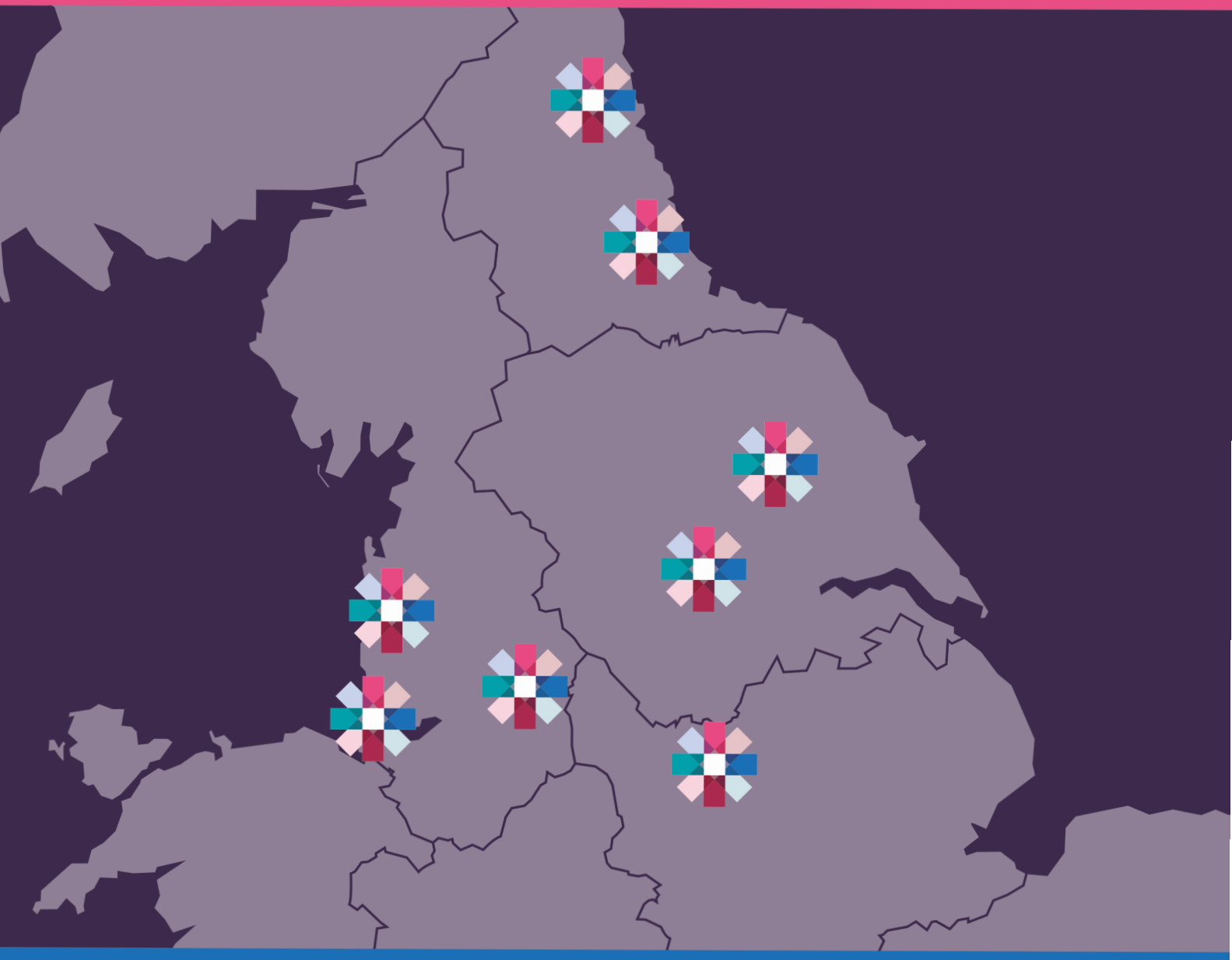
nhsa
Northern Health Science Alliance

A Health Partnership for Northern England

THE NORTHERN POWERHOUSE IN HEALTH RESEARCH



A SCIENCE AND INNOVATION AUDIT

MAIN REPORT | JUNE 2018

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The Northern Powerhouse in Health Research - A Science and Innovation Audit

Main Report
June 2018

Submitted by the Northern Health Science Alliance Ltd

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1 Introduction to the North . . . and our SIA's footprint

In Autumn 2015, the UK Government announced regional Science and Innovation Audits (SIAs) to catalyse a new approach to regional economic development. SIAs enable place-based consortia to focus on analysing regional strengths and identify mechanisms to realise their potential. In the North of England, the Northern Health Science Alliance (NHSA) has brought partners together to focus on the North's strengths in **Data for Better Health and Wealth** and **Precision Medicine.**

This report presents the results, which includes broad-ranging analysis of **The Northern Powerhouse in Health Research's** capabilities, the challenges, and the substantial opportunities for future economic growth.

Headline Messages

- This Science and Innovation Audit (SIA) highlights the North's potential to drive real-world clinical research across its 16m population by drawing on organisations' and individuals' expertise in, and knowledge of, Health and Life Sciences. It reviews the tangible and intangible assets in the North of England for:
- **Data for Better Health and Wealth,** which is *the ability to develop and implement Learning Health Systems* where progress in Science, Informatics, and Care Culture come together to generate new knowledge as an ongoing outcome of the care process, and deliver continuous improvement in Health and Healthcare; [1] and
- **Precision Medicine,** which is the search for, and application of, the right treatment, at the right dose, to the right patient, at the right time.
- By working with place-based communities, supported by initiatives such as #Datasaveslives and Connected Health Cities (CHC), and pioneering assets such as the Great North and Leeds Care Records and the Salford Lung Study, the North is in prime position to diffuse and embed digitally-enabled **Precision Medicine** research and application at scale, for the benefit of UK citizens and the national economy.

