceuticals Sector in Scotland January 2021
[30] https://www.cso.scot.nhs.uk/precision-medicine-alliance-scotland/
[31] World Innovation Summit for Health (WISH) (2016) Precision Medicine, A Global Action Plan for Impact – Report of the WISH Precision Medicine Forum
[32] https://www.gla.ac.uk/media/Media_639152_smxx.pdf
[33] https://ourscottishfuture.org/wp-content/uploads/2023/02/PRECISION-MEDICINE-V2-SML.pdf
[34] https://www.globenewswire.com/en/news-release/2022/11/07/2549869/0/en/Precision-Medicine-Market-Size-is-Projected-to-Reach-175-6-Billion-by-2030-Registering-a-CAGR-of-11-5-Strategic-Market-Research.html

that will tackle health conditions of major importance in Scotland, including diseases that disproportionately impact on those at risk of socioeconomic disadvantage.[35]

Personalised nutrition

2.31 Personalised nutrition as an industry refers to services and products that involve the provision of individualised targeted dietary advice that is focused on achieving lasting dietary behaviour change that is beneficial to an individual's health. The industry operates at the intersection between health advisory, the wellness sector and the agricultural and food provision sectors. Commercial personalised nutrition services mostly provide advice, purportedly based on the latest scientific evidence showing the causal connections between an individual's characteristics (such as lifestyle factors, age, sex, but also with regards to genes, blood parameters and gut microbe) and their physiological responses to food. Commercial services also include the provision of personalised supplements, vitamins and tailored subscription meal plans.[36]

2.32 Difficulties in quantifying the size of the personalised nutrition market have been noted by the Food Standards Agency, as a result of the sector being an emerging market with large scale investments only becoming more mainstream in the last five or so years, and with its unclear positioning as a market between the health and wellness sector, and the food and nutrition sector.[37]

2.33 However, using the working definition compiled in research undertaken for Scottish Enterprise previously for the "Healthy Eating, Nutrition, & Weight Loss" subcategory of the Wellness Economy, this subsector accounted for 4,353 businesses in Scotland in 2021, employing 40,525 in the sector.[38] This subsector has a current market size (as measured by total spend by consumers in Scotland) of just over £1 billion and has an estimated 5.1% growth rate between 2020-2025. The subsector is expected to contribute £4.1 billion in Gross Value Added (GVA) by 2030.[39]

2.34 Key assets within Scotland's innovation ecosystem with regards to personalised nutrition include:

- the Rowett Institute (University of Aberdeen), which leads on many Scottish Government research programmes in the fields of food in equalities, food security and obesity and has a specialised Human Nutrition Unit which delivers voluntary dietary trials in its research;
- the James Hutton Institute, which considers the sustainable use of land and natural resource, including sustainable solutions for crop production and healthy eating;
- the Industrial Biotechnology Innovation Centre (IBioIC), which is currently investigating emerging biochemistry processes within the food and drink sector;
- the Scottish Centre for Food Development (Queen Margaret University in Edinburgh), which carries out projects in partnership with food and drink companies, industry partners and other academic institutions in product development, consumer insight, sensory analysis and food industry training;
- Food Innovation @ Abertay (Abertay University), which is a practical innovation support service to food and drink businesses. The programme offers solutions to business challenges in the industry through product development and product reformulation, in order to better improve businesses' product ranges and production techniques; and

[35] https://www.cso.scot.nhs.uk/precision-medicine-alliance-scotland/
[36] https://www.food.gov.uk/print/pdf/node/15151
[37] Ibid.
[38] Additional Research (2021) The Economic Opportunity of the Wellness Economy for Scotland for Scottish Enterprise
[39] Unfortunately, no further disaggregation or granularity is available. Whilst there are example companies in each (including Scottish economies) there is no quantified sub-sector breakdown.

- Scotland Food and Drink, an industry-led body that is supported by Scottish Government to reinforce Scotland's reputation as a market leader in the food and drink industry.

Collaboration and partnership working in the Scottish Healthcare ecosystem

2.35 As mentioned, the Digital Health and wider Life sciences clusters are well supported in Scotland to aide further growth and innovation. Understanding the importance of the triple helix, multiple cross sector groups and partnerships have been established to support numerous areas of the sector. The Life sciences Scotland Industry Leadership Group (ILG) is an example of this, working across industry and education, the subgroup focuses on developing and promoting life science technical skills to address skills and labour demand in this emerging sector.

2.36 In supporting the growth of the sector, there has been an emphasis on creating interconnectedness and nurturing innovative solutions for a growing number of subsectors. The Scottish Health Innovation Partnerships (SHIP) is an example of this sector management, acting as a liaison service between NHS Scotland and the Life sciences industry, to promote Healthcare innovation and its importance for both the Scottish economy and an improved Healthcare service.

2.37 As there is a broad definition of health, there are a wider range of intersecting and overlapping subsectors within Digital Health and Healthcare innovation. Due to a number of factors such as clusters and the intersecting nature of the subsectors, Scotland has been successful in promoting the cross fertilisation of ideas. This success has allowed a greater degree of oversight and planning throughout the sector and across the triple helix of government, academia and industry. This has been described as applying a system-wide lens to align infrastructure, business growth, supply chains and technologies to support innovation and the emerging sub-sectors. This has enabled Scotland to develop clusters in specialised areas of digital health/ Healthcare innovation, whilst being supported within the wider sector umbrella. According to current Office for Life sciences statistics, in 2021/22 Scotland was home to c.7% of all UK Life Science businesses, and around 8% of all Biopharmaceutical businesses.[40]

2.38 With the success of Digital Health and Healthcare innovation in Scotland, it has encouraged an uptake in health adjacent sectors. As almost 200,000 people work in Healthcare in Scotland, it has encouraged innovation and investment within the Digital Health and Care sector, which has grown to employ around 7,000 people. This workforce is supplemented by an annual pipeline of 70,000 graduates and 17,000 graduates with Digital Health expertise[41]. This ecosystem is supported by the Digital Health Doctoral Training Centre in Edinburgh and the wider UK having three of the four top universities globally for health, clinical and preclinical studies.

[40] https://www.gov.uk/government/collections/bioscience-and-health-technology-database-annual-reports
[41] https://strathprints.strath.ac.uk/65383/1/Rimpilainen_DHCI2016_Digital_Health_Economy_in_Scotland.pdf

3 Components of a successful health ecosystem

Introduction

3.1 There are many components to a successful and well-functioning Health innovation ecosystem and most economies have some or all of these to a greater or lesser degree. This Chapter discusses the key elements of what constitutes a successful Health innovation ecosystem and then goes on to explore the role of Digital Health innovations within the ecosystem and how the benefits of these digital innovations can be maximised. Health innovations can greatly enhance the quality, breadth and efficiency of a Healthcare system.

Components of a successful health ecosystem

3.2 The ecosystem concept initially emerged as a means of explaining and managing innovation, business growth and entrepreneurship at a regional level. In his 2010 paper 'The Big Idea: How to start an entrepreneurial revolution', Isenburg described a start-up ecosystem as:

> *"a set of networked institutions […] with the objective of aiding the entrepreneur to go through all the stages of the process of new venture development. It can be understood as a service network, where the entrepreneur is the focus of action and the measure of success".*[42]

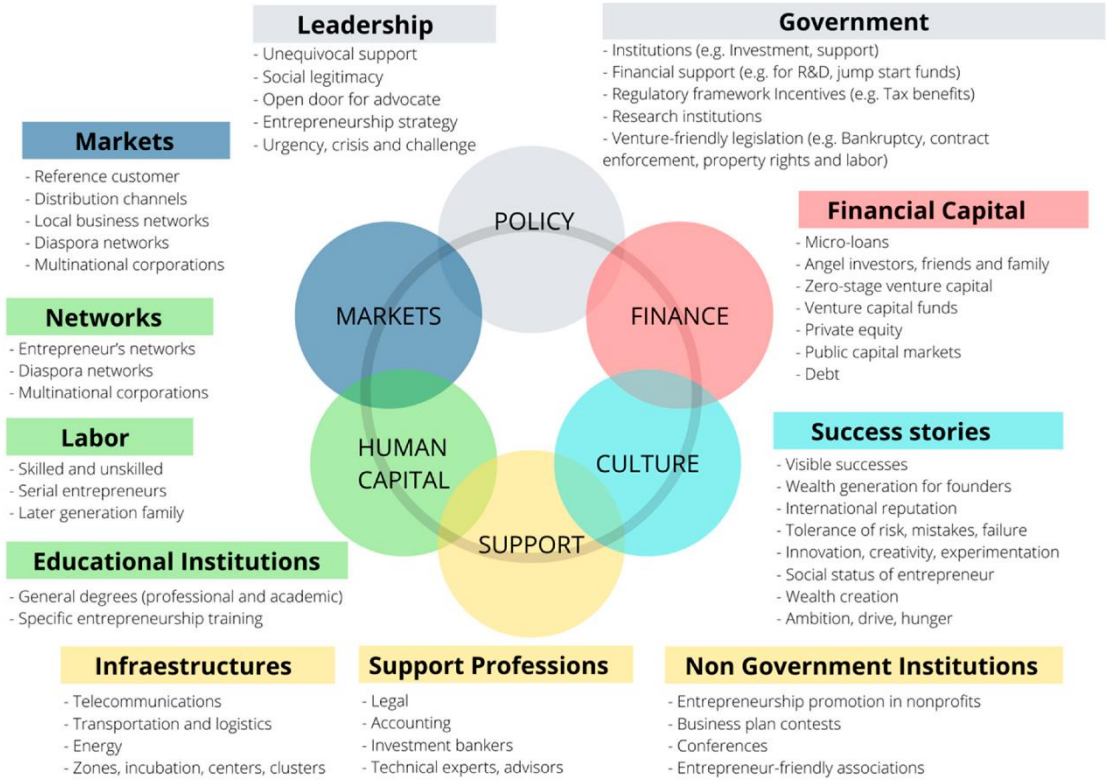
The diagram below shows how Isenburg conceptualised the ecosystem, in this case for a startup ecosystem, which is applicable to health innovation start-up businesses, and more widely to the whole health innovation ecosystem.

3.3 At the centre of the diagram is the entrepreneur (and their team), who create a start-up business with the ambition to grow it. The supporting environment (the ecosystem) has two levels:

- **Contextual factors (Level 1)** that differ in each region and determine the conditions in which activities take place. These factors can be divided into political and legal framework; the cultural and institutional environment; and economics and regional dynamics.
- **The actors that support the entrepreneurs (Level 2)**. These actors can be divided into different areas including research (universities and laboratories); public support (business support and grant providers); and professional support (management consultants, legal firms and accountants). Good ecosystems have symbiotic relationships between actors.

[42] Isenberg, D. J. (2010). The big idea: how to start an entrepreneurial revolution. Harvard Business Review, 88, pp.40–50; further developed in: Isenberg D (2011) The entrepreneurship ecosystem strategy as a new paradigm for economic policy: principles for cultivating entrepreneurship. Presentation at the Institute of International and European Affairs, Dublin, 12 May 2011

Figure 3.1: Innovation ecosystem conceptualisation



Source: Morant-Martinez et al., 2019[43], based on Isenberg, 2010, 2011

3.4 There are various schools of thought on how to create and enable business support ecosystems, varying from **top-down approaches** where governments seek to create ecosystems and focus on specialist inputs, including technology parks or innovation hubs (but which may crowd out the private sector) and **bottom-up approaches** focused on fostering cultural change towards a founder-friendly environment.[44]

3.5 McKinsey, in their 2015 article *The Eight Essentials of Innovation*[45], identify eight elements that are required for successful innovation. These can be applied to any innovation ecosystem including Healthcare, although the factors are best suited to tests for innovation in individual firms. McKinsey argue the first four (aspire, choose, discover, evolve) are strategic and creative in nature, whereas the second four (accelerate, scale, extend, mobilise) are associated with how to deliver and organise for repeated innovation over time, with sufficient value to contribute and increase overall performance.

[43] Morant-Martinez, O. et al. (2019) Ecosystem Model Proposal in the Tourism Sector to Enhance Sustainable Competitiveness, Sustainability 2019, 11(23), 6652; https://doi.org/10.3390/su11236652
[44] 'In Innovation Quest, Regions Seek Critical Mass' (Regalado, 2013) Fiona Murray, professor at the MIT Sloan School,
[45] https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/the-eight-essentials-of-innovation

Table 3.1: McKinsey's Eight Essentials of Innovation

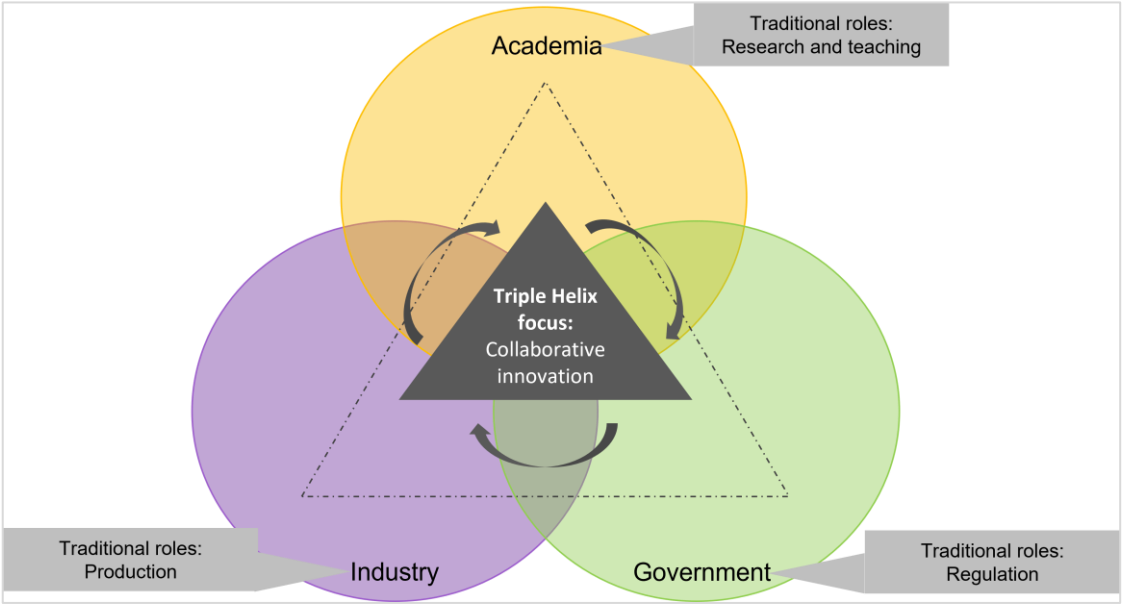
Component	Testing for Innovation
Aspire	Is innovation-led growth regarded as critical and are there cascaded targets that reflect this?
Choose	Is there investment in a coherent, time- and risk- balanced portfolio of initiatives with sufficient resources?
Discover	Are there differentiated business, market and technology insights that translate into value propositions?
Evolve	Are new business models created that provide defensible and scalable profit sources?
Accelerate	Are innovations developed and launched quickly and effectively?
Scale	Are innovations launched at the right scale in relevant markets and segments?
Extend	Are external networks capitalised on?
Mobilise	Are people motivated, rewarded and organised to innovate repeatedly?

Source: McKinsey, 2015

3.6 Although a little abstract – and based more at an individual firm level – the eight essentials introduce the requisite components of a successful Health innovation ecosystem. There needs to be the initial aspiration and recognition that innovation-led growth is critical (in policy-on scenarios) as the 'aspire' and a mix of innovation investment (the 'choose'). Research and insight (the 'discover') is required to inform innovation policy and new business models must be created and supported to 'evolve' innovation-led action.

3.7 What is clear from the work of Isenberg on the innovation ecosystem – and the essentials of McKinsey – is that different parts of the ecosystem must come together in ways that are mutually supportive and reinforcing. In term of Health innovation ecosystem, there have traditionally been three key pillars: Academia; Industry; and Government, the so-called Triple Helix.[46] The triple helix framework highlights the interactions between academia, industry and government that foster economic and social development and can give rise to new intermediary institutions (such as the Innovation Centres in Scotland).

Figure 3.2: The Triple Helix: Government – Industry - Academia



Source: Etzkowitz and Leydesdorff, 1995

[46] Etzkowitz, H. and Leydesdorff, L. (1995) The Triple Helix – University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development.

3.8 The following table sets the key roles of each of the three key players in a health/Healthcare innovation ecosystem. NHS Scotland as a Health and Care provider is a public sector organisation, but also has some functions in common with industry (e.g. product and technology development, purchasing, creation of spinouts, etc.)

Table 3.2: Key Drivers within the Triple Helix

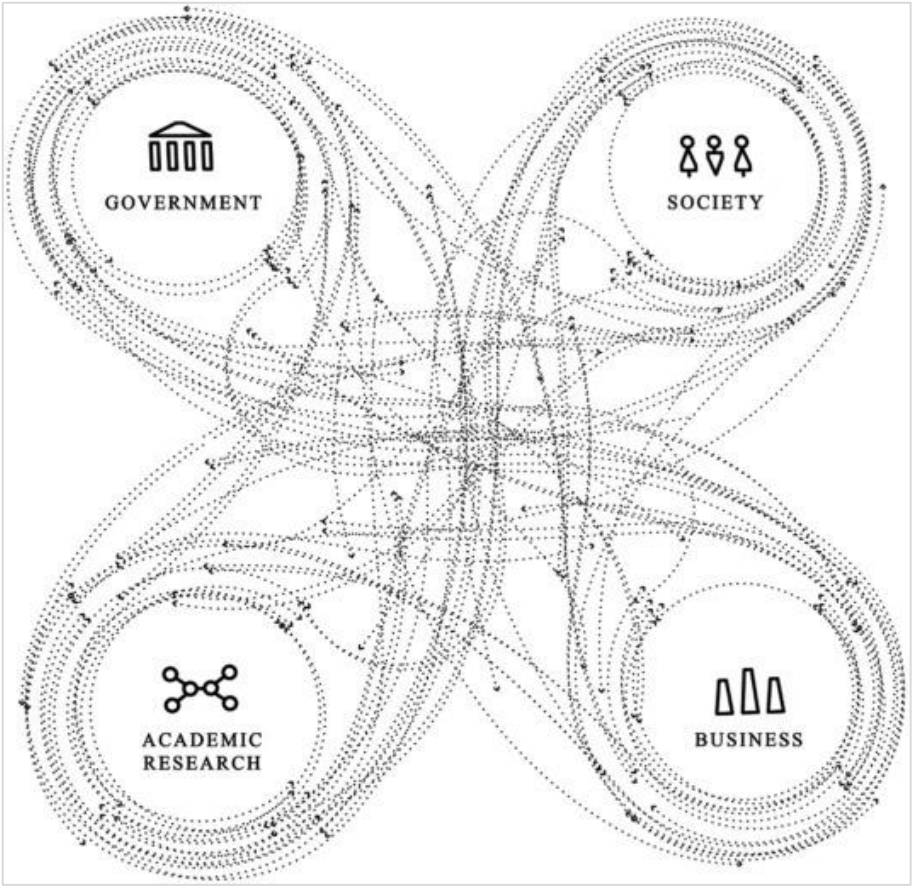
Health & Care (Public sector)	Industry	Academia
Partners with industry to co-develop products and new technologies	Partners with Healthcare to co-develop products and new technologies	Partners with industry to co-develop products and new technologies
Partners with academia to co-develop products and new technologies	Partners with academia to co-develop products and new technologies	Partners with Health & Care to co-develop products and new technologies
Develops new products internally	Develops new products internally	Develops new products internally
Adopts new technologies	Purchases from Scotland (and elsewhere) / has a supply chain	Purchases from Scotland (and elsewhere)
Purchases from Scotland (and elsewhere)	New companies are founded	Creates spinouts
Creates spinouts	Employs people	Employs people
Employs people	Receives some government funding (grants etc.)	Consumes government budget
Provides care & treats patients		
Consumes government budget		

Source: Scottish Enterprise, 2023

3.9 The Triple Helix Government-Industry-Academia framework has been extended to include the public, consisting of civil society and the media.[47] This adaptation seeks to bridge the gap between innovation and civil society, and it claims that under the triple helix model, the emerging technologies do not always match the demands and needs of society, thus limiting their potential impact. The framework consequently emphasises a societal responsibility of universities, in addition to their role of educating and conducting research.

[47] Carayannis and Campbell (2009) Mode 3 and Quadruple Helix: toward a 21st century fractal innovation ecosystem.

Figure 3.3: The Quadruple Helix: Government – Industry – Academia – Society

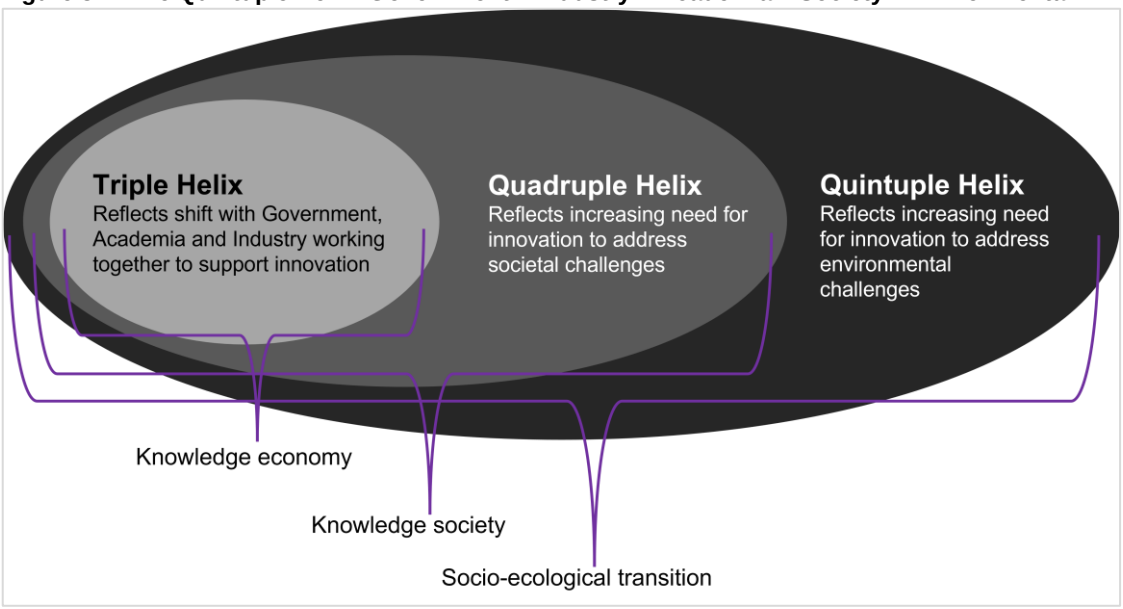


Source: Carayannis and Campbell, 2009

3.10 A further adaptation sees the introduction of a fifth element representing the natural environment.[48] This quintuple helix thereby acknowledges the role of innovation in addressing critical issues relating to sustainable development, including climate change. These are embedded in Scotland's policy and delivery environments, and thus Scotland's ecosystem – for example, NHS Scotland's net zero targets with regard to Healthcare requirements for public/patient benefits.[49] A figure demonstrating the extension of the models over time is indicated is below.

[48] Carayannis and Campbell (2012) The Quintuple Helix innovation model: global warming as a challenge and driver for innovation'.
[49] https://www.gov.scot/publications/nhs-scotland-climate-emergency-sustainability-strategy-2022-2026/pages/6/

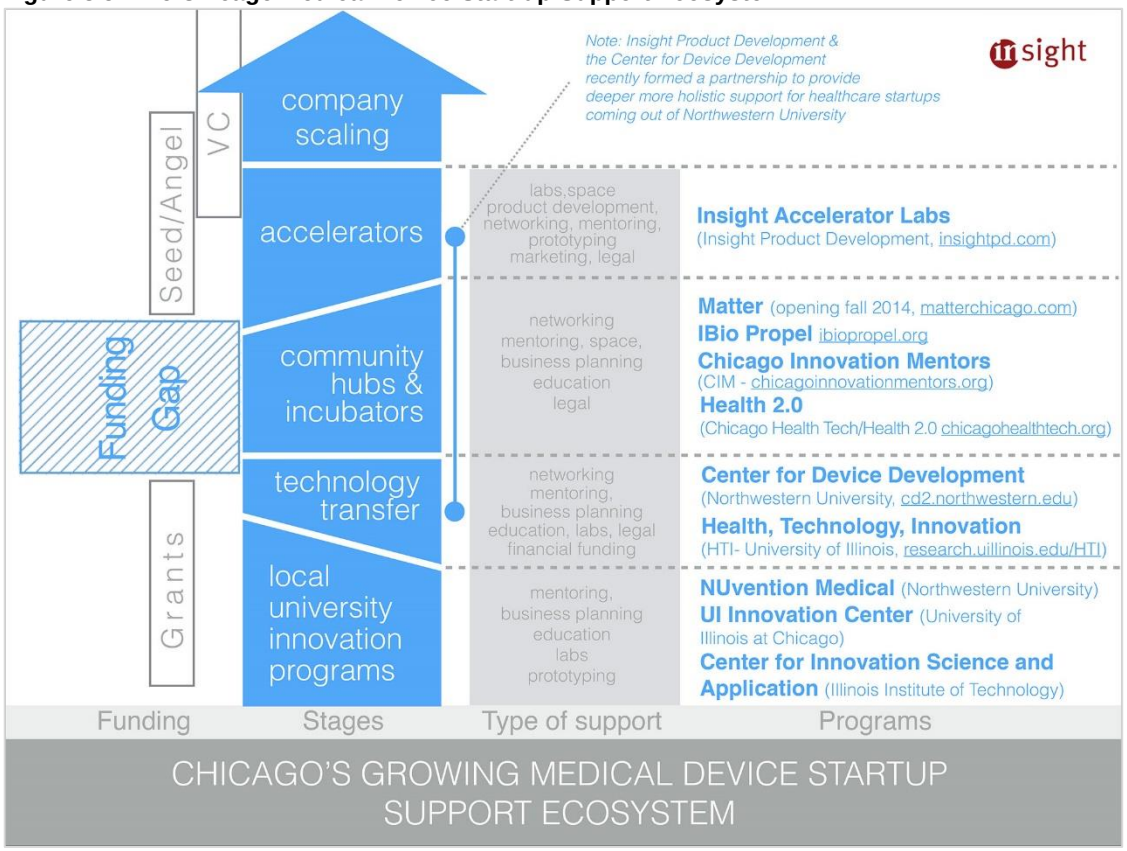
Figure 3.4: The Quintuple Helix: Government – Industry – Academia – Society - Environmental



Source: Adapted from Carayannis and Campbell, 2012

3.11 It is clear that the industry-government-academia triple helix is critical to collaborative innovation, within the context of the fourth and fifth dimensions of society and the environment. Operationalising Healthcare innovation requires key components. The Chicago Medical Device start-up support ecosystem remains a good model for growing innovative companies in a Healthcare setting, with key components access to finance, University programmes and support for technology transfer and incubators. Government support underpins the model which includes accelerators and company scaling to grow companies of greater size and impact.

Figure 3.5: The Chicago Medical Device Start-up Support Ecosystem



Source: Nemera Insight PD, 2023

Good practice in innovation and collaboration

Israel

3.12 In January 2021, Israel implemented Health Level 7 (HL7 ®) Fast Healthcare Interoperability Resources (FHIR) V4 standards across its healthcare system.[50] This was done in response to issues of increasingly decentralised and fragmented health data, data flow challenges caused by a lack of consistency in data coding standards, and the compounding of challenges by the COVID-19 pandemic. The aim of the FHIR was to improve interoperability and the exchange of information in a standardisation of data processed and sharing across the Healthcare system. The introduction of the FHIR has given rise to an open FHIR community managed by 8400 The Health Network, a leading HealthTech network of Israeli leaders in the public and private sector.[51] This has stimulated the development of a series of collaborative projects focused on areas including: healthcare staff-patient communication; digital prescriptions and efficiency in medication approval; increased effectiveness of health insurance reimbursement processes for health management organisations; and cross-platform data sharing to support home treatment.

New Zealand

3.13 A good example of a private company developing a digital health solution in collaboration with the healthcare system is the Sparx app in New Zealand.[52] This uses gamification to improve teen mental health. The app that has been developed using funding through the Prime

[50] https://www.who.int/docs/librariesprovider2/default-document-library/israel-advancing-interoperability-and-data-sharing-in-the-health-system-(2021).pdf?sfvrsn=b87efb41_1&download=true
[51] https://www.8400thn.org/
[52] https://www2.deloitte.com/us/en/insights/industry/health-care/digital-health-technology.html

Minister's National Youth Mental Health Initiative. The Sparx app uses cognitive behavioural therapy to assist teenagers with mild to moderate depression and anxiety. Teenagers sign up and play as avatars exploring a 3D world to complete game challenges. The app tracks each player's progress through administering a patient health questionnaire, PHQ-9 (a validated mental health assessment tool) as the player progresses.[53] In 2021, a second version was launched (Sparx 2.0), with improved support for Māori, Pacific Island and LGBTQI+ adolescents.[54]

3.14 This demonstrates the value of private-public collaboration through demand-led innovation challenges to drive improvement in Healthcare provision. The successes of the Sparx app also demonstrate the effectiveness of consumer/patient engagement and self-help in improving health outcomes as part of the innovation process.

Role of innovation in Healthcare

3.15 Within a successful overall Healthcare ecosystem, the role of Health innovation is critical. It is clear the Healthcare innovation system must bring together to the expertise of academia with industry (through two-way knowledge and technology transfer) brokered, facilitated and nurtured by Government intervention. Innovation in healthcare delivers a wide range of benefits, from improved patient outcomes, to cost savings and efficiency gains in delivering healthcare to developing new skills and approaches in healthcare.

3.16 Health and Digital Health innovations are at the very interface of the Triple Helix – the space where innovation is the most intensive (cutting edge) and extensive (happening across a range of activities and disciplines in Healthcare). In Scotland, Digital Health innovations bring together the academic and industry expertise in Healthcare (including leading R&D, for example in cancer) with leading expertise in digital, data and AI. Scotland has some leading expertise in the digital/data sphere, from the work of The Data Lab Innovation Centre, leading industry players and additional Higher Education Institutes.

3.17 It is this coming together that allows the application of technology and digital processes in the Healthcare sector. As Chapter 2 highlights, this is typically involving the use of computing platforms, connectivity, software, and sensors, etc., for Healthcare and related uses.[55] As Chapter 2 also highlights, innovation in Healthcare is a critical means for improving Healthcare provision and health outcomes, reducing inefficiencies in Health and Care delivery and making Healthcare more person-centred and personalised, a key growth sub-sector within Healthcare. Healthcare innovation involves new/improved product, process and service development (invention) led by industry/academia (supported by Government) and its application (adoption) in the healthcare system through clinicians and allied staff. To be of maximum benefits this then needs rolled out more widely (diffusion). This invention-adoption-diffusion approach has been well articulated by Kelly and Young in Promoting innovation in healthcare (2017).[56].

3.18 Health innovation interventions therefore bring benefits for the economy in terms of business growth and enterprise (direct benefits) in the form of increased GVA, employment, productivity, exports and innovation-led start-ups. The interventions also bring savings in the provision and efficiency of Healthcare in the form of reduced costs of Healthcare provision and lower unit costs of treatment, particularly through the use of data/AI and person-centred approaches (indirect benefits). Further, Health innovations bring benefits to people and society in terms of health and wellbeing (social benefits). By investing in innovation in healthcare

[53] https://patient.info/doctor/patient-health-questionnaire-phq-9
[54] http://oro.open.ac.uk/86788/3/10398562231153061.pdf
[55] https://www.fda.gov/medical-devices/digital-health-center-excellence/what-digital-health
[56] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6502619/

there are better patient outcomes at lower cost which allows greater investment in innovation in a “virtuous cycle” of improvements.

Summary

3.19 A model Healthcare innovation ecosystem brings together industry and academic expertise, facilitated, nurtured and supported by Governments and their agencies. The ecosystem supports start-up, innovation and growth in Healthcare businesses through bringing together the key components of success identified in this Chapter, notably access to finance, people/skills and networks. An effective ecosystem is one where the various components are mutually reinforcing, one that helps support growth in Healthcare businesses (economic drivers) with benefits for people and society (health and social).

3.20 The economic benefits from Digital Health interventions are expressed in terms of traditional economic indicators (GVA, jobs, productivity), the direct benefits, whereas benefits arising from better Healthcare are typically measured in terms of cost savings for patient care, the indirect benefits. Social benefits are also significant, with digital Healthcare interventions having the potential to help provide solutions leading to happier and healthier citizens. The benefits of the Healthcare innovation system can thus be disaggregated into direct, indirect and social impacts. These are covered in the next Chapter.

4 Segmenting health costs and impacts

Introduction

4.1 The following provides a summary of the developing approach to modelling Health innovation impacts. This is very much a work-in-progress, and the power of the model will come in furthering the robustness of assumptions and added depth and detail to the impacts, particularly attributable indirect benefits. The Health innovation sector is broad and itself touches on many sectors (digital/AI, pharma manufacturing, etc.) so that even fully identifying direct impacts represents considerable challenges.

Health impact segmentation

Direct impacts

4.2 Direct impacts of health and Healthcare innovation typically relate to conventional measures of economic impact, such as the ones below:

- Number of businesses;
- Employment (increased or safeguarded);
- Turnover (increased or safeguarded);
- Gross Value Added (GVA);
- R&D (Business Expenditure on R&D; BERD);
- Exports; and
- Start-ups.

Size of the market

4.3 Several research organisations provide a market value for the Health innovation sector (or aspects of it, such as digital health). These market estimates are the value of Business to Consumer (B2C) sales of products and services. For example, one source for the B2C value of the Digital Health market include Digital Fitness & Wellbeing Apps and Devices, eHealth Apps and Devices, Online Pharmacy and Online Doctor Consultations. It is worth noting that overall Healthcare expenditure does not necessarily translate to increased economic benefit or Healthcare outcomes.