[1] The Institute of Medicine (J Am Med Inform Assoc. 2015 Jan; 22(1): 43–50. Published online 2014 Oct 23. doi: 10.1136/amiajnl-2014-002977).

- Our aim is that this SIA can play a vital role in progressing the Life Sciences Industrial Strategy and the proposed Northern Life Sciences Industrial Strategy Sector Deal. Our vision is that over the next 10 years, the North of England will:
    - Be a globally recognised centre for applied Health Innovation with strengths in (i) **Data for Better Health and Wealth**, and (ii) **Precision Medicine**;
    - Be one of the world's most connected and networked regions for Applied Health Innovation – attracting significant levels of public, private, and voluntary sector investment, based on a track record of excellence in applied Health Innovation;
    - Apply Health Innovation by bringing together unique combinations of assets and expertise with which to conduct research;
    - Nurture local applied Health Innovation talent in research, clinical practice, entrepreneurship and business management, and attract and retain Health Innovation talent from around the world; and
    - Become a healthier and more economically productive place in which to live, narrowing the North's health, wealth and productivity gaps compared with the South of England.

Our Place in a Nutshell

Geography and Partners

1.1 The footprint of the Northern Powerhouse in Health Research (NPiHR) area is formed by eight cities and their hinterlands: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield, and York (Figure 1-1). The research-intensive Universities in each of the cities form the N8 Research Partnership. The Life Science businesses in the North work collectively through the membership organisation Bionow. Four Academic Health Science Networks (AHSNs)[2] and 11 Local Enterprise Partnerships (LEPs) operate in the SIA's geography. And the Northern Health Science Alliance (NHSA) works on a pan-Northern basis with these organisations and networks.

1.2 As articulated by former Chancellor of the Exchequer George Osborne, the cities of the North are individually strong but have some way to go to be collectively great. By creating stronger synergies across the region and more connected cities, there is huge untapped potential to be unlocked, which will boost the UK economy as a whole.

> 'Together our Northern cities can be more than the sum of their parts'[3]

1.3 Drawing on the learning of the preceding Round 1 and 2 SIAs, this SIA does not standalone. Rather, it is complementary to and supportive of other extant Life Science and Data SIAs in the North and across the wider UK. These include the Leeds MedTech SIA, the Greater Manchester/Cheshire SIA's focus on Advanced Materials and Applied Health Innovation, the Liverpool+ SIA's commitment to Infectious Disease and High-Performance and Cognitive

[2] (1) Academic Health Science Network North East and North Cumbria, (2) Innovation Agency Academic Health Science Network for the North West Coast, (3) Yorkshire & Humber partners Academic Health Science Network, and (4) Greater Manchester Academic Health Science Network.

[3] Osbourne G, *'Chancellor: 'We Need A Northern Powerhouse' - GOV.UK'* (Gov.uk, 2017) [online] Gov.uk. **https://www.gov.uk/government/speeches/chancellor-we-need-a-northern-powerhouse**

Computing as well as the Sheffield-Lancaster SIA focus on Driving Productivity Growth Through Innovation in High Value Manufacturing in multiple areas, including health technologies. Other opportunities also exist for establishing links to the Bio-economy across Yorkshire, the North East's focus on Ageing and Digital activities, and work to drive forward the Health and Social Care freedoms that devolution in one of the North's major agglomerations is testing. Equally important, we see this SIA as playing a key role in helping to progress the Life Sciences Industrial Strategy and the proposed Northern Life Science Industrial Strategy Sector Deal, and how this presents in different areas across the North. We want this SIA to be seen as extending, enhancing and fully enabling of these initiatives, with their own performance being used as metrics/key performance indicators in our success on equal measure.

Economy

1.4 The North of England is an integral part of the UK economy, generating c. £327 billion Gross Value Added (GVA) in 2015. This is approximately one-fifth of the national UK output.[4] A quarter of UK people live in our SIA's footprint, a population of almost 16 million. The proportion of our population who are of Working-Age (aged 16-64) is c. 63 per cent, close to the UK average.[5]

1.5 Our economy hosts almost 23 per cent of the UK's jobs, with a job density[6] of 0.78 in 2015, slightly below the UK average of 0.83.[7]

1.6 While there are areas of high productivity, such as Cheshire and Warrington, the well-known pan-northern productivity gap with the South of England, persists. Productivity in the North is consistently below the UK average. In 2015, GVA per hour worked was £28 compared to c. £32; whilst GVA per filled job in the SIA area was 87 per cent of the UK average, at £44,078 compared to £50,830.[8] This indicates potential for improvement, if the North can match the UK average.

1.7 Annual earnings[9] in 2016 in the SIA's footprint were £25,402, 90 per cent of the UK average. This is a 2.6 per cent nominal increase on 2015.[10]

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[4] ONS (2015), Gross Value Added (GVA), **https://www.ons.gov.uk/economy/grossvalueaddedgva**

[5] ONS (2016), Population and Migration, **https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration**

[6] 'Jobs density is defined as the number of jobs in an area divided by the resident population aged 16-64 in that area' (Nomis). Data for the SIA area has been calculated as a population-weighted average using data at the Local Authority District (LAD) level.

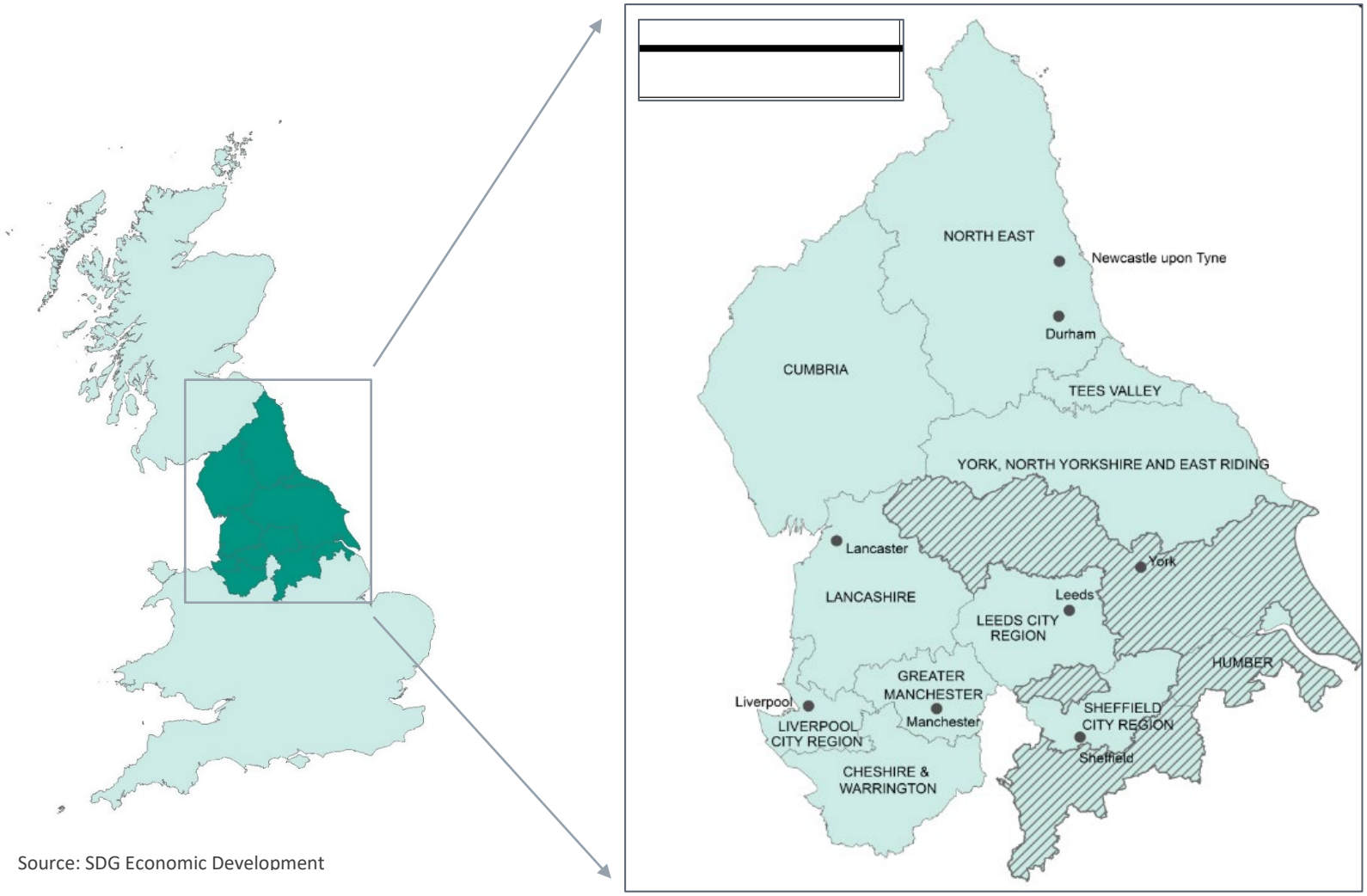
[7] ONS (2015), Jobs Density, **https://www.nomisweb.co.uk/**

[8] ONS (2015), Regional and sub-regional productivity in the UK, **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/regionalandsubregionalproductivityintheuk/jan2017**

[9] Median Annual Gross full-time annual earnings 2016 and percentage change from 2015 in nominal terms. Data has been calculated as population-weighted averages using data at LAD level.

[10] ONS (2016), Annual Survey of Hours and Earnings, **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2016provisionalresults**

Figure 1-1: Map of the Northern Powerhouse



Source: SDG Economic Development

1.8 The proportion of the population who are employed in Science, Research, Engineering and Technology professions or associated professions is just under 6 per cent, compared to just under 7.5 per cent for the UK as a whole. The North of England also has a smaller proportion of its population qualified to NVQ Level 4+ at c. 38 per cent compared to 43.5 per cent nationally. There are more people in the North with no qualifications at c. 5 per cent, which is 0.2 per cent higher than the UK average.[11] We need far more higher-skilled workers and many fewer unskilled ones.

> 'If the North were an independent country, it would be the tenth largest economy in Europe'[12]

Connectivity

1.9 Transport is a key element in the vision for the Northern Powerhouse's future economic prosperity. Successful clusters are, typically, formed in cities and regions that allow individuals to undertake high-risk economic activities, such as starting a new company or professional operations, in lower-risk environments, such as not needing to move house and/or changing children's schooling. In places that don't have self-contained 'cluster capacity,' efficient inter-city connectivity between areas helps workers to access new opportunities whilst not changing their residential locations. Said another way, transport connectivity is helpful in making places and regions 'sticky' for workers, so that they and the skills they embody are retained and not lost to competitor locations. Hence the importance the North places on transport planning and investment, for example around High Speed Rail.

1.10 The Northern Powerhouse is host to four major ports, which handle 35 per cent of total port throughput for the UK and it has good motorway connectivity.[13] It also has several large airports, including Manchester Airport, the largest outside of London.[14] Improving east-west connectivity across the North is a priority for enabling economic growth. The vision for an enhanced east-west connection is currently being pursued by Transport for the North. In terms of road, a TransPennine Tunnel option under the line of the existing A628 is being pursued, to contribute to improved highway connectivity for people and freight.