4.4 Indications of the size of the market are given below. For example, global Healthcare expenditure was estimated at $8.3tn globally in 2018. Expenditure in Digital Health globally could be worth $981.5bn by 2032 (£804bn). In the UK (using the Deloitte estimate of the UK share of the global market), this could be £54bn by 2032 (UK).

4.5 Example sources of market size data are set out below. This gives an indication of scale of the market opportunity for Scottish businesses.

Table 4.1: Estimates of Healthcare market segment values

Segment	Value	Source
Healthcare expenditure, UK (£, 2022)	283,000,000,000	ONS, 2023 https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/Healthcaresystem/bulletins/Healthcareexpenditureukhealthaccountsprovisionalestimates/2022
Health expenditure, Global ($, 2018)	8,300,000,000,000	WHO, 2020 https://www.who.int/publications-detail-redirect/9789240017788
Global Healthcare services market ($, 2024)	8,963,640,000,000	TBRC, Healthcare Services Global Market Report 2024 https://www.thebusinessresearchcompany.com/report/healthcare-service-global-market-report
Digital Health Global ($, 2024)	379,000,000,000	July 2019 report, forecast for 2024 Global Market Insights
Digital health, Global ($, 2032)	981,500,000,000	2023 Global Market Insights report https://www.gminsights.com/pressrelease/digital-health-market
Precision Medicine, Global ($, 2028)	118,000,000,000	2024 Research and Markets report https://www.researchandmarkets.com/reports/5939371/precision-medicine-global-market-report
Digital health, Global (£, 2014)	43,000,000,000	Deloitte 2015 report; forecast for 2018 *UK estimated share of global market = 6.74%*
Digital health, UK (£, 2018)	2,900,000,000	Deloitte 2015 report; forecast for 2018
Digital health, UK (£, 2024)	3,280,000,000	July 2019 report, forecast for 2024 Global Market Insights - cited in https://digitalhealth.london/investing-in-the-digital-health-sector
Digital health, UK (£, 2023)	3,337,400,000	https://www.statista.com/outlook/dmo/digital-health/united-kingdom *This is revenue for B2C businesses - largest = digital fitness & wellbeing*
Digital health, UK (£, 2027)	4,715,000,000	https://www.statista.com/outlook/dmo/digital-health/united-kingdom *This is revenue for B2C businesses - largest = digital fitness & wellbeing*
Precision medicine Global ($, 2023)	29,100,000,000	Markets and Markets, 2023 https://www.marketsandmarkets.com/Market-Reports/precision-medicine-market-215185595.html
Precision medicine Global ($, 2028)	50,200,000,000	Markets and Markets, 2023 https://www.marketsandmarkets.com/Market-Reports/precision-medicine-market-215185595.html

Defining the sector

4.6 As with the size of the market, for the direct impacts (jobs, GVA etc.) the value will vary according to the definitions used. Definitions are readily available through SG Growth Sector statistics, and the UK Office for Life Science (OLS) database. The Campbell Report also provides a definition.

4.7 The Life sciences sector information is provided in the Scottish Government Growth Sector database. The business base is estimated at 590 in 2023 (down from 605 in 2022), with total employment at 23,000 (at 2022 figures; latest available).

Table 4.2: Health Innovation Life sciences & HealthTech sector – size and value; SG Growth Sector statistics (December 2023 publication)

Metric	Value	Date
Number of businesses	590	2023 data, updated December 2023
Employment	23,000	2022 data, updated November 2023
Turnover	£4,060,200,000	2021 data, updated August 2023
GVA	£2,223,700,000	2021 data, updated August 2023
R&D (Business Expenditure on R&D – BERD)	£366,000,000	BERD, 2020 (not being updated currently)
Exports	£1,820,000,000	2019 data, updated November 2021
Start-ups	50	2021 starts, March 2023 data

Source: Scottish Government Growth Sector Database, 2024

4.8 Contrasting data is available through the OLS. This places the Life sciences business base (across Biopharmaceuticals and Medical Technology) at 509, with employment at 18,664 in 2021/22. Estimated turnover is higher, at £6.995 billion. Both OLS and SG Growth Sector data is calculated using their own sourcebooks for Life sciences companies; SG Growth Sector data also draws on SIC codes to inform calculations.

Table 4.3: Health Innovation Life sciences sector – size and value; OLS statistics, 2021/22

Metric	Value
Number of businesses	509
Employment	18,664
Turnover	£6,994,872,000

Source: Office for Life sciences, 2023

4.9 The Campbell Report adopts the following definition for what it terms the ***Health Innovation Life sciences & HealthTech*** sector[57]:

Table 4.4: Health Innovation Life sciences & HealthTech sector definition

Pharmaceutical Innovation	Health Technology
Advanced Therapies & Vaccines	Digital health
Precision Medicine	AI and Data Driven Innovation
Health Informatics	Innovation Landscape
Digital Process & Manufacturing	Image & Diagnostics
Drug Discovery & Clinical Research	

Source: Scottish Government, 2021

4.10 In quantifying the sector in the web-based summary, the report uses the Life sciences sector, itself defined as using Standard Industrial Classification (SIC) codes (as below) plus additional sourcebook matching of Life sciences sector known to Scottish Enterprise:

Table 4.5: Health Innovation Life sciences & HealthTech sector SIC code definition

SIC 21: Manufacture of basic pharmaceutical products and pharmaceutical preparations
SIC 26.6: Manufacture of irradiation, electromedical and electrotherapeutic equipment
SIC 32.5: Manufacture of medical and dental instruments and supplies
SIC 72.11: Research and experimental development on biotechnology
SIC 72.19: Other research and experimental development on natural sciences and engineering
Plus - sourcebook 'matching' by SE – 2014 and 2022

Source: Scottish Government, 2021

[57] https://www.gov.scot/publications/campbell-report-roadmap-investment-health-innovation-life-sciences-healthtech-scotland/

4.11 It should be noted, however, that even the Campbell Report (main report) includes a proportion of Chemical Sciences in estimating the size of the Health innovation sector, namely 'Pharmaceutical services', so that employment in the sector is given as 40,000.

4.12 Further, the Campbell Report definition may still underplay the full extent of the Health Innovation sector. For example, Personalised Nutrition is estimated to be 10% of the global Food & Drink market (Global Wellness Institute). Applied to Scotland, this is an additional 1,750 businesses, and 12,200 jobs. The Wellness Economy is drawn more widely still, with an estimated market value in Scotland of some £6.6bn. This includes relevant markets such as Public Health, Prevention, & Personalised Medicine at £356m, although other parts of the Wellness Economy (e.g. Wellness Tourism, Personal Care & Beauty) are less relevant.

4.13 There is also data on subsets of the sector. For example, the Scottish Health Research & Innovation Ecosystem (SHRIE) Database (which seeks a bottom-up assembly of the health innovation ecosystem) names 156 organisations, and this includes research organisations, many of which exist to support health innovation in Scotland. This captures over one quarter of the size of the Life sciences sector.

Indirect impacts

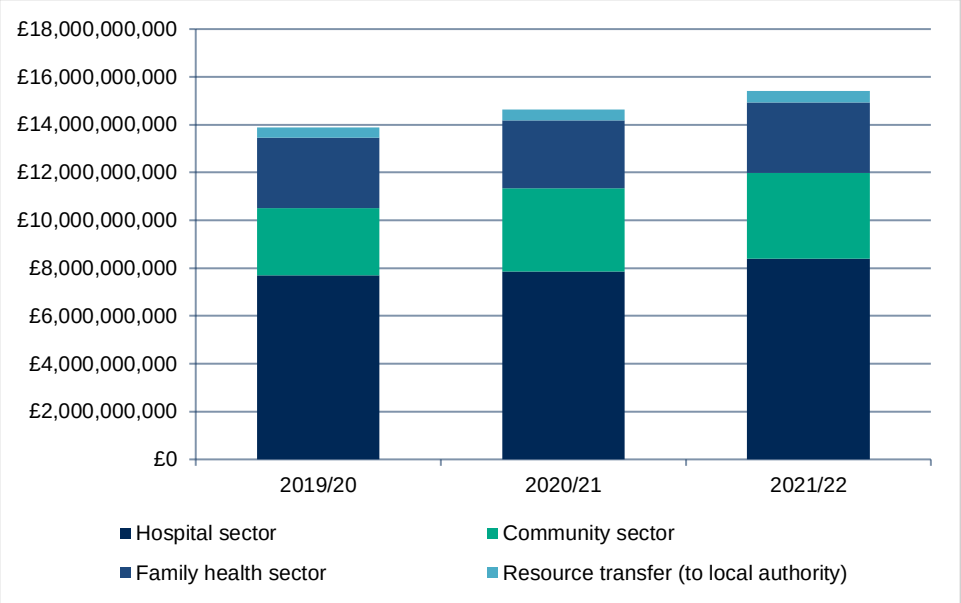
4.14 Indirect impacts typically relate to the cost savings achieved from implementing Health innovation solutions. The key to identifying indirect impacts is establishing the relationship between health benefits (and the cost savings associated with this) and innovation activity in Scotland's Health sector – as well as that of the Health innovation sector specifically, i.e., **which of the potential cost savings are attributable to Health innovation activity, and the Health innovation sector**. This is where the concept of the logic chain comes into play – more advanced or innovative therapies and vaccines (Pharm Innovation) translate into x health benefits with a cost saving (or treatment) of y.

NHS Scotland expenditure

4.15 NHS Scotland expenditure data presents the total spend on Healthcare in Scotland, across different Healthcare sectors. The overall expenditure in NHS Scotland in 2021/22 was £15.4bn, up by c.11% in real terms (c.16% increase in cash terms) from 2019/20 expenditure (Figure 4.1). Much of the overall increase in NHS spend within Scotland over the period has been driven by an increase in spend within the Community sector (+29% increase (real terms; +36% in cash terms) from 2019/20 to 2021/22). It is worth noting that this is only a portion of Healthcare spend, as it does not include local government spend on Healthcare. In addition, it does not include private Healthcare expenditure or individual consumer product purchases. However, it is worth giving due cognisance to the size of health service – both staff costs and NHS Scotland costs associated with the Community sector are more than the total turnover of the Life sciences sector. In addition, the NHS Scotland workforce, at around 158,400, is significantly larger than for Life sciences.[58] Given the scale of NHS Scotland spending and size of its workforce, it is a reasonable assumption that the impact of implementing innovations in Healthcare within NHS Scotland could be sizeable – and such indirect impacts would certainly be comparable with direct impacts as discussed in the previous section.

[58] https://turasdata.nes.nhs.scot/data-and-reports/official-workforce-statistics/all-official-statistics-publications/05-december-2023-workforce/

Figure 4.1: High-level NHS costs, NHS Scotland, 2019/20 – 2021/22 (real term value)



Source: Public Health Scotland – NHS Scotland health service costs for financial year 2021/22 High-level costs summary (2023)

4.16 Hospital expenditure accounted for over half (54%) of NHS Scotland spend. Key spend lines within Hospital sector expenditure include staff costs, pharmacy services and administration (Table 4.6).

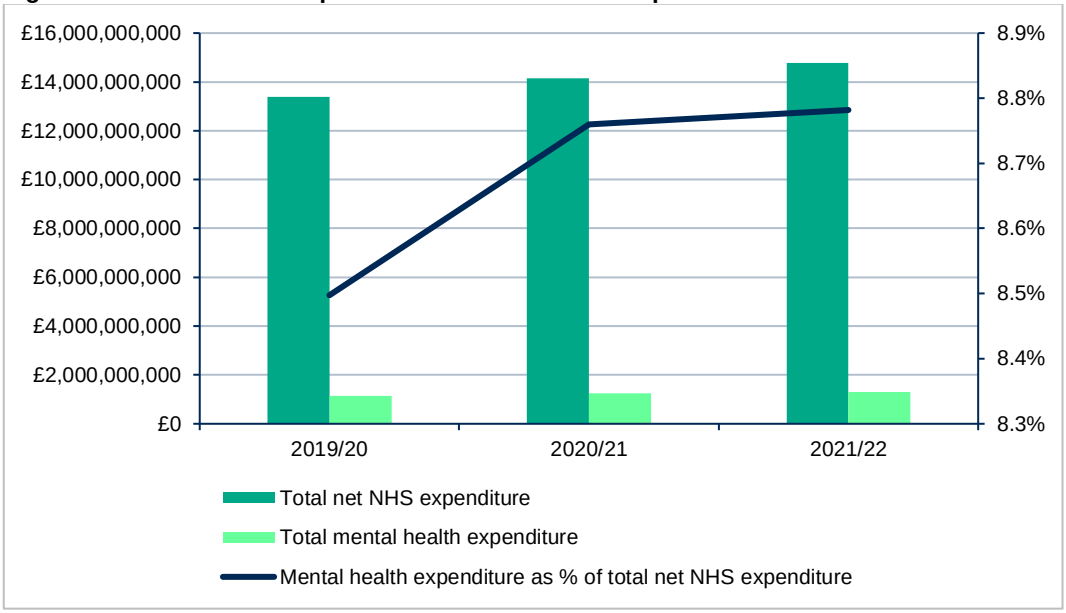
Table 4.6: Key Hospital sector expenditure lines, 2021/22

Total staff costs	£5,737,210,876
Pharmacy services	£1,067,095,067
Administration	£681,622,351
Facilities	£688,047,475
Cost of teaching and research	-£105,619,948

Source: Public Health Scotland – NHS Scotland health service costs for financial year 2021/22 High-level costs summary (2023)

4.17 Across all NHS Scotland spend, expenditure on Mental Health services and treatment totalled c.£1.29m in 2021/22. This accounted for around c.9% of all NHS Scotland spend, a proportion that has been increasing in recent years.

Figure 4.2: Mental health expenditure as % of net NHS expenditure



Source: Public Health Scotland – Mental Health expenditure 2021/22 (2023)

Cost of intervention and unit costs of services

4.18 NHS Scotland expenditure evidence also provides the net cost per case of particular surgical, medical and maternity interventions. As Table 4.7 shows, the cost per case ranges from c.£80 for a day case to almost £29,000 for an inpatient case. However, this does not present the total cost of treatment per case, but rather that of a single medical or surgical intervention. It is likely that a programme of treatment for a given health condition will incur a series of costs across the hospital, primary/family health and/or community Health sectors. Whilst there is a good range of data on NHS Scotland expenditure, there is limited information on whether this expenditure – and expenditure in terms of cost per case – is comparatively high or low. Nevertheless, the pathway to improvement – and thus cost reduction is either:

- Measures to reduce the costs of service, e.g. more cost-effective treatments, or the ability to deliver care as day or outpatient cases instead of inpatient cases; or
- The means to lower total case numbers, e.g. through preventative medicine, exercise, nutrition, etc. or more effective treatments.