Health Issues and Outcomes

1.11 The North's population has a high health burden, with lower health outcomes and life expectancy than the South of England. Research conducted by the Universities of Manchester

[11] ONS (2016), Annual Population Survey, **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/methodologies/annualpopulationsurveyapsqmi**

[12] IPPR North (2017). *HOUSE OF LORDS STATE OF THE NORTH DEBATE.* [online] Available at: **https://www.ippr.org/files/IPPR%20North%20-%20State%20of%20the%20North%20briefing.pdf?noredirect=1**

[13] Laybourn-Langton, L., Corlett, J. and Cox, E. (2017). *Gateways to the northern powerhouse: A northern ports strategy. IPPR*. **https://www.ippr.org/publications/gateways-to-the-northern-powerhouse**

[14] Manchester Airport (2017). *Airport Summary | Manchester Airport.* **http://www.manchesterairport.co.uk/about-us/media-centre/fact-sheets/airport-summary/**

and York[15] found that while overall life expectancy has improved in the North and the South of England, the gap in life expectancy between the North and the South has not closed: premature mortality (deaths per 10,000 aged <75 years) declined from 64 to 28 in Southern England relative to a decline from 72 to 35 in Northern England from 1965 to 2015 (Figure 1-2).

1.12 The research also found that excess mortality for the Northern 25-34 and 35-44 age groups increased sharply between 1995 and 2015, due to Northern mortality increasing (for ages 25-34) or plateauing (for ages 35-44) from the mid-1990s, while Southern mortality mainly declined (Figure 1-3). Thus, despite a relatively benign economic climate and the implementation of national policies to reduce inequalities in health, the gap in mortality rates between the North and the South has remained persistent: dying early is 20 per cent more likely in the North than in the South and a gap of two years remains in the life expectancy of those in the North relative to those in the South. The research concluded that there have been approximately 1.17 million premature deaths in the North, since 1965.

1.13 Early mortality and the associated higher sickness absence rates in the North adversely affect overall productivity via fewer hours worked and lower physical productivity for those who attend work but are not fully fit (Figure 1-4). Thus, there is an economic case for intervention to reduce the negative externalities associated with poor health outcomes, specifically, sub-optimal use of the workforce available and higher running costs for the NHS.

The importance of research for health outcomes

1.14 There is a clear inverse correlation between NHS hospital research spend and mortality rates.[16] Therefore, increased investment in health research in the North is likely to contribute to improved health outcomes in part because innovative trials lead to earlier access to potential treatments and importantly because top researchers and clinicians will be operating in these health systems.

And so, the Compound Challenge?

1.15 So, on the one hand the North is not delivering on its economic potential, both in terms of its productivity *and* the proportion of its people who could, and should, be working. At the same time, the North's Health and Care outcomes are not where they should be. Given that healthy citizens are a key prerequisite for a productive and efficient workforce, there is a real opportunity to contribute to Northern prosperity by ensuring our people and the workforce is healthier, and that the Health and Care systems, which support these are increasingly world-class in what they do and how they do it. Accordingly, **the beating heart of this SIA is the opportunity to unlock the wealth opportunity of the North by developing and implementing greater health innovation across the North's c. 16 million population**.

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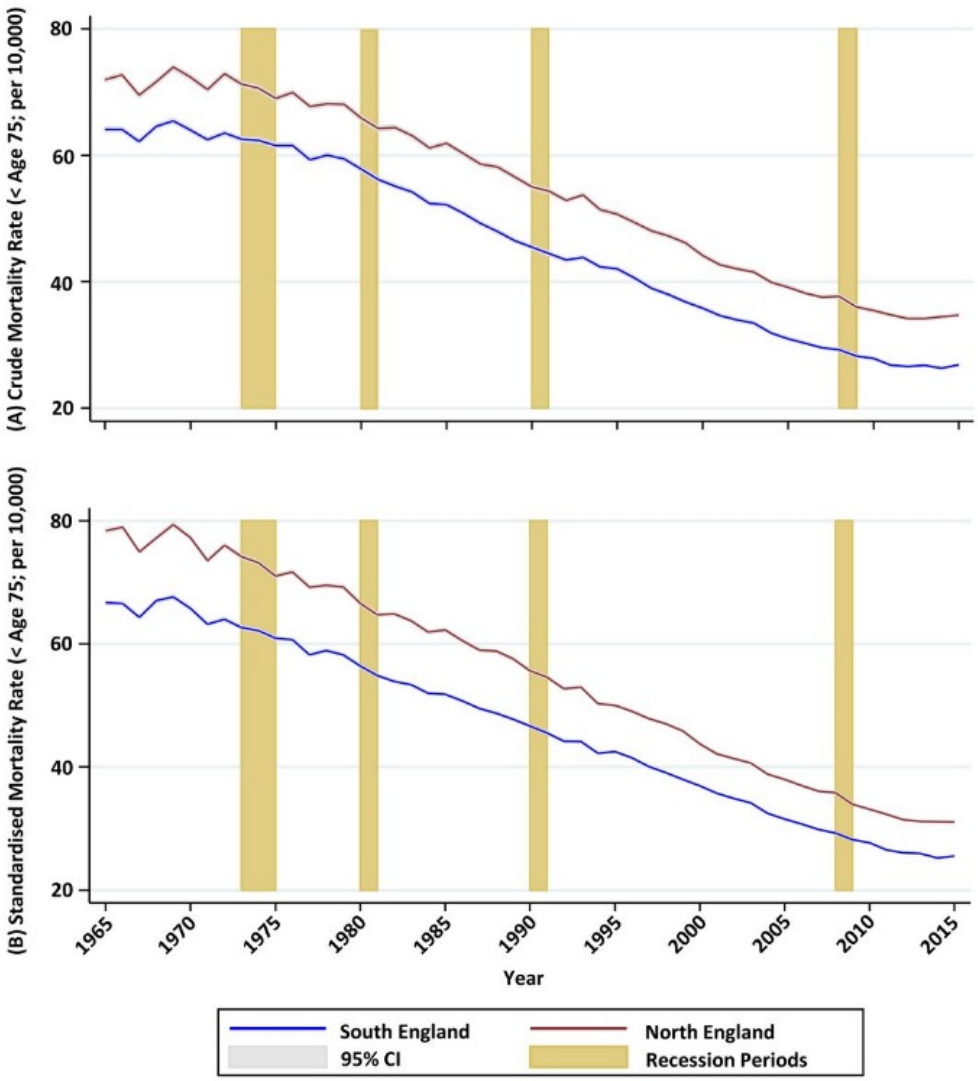
[15] Buchan, I. E., Kontopantelis, E., Sperrin, M., et al (2017), "North-South disparities in English mortality 1965-2015: longitudinal population study", *J Epidemiol Community Health*, 71:928-936, **http://jech.bmj.com/content/early/2017/07/14/jech-2017-209195**

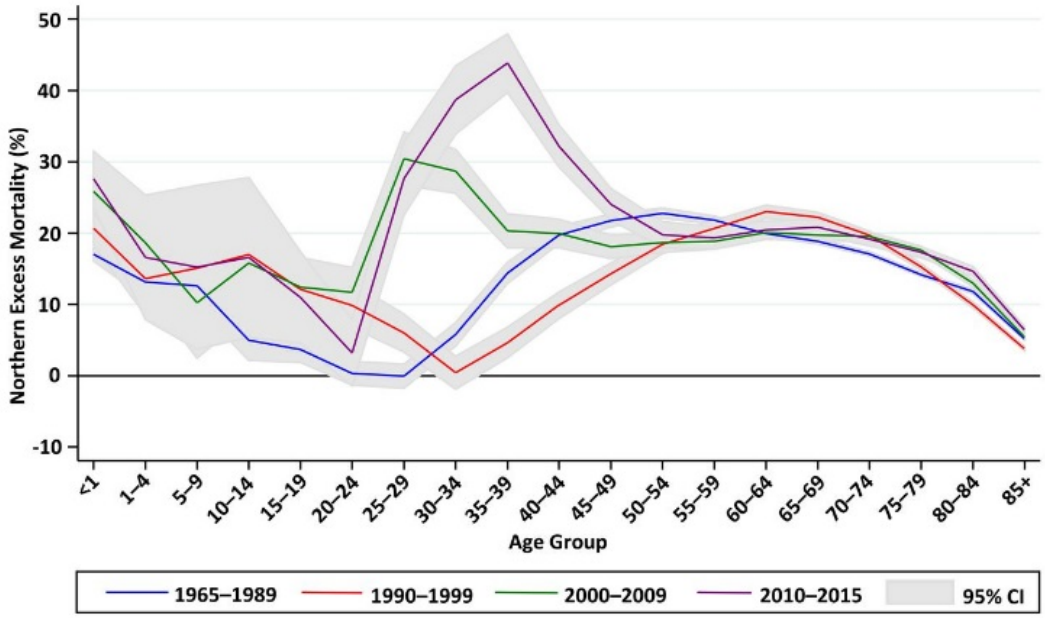
[16] Ozdemir B, Karthikesalingam A, Sinha S, Poloniecki J, Hinchliffe R, Thompson M, Gower J, Boaz A and Holt P (2015) 'Research Activity and the Association with Mortality', *PLoS ONE* 10(2)

Figure 1-2: Premature (age <75 years) mortality for men plus women in the North and South of England, 1965–2015



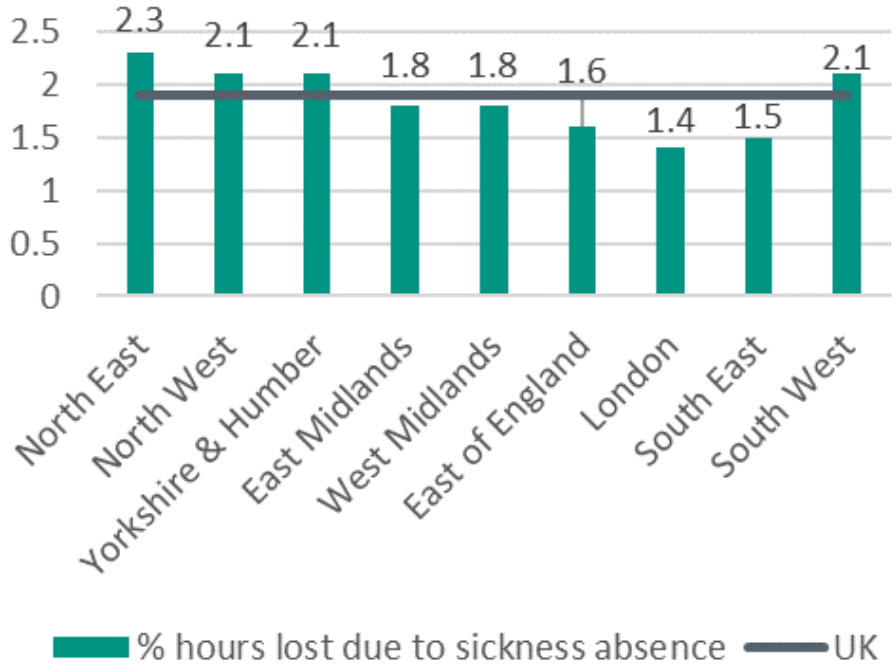
Source: Buchan, I. E., Kontopantelis, E., Sperrin, M., et al (2017), "North-South disparities in English mortality 1965-2015: longitudinal population study", *J Epidemiol Community Health*, 71:928-936, **http://jech.bmj.com/content/early/2017/07/14/jech-2017-209195**

Figure 1-3: Excess mortality in the North compared with South of England by age group in four periods between 1965 and 2015



Source: Buchan, I. E., Kontopantelis, E., Sperrin, M., et al (2017), "North-South disparities in English mortality 1965-2015: longitudinal population study", *J Epidemiol Community Health*, 71:928-936, **http://jech.bmj.com/content/early/2017/07/14/jech-2017-209195**