4.19 It is also worth considering that many of the cases requiring treatment could be considered avoidable – that is, they are a result of negative externalities such as over-consumption, pollution, inactive and sedentary lifestyles. In many instances, these costs are not paid for by the industries or actors responsible for or contributing in some way to the illnesses, conditions, etc. requiring treatment. For example, recent research indicates that the global incidence of cases of non-communicable diseases (NCDs) would reach almost 500 million by 2030 in the absence of a change in physical inactivity, resulting in costs of around $520 billion. It concluded that this health and economic burden of physical inactivity is avoidable.[59] Similarly, the UK Government Health and Social Care Secretary highlighted research that estimated up to 40% of NHS costs go towards treating avoidable conditions.[60]

[59] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9748301/
[60] https://www.gov.uk/government/speeches/together-we-can-revolutionise-the-nhs-through-individual-responsibility

Table 4.7: Cost per case of specialist surgical, medical and maternity interventions

Acute speciality	Net inpatient expenditure (£000s)	Inpatient cost per case (£)	Net day case expenditure (£000s)	Day case cost per case (£)	Net outpatient expenditure (£000s)	Outpatient cost per case (£)
Accident & Emergency	12,829	972	-	-	228,648	133
Acute Other	2,947	5,012	-	-	2,115	128
Cardiac Surgery	49,698	8,355	<1	621	1,506	142
Cardiology	103,461	3,430	19,997	1,499	25,624	143
Clinical Genetics	-	-	-	-	6,195	342
Clinical Oncology	51,189	6,883	27,511	969	34,227	256
Communicable Diseases	17,736	3,335	2,576	950	8,715	224
Coronary Care Unit	39,694	1,910	-	-	-	-
Dental	142	2,191	3,952	673	20,104	134
Dermatology	3,510	5,358	308	915	58,365	126
Ear, Nose & Throat	47,755	2,679	19,158	1,487	29,006	121
Gastroenterology	53,074	2,939	27,842	665	46,955	209
General Medicine	544,917	1,682	7,742	619	38,060	211
General Practice	106,493	7,248	880	274	1,406	76
General Surgery (excl. Vascular)	350,874	2,814	84,840	1,017	57,426	151
Geriatric Assessment	388,532	4,559	-	-	10,855	182
Gynaecology	62,625	2,651	22,150	1,116	36,519	165
Haematology	68,870	8,520	44,476	804	47,006	152
High Dependency Unit	88,912	2,459	-	-	-	-
Intensive Care Unit	163,584	8,872	5,167	873	8,219	149
Maxillofacial Surgery	23,650	5,587	6,416	1,134	8,368	118
Medical Oncology	30,222	7,688	49,179	1,212	54,639	734
Medical Other	22,156	6,359	4,508	1,057	34,871	175
Medical Paediatrics	76,935	1,236	1,779	579	21,471	169
Nephrology	46,477	5,264	732	532	14,853	191
Neurology	31,351	6,023	6,379	1,025	25,012	180
Neurosurgery	68,851	8,056	573	810	3,254	162
Obstetrics GP	2,661	7,646	-	-	78	34
Obstetrics Specialist	184,144	2,385	13,635	585	35,680	115
Ophthalmology	15,991	3,380	74,178	1,500	81,128	150
Oral Surgery & Medicine	4,638	5,820	5,872	1,556	7,536	115
Orthopaedics	350,506	5,179	41,479	1,648	62,684	127
Plastic Surgery & Burns	48,360	4,929	13,998	1,246	13,834	127
Rehabilitation Medicine	35,063	19,234	<1	405	3,187	234
Respiratory Medicine	80,491	2,515	4,295	935	31,806	211
Rheumatology	9,633	3,724	4,964	1,187	28,196	178
Special Care Baby Unit	86,505	12,265	-	-	-	-
Spinal Paralysis	8,178	28,695	-	-	-	-
Surgical Paediatrics	16,171	3,947	3,921	1,498	2,231	138
Thoracic Surgery	16,789	4,249	<1	80	750	143
Urology	77,742	2,512	28,303	767	25,963	126
Vascular Surgery	46,502	5,229	4,017	1,247	6,005	141
All Specialties (excl. Long Stay)	**3,439,857**	**3,117**	**530,828**	**1,037**	**1,122,499**	**155**

Source: ISD Scotland/Public Health Scotland – Specialty costs (2023)

4.20 Other evidence available from related sources gives an indication of the unit cost of other health services. The Unit Costs of Health and Social Care 2022 Manual[61] provides units costs of specific health and social care services. Although primarily concerned with NHS services in England, it nevertheless gives a good indication of service costs, and it is assumed that there are similar costs in Scotland. For example, when considering typical GP costs, there are some clear differences in cost depending on how cases are handled. A typical in-survey consultation costs £41 not counting prescription costs. However, evidence suggests that e-consultations cost around the same *including* prescription and other costs. Similarly, nurse-led triage of cases costs just over half that of GP-led triage. This points to areas where the application of innovation-based interventions may lead to significant cost savings where this

[61] PSSRU and the Centre for Health Economics (CHE) (2023) Unit Costs of Health and Social Care 2022 Manual

can be done at scale. It is understood that GP triage and waiting times are a particular issue for Scotland, with overall positivity in arrangements to see a GP in Scotland steadily decreasing.[62]

Table 4.8: Indicative unit costs of selected health and social care services, 2022

Health and social care service	Average unit cost (£)
Average cost of in-surgery consultation, excluding prescriptions	£41
Prescription costs per consultation	£33
Average cost of GP e-consultation (including prescription costs, fit notes, referral letters, etc.	£41.13
Cost per GP-led triage	£15.50
Cost per nurse-led triage, including decision support software	£8.69

PSSRU/ Centre for Health Economics (CHE) Unit Costs of Health and Social Care 2022 Manual (2023)

Considering the impact of innovation interventions

4.21 The aim of the model is to estimate the overall level of impact of Health innovations on Healthcare costs (with regard to indirect impacts). However, as will be discussed in subsequent chapters, the nature of the available evidence constrains the ability to link the outcome of innovation-driven interventions to macro-level savings.

4.22 The challenge for the model is the sheer number of health conditions for which Health innovation may have an impact in terms of cost savings. The Scottish Public Health Observatory[63] (ScotPHO) lists the following conditions, all of which Health innovation has the potential to impact positively. These include:

- Allergic conditions
- Asthma
- Cancer
- Chronic Liver Disease
- Chronic Obstructive Pulmonary Disease (COPD)
- Coronary Heart Disease
- Coronavirus (COVID-19)
- Diabetes
- Epilepsy
- Hepatitis C
- Infections
- Injuries
- Kidney Disease
- Mental Health
- Multiple Sclerosis
- Oral Health
- Screening
- Stroke
- Suicide

4.23 The ScotPHO quantifies the prevalence of each of these. However, the whole cost of treatment for each of these may not necessarily be able to be determined, given the range of factors that influence the extent to which an individual receives (and is able to receive) treatment. Nevertheless, there is some evidence to inform the logic model. Nevertheless, in some cases, it is possible to gauge their incidence relative to other countries. For example, current evidence suggests that around 700,000 people (approximately 13% of the population)

[62] See for example: https://www.gov.scot/publications/general-practice-access-short-life-working-group/
[63] https://www.scotpho.org.uk/health-conditions/

have cardiovascular disease in Scotland, with coronary heart disease accounting for around 29% of deaths.[64] In contrast, the incidence of cardiovascular disease in Japan is 1.67 million, or around 1.3% – approximately 10% of the rate in Scotland – and coronary heart disease accounts for around 15% of deaths. Much of this difference is attributable to differences in diet as well as other cultural factors.[65]

4.24 For example, *A Healthier Future: Scotland's diet and healthy weight delivery plan* sets out the incidence and cost of obesity and diabetes in Scotland, and potential savings areas from identified interventions. This is set out in Table 4.8, along with additional evidence regarding obesity and diabetes. Based on our understanding of approaches in Personalised Nutrition and Health innovation, there is some scope to assume that application of novel approaches could result in cost savings for obesity treatments. As an example to illustrate the scale of the challenge, the assumption that Personalised Nutrition could prevent 5% of the costs of treating obesity, or that Health Innovation could prevent 10% of the costs of treating obesity, then this could result in some considerable savings in terms of NHS Scotland expenditure – based on current estimated costs of treating obesity, anywhere between £18m and £60m. This will be further explored through the model in Chapter 6.

Table 4.9: Costs of obesity, diabetes and being overweight

Indicator	Metric	Measure
Adults who are overweight	65%	Scotland, 2021
Adults who are obese	30%	Scotland, 2021
Adults who are morbidly obese	4%	Scotland, 2021
Number of preventable cancers associated with obesity	2,200	per annum
Cost of treating conditions associated with being overweight and obese	£330m-600m	Cost per annum
Cost to the Scottish economy of overweight and obesity, including labour market related costs such as lost productivity	£0.9bn-£4.6bn	Cost per annum
Those with registered Type 2 Diabetes in Scotland	328,000	Scotland, 2021 (c.6% of the population)
Estimate of those with undiagnosed Type 2 Diabetes in Scotland	49,000	NHS Research Scotland Estimate
Those at risk of developing Type 2 Diabetes in Scotland	620,000	NHS Research Scotland Estimate
If Personalised Nutrition (only) approaches prevented 5% of costs of treating obesity	£18m-£30m	Savings per annum
If Health Innovation (only) approaches prevented 10% costs of treating obesity	£36m-£60m	Savings per annum
Total (at 15%)	£54-£90m	Savings per annum

Source: Scottish Government, A Healthier Future: Scotland's diet and healthy weight delivery plan (2018); Scottish Government, Scottish Health Survey 2021 (2022); Scottish Diabetes Group/Diabetes Scotland (2023); NHS Research Scotland (2023)

4.25 However, it is perhaps worth noting that if Health innovation was able to reduce obesity rates in Scotland equivalent to those in other countries, then significantly greater savings could in theory be realised (other external environmental and cultural factors, e.g. diet, notwithstanding).

[64] https://www.bhf.org.uk/-/media/files/for-professionals/research/heart-statistics/bhf-cvd-statistics-scotland-factsheet.pdf
[65] https://www.nature.com/articles/s41430-020-0677-5

Table 4.10: Costs of obesity, diabetes and being overweight

Indicator	Savings per annum
If Health Innovation (only) approaches prevented 10% costs of treating obesity	£36m-£60m
If Health Innovation (only) approaches reduced rates to equivalent of obesity rates in Norway = c.18% reduction in costs of treating obesity	£59m-£108m
If Health Innovation (only) approaches reduced rates to equivalent of obesity rates in France = c.24% reduction in costs of treating obesity	£79m-£144m
If Health Innovation (only) approaches reduced rates to equivalent of obesity rates in Japan = c.83% reduction in costs of treating obesity	£274m-£498m
If Health Innovation (only) approaches reduced rates to equivalent of obesity rates in South Korea = c.83% reduction in costs of treating obesity	£281m-£510m

Source: Scottish Government, A Healthier Future: Scotland's diet and healthy weight delivery plan (2018); Scottish Government, Scottish Health Survey 2021 (2022); Scottish Diabetes Group/Diabetes Scotland (2023); NHS Research Scotland (2023); World Obesity – Global Obesity Observatory (2024)

4.26 It is also worth noting that savings realised here may potentially displace economic activity elsewhere – e.g. in food and drink manufacturing or food service industries – with healthier eating patterns and decreased consumption possibly leading to reduced economic impacts. However, such a change may also lead to new economic opportunities – and thus impacts – for food and drink industries.

4.27 Age-related Healthcare and geriatric medicine is an increasing area of attention, given the anticipated impact of ageing on the prevalence on a wide range of morbidities (and co-morbidities), and thus on the Healthcare system in Scotland.[66] Scotland has a lot of experience in genetics, epigenetics and age-related medicine, and could adopt strengths in this area to bring solutions which would address these challenges through slowing ageing, and contributing to an increase in healthy life expectancy.

Social impacts

4.28 Social impacts principally relate to:

- Healthier Citizens;
- Happier Citizens.

Healthier citizens

4.29 There are some crossovers here with the indirect (economic) impact of healthier citizens (for example, a reduced absence from work). However, healthier citizens derive a range of additional benefits, including:

- Increased economic contribution (individuals enabled to remain in employment);
- Increased participation (e.g. citizenship, volunteering);
- Increased independent living (this has strong links to Health innovation through telehealth, remote and assisted living allowing, for example, older persons to spend more time at home);
- Active lifestyle health benefits (links to AI/wearables); and
- Better nutrition (links to Personalised Nutrition).

4.30 There are key indicators, such as life expectancy (and years of good health) in the model. Again, establishing a link between Health innovation and social impacts is key component of the model.

[66] See for example: https://www.nature.com/articles/s43587-021-00080-0

4.31 Life expectancy represents the average number of years of life remaining if a group of were to experience the mortality rates for a particular year over the course of their remaining life.[67] Life expectancy at birth for 2019-2021 in Scotland was 76.6 years for males, and 80.8 years for females. In terms of life expectancy, Scotland has historically been amongst the lowest in Western Europe according to EU data from Eurostat. Additionally, Scotland has the lowest life expectancy of all UK countries. Scotland's life expectancy rose gradually over the time periods 2000-2002 and 2012-2014, (16.2 weeks per year for males and 9.9 weeks per year for females).[68] However, between the periods of 2012-2014 and 2017-2019, life expectancy remained almost constant before falling between 2017-2019 and 2019-2021 (14.6 weeks per year for males and 7.9 weeks per year for females).[69] In the period of 2018-20 life expectancy fell again, by more than 11 weeks for males and almost 8 weeks for females; it is expected that majority of this fall is due to mortality from COVID-19.[70]

4.32 Similarly, healthy life expectancy measures how many years a given group will spend in good health over their lifespan.[71] Health life expectancy has decreased for both males and females and is now lower in 2019-2021 than it was in 2009-2011. Deprivation is a large factor in the healthy life expectancy of people in Scotland, evidenced by a difference of 24.9 healthy life expectancy years between the females in the least deprived and most deprived deciles. For males that difference increases to 26.0 years. Scotland has lower healthy life expectancy than the rest of UK, with people in the most deprived areas of Scotland spending more than a third of life in poor health.[72]

4.33 A Quality Adjusted Life-Year measures the state of health of a person or group in which the benefits, are measured in terms of length of life and are adjusted to reflect the quality of life. In short, one quality-adjusted life year (QALY) is equal to 1 year of life in perfect health[73] and allows the health impact on both life years and quality of life to be expressed in a single measure.[74] In a Scottish context, it is used in Scottish medicine to help NHS Scotland determine whether or not a medicine offers good value for money.[75] Additionally it is used as a social indicator in the Fair Start Scotland: economic evaluation[76] to measure improvements in individuals health as a result of individuals becoming employed. The HM Treasury Green Book measures one QALY represents the value of an additional life year lived with no problems with mobility, self-care or usual activities, no pain or discomfort, and no anxiety or depression.[77] Essentially, a life year in perfect health.

Happier citizens

4.34 There is a strong link between healthy citizens and happy citizens. However, gauging the latter typically involves relying on qualitative indicators or value-based assessments of happiness or quality of life – including satisfaction indicators.

4.35 Mental health is a state of well-being where individuals realise their own potential; coping with life's stresses, working productively, and contributing to their community.[78] It is worth noting that mental health is just one aspect of happiness, and there are other measures of happiness. Nevertheless, positive mental health promotes an overall better quality of life, a healthier lifestyle, improved physical health, better social relationships, and higher educational

[67] https://ec.europa.eu/health/indicators/docs/echi_10_ds_en.pdf
[68] https://www.nrscotland.gov.uk/files/statistics/life-expectancy-in-scotland/19-21/life-expectancy-19-21-report.pdf
[69] Ibid.
[70] Ibid.
[71] https://www.parliament.uk/globalassets/documents/post/postpn257.pdf
[72] https://www.nrscotland.gov.uk/files//statistics/healthy-life-expectancy/19-21/healthy-life-expectancy-19-21-report.pdf
[73] https://www.nice.org.uk/glossary?letter=q
[74] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/216003/dh_120108.pdf
[75] https://www.scottishmedicines.org.uk/media/2839/guide-to-qalys.pdf
[76] https://www.gov.scot/publications/fair-start-scotland-economic-evaluation/pages/11/
[77] https://assets.publishing.service.gov.uk/media/60fa9169d3bf7f0448719daf/Wellbeing_guidance_for_appraisal_-_supplementary_Green_Book_guidance.pdf
[78] https://www.gov.scot/publications/scottish-health-survey-2021-volume-1-main-report/pages/7/

attainment.[79] Mental disorders often coexist with physical illnesses, and individuals with severe mental disorders typically have a life expectancy 15-20 years shorter than the general population.[80]

4.36 Poor mental health, including mental disorders, have a significant impact on individuals, their families, as well as the wider community. [81]Poor mental health is also associated with both poverty and social exclusion, with factors such as loneliness contributing to the continuation of poor mental health.[82] Some population groups at an increased risk include those with poor mental and/or physical health, those living in poverty, those with disabilities, those from LGBTI or minority ethnic communities, and carers.[83] Measures of happier citizens include the Warwick-Edinburgh Mental Wellbeing Scale, Revised Clinical Interview Schedule (CIS-R), anxiety and depression scores, attempted suicide and self-harm, and adult loneliness.[84]

[79] https://psychrights.org/countries/WHO/who2009.pdf
[80] https://www.gov.scot/publications/mental-health-strategy-2017-2027/
[81] https://www.who.int/publications/i/item/9789241564618
[82] https://www.healthscotland.scot/media/1712/social-isolation-and-loneliness-in-scotland-a-review-of-prevalence-and-trends.pdf
[83] Ibid.
[84] https://www.gov.scot/publications/scottish-health-survey-2021-volume-1-main-report/pages/7/#ref

5 Data limitations and evidence base constraints

Introduction

5.1 This study set out to model the direct, indirect and social impacts of Health innovation in Scotland, and present them in an overarching model to understand how supporting Health innovation can drive economic and social impacts for the benefit of the Scottish economy and wider society in Scotland. However, a number of factors have impacted on the ability to do this without relying on a considerable series of assumptions. These factors are set out in this chapter, along with the general limitations on the available data on Healthcare innovation.

Limitations, constraints and data gaps

Direct impact data

5.2 The main focus of the model is on direct impacts. That is, the primary concern is with jobs created, company formation and business start-ups or spinouts, increased Gross Value Added (GVA), increased business expenditure on R&D (BERD), growth in exports, higher levels of inward investment, etc. For these, there is relatively good baseline data, as outlined in Chapter 4, although even gathering the data for these indicators is not without its challenges, largely relating to isolating Health innovation baselines within the overall Healthcare sector.

5.3 The greater challenge (see below) is relating the change in direct impact indicators, to inputs i.e., the extent to which an increase in Healthcare innovation business start-ups, say, is linked to the Government, academic and private sector spend on Healthcare innovation. This is by no means straightforward – and the increase in Healthcare innovation business start-ups in this example relates to just one direct impact amongst many direct, indirect and social impacts.

Indirect impact data

5.4 The general situation in respect of available evidence is that there is a considerable number of disparate bits of evidence, focused on specific interventions or innovations within the overall Healthcare sector. The impact evidence is typically focused more on *indirect* rather than direct impacts – i.e. fiscal savings within Healthcare systems arising from greater efficiencies.