Figure 1-4: Percentage of hours lost due to sickness absence rates by region



Source: ONS (2016), Annual Population Survey, **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/methodologies/annualpopulationsurveyapsqmi**

Science and Innovation Assets and Capabilities

Life Sciences in the UK

1.16 The UK is internationally renowned as a centre of excellence for Life Sciences with a strong asset base across the Life Sciences value chain.[17] This includes pioneering fundamental and applied research within and across many institutions, bridged by extensive ability to conduct clinical trials in and alongside an integrated health system with high-quality data for research and direct patient care. Life Sciences are an important part of the UK's economic ecosystem, generating over £70 billion in turnover each year across 5,649 companies, which employ 241,000 scientists and staff. Life Sciences can be broken down into two main sectors, Biopharma which generates £48.2 billion in annual turnover, and Med Tech, which generates £22.2 billion in annual turnover. Digital Health is a fast-growing segment of the Med Tech sector with over 10,000 employees, a turnover of over £1.2 billion and a 19 per cent share of all UK Med Tech companies.[18] The Life Sciences industry continues to be internationally competitive, with high rates of productivity compared to other G7 countries.[19] The UK's Industrial Strategy (discussed in more detail in Appendix 2) highlights the importance of Life Sciences for the UK.

Life Sciences and Health Innovation in the North

Economic and business base

1.17 The Northern Powerhouse Independent Economic Review (NPIER)[20] identified Health Innovation as one of the North's four prime capabilities.[21] The NPIER recognised two main specialisms within Health Innovation, Life Sciences and Healthcare Technologies. Healthcare Technologies includes Medical Technologies[22] and Devices for e-health, as well as health analytics and clinical research.

1.18 Life Sciences are an integral part of the North's economic ecosystem. IPPR North's *Health Innovation: Breathing life into the Northern Powerhouse*, reports that the Life Sciences industry generates £17.5 billion in the North and is forecast to grow by 44.6 per cent by 2030. The sector employs 7.5 per cent of the region's workforce with forecast employment growth

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[17] Office for Life Sciences [OLS] (2017) *Life sciences: industrial strategy.* **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/650447/LifeSciencesIndustrialStrategy_acc2.pdf**

[18] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the landscape of the medical technology and biopharmaceutical sectors in the UK*, Annual report 2017. **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707072/strength-and-opportunity-2017-bioscience-technology.pdf**

[19] Office for Life Sciences [OLS] (2017) *Life sciences: industrial strategy.* **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/650447/LifeSciencesIndustrialStrategy_acc2.pdf**

[20] Transport for the North [TfN] (2016) *The Northern Powerhouse Independent Economic Review: Final Executive Summary Report.* **http://www.transportforthenorth.com/wp-content/uploads/Northern-Powerhouse-Independent-Economic-Review-Executive-Summary.pdf**

[21] Prime capabilities are defined as those areas in which the Northern Powerhouse has a globally competitive advantage. The other three capabilities are: Advanced manufacturing (processes and materials), Energy, and Digital.

[22] This identified strength has been explored in greater detail for Leeds City Region in the Wave 2 SIA *'Opportunities and Growth: Medical Technologies in the Leeds City Region'*.

of 4.5 per cent.[23] The Northern Powerhouse hosts over 1,270 businesses in the Life and Health Science sector, which support approximately 49,800 jobs in the SIA area.[24] [25]

1.19 The North is also an integral part of the UK's Digital Economy, with 18 per cent of the UK's tech-workers, and the biggest tech-cluster outside London (Manchester), and is home to Sage UK in Newcastle, one of the few FTSE 100 listed tech companies.[26]

Networks and supporting 'soft' infrastructure

1.20 The North has a network of world-class sites and facilities that are integrated with industry, academia and clinical research through a network of gateway organisations. These organisations facilitate, amongst other things, innovation and industry collaboration (Table 1-1).

Table 1-1: Northern Powerhouse gateway organisations

Northern Health Science Alliance (NHSA) – Supports the establishment of multi-centre clinical research and development projects. The Life Sciences Industrial Strategy cites the NHSA as an essential ingredient in the development and support of a successful Life Sciences cluster (OLS, 2017, p.40) and the Life Sciences Sector Deal states the NHSA will work with industry and government 'to support the growth of the north's Life Science and health innovation economy' through a Northern Life Science Sector Deal (OLS, 2017, p.17). *Membership*: N8 Member Universities, 4 Academic Health Science Networks and 8 NHS Teaching Hospitals.
N8 Research Partnership – The eight research-intensive universities in the Northern Powerhouse, who collectively bring in over £800m in research income or 19 per cent of the UK total. They produced 100+ publications ranked amongst the top 1 per cent in the areas of AgriScience, Regenerative Medicine, Big Data and AgriTech between 2008 and 2012 (government priority areas) and they also produced over 5000 publications ranking in the global top 10 per cent in the same timeframe for Life Sciences more generally. The N8 Universities are also strong in innovation, with particularly strong links to regional business, local government and schools in their areas. *Membership:* the universities of Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York.
Tech Nation, formerly Tech North – Part of Tech City UK, supports the growth of the digital business sector across the North through a series of programmes, events, research and editorial focusing on start-ups, investment, people, skills and the digital ecosystem.
Bionow – Sponsored by AstraZeneca, Lancaster University, University of Liverpool, University of Manchester, Newcastle University, Durham University and Manchester Metropolitan University, Bionow is a membership organisation for businesses in the biomedical and Life Science sectors in the North. Bionow supports business growth, competitiveness and innovation for smaller start-up businesses and established growing businesses. Bionow has around 300 industry members across the North (Bionow, 2018).

[23] Raikes L (2016) *Health innovation: Breathing life into the northern powerhouse, IPPR North.* **http://www.ippr.org/publications/health-innovation-breathing-life-into-the-northern-powerhouse**

[24] This is a sum of the North West, the North East and Yorkshire and the Humber calculations made in Strength and Opportunity 2017. These original employment figures are calculated as a sum of 'Biopharma core', 'Biopharma Service & Supply', 'Med Tech core' and 'Med Tech Service & Supply'.

[25] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the data behind the charts, data,* Bioscience and health technology database: annual report 2017. **https://www.gov.uk/government/publications/bioscience-and-health-technology-database-annual-report-2017**

[26] Tech North. (n.d.). *About us*. [online] Available at: **https://technorthhq.com/about/**

Academic Health Science Networks (AHSN) – Enable companies to grow and create jobs by helping the NHS and industry engage more productively, focused on proven innovations that meet defined local needs.

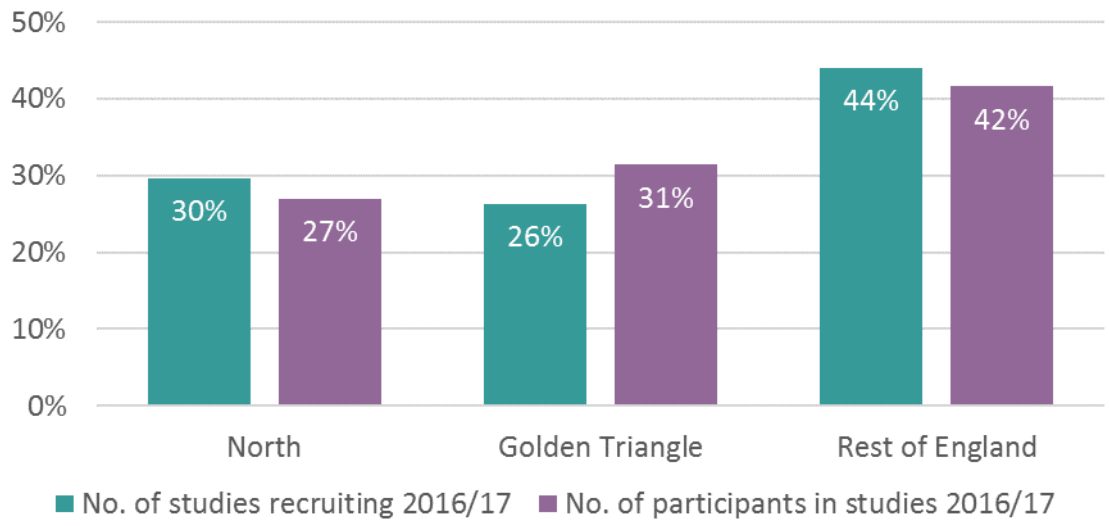
AHSNs: Academic Health Science Network North East and North Cumbria, Innovation Agency Academic Health Science Network for the North West Coast, Yorkshire & Humber partners Academic Health Science Network, Greater Manchester Academic Health Science Network.

Local Enterprise Partnerships (LEPs) – Business-led partnerships driving economic growth.

Membership: Cheshire and Warrington, Cumbria, Greater Manchester, Humber, Lancashire, Leeds City Region, Liverpool City Region, North Eastern, Sheffield City Region, Tees Valley and York, North Yorkshire and East Riding.

Source: SDG-ED using UK Trade and Investment [UKTI] (2016) *Northern Powerhouse – Opportunities in Life Sciences: pitch deck.* **http://www.n8research.org.uk/media/The-NPH-Life-Science-Pitch-Deck.pdf**

Figure 1-5: Clinical Trial Data for 2016-17



Source: National Institute for Health Research (NIHR) Clinical Research Network (CRN), (2017), NIHR Research Activity League Table, **https://www.nihr.ac.uk/research-and-impact/nhs-research-performance/league-tables/**

1.21 Effective cross-sectoral partnerships have supported innovation, such as a recent project between Tech Nation (formerly Tech North) and NHSA to develop a Health Tech App. The app targets potential investors for the region and provides key facts and figures on the Health Tech sector in the North. Another important example of cross-sectoral partnership can be seen in Bradford. Leeds City Region and Bradford are home to TPP[27] and EMIS Health,[28] which together account for over 90 per cent of UK primary care electronic patient records. Working with TPP, Bradford NHS and the City of Bradford Metropolitan District Council have rolled out the first Integrated Care Data Record comprising both health and social care records, based on SystmOne, covering a population of some 600,000 people.

[27] TPP is a UK based IT company, dedicated to delivering world-class healthcare software through our innovative products; SystmOne, SystmConnect, SystmInsight and SystmOnline.

[28] A supplier of electronic patient record systems and software used in primary care in England.

Recruitment for Clinical Trials

1.22 Our SIA area delivers more clinical trials (for the number of studies that are recruiting) than London, Oxford and Cambridge combined (Figure 1-5). The North is also home to the top NHS Trust nationally for the number of clinical trial studies, the Newcastle Upon Tyne Hospitals NHS Foundation Trust, as well as two other top-ten Trusts.[29] [30] Our SIA area also has a network of clinical research networks, with four of the 15 local clinical research networks based in the North. This means that patients can be recruited from across the regional geographic footprint and across all levels and providers of care.

1.23 The North has a diverse and stable patient population of almost 16 million, which covers most major diseases and health states.[31] The variety of health issues and the scale at which they present in the North of England means that the SIA geography is ideally placed to conduct research and host clinical trials.