5.5 Most Health innovation interventions are (sensibly) focused on clinical/ medical/ surgical outcomes. They are concerned with reduction in surgery times, or success rates of patient procedures and treatments, with some consideration of gains related to quality-adjusted life years (QALY) for patients. The indicators (and evidence) therefore typically relate to measures such as reduced cost of treatments, increased number of patients treated and the positive patient health impacts. However, the evidence is typically based on the effectiveness/ impact of a particular Health innovation.

5.6 The result is available evidence which is piecemeal i.e., based around certain interventions or health issues, rather than comprehensive. The evidence gives consideration to a particular intervention, often within a specific context – generally preventing meaningful extrapolation from micro to macro, because of the complex set of interdependencies in each case (for example with the health benefits for cancer patients from increased data collection/AI analysis applying to the specific cancer subject to the Health innovation). This makes modelling of indirect impact very difficult, although some broad generalisation of impacts (savings, etc.) may be useful for illustrative purposes.

Indirect and social impacts

5.7 In the case of many indirect and some social impacts, such as savings, these may often prove to be theoretical with no savings realised in practice. For example, reduction in hospital bed occupations, reduced hospital time in procedures, etc. may actually result in more patients being treated, but with no change in hospital capacity in practice. This will of course translate to a smaller amount of time spent in hospital or reduced waiting times for procedures for individuals. However, there would be no meaningful impact in terms of cost reduction on the Healthcare system side, though there would of course be corresponding gains in terms of outputs. Similarly, given continued pressure on Healthcare budgets, any savings realised in a given surgical procedure or clinical treatment will likely free up budget to re-allocate to another surgical or clinical intervention, thus resulting in no overall saving to Healthcare spend.

5.8 The qualitative nature of many social impacts also impacts on the ability to model these particular impacts. They can be described, but more robust quantification is often difficult, for example for improvements to quality of life or ability to lead a more active lifestyle. In available evidence there is some consideration of quality-adjusted life years (QALY), but it is difficult to equate these to changes in healthy life expectancy without giving due cognisance to other influencing factors. Other wider impacts and benefits are also difficult to quantify or monetise, such as increased social/community engagement as a result of improved physical or mental health. There is some consideration of ways to quantify or monetise such social impacts, for example through Global Value Exchange (GVE)[85], but verification and robustness of measures not always guaranteed.

Commercial benefits of Health innovation

5.9 As alluded to above under direct impacts, evidence on the commercial aspects of Health innovation is also relatively limited i.e., the specific economic impacts from investment in Health innovations. Partly, this is due to the focus on indirect benefits (reduced cost of treatment, increased patient health), rather than the benefits to the Healthcare sector and regional and national economies.

5.10 Where commercial benefit data exists, this is not always focused on Healthcare innovation, but innovation per se, such as accelerators and other mechanisms and programmes to support (non-sector specific) commercialisation of R&D, business start-up and growth. There are some exceptions – and examples are provided in Chapter 7. There are also practical challenges, not least the time taken for commercial benefits to accrue, where there is a long lag time from initial research to the development phase, to clinical trials, to regulatory approval and adoption. Where this sequence is tracked, there may still not be large scale application of the Healthcare innovation (which may be a pilot project requiring scale-up). Therefore, a key challenge for economic development agencies is understanding *where* companies are selling their innovations, *to what extent* these are being sold into the NHS and healthcare services in Scotland, and *the extent to which* these are making an impact on the delivery of Healthcare services. This is necessary to understand the relationship between direct, indirect and social impacts and benefits.

5.11 Therefore, whilst some data and evidence exist, this is typically in relation to specific Healthcare innovation products – perhaps supported by an accelerator – where the commercial return for the public/private investment has been captured and evidenced. Even here, more recent evaluation evidence has been interrupted by COVID, given the length of time before which the benefits of R&D commercialisation typically accrue.

[85] https://globalvaluexchange.org/

Impact on modelling

5.12 The limitations and constraints set out above impact on the full modelling of the logic chain set out in the subsequent chapter. The disparate nature of evidence, combined with the particular focus on certain specific (and therefore isolated) impacts through evaluation of Healthcare innovations and interventions, as well as needing to reflect all influencing factors and externalities, all result in a high degree of difficulty in building a coherent, linked model. In essence, impacts can only be easily understood in relative isolation. Direct impacts are quite separate to indirect impacts, which are quite separate to social impacts, and so on i.e., there is different logic or rationale to each. The driver for commercialising R&D of Healthcare innovation for an investment firm will be financial (the return on investment), for a Healthcare provider it will be patient outcomes and efficiency gains.

5.13 Consequently, we cannot take a bottom-up approach to build a model that estimates cumulative impacts across the direct, indirect and social domains. In light of the complexity of factors regarding Health innovations, but also within the scope of this commission, it is unrealistic to scale up from any individual impacts identified. This is on the basis of robustness; any given cumulative impacts resulting from the modelling would necessarily be open to a high degree of scrutiny, and ultimately hard to defend. Conversely, any top-down approaches to estimating the impacts from Health innovation would be too nebulous, and too heavily reliant on a range of assumptions and a web of interdependency.

Assumptions and caveats

5.14 The model therefore cannot readily (and so does not attempt to) unpick the inter-relationship of all the different aspects in Healthcare. There are simply too many variables, and the questions are too big to answer. The following illustrate this:

- What would be the economic benefit of matching levels of health/life expectancy for benchmark countries or for addressing issues with particular groups/communities – e.g. could we say if we matched UK/Spain for lifespan, health quality/health span, etc this would equate to X costs savings to the NHS, X more people in employment, etc? Whilst the model seeks to assess the impact of matching healthcare *expenditure* in comparator countries, it is not able to work back from saying what the impact in Scotland would be if we matched (higher) life expectancies in comparator nations.

Or

- With respect to lack of investment in data and digital in the health and social care sectors by Scottish businesses translated into products in the marketplace – is this about lack of funding or lack of translation into the Scottish marketplace/NHS adoption? Could we say if Scotland invested X more in digital and data then we would see X impact on products in the marketplace, or is it about saying if we addressed X issue (e.g. reduced the average time for innovations to be adopted into NHS practice) then this would result in X,Y, and Z? This is a detailed and specific point related to pace of introducing new innovations in the NHS (and related processes and barriers) and, whilst relevant and of considerable interest, is beyond the scope of modelling here.

5.15 These – and other similar questions – are substantive, and issues worthy of research in their own right. Our approach to the logic model - and subsequent modelling – are therefore necessarily illustrative in nature only based on identified examples where evaluation evidence exists. Some ‘what if’ scenario modelling is included (if, say, Scotland matched comparator investments in certain Healthcare innovations), but largely the impacts captured and ‘modelled’ are a bringing together of available evidence, rather than modelling in the strictest sense of the term.

6 An initial logic model

Introduction

6.1 This Chapter introduces a logic model to track the activities, outputs, outcomes and impacts associated with Digital Health innovation interventions. For a variety of reasons, not least those identified in the previous chapter regarding data availability and limitations, this is not straightforward. A key challenge in developing a logic model is isolating Digital Health innovation interventions, since a logic model typically traces the flow from resource inputs (interventions) through to activities/outputs, outcomes and impacts. As Chapter 3 demonstrates, the Health innovation ecosystem is complex with multiple interlinked factors, making it quite difficult to plot a logical flow from discrete interventions.

6.2 Nonetheless, there is value in seeking to develop and present a logic model, albeit with limitations, notably in relation to quantified impacts. The indicators alone at each stage of the logic model are a useful guide and checkpoint for Scottish Enterprise and partners when considering Digital Health innovation intervention. It is important to note that the inputs and activities (as presented) are indicative and not intended to be definitive – there are other healthcare innovation inputs and activities. For example, we reference Digital & Data spend as an input yet recognise there is health innovation expenditure that is broader than this. Nonetheless, by including indicative inputs/activities there is a greater possibility of tracing the logic from intervention to impact for these selected examples.

The logic model

6.3 The following table presents the logic model. Appendix 1 set out our observations on data availability for each indicator.

Figure 6.1: Initial logic model

Logic model title	**Health Innovation Ecosystem in Scotland – Logic Model**
Interventions	Support for Health & Social Care Digital and Data £ (SE/HIE, Scot Gov); NHS Procurement Sector based initiatives – FemTech; Personalised Nutrition (SE & partner) R&D in AI/data & human health (HE/FE, Innovation Centres/Institutes)

Theory of change

Scotland has considerable strengths in Healthcare innovation and R&D. It also performs poorly on many health indicators, with considerable health inequality and poor health in disadvantaged communities in particular.

The investment in the Health innovation ecosystem is centred on addressing the following (which represent market failures in the Healthcare innovation ecosystem):

- Poor health and lower than average life expectancy, particularly in certain groups/communities;
- Sub-optimal efficiency in the health and social care sectors, with greater spend on treatment rather than prevention;
- Barriers to entry for Scottish businesses seeking to provide digital and data solutions/ sell into the NHS;
- Lack of investment in data and digital in the health and social care sectors by Scottish businesses translated into products in the marketplace.

Whilst these represent considerable barriers to an effective health innovation ecosystem, Scotland has strengths in academia and early-stage R&D, including AI/data and specific human health specialisms. It also has a favourable policy environment, including the former Health for Wealth National Programme (HfW, which commenced in 2021 and which sought to "contribute to realising the vision of the future in which Scotland is a world-class health & care economy, where innovation flourishes and citizens live longer and healthier lives. The HfW opportunity was underpinned by the need and desire to improve the sustainability and effectiveness of health and care systems globally".

The rationale for intervention is based on capitalising on Scotland's strengths in health R&D to improve health outcomes and the competitiveness of Scottish businesses.

Inputs	**Activities**	**Outputs**	**Outcomes**
Public Sector Inputs • Digital & Data support spend £ (SE, SG, NHS) • NHS Procurement (innovative solutions) • Spend on sector-based initiatives – FemTech, Personalised Nutrition • Spend on R&D & Commercialisation in AI/ data, human health	<u>Digital & Data Support</u> • New product & process development support, Grant for R&D • Market intelligence • Modelling and testing of products/processes in test environment <u>R&D & Commercialisation in AI/data, human health</u> • New product & process development (e.g. Innovation Centres)	<u>Digital & Data Support</u> • New (Scottish) businesses providing digital & data services & solutions in health & social care (start-up businesses) • New digital & data products & services in H&SC <u>R&D & Commercialisation</u> • Spend on R&D in businesses (BERD) & public sector (GERD) • New patents/IP (Health innovation)	**Theme-specific outcomes** *(from SQW National Evaluation Framework for City Deals/Devolved Deals – 4B Enterprise & Innovation Advice & Support, and ITT)* • **Growth in turnover of assisted businesses (£)** • **Increased GVA** • **Growth in employment of assisted businesses (number of employees)** • Increased company formation, and spinouts from academia/NHS Scotland • Improved business survival rates

Private Sector • Digital & Data R&D £ • Innovative & preventative solutions to the NHS £	• Modelling and testing of products/processes in test environment • Academic/business partnerships (ICs, KTPs) • Skills pipeline development (Masters/PhD) • Some investment/funding support <u>Sector-based Initiatives</u> • Market intelligence • Investment/ funding support – e.g. Investment calls for sector-based initiatives (e.g. PN) • Further R&D support? • Commercialisation support programmes • Market development programmes • Supply chain programmes <u>NHS Procurement & Selling into NHS</u> • Support for Clinical Trials • Innovation Testbeds (Scottish Government) • Evaluation/Validation of ideas, approaches, kits, prototype devices developed by clinicians and/or researchers • Meet the Buyer and/or Access to Market events? • Demand-led innovation funding calls • Development of targeted thematic innovation networks • Medical innovation and commercialisation accelerators • £ for new solutions introduced • Other preventative health programme spend	• New products/services to market <u>Sector-based Initiatives</u> • New start-up businesses (as above) • New products & services in H&SC (as above) • New patents/IP (as above) • New funds established • Exports of Health innovation products & services <u>NHS Procurement & Selling into NHS</u> • Uplift in clinical trials • New Health innovation/ prevention products & services taken up by the NHS • Increase in spend by NHS Health Boards on innovation/prevention products & services • Increase in value of contracts secured by companies selling into NHS <u>Partnership Approaches to Health Challenges</u> • No. of joined investment calls • Partnerships/joined decision-making agreements • Increase in joint approach to clinical evaluation of new products and services in test and real-world environments	• Increase in the no. of businesses that are innovation active • New/improved products entering the market • Growth in exports of assisted businesses • New/improved processes adopted • Increased expenditure on business R&D • Enhancement of local innovation ecosystem and networks • Increased industry collaboration with NHS Scotland • Increased industry collaboration with Social Care providers in Scotland **Broader economic outcomes** *(from NEF, ITT, others)* • Increased overall levels of entrepreneurship • Improved productivity (4B) • Increased employment and GVA in supply chain • Reduced timeline for clinical evaluation/validation of new products and services • Increased commercialisation of ideas and approaches developed by clinicians and researchers **Indirect outcomes/impact** • Reduced cost of treatment of preventable conditions/ exchequer savings • Greater efficiency arising from improvements in NHS systems and processes • Reduction in patient time in Healthcare settings, thus reducing demand on NHS services • Reduction in demand on acute Healthcare services

	<u>Partnership Approaches to Health Challenges</u> • Joined Health innovation initiatives – public, private, Government <u>Other</u> • Partnership working and knowledge exchange • Joint funding for new initiatives, product/process testing, validation and clinical evaluation • Triple helix approach to research, testing, validation • Joint decision-making on Health innovation interventions		• Reduction in demand on GPs and other primary care services • Reduced demand on Social Care sector through improved Healthcare management for individuals **Social outcomes/impact** • Improved health outcomes • Increased (healthy) life expectancy • Reduction in preventable conditions • Improved management of health conditions, reducing impact on life/work • Increased economic activity/productivity and reduction in limiting long-term illnesses
Expected timescales for inputs / activities / delivery of outputs and outcomes			
See UK National Evaluation Framework[86]	*See UK NEF*	*See UK NEF*	*See UK NEF*
Relationship to other interventions • Other SE and partner activities e.g. place-based/ neighbourhood approaches • Other Health & Wellbeing spend (e.g. health awareness, preventative campaigns e.g. smoking, healthy eating) • Inward investment/ FDI – potential to be included in the above if leading to product/process/service innovation • Schools/education agenda – where there is a focus on prevention			

[86] https://www.sqw.co.uk/about-us/news/evaluation-informs-government-investment-economic-growth

Shortcomings arising from data gaps and evidence constraints

Inputs and activities

6.4 The model focuses on where SE and partners have developed interventions, and these are the inputs and activities described in the logic model. In terms of inputs, an ideal logic model would quantify these inputs, although given the complexity of the digital Healthcare ecosystem – and the inputs from academia, Government and industry – this in itself is far from straightforward, representing a sizeable commission in its own right.

6.5 In terms of the activities, again, the ones in the logic model are the broad types of activities in which SE and partners are involved, namely Digital & Data support; R&D and Commercialisation, including new products and process development; Sector-based initiatives including supply chains, investment and market development programme support; Support for selling into the NHS and other procurement programmes; and Partnership development. The suite of activities is not exhaustive, and others could be included and/or the activities could be segmented in alternative ways (access to finance, skills/people interventions etc.).

6.6 Again, as with inputs, the key limitation is the challenge in quantifying or baselining the *scale* of current levels of each type of activity. For example, what is the scale of current support for businesses and start-ups to sell into the NHS via Clinical Trials, Innovation Testbeds and support for idea validation etc., again given that these activities come from academia and industry, supported by Government.

Outputs and outcomes

6.7 The same key limitation applies to outputs and outcomes in the logic model, in terms of the challenges associated with quantifying these and establishing a current baseline. Whilst it is possible to baseline some indicators (number of digital Healthcare sector businesses, employment, GVA – see Chapter 4) others are more difficult to establish (new products/processes adopted, industry/NHS collaboration etc.). Even where the indicators are more straightforward (jobs, GVA etc.) there are still challenges defining what constitutes a digital Healthcare intervention (as opposed to non-digital interventions etc.). Work for SE and partners in seeking to isolate procurement spend on digital and data in the health and social care sectors identified the practical challenges of collecting this data (including data reliability and ensuring the data related specifically to digital and data solutions).

Causal links between stages of the logic chain

6.8 The greatest challenge in developing a meaningful logic chain is quantifying the relationship between inputs/activities and outputs/outcomes. A few questions illustrate this challenge:

- With respect to academic/business partnerships (ICs, KTPs etc) available in Scotland - how could increasing the number of partnerships/academia-Healthcare relationships impact on economic and health outcomes and impacts?
- Skills pipeline development (Masters/PhD) - what evidence is there that improving the skills availability/quality impacts on economic and health outcomes and impacts? How could Scotland be benchmarked and compared to show the potential impact of improving skills?
- Support for clinical trials - how many clinical trials/what scale of clinical trials happen in Scotland currently and what is the value of trying to increase this – e.g. economic and health outcomes and impacts?
- Medical innovation and commercialisation accelerators - how much of this happens in Scotland? What evidence is their around economic and health outcomes and impacts that could be extrapolated on?

- Other preventative health programme spend - are there examples of other countries that spend more on preventative health and studies showing the difference this makes to economic and health outcomes and impacts?

6.9 Obtaining an answer to any one of these questions is a substantial research project in its own right, which illustrates the challenges in developing a model of Healthcare interventions in terms of identifying direct, indirect and social impacts. There are multiple factors inherent in answering each one of the questions above, the majority of which are interlinked. Nonetheless, it is possible to identify some key causal relationships via analysis of project and programme evidence and scenario modelling. This is explored in the next Chapter.

7 Modelling Health innovation impacts

Introduction

7.1 The preceding chapters have set out an understanding of health impacts, alongside a consideration of limitations of existing evidence and data, before presenting the logic model for Healthcare innovations and their potential impacts in Scotland. This chapter sets out an initial modelling of potential impacts, across the direct, indirect and social domains as set out previously in the report. Given the previously discussed limitations of data and evidence and the effect of this on full modelling, potential impacts are set out on a case-by-case basis.

Health innovation impacts

Direct economic impacts

7.2 Direct economic impacts are impacts for the Scottish economy arising directly from businesses active in the sector, i.e., Digital Health innovations. The core economic impacts are those associated with more productive businesses in the digital heath innovation sector. More productive Digital Health innovation businesses are typically more profitable and able to invest and grow, creating more Digital Health innovation sector jobs and increased turnover in sector businesses. This is the key economic rationale for supporting the sector i.e., that successful Digital Health innovation companies in Scotland will generate net additional Gross Value Added (GVA) for the economy.

7.3 The logic model in the previous chapter lists the following core economic impact indicators:

Core economic impact indicators

- Growth in turnover of assisted businesses (£)
- Increased GVA
- Growth in employment of assisted businesses (number of employees)[87]

7.4 As also detailed in the previous chapter there a number of other relevant direct economic impact indicators (theme-specific indicators from the National Framework). Again, these relate to the performance and establishment of businesses in the Health innovation sector, such as business formation/start-up, new products and processes, exports and business survival.

7.5 These are:

Additional direct impact indicators

- Increased company formation, and spinouts from academia/NHS Scotland
- Improved business survival rates
- Increase in the no. of businesses that are innovation active
- New/improved products entering the market
- Growth in exports of assisted businesses
- New/improved processes adopted by businesses and by NHS Scotland
- Increased expenditure on business R&D
- Enhancement of local innovation ecosystem and networks
- Increased industry collaboration with NHS Scotland
- Increased industry collaboration with Social Care providers in Scotland

[87] 'Assisted' businesses here include any businesses supported to develop new/improved healthcare innovation products, processes and services; also includes start-up/growth innovation businesses

7.6 There are also *broader* direct economic impacts arising from the performance of businesses in the sector.

Broader economic outcomes

- Increased overall levels of entrepreneurship
- Improved productivity
- Increased employment and GVA in supply chain
- Reduced timeline for clinical evaluation/validation of new products and services
- Increased commercialisation of ideas and approaches developed by clinicians and researchers

7.7 Chapter 3 has identified a baseline for a number of these indicators.

Table 7.1: Health Innovation Life sciences & HealthTech sector – size and value; SG Growth Sector statistics (December 2023 publication)

Metric	Value	Date
Number of businesses	590	2023 data, updated December 2023
Employment	23,000	2022 data, updated November 2023
Turnover	£4,060,200,000	2021 data, updated August 2023
GVA	£2,223,700,000	2021 data, updated August 2023
R&D (Business Expenditure on R&D – BERD)	£366,000,000	BERD, 2020 (not being updated currently)
Exports	£1,820,000,000	2019 data, updated November 2021
Start-ups	50	2021 starts, March 2023 data

Scottish Government Growth Sector Database, 2023

7.8 The challenge is to establish the causal links between the resource inputs into the Health innovation ecosystem and the changes in three key indicators of GVA, turnover and employment.

7.9 There are a number of key interventions that stimulate direct economic impacts, which are set out below, although to be of maximum use for modelling there would be an established baseline of activity for each of the listed interventions. These are features of the Health innovation ecosystem highlighted in Chapter 3:

- **Accelerators** – these bring together intensive business support (coaching, mentoring) with increase access to finance and access to skills (academic, graduate) and R&D (including kit).
- **Access to finance schemes** – such as R&D Tax Credits, innovation vouchers, Grant for R&D schemes – these are not always Healthcare specific, although many policy interventions will have Healthcare/medical tech/Life sciences as a priority sector;
- **Innovation support programmes** – to stimulate new product, process and service improvements in the Healthcare sector, typically by supporting the development and introduction of innovations (entrepreneurship and intrapreneurship)
- **Workforce development/ skills programmes** – such as Knowledge Transfer Partnerships, Masters with wrap-around placement support and other projects/ programmes helping the individual to develop their skills which also benefit the company (e.g., a post-graduate working on developing a new product/innovation).
- **Access to kit and expertise** – programmes which allow businesses to prototype or carry out other R&D using HEI/other Institution kit and or drawing in academic expertise (such as consultancy),

7.10 Some policy interventions and programmes will bring together aspects of each of the above, for example the Innovation Centres in Scotland.

7.11 The key mechanism for understanding the relationship between such policy intervention inputs and outcomes/impacts is via evaluation evidence. The challenge here is that the Health innovation ecosystem is so multi-faceted that isolating factors is difficult. Whilst we have focused on interventions where there is evidence of direct impact, it is also true to say there are multiple factors that affect the scale of impact of any of the interventions above; for example, there will be increased direct impacts arising those parts of the NHS which where there is greater willing and capability of working effectively with industry to prototype innovations, share data and develop spin-out companies. Nonetheless, any modelling of impacts must be based on available evaluation evidence.

7.12 There are good examples of evaluation evidence demonstrating the impacts of investing in Digital Health innovation.

Accelerators

Table 7.2: Accelerators

Example: Accelerators: Digital Health London (Accelerator)		
Inputs £3.4m Programme (including ERDF) **Activities** support in developing, testing, and piloting innovations in the NHS, helping SMEs' understanding of market demand and for direct links to NHS.	Outputs	113 supported in total - 4 x cohorts of 1 year (25-30 per cohort). NB – high demand, 553 applications
	Outcomes	32 new products to market achieved at interim (Year 3 of 4); 26 new products to firm (targets of 50 expected to be reached)
	Direct Impacts	GVA: programme spend = 14.5:1 (from £2.5m spent at time of evaluation) 513 gross jobs (at gross cost per job of £4,926); 90% expected to increase turnover, 91% some form of additionality

Source: Evaluation of the Big Lottery Reaching Communities Step Forward Project (digitalhealth.london)

Workforce development and entrepreneurship

Table 7.3: Workforce development and entrepreneurship

Example: Accelerators: NHS Clinal Entrepreneur Programme (Intra/Entrepreneurship)		
Inputs £0.73m Programme (plus in-kind match funding) **Activities** skills, training, knowledge to develop innovative solutions 513 Clinical Entrepreneurs supported (uniquely) exists at the intersection of: incubator/ accelerator programmes; wider business and innovation support; and specific support within the Healthcare environment	Outputs	New innovations developed included: software packages, mobile apps, service delivery, education tools and telecare
	Outcomes	71% had/expected to introduce new products/processes/services; 53% commercialisation 65% started a company (117 new companies from 179 responses)
	Direct Impacts	882 additional jobs (net); £37m in additional sales (2016-2022) - 50:1 (gross) sales to input GVA per annum = £32.5m (2016-2022) 15% pure additionality; 59% partial additionality =44:1 (gross) GVA: investment per annum
Scotland Inputs: £63,000 (2 years) Activities: 18 clinicians supported (5 in year 5, 12 in year 6)	*Outcomes*	*If Scotland = UK share:* *- 11 innovations (based on prorate share of 551 innovations UK by year 6)* *- Reach 2.7m private, professional and patient users of products, processes, and services* *- 8 or 9 new business start-ups* *- £17m of new investment over 6 years* *- 58 jobs over 6 years*

Source: Evaluation Report – NHS Clinical Entrepreneur Programme (nhscep.com); Scotland analysis via Scottish Enterprise

Scenario modelling: Using impact measurement and modelling to drive intervention

7.13 Given the data limitations identified in Chapter 5 and elsewhere, and the breadth and scale of Health innovation impacts, one of the key challenges is to demonstrate the value of continued investment in Health innovation. Impacts and benefits of Health innovation are multiple, interlinked, complex and invaluable to healthy economies and people – so scenario modelling can be beneficial to demonstrate the benefits of increased investment.

7.14 There are a number of ways that show that if Scotland increased its expenditure in certain areas of Healthcare, it may expect a commensurate increase in performance against certain indicators. Care needs to be taken when extrapolating in this way – given that there may be a raft of factors that determine whether an increase in investment or expenditure in one area of the Healthcare system in one country/region similarly applies in Scotland.

7.15 At the same time, scenario modelling is helpful in illustrating the difference comparable investment in Healthcare could make, and/or the gap between countries/regions that invest heavily in Healthcare and those less that may be less willing or able to spend similarly.

7.16 The following represent key indicators based on such modelling of potential scenarios:

Forecast growth in Healthcare

7.17 The COVID-19 pandemic led to increases use of key digital technologies. UK-wide research in 20201 estimated that Covid-accelerated Digital Transformation (CADT) through boosted investment and fast adoption of CADT technologies will increase UK GDP by £232bn, or 6.9%, by 20240[88]. Of this, one third (£75bn) is estimated to arise through public sector investment; and of this, one third (£33bn, UK) is estimated to be directly through tech-enabled healthcare.

7.18 The £33bn uplift in GDP arising from tech-enabled healthcare is equivalent to a 1% increase in the whole GDP (UK) by 2040. A 1% increase in GVA (applying the 1% to GVA rather than GDP) in Scotland, by 2040, would equate to £1.59bn in additional GVA by 2040, almost equivalent to the whole of the current Life sciences GVA of £1.6bn.

7.19 If Scotland matches the forecast UK growth in the value of the Digital Health sector (2023 - 2027), this equates to £82.7m (UK growth over the same period is estimated at £200.2m)[89]. This is business to customer (B2C) revenue, the largest sub-sector of which is digital fitness and wellbeing.

Expenditure on Healthcare

7.20 The OECD average for expenditure on Healthcare is 13.93% of GDP. UK expenditure is 11.94%. 'High income' countries spend on average 14.92% of GDP on Healthcare[90]. The following shows the *additional* Healthcare employment, number of businesses and business turnover in Scotland if there was an increase in spend in Scotland equivalent to the OECD and high-income country levels.

7.21 The World Bank data on healthcare expenditure covers Government spending and individual (private) spend on healthcare and so the following Table shows the increased expenditure applied to both the number of businesses, employment and turnover *and* to total NHS spend

[88] https://www.virginmediabusiness.co.uk/pdf/RevTheEv/CEBR%20Health%20Report%20VMBD_CEDG.pdf
[89] https://www.statista.com/outlook/dmo/digital-health/united-kingdom
[90] https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS

and employment. The increases in the Table below are applied to be the baseline for the Life sciences sector in Scotland.

Table 7.4: Modelling increase in Life sciences businesses per capita

Impact of Additional Spend on Healthcare (as % of GDP)		
If Scotland equalled the average % of GDP spend	***OCED***	***High income***
Additional Number of Businesses	101	105
Additional Employment	3,000	3,136
Additional Business turnover	536,550,000	560,816,080
NHS Expenditure (baseline £15.4bn)	2,145,000,000	2,159.800,000
NHS Employment (baseline 184,000)	25,631	25,787
NHS GVA of £4.6bn ***(based on NHS employment @ £24,229 GVA per head - SABS+2021+TABLES.xlsx (live.com)***	£621m	£625m

Life sciences businesses per head

7.22 Scotland has a relatively high number of Life sciences businesses per head, above many of the UK English regions. However, the following shows the number of additional businesses if Scotland were to match the two English regions with the highest number of Life sciences businesses per head (London and the South East, the second ranked region and the East of England, the highest ranked).[91]

Table 7.5: Modelling increase in Life sciences businesses per capita

Life sciences businesses per head of population			
	Scotland baseline	***If Scotland reached the London & SE proportion***	***If Scotland reached the East of England proportion***
Life sciences businesses per 10,000	0.95	1.10	1.27
Life sciences businesses*	515	+50	+141
Employment	18,000	+1,740	+4,943
Turnover	£3.219 bn	+£311.3m	+£884m
GVA	£1,655,200,000	+£160m	+£454.5m
Exports	£1,820,000,000	+£176m	+£499.8m
Start-ups	50	+4	+14

** Note: This is Bioscience and health technology sector statistics 2021 - GOV.UK (www.gov.uk), the increases would be +58 and +166 respectively if applied to the 605 businesses identified by the Scottish Growth Sector Statistics for Life sciences*

7.23 There are key points arising from the modelling of direct impacts which show that increased investment and expenditure on health innovations leads directly to increased economic performance:

- If the estimated UK uplift in post pandemic tech-enabled healthcare materialises, this would add £1.59bn in GVA in Scotland;
- If Scotland matched the OECD member average for healthcare expenditure per capita (Government and private), this would add £2.145bn in annual spending leading to an increase in GVA for the NHS workforce alone of £621m;

[91] https://www.gov.uk/government/statistics/bioscience-and-health-technology-sector-statistics-2021/bioscience-and-health-technology-sector-statistics-2021; also https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/populationandhouseholdestimatesenglandandwales/census2021

- Matching the OECD average spend would generate 101 additional Life sciences sector businesses (+17%), 3,000 jobs and £537m in additional turnover;
- If Scotland matched the leading UK region (East of England), there would be 166 more Life sciences businesses (+27%), generating almost 5,000 more jobs, with £884m in additional sector turnover and £454m in sector GVA;
- Investing in key health innovation interventions, such as the Clinical Entrepreneur Programme would have direct economic impacts. Investing £63,000 (plus in-kind NHS funding) could directly lead to 58 new jobs, 8-9 new business start-ups and £17m in new investment, based on evidence from the UK-wide programme;
- Evidence from accelerators is that these, too, are highly effective, with ability to generate GVA return on investment in excess of 14:1 (London-based accelerator). If Scotland achieved just half the benefits arising in London, a £3m investment may generate 250 Life sciences jobs, with high levels of additionality (90%+).

Indirect economic impacts

7.24 Indirect economic impacts are those impacts realised either as savings in Healthcare expenditure, greater efficiency, or in other fiscal terms – such as a reduction in the number of illness-driven benefit payments. Much evidence in the literature regarding Healthcare innovation is concerned with financial savings in Healthcare expenditure terms, or in terms of Healthcare efficiency – that is, reduction in hospital admissions, reduction in length of procedures or treatment time, etc. A selection of such innovation is summarised below, with modelling of potential impact in a Scottish context included on a case-by-case basis.

7.25 The Lenus Health project as cited in the Campbell Report has had a considerable positive impact in terms of reduced admissions for Chronic Obstructive Pulmonary Disease (COPD).[92] Supported by InnovateUK funding and working in partnership with NHS Greater Glasgow and Clyde and Digital Health and Care Institute, it used a digital COPD support service to aggregate data from wearable technology and respiratory devices in conjunction with patient reported outcomes and clinical history data to provide clinical care teams and patients with a more robust view of their COPD condition. This has achieved a significant reduction in COPD-related emergency admissions and hospital beds (Table 7.6).

Table 7.6: Impacts of the Lenus Health project

Reduced COPD (Chronic Obstructive Pulmonary Disease) Emergency Admissions	Reduction by 28%
Reduced COPD (Chronic Obstructive Pulmonary Disease) Hospital Beds	Reduction by 38%

7.26 Another project, CHROMED, also targeted improvements in treatment of patients with COPD. The project introduced innovative technology for daily home monitoring of COPD patients. The project was designed to evaluate changes in patients' health and quality of life and cutdown Healthcare cost of individuals grappling with Chronic Obstructive Pulmonary Disease (COPD) and related conditions such as Chronic Heart Failure (CHF) and Sleep Disordered Breathing (SDB).[93] It has a similar impact on COPD patients to the Lenus Health Project including reduction to COPD patient admissions as well costs per patient, as shown in table 7.8 below:

Table 7.7: Impacts of the CHROMED project

Reduced COPD (Chronic Obstructive Pulmonary Disease) Hospital Admissions	Reduction by 38%

[92] https://www.gov.scot/binaries/content/documents/govscot/publications/independent-report/2021/12/campbell-report-roadmap-investment-health-innovation-life-sciences-healthtech-scotland2/documents/campbell-report-roadmap-investment-health-innovation-life-sciences-healthtech-scotland/campbell-report-roadmap-investment-health-innovation-life-sciences-healthtech-scotland/govscot%3Adocument/campbell-report-roadmap-investment-health-innovation-life-sciences-healthtech-scotland.pdf
[93] https://cordis.europa.eu/project/id/306093/reporting

Reduced COPD (Chronic Obstructive Pulmonary Disease) Healthcare costs per patient per year	€3,883

7.27 If the approaches used in the Lenus Health project or CHROMED project were adopted across Scotland, it could reasonably be assumed a reduction of 38% in COPD hospital beds or admissions is equivalent to Respiratory inpatient cases. Based on data presented earlier in Chapter 4 (Table 4.6), and also assuming a corresponding reduction in Respiratory Medicine day cases and outpatients it can be expected that savings in the region of £44.3m of Healthcare expenditure might be realised, assuming that costs per case are unaffected.

7.28 However, this also assumes that there would be no need for re-allocation of NHS Scotland budget elsewhere for other treatments or procedures, which is unlikely; as such the estimated savings are theoretical and thus illustrative only.

Table 7.8: Expenditure and cost per case: Respiratory Medicine; savings based on Lenus Health project findings

Respiratory Medicine	Current net expenditure (£000s)	Cost per case (£)	Net expenditure under Lenus Health innovation savings (£000s)	Potential saving (£000s)
Inpatient	80,491	2,515	49,900	30,600
Day care	4,295	935	2,700	1,600
Outpatient	31,806	211	19,700	12,100

Source: Adapted from ISD Scotland/Public Health Scotland – Specialty costs (2023)

7.29 Health innovations can help Healthcare workers and patients manage long-term conditions. One innovation which helps with this is PARK IT 2.0 which allows doctors and patients make improved decisions patient's changing Parkinsons Disease. The PARK-IT 2.0 project uses an automated monitoring method for patients with Parkinson's Disease. Symptoms include movement problems, freezing, and hidden non-motor symptoms causing confusion and speech difficulties. Monitoring is done through an autonomous wearable medical device worn on the waist. The device, equipped with embedded sensors and advanced algorithms, identifies and records Parkinson's motor symptoms, particularly fluctuations. Information collected is accessible through a mobile app, enabling Healthcare professionals and patients to make informed decisions about personalised PD treatment. It is thought that one of the potential impacts of this innovation is the reduction of the Total Cost of Care by 30%, resulting in an estimated treatment cost of €3,500 per patient (down from €4,550 per patient).

7.30 Assuming similar savings across inpatient, day case and outpatient treatment, this could result in savings of up to £18.8m in NHS Scotland expenditure. Given that no further breakdown of costs for treatment of different neurological treatments are available, this assumes that savings of 30% are realised across all Neurology spend.

Table 7.9: Expenditure and cost per case: Neurology; savings based on PARK IT 2.0 project findings

Acute speciality	Current net inpatient expenditure (£000s)	Inpatient cost per case (£)	Net inpatient expenditure under PARK IT 2.0 innovation savings (£000s)	Saving (£000s)
Neurology inpatient	31,351	6,023	21,900	9,400
Neurology day case	6,379	1,025	4,500	1,900
Neurology outpatient	25,102	180	17,500	7,500
			Total potential savings	18,800

Source: Adapted from ISD Scotland/Public Health Scotland – Specialty costs (2023)

7.31 The BEACON care system (part of the ICU-CARE project)[94] is an ICU project which uses computer-based system to help with decisions about ventilators in the ICU. This system uses special algorithms to monitor each patient separately, assisting in deciding how to use ventilators effectively. The aim is to reduce the time patients spend in the ICU and the costs associated with it. it enables nurses and low skilled/new staff to optimise ventilation management, when ICU doctors or Respiratory Therapists are scarce resources. The BEACON Care system is expected to generate a reduction in the length of stay in ICU by 15-25%. Assuming an average of 20% reduction in the length of stay in ICU, and this equates to a similar proportion of savings on NHS Scotland expenditure, then it would be expected that

Table 7.10: Expenditure and cost per case: Neurology; savings based on BEACON/ICU-CARE project findings

Acute speciality	Current net inpatient expenditure (£000s)	Inpatient cost per case (£)	Net inpatient expenditure under BEACON/ICU-CARE innovation (£000s)	Saving (£000s)
ICU inpatient	163,584	8,872	130,900	32,700
ICU day case	5,167	873	4,100	1,000
ICU outpatient	8,219	149	6,600	1,600
			Total potential savings	35,300

Source: Adapted from ISD Scotland/Public Health Scotland – Specialty costs (2023)

7.32 Though many reviews and evaluations of innovative Healthcare interventions continue to focus on consideration of medical outcomes[95], some do consider cost impacts and longer-term health outcomes for patients. For example, there have been a number of studies that have considered the impact of Healthcare ICT – the application of different digital- and technology-based innovative interventions – on cost of Healthcare (indirect impact) and health outcomes (social impact). Gentili et al.'s 2022 paper[96] reviewing Healthcare ICT adoption was primarily concerned with hospital outcomes for inpatients; however, it also examined cost impacts. In its review of 37 intervention evaluations, whilst many innovations resulted in increased incremental costs with mixed results in terms of incremental cost effectiveness ratios (ICER; a summary measure representing the economic value of an intervention, compared with an alternative (comparator)), some innovations did result in cost savings, including:

- The use of telerehabilitation after total knee replacement in Italy on average saved $263 per person versus usual care (18% reduction).[97]
- Using telemedicine for orthopaedic consultations in partnership with the University Hospital of North Norway in a remote clinic in northern Norway reduced cost of Healthcare provision by €19,500, though the break-even thresholds were 151 patients per year from a societal cost perspective, and 183 patients per year from a Healthcare cost perspective (c.35% reduction).[98]
- The use of an out-of-hospital Virtual Sleep Unit (VSU) based on telemedicine to manage all patients with suspected obstructive sleep apnoea (OSA) in a Spanish sleep unit trial saved around €153 per intervention versus typical hospital treatment (22% reduction).[99]
- A Telemedicine Program, called Singapore Integrated Diabetic Retinopathy Program (SiDRP) provides "real-time" assessment of diabetic retinopathy photographs by a

[94] https://cordis.europa.eu/project/id/804955
[95] For example, see: Kruse, C.S. and Beane, A., 2018. Health information technology continues to show positive effect on medical outcomes: systematic review. Journal of medical Internet research, 20(2), p.e8793
[96] Gentili, A. et al. (2022) The cost-effectiveness of Digital Health interventions: A systematic review of the literature. Front Public Health. 2022; 10: 787135. Published online 2022 Aug 11. doi: 10.3389/fpubh.2022.787135
[97] Fusco, F. and Turchetti, G. (2016) Telerehabilitation after total knee replacement in Italy: cost-effectiveness and cost-utility analysis of a mixed telerehabilitation-standard rehabilitation programme compared with usual care. BMJ Open. 6:e009964. doi: 10.1136/bmjopen-2015-009964
[98] Buvik, A. et al. (2019) Cost-Effectiveness of Telemedicine in Remote Orthopedic Consultations: Randomized Controlled Trial, J Med Internet Res. 2019 Feb; 21(2): e11330. Published online 2019 Feb 19. doi: 10.2196/11330
[99] Lugo, V.M. et al. (2019) Comprehensive management of obstructive sleep apnea by telemedicine: Clinical improvement and cost-effectiveness of a Virtual Sleep Unit. A randomized controlled trial. PLoS One. 2019; 14(10): e0224069. Published online 2019 Oct 24. doi: 10.1371/journal.pone.0224069

centralized team of trained and accredited graders supported by a tele-ophthalmology information technology infrastructure generated cost savings of $173 per patient (6% reduction).[100]

- The Telemonitoring of Crohn's Disease and Ulcerative Colitis (TECCU) Web platform for telemonitoring complex inflammatory bowel disease and nurse-assisted telephone care in Spain resulted in a median cost reduction of €211 per patient (20% reduction).[101]

7.33 However, there is a high degree of complexity in attempting to model these savings in a Scottish context. The available granularity in NHS Scotland expenditure data, granularity in cost saving data from evaluations of Health innovations, and the context-specific nature of findings from studies as outlined above have implications for modelling. Specifically, fuller extrapolation and modelling to demonstrate potential impacts within the Scottish Healthcare context to a reasonable degree of detail and robustness is, at the very least, challenging.

7.34 Nevertheless, the scenarios illustrated above – coupled with evidence on the degree to which Healthcare expenditure is avoidable – present some evidence on which to base some broad modelling of cost reduction across total NHS Scotland expenditure.[102,103,104] Based on the evidence reviewed, we have assumed a number scenarios (Low-Medium-High), with percentage reductions applied in each instance, across different Healthcare sectors. Higher percentages have been assumed within the Hospital sector to reflect the percentage reduction findings in hospital settings. Consequently, savings of between around £2.4bn and £5.5bn could be realised if Health innovations were able to realise savings of the order generated by the examples set out above.

Table 7.11: Potential indirect (Healthcare expenditure) savings

NHS Scotland sector spend	Real-term expenditure (£m), 2021/22	Low scenario			Medium scenario			High scenario		
		Reduction	Saving (£m)	Expenditure (£m)	Reduction	Saving (£m)	Expenditure (£m)	Reduction	Saving (£m)	Expenditure (£m)
Hospital sector	8,386	20%	1,677	6,709	30%	2,516	5,870	40%	3,354	5,031
Community sector	3,602	10%	360	3,242	20%	720	2,882	30%	1,081	2,521
Family health sector	2,937	10%	294	2,643	20%	587	2,350	30%	881	2,056
Resource transfer to local authority	476	10%	48	429	20%	95	381	30%	143	333
Total NHS Scotland expenditure	**15,400**	**-**	**2,379**	**13,022**	**-**	**3,919**	**11,482**	**-**	**5,459**	**9,942**

Source: Consultant's modelling, adapted from Public Health Scotland – NHS Scotland health service costs for financial year 2021/22, High-level costs summary (2023)

[100] Nguyen, H.V. et al. (2016) Cost-effectiveness of a National Telemedicine Diabetic Retinopathy Screening Program in Singapore. Ophthalmology. 123:2571–80. doi: 10.1016/j.ophtha.2016.08.021
[101] Hoyo, J.D. et al. (2019) Telemonitoring of Crohn's Disease and Ulcerative colitis (TECCU): cost-effectiveness analysis. J Med Internet Res. 21:e15505. 10.2196/15505
[102] Written evidence from UK Health Forum (NHS0142) and from the Health Foundation (NHS0172) to Select Committee on the Long-term Sustainability of the NHS: The Long-term Sustainability of the NHS and Adult Social Care, Report of Session 2016-17, HL Paper 151; at: https://publications.parliament.uk/pa/ld201617/ldselect/ldnhssus/151/15109.htm
[103] World Health Organization (2014) Noncommunicable Diseases (NCD) Country Profiles – United Kingdom http://www.who.int/nmh/countries/gbr_en.pdf
[104] https://www.healthscotland.scot/media/1086/health-inequalities-what-are-they-how-do-we-reduce-them-mar16.pdf

Social impacts

7.35 Gains in terms of quality-adjusted life years (QALYs) or cost changes/savings per QALY gained can be used as a measure of the effectiveness of an intervention's propensity to improve a citizen's quality of life in comparison to the monetary costs of the intervention.

7.36 Many of the same studies reviewed by Gentili et al (2018) as discussed above also identified a number of social impacts, that is, benefits in terms of health improvements for patients. A number of the studies identified benefits in terms of improved quality of life or QALY gains. For example, a project piloting a tele-rehabilitation system following total knee replacement led to some improvement in range of motion versus standard rehabilitation, as well as realising a $263 cost saving per patient.[105]

7.37 Similarly, a study conducted by McKenna, Dwyer and Rizzo (2018) looking at the introduction of greater Healthcare ICT systems in New York State[106] found that there was an average positive effect on patient outcomes and Healthcare productivity. Hospital severity-adjusted mortality decrease by 0.3 percentage points; when considering Medicare patients only, Healthcare ICT adoption decreased a hospital's severity-adjusted mortality rate by 0.5 percentage points, thus helping to provide better quality of care and better patient outcomes. Similar improvements arising from Healthcare ICT adoption in patient outcomes and illness severity were found in patients with one of four common diagnoses (acute myocardial infarction, congestive heart failure, coronary atherosclerosis, and pneumonia) in a study by McCullough et al. (2016). Across the technologies studied, they attribute the benefits to improved information management and co-ordination rather than the role of ICT in clinical decision support.[107]

7.38 The Shape intervention used a multi-faceted system including personalised phone coaching from Healthcare staff, a custom skills training plan, and self-monitoring by patients using a fully automated phone system that responds interactively. The program aimed to address obesity in individuals from communities which statistically have a higher risk of being obese over a 12-month period by allowing both mental and physical support. The primary measure of effectiveness in the trial was weight change from baseline to 12 months. Weight change was converted into a health-related quality of life change score. The main impact from the intervention was a difference in weight change in patients, which was transformed to estimated quality of life gains based on likely weight loss maintenance.[108]

Table 7.12: Impact of Shape intervention

Intervention	Saving ($) per QALYs
Shape	$55,264
A Spanish-language Internet-based cognitive-behavioural therapy (iCBT)	€-169.50
Digital therapeutics for Type 2 Diabetes and Hypertension	$2,168 to $12,877 per QALY gained

Source: Krishnan et al. (2019)

7.39 Project CLIQ (Community Link to Quit) was smoking cessation strategy which used electronic health records and interactive voice recognition technology to connect low- to moderate-income smokers with counselling, medications, and social services.[109] The aim of the project

[105] Fusco, F. and Turchetti, G. (2016) Telerehabilitation after total knee replacement in Italy: cost-effectiveness and cost-utility analysis of a mixed telerehabilitation-standard rehabilitation programme compared with usual care. BMJ Open. 2016; 6(5): e009964. Published online 2016 May 17. doi: 10.1136/bmjopen-2015-009964
[106] McKenna, R.M., Dwyer, D. and Rizzo, J.A., 2018. Is HIT a hit? The impact of health information technology on inpatient hospital outcomes. Applied Economics, 50(27), pp.3016- 3028
[107] McCullough, J.S., Parente, S.T. and Town, R., 2016. Health information technology and patient outcomes: the role of information and labor coordination. The RAND Journal of Economics, 47(1), pp.207-236.
[108] Krishnan, A. et al. (2019) A Digital Behavioral Weight Gain Prevention Intervention in Primary Care Practice: Cost and Cost-Effectiveness Analysis. J Med Internet Res. 2019 May; 21(5): e12201. Published online 2019 May 17. doi: 10.2196/12201.
[109] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5896510/

was to be a proactive method to engage communities of low to moderate income backgrounds and encourage them to quit.[110] This is important as one indicator of addressing health social inequalities is smoking cessation due to the higher prevalence of tobacco deaths in people from lower-income backgrounds.[111]

7.40 ReMiND (Reducing Maternal and Newborn Deaths), was a mobile Health application that tracks and supports clients for the Accredited Social Health Activist (ASHA) in India and provides inputs for individualised service and counselling needs.[112] The aim was to address maternal and child deaths in areas with low coverage of key maternal, neonatal and child health (MNCH) services. The purpose was to improve various health indicators through strengthening the Healthcare system. From societal perspective, there was a cost saving of USD 425 million with ReMiND including a cost saving of $90 per DALY (Disability-adjusted life year) averted and $2,569 per death averted. From a health system perspective, the intervention estimated an incremental cost of $205 per DALY averted and $5,866 per death averted. Importantly, it was estimated that the implementation of ReMiND would save over 2 million disability-adjusted life years (DALYs; essentially a measure of years in perfect health lost).

7.41 Other gains in terms of quality of life have also been demonstrated or at least estimated by innovative approaches. For example, Sime Diagnostics' Clinical AI Platform uses artificial intelligence to predict and test for neonatal respiratory distress syndrome (RDS) and chronic lung disease.[113] Whilst clinical trials and validation are still ongoing, it is anticipated that through using the Clinical AI platform's algorithm, doctors are better able to predict CLD within babies and deliver early targeted treatment before disease onset; enabling them to improve clinical outcomes, prevent chronic co-morbidities and reduce costs. Effective treatment on mature babies has the potential for them to reduce the likelihood of chronic respiratory problems in later life.

Modelling social impacts

7.42 In many instances, identified social impacts are either specific to the particular intervention and context within which they are realised, or are discussed in general terms only without any fuller investigation beyond the scope of the intervention's evaluation. Whilst this is understandable, for example given the scope available budget for funded innovation projects, it constrains the ability to model social impacts beyond their expression in broad terms in the logic model.

7.43 However, applying the findings from the Northern Powerhouse Health for Wealth study examining the impact of health on productivity, we can extrapolate the impact of realising an increase in NHS Scotland spending, or of the impact of Health innovation on changes in ill health rates, for example.[114] This would see both social and additional indirect fiscal impacts.

7.44 Based on the findings of Northern Powerhouse study, Assuming 10% increase in NHS spend results in 3% decrease in economic inactivity:

- **c.22,900** people aged 16-64 become economically active.
- Assuming they receive Scottish median annual salary of £29,842, this would generate:
  - **£683.4 million** in additional wages;
  - Tax receipts of almost **£79.6 million**; and
  - National Insurance contributions of around **£39.6 million**.

[110] Ibid.
[111] https://ash.org.uk/uploads/ASH-Briefing_Health-Inequalities.pdf
[112] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6020234/
[113] https://simedx.com/nicu/
[114] https://eprints.whiterose.ac.uk/146595/1/NHSA_REPORT_FINAL.pdf

- If all previously claimed Universal Credit, this could potentially reduce benefit expenditure by up to **£243 million**.

Table 7.13: Modelled impacts of increase in NHS spending

	Low case **5% increase in NHS spend**	Mid case **10% increase in NHS spend**	High case **15% increase in NHS spend**
Increase in economic activity (N)	*11,450*	22,900	*34,350*
Increase in wages/salaries (£m) *Assumes 2023 median Scottish salary of £29,842*	*341.6*	683.4	*1,025.1*
Tax receipts (£m)	*39.8*	79.6	*119.3*
NI receipts (£m)	*19.8*	39.6	*59.3*
Benefits savings (£m) ***Based on average Universal Credit payment of £10,600 per annum***	*121.4*	242.7	*£364.1*

Based on findings from Bambra, C.L. et al./NHSA (2018) Health for Wealth: Building a Healthier Northern Powerhouse for UK Productivity. Research Report

7.45 Similarly, If Health innovation was able to drive comparable change in rates of ill health (1.2%) and mortality (0.7%), positively impacting on productivity, then this would result in an uplift in GVA per head of **2.6%**. Based on the latest available SABS data (2021):

- Scottish GVA would potentially rise from £45,235 to **£46,411**.
  - This equates to **+£1,176** per head.
- An additional GVA of **£2.12 billion** per annum would be generated.

7.46 This could also potentially see up to 7,500 people previously with ill health, or who would otherwise have died, become or remain economically active.[115] This would potentially generate:

- **£223.8 million** in additional wages;
- Tax receipts of **£26.1 million**; and
- National Insurance contributions of **£12.9 million**.

[115] Based on latest available data on economic inactivity for Scotland from the Annual Population Survey (2024), and latest available mortality rates for Scotland from National Records of Scotland (2024).

Table 7.14: Modelled impacts of impact of increased Health innovation on ill health and mortality rates

	Low case **0.6% change in ill health rates**	Mid case **1.2% change in ill health rates**	High case **1.8% change in ill health rates**
Increase in economic activity (N)	*3,750*	7,500	*11,250*
Increase in wages/salaries (£m) *Assumes 2023 median Scottish salary of £29,842*	*111.9*	223.8	*335.7*
Tax receipts (£m)	*13.0*	26.1	*39.1*
NI receipts (£m)	*6.5*	12.9	*19.4*
Benefits savings (£m) ***Based on average Universal Credit payment of £10,600 per annum***	*11.7*	23.3	*34.9*

Based on findings from Bambra, C.L. et al./NHSA (2018) Health for Wealth: Building a Healthier Northern Powerhouse for UK Productivity. Research Report.

7.47 As per the previous modelling scenario, if all those with improved ill health previously claimed Universal Credit, and half of those who would otherwise have died under the assumptions in this model also previously claimed Universal Credit, then this could potentially reduce benefit expenditure by up to **£23.3 million**.

8 Conclusions

Introduction

8.1 Despite the shortcomings of available data on Health innovation impacts, it is possible to gain insight into the sort of impacts that could be expected in the Scottish Healthcare ecosystem if ambitions to build a world-leading Health and Care innovation ecosystem, and exploiting the potential of digital technologies and data to transform Healthcare to do so, are to be realised. This chapter presents our concluding remarks on modelling the impacts of Healthcare innovation gains, along with reflections on the requirements to underpin a full working economic model.

Concluding remarks

8.2 There is clearly a wide range of positive impacts arising from the adoption of both digital and non-digital innovations within Healthcare. In particular, there are strong direct and indirect economic benefits that can be demonstrated through surgical, clinical or medical trials, new products, processes and services and evaluation of innovation adoption. These are both direct economic impacts in terms of Healthcare innovation sector gains for the Scottish economy and indirect economic benefits in terms of cost efficiencies. These are allied to considerable health impacts for patients. Though somewhat more limited evidence exists regarding social impacts, these can also be seen as a benefit of Health innovation.

8.3 The modelling of direct economic impacts shows the massive opportunities that arise from investment in healthcare innovation in Scotland. The estimated UK uplift in post pandemic tech-enabled healthcare, applied to Scotland, would add £1.59bn in GVA. Were Scotland to match the OECD member average for healthcare expenditure per capita (Government and private), this would add £2.145bn in annual spending leading to an increase in GVA for the NHS workforce alone of £621m.

8.4 These are very considerable incentives to invest in healthcare innovation. Matching the OECD average spend would generate 101 additional Life sciences sector businesses (+17%), 3,000 jobs and £537m in additional turnover. Scotland already performs well for the number of Life sciences businesses per capita (third in the UK), but if it were to match the leading UK region (East of England), there would be 166 more Life sciences businesses (+27%), generating almost 5,000 more jobs, with £884m in additional sector turnover and £454m in sector GVA.

8.5 As the report notes, investing in key health innovation interventions, such as the Clinical Entrepreneur Programme would have direct economic impacts. Investing £63,000 (plus in-kind NHS funding) could directly lead to 58 new jobs, 8-9 new business start-ups and £17m in new investment, based on evidence from the UK-wide programme. Evidence from accelerators is that these, too, are highly effective, with the ability to generate GVA return on investment in excess of 14:1 (London-based accelerator). If Scotland achieved just half the benefits arising in London, a £3m investment may generate 250 Life sciences jobs, with high levels of additionality (90%+).

8.6 There are also potentially large indirect impacts that could be realised. Savings of between around £2.4 billion and £5.5 billion could be realised by NHS Scotland if Health innovations were able to realise Healthcare expenditure savings in line with evidence from elsewhere.

8.7 Similarly, increased spending and levels of innovation in Healthcare can drive a number of social and associated fiscal impacts. It is anticipated that an increase in Healthcare spending could drive an increase in economic activity, in turn generating additional salaries of up to

£683.4 million, with corresponding Income Tax and National Insurance receipts of £79.6 million and £39.6 million.

8.8 Further, increased Health and Healthcare innovation has the potential to reduce economic inactivity and generate additional annual salaries of up to £223.8 million, with corresponding Income Tax and National Insurance receipts of £26.1m and £12.9 million. It could also drive productivity increases, helping to stimulate an uplift of GVA worth an additional £2.12 billion per annum.

8.9 Consequently, there is a strong rationale for continued investment in Health innovation, and for public sector intervention to stimulate greater collaboration through triple-helix approaches. Healthcare innovation therefore continues to be a priority in Scotland for SE and partners, and indeed more widely across enterprise agencies and other public sector bodies.

Towards a working model of Health innovation impacts

8.10 The primary purpose of modelling is to establish or reinforce the case for continued public sector intervention in health and Healthcare innovation. The available evidence from Scotland, elsewhere in the UK and globally does this to a greater or lesser extent, but is unable to do so in a coherent manner that sets out comprehensive and joined-up picture of direct, indirect, social impacts. Nevertheless, the available evidence, whilst not comprehensive, still allows for a composite overview of impacts to provide an understanding of the likely impacts arising from Healthcare innovation, and thus support any arguments in favour of continued public sector intervention to drive greater levels of innovation and subsequent impacts and benefits.

Required approach

8.11 To progress towards a fuller modelling of impacts arising from innovations in Health, Healthcare and digital Healthcare in particular, an integrated approach that tackles modelling from different angles is required:

- The model should employ a top-down approach to modelling direct economic impacts, essentially to demonstrate the scale of potential gains – the 'size of the prize', drawing on comparative data from other markets and economies to infer the scale of comparative increases in the Scottish Healthcare sector. This would provide insights in terms of target-setting using a relatively broad approach.
- The top-down benchmarking should be complemented with a modelling approach to scale up available data to forecast impacts across the three domains (direct, indirect, social). This would provide a series of 'what-if' scenarios similar to those presented above.

Required data and other factors

8.12 To achieve this, a number of required inputs and intelligence need to be in place. Through the course of this commission, we have assembled available data to model as far as possible; additional data will make a fuller modelling of impacts possible:

- Broad macro-economic forecasting at the national and/or global level, to underpin understanding of growth scenarios of different health/Healthcare markets. At the national level in particular, there is limited intelligence on forecast growth of the Healthcare sector, and there may be some value in commissioning further work to inform any future modelling (and thus future interventions). Some modelling is undertaken for growth sectors, e.g. to inform Sector Skills Assessments produced by Skills Development Scotland,

- Clear evidence of results and outputs from Health innovation projects, such as may be available through evaluations and clinical trial outputs. For example, evaluation reports from projects funded through the last ESIF programming period may provide this – though much ERDF funding was focused on 'mainstream' business support. Similarly, Horizon 2020 funding through SME mechanisms in theory could provide this given the focus on demonstration and commercialisation in certain streams, but project reporting is inconsistent at best, and evaluations are arguably light touch, and centred on essential Commission reporting requirements. This effectively constrains the extent to which direct, indirect and social impacts are identified and reported. There is a need for clarity and consistency of findings through evaluation of Healthcare innovation projects in terms of jobs/GVA, but also Healthcare savings, and benefits for patients/beneficiaries of treatments. Neither of these are readily available. What is required is a fuller suite of metrics and indicators, coupled with longer-term tracking of Healthcare products, services and interventions, e.g. beyond initial provision of Healthcare service through the innovation. However, this would likely require a substantive increase in budget allocated to evaluations in order to track such metrics, and those relating to wider social impacts in particular.
- A detailed understanding of the socio-economic context(s) in which Health innovation impacts are realised – to identify what other contributory factors there are (e.g. environmental, lifestyle, socio-political, etc.), and the extent to which attribution to innovations may be determined.

Wider observations

8.13 The scope and resource of this commission has only been able to cover a fraction of possible aspects to modelling Health innovation impacts. Throughout the report, issues and lines of enquiry in aligned areas of investigation have been highlighted, noting the extent to which the study *could* be extended given additional time and resource.

8.14 Each consideration is arguably a study in its own right, e.g. the extent to which addressing barriers to market entry may stimulate greater economic activity with regard to Health innovation; the impact of improving healthy life expectancy on Healthcare expenditure/savings; the length of time to market for Health innovations, and the impact of reducing product development cycle timescales, demonstrating market readiness and achievement of full commercial activity (essentially compressing the time required to progress through TRLs).

8.15 Fully understanding the extent to which outcomes can be attributed to interventions will always require a number of assumptions. In practical terms, any full-blown model should acknowledge that it would be demonstrating impacts that Health innovations have contributed to, rather than can be considered solely responsible for.

8.16 Ensuring required data is collected in evaluations of different healthcare innovation interventions will be challenging. There will be a range of funders to influence in order to begin putting measures in place to achieve granular collection of data at the evaluation stage. However, the evaluation phase of projects typically constitutes a relatively (and prohibitively) small proportion of research budgets – and so thorough data collection is not incentivised. Better ways of achieving this should be explored. This could include adopting a standardised approach to data capture and reporting, focusing primarily on metrics and reducing the requirement for extensive narrative, or trialling a multi-stage approach to evaluation which seeks to gain intelligence on desired outcomes across the direct, indirect and social domains, with data capture occurring at specified time intervals – e.g. at point of Healthcare provision, immediately after provision, and 3-6 months after provision.

Appendix 1: Modelling indicators and observations on data availability

Indicator	Data availability and commentary
Inputs	
Public Sector Inputs	
Digital & Data support spend £ (SE, SG)	Partial availability Bespoke analysis required – feasibility work undertaken by SE/ILLG
NHS Procurement (innovative solutions)	
Spend on sector-based initiatives – FemTech, Personalised Nutrition, etc.	Yes Data available through SE, partners –needs assembled/ aggregated
Spend on R&D & Commercialisation in AI/ data, human health	Partial availability Bespoke analysis required, through SFC, Innovation Centres, etc.
Private Sector Inputs	
Digital & Data R&D £	No Primary research required (some data via NHS/ local authority procurement data)
Innovative & preventative solutions to the NHS £	Partial Bespoke data analysis would be required – feasibility work undertaken by SE/ILLG
Activities	
Digital & Data Support	
New product & process development support, Grant for R&D	Partial Data needs assembled, via public sector interventions
Market intelligence	
Modelling and testing of products/processes in test environment	
R&D & Commercialisation in AI/data, human health	
New product & process development (e.g. Innovation Centres)	Partial Data needs assembled, via public sector interventions (e.g. Innovation Centres)
Modelling and testing of products/processes in test environment	
Academic/business partnerships (ICs, KTPs)	No Data needs to be identified
Skills pipeline development (Masters/PhD)	Yes Data needs to be assembled
Some investment/funding support	No Data needs to be identified
Sector-based Initiatives	
Market intelligence	For these indicators, data on activities within the scope of key partners can be assembled/ aggregated – although there would be considerable work to deliver this, so would need to be commissioned as part of a baseline
Investment/ funding support – e.g. Investment calls for sector-based initiatives (e.g. PN)	
Further R&D support	
Commercialisation support programmes	
Market development programmes	
Supply chain programmes	
NHS Procurement & Selling into NHS	
Support for Clinical Trials	For these indicators, data on activities within scope (i.e. for NHS Scotland) needs to be assembled/ aggregated – although there would be considerable work to deliver this, so would need to be commissioned as part of a baseline
Innovation Testbeds (Scottish Government)	
Evaluation/Validation of ideas, approaches, kits, prototype devices developed by clinicians and/or researchers	
Meet the Buyer and/or Access to Market events	
Demand-led innovation funding calls	
Development of targeted thematic innovation networks	
Medical innovation and commercialisation accelerators	

Indicator	Data availability and commentary
£ for new solutions introduced	
Other preventative health programme spend	
Partnership Approaches to Health Challenges	
Joint health innovation initiatives – public, private, Government	Data on activities within scope needs to be assembled/ aggregated – although there would be considerable work to deliver this, so would need to be commissioned as part of a baseline
Other	
Partnership working and knowledge exchange	Data on activities within scope needs to be assembled/ aggregated – although there would be considerable work to deliver this, so would need to be commissioned as part of a baseline
Joint funding for new initiatives, product/process testing, validation and clinical evaluation	
Triple helix approach to research, testing, validation	
Joint decision-making on health innovation interventions	
Outputs	
Digital & Data Support	
New (Scottish) businesses providing digital & data services & solutions in health & social care (start-up businesses)	No Primary research would be required to obtain data
New digital & data products & services in H&SC	
R&D & Commercialisation	
Spend on R&D in businesses (BERD) & public sector (GERD)	Yes However, there is a time lag in data availability; additionally, available data may not be specific to Healthcare innovation
New patents/IP (health innovation)	
New products/services to market	No Primary research would be required to obtain data
Sector-based Initiatives	
New start-up businesses (as above)	Outputs from initiatives within scope of key partners can be assembled/ aggregated – although work to do so would need to be commissioned as part of baseline
New products & services in H&SC (as above)	
New patents/IP (as above)	
New funds established	
Exports of health innovation products & services	
NHS Procurement & Selling into NHS	
Uplift in clinical trials	Outputs from NHS activity/ initiatives within scope of key partners can be assembled/ aggregated – although work to do so would need to be commissioned as part of baseline
New health innovation/ prevention products & services taken up by the NHS	
Increase in spend by NHS Health Boards on innovation/prevention products & services	
Increase in value of contracts secured by companies selling into NHS	
Partnership Approaches to Health Challenges	
No. of joined investment calls	As above
Partnerships/joined decision-making agreements	
Increase in joint approach to clinical evaluation of new products and services in test and real-world environments	
Impact	
Theme-specific outcomes	
Growth in turnover of assisted businesses (£)	Yes Turnover data is available via published datasets, but needs related to healthcare innovation (Life sciences sector would be the best fit currently), and ideally the data would be attributed to specific intervention/ support via primary research
Increased GVA	Yes GVA data is available via published datasets – caveats as above

Indicator	Data availability and commentary
Growth in employment of assisted businesses (number of employees)	Yes Employment data is available – caveats as above
Increased company formation, and spinouts from academia/NHS Scotland	Data needs collected/assembled
Improved business survival rates	Yes Survival rates available– subject to similar caveats as above
Increase in the number of businesses that are innovation active	Data needs collected/assembled
New/improved products entering the market	
Growth in exports of assisted businesses	Yes Export data available – subject to similar caveats as above
New/improved processes adopted	As per products above
Increased expenditure on business R&D	Yes BERD data available – subject to similar caveats as above
Enhancement of local innovation ecosystem and networks	Data needs collected/assembled
Increased industry collaboration with NHS Scotland	
Increased industry collaboration with Social Care providers in Scotland	
Broader economic outcomes	
Increased overall levels of entrepreneurship	Data needs collected/assembled
Improved productivity	
Increased employment and GVA in supply chain	
Reduced timeline for clinical evaluation/validation of new products and services	
Increased commercialisation of ideas and approaches developed by clinicians and researchers	
Indirect outcomes/impact	
Reduced cost of treatment of preventable conditions/ exchequer savings	Requires primary research – related to applied interventions
Greater efficiency arising from improvements in NHS systems and processes	
Reduction in patient time in healthcare settings, thus reducing demand on NHS services	
Reduction in demand on acute health care services	
Reduction in demand on GPs and other primary care services	
Reduced demand on Social Care sector through improved health care management for individuals	
Social outcomes/impact	
Improved health outcomes	Published dataset – although needs attribution to intervention(s)
Increased (healthy) life expectancy	
Reduction in preventable conditions	Requires primary research – related to applied interventions
Improved management of health conditions, reducing impact on life/work	
Increased economic activity/productivity and reduction in limiting long-term illnesses	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