Research funding for Life Sciences in the North

1.24 Bespoke research undertaken by Technopolis for this SIA (Appendix 8)[32] shows that organisations in the NPiHR's footprint led around 1,320 projects (18 per cent of all projects and c. 17 per cent of all funding for the UK) on **Data for Better Health and Wealth** and 1,582 projects (c. 17 per cent of all projects and c. 14 per cent of all funding for the UK) on **Precision Medicine** in the ten-year period of 2007 to 2017. The analysis also shows the North was a partner in 1,682 projects on **Data for Better Health** (accounting for c. 23 per cent of all projects and c. 30 per cent of all funding for the UK) and a partner in 1,985 **Precision Medicine** projects (accounting for c. 21 per cent of all projects and c. 25 per cent of all funding for the UK).

1.25 The Technopolis analysis also shows that the North has a particularly strong track record in accessing research funding for ageing; it led c. 20 per cent of projects in the period 2007-2017 (accounting for c.24 per cent of all funding).

1.26 In terms of funding sources for **Data for Better Health**, the EPSRC funds the largest number of projects for the North (662 c. 40 per cent) and is the single largest source of the North's funding (c. £533.5 million, c. 55 per cent). Innovate UK funds the second largest number of projects, 284, but accounts for only c. 6 per cent of funding (£72 million). The MRC funds 245 projects (c. 15 per cent of all projects) and £253 million (c. 22 per cent of all funding).

1.27 While the Technopolis analysis of funding sources for **Precision Medicine** shows the BBRSC funded the largest number of projects (895, c. 45 per cent) but provided only c. 27 per cent of

[29] The Newcastle Upon Tyne Hospitals NHS Foundation Trust, Leeds Teaching Hospitals NHS Trust and Sheffield Teaching Hospitals NHS Foundation Trust

[30] National Institute for Health Research (NIHR) Clinical Research Network (CRN), (2017), NIHR Research Activity League Table, **https://www.nihr.ac.uk/research-and-impact/nhs-research-performance/league-tables/**

[31] Buchan, I. E., Kontopantelis, E., Sperrin, M., et al (2017), "North-South disparities in English mortality 1965-2015: longitudinal population study", *J Epidemiol Community Health*, 71:928-936, **http://jech.bmj.com/content/early/2017/07/14/jech-2017-209195**

[32] The source of data analysed is UKRC's Gateway to Research, which includes most R&D activity funded by the UK research councils, but also any grants by InnovateUK. This means that these data not only comprise research grants, but also feasibility studies, pilots, prototypes and proof of concepts, KTNs, innovation voucher grants, etc.

funding (£329.5 million), the MRC funded the second largest number of projects, 414, (c. 21 per cent) and the largest share of all funding, c. 36 per cent (£452m).

1.28 Reviewing EU Framework Programmes from 2007-2017, our SIA area has led 8.5% of all UK projects across the Seventh Framework Programme and Horizon 2020. This equates to approximately £12bn in funding value; 8% of the total funding to the UK. The two largest sub-programmes are 'Information and Communication' and 'Health', which together accounted for 26.9% of the funding that the North received under EU Framework Programmes.

1.29 Health Research Classification System (HRCS) reports that in 2014 the three Northern regions received £273m in non-business-related health research funding through 2,334 funding awards from 64 funders. This equates to approximately 13.5 per cent of all funding. Although significant, the North as a whole has received less than London (£649.4 million or 32.1 per cent) and the South East (£319.9 million or 15.8 per cent). Analysis of HRCS data from IPPR North[33] shows that 39 per cent of this was from research councils, almost one-quarter from the Medical Research Council, 36 per cent from charities (Cancer Research and Wellcome Trust accounting for around one-quarter of the funding); and 25 per cent from government departments (almost all from the Department of Health).

1.30 The IPPR North report estimated the likely value of private sector funding for R&D – as regional-level data for R&D investment in Life Sciences are not available. It identified a proxy figure, namely, business investment in R&D in the chemicals sector, of which pharmaceuticals is a part. The report noted that almost 20 per cent of private sector spending was in the North – a larger share than the North's share of public sector R&D investment. The report highlights the North's relative strength in applied and translational research, illustrated by its share of awards for research in health services (21 per cent), disease management (20 per cent), and treatment development (17 per cent). But it notes the relatively small-scale nature of these funding pots, and the North's over-reliance on them for research funding. For example, 22 per cent of the North's funding is in aetiology (£60m), but this accounts for only 10 per cent of UK spend.

1.31 The North-South disparity in investment is also apparent in funding for National Institute for Health Research (NIHR) Biomedical Research Centres (BRCs). There are 20 BRCs, four of which are in the North (Leeds, Manchester, Newcastle, and Sheffield). Over five years, £816m has been allocated to BRCs, of which the North has received less than 7 per cent, relative to 83 per cent to institutions in the 'Golden Triangle'.[34]

The North has a track record of accessing and managing large-scale funding and of attracting significant private sector investment, but it is over-reliant on relatively small funding pots. A key goal of partners in the NPiHR is that the North should raise its share of health research funding to 20 per cent. This improvement should be achieved through better coordination of health innovation assets across the North and by a shift in

[33] Raikes L (2016) *Health innovation: Breathing life into the northern powerhouse, IPPR North.* **http://www.ippr.org/publications/health-innovation-breathing-life-into-the-northern-powerhouse**

[34] National Institute for Health Research [NIHR] (2017) *NIHR research activity league table, League Table 2016-17* 'NIHR Research Activity League Table 2016-2017'. **https://www.nihr.ac.uk/research-and-impact/nhs-research-performance/league-tables/league-table-2016-17.html**

funders' priorities to ensure sufficient resources are available for testing, validation, diffusion and adoption of innovation – in the context of a learning health system.

Stakeholders' views on funding trends

1.32 Stakeholders (from universities, the NHS, and business) were consulted on trends in funding and the development of the wider funding framework – both in workshop format and at steering group meetings. They identified the following current initiatives in the North as significant:

- It is difficult to get specific data on funding for Precision Medicine, which can restrain our understanding;
- The Medical Research Council is increasing funding to Stratified Medicine, which should enhance the North's role in research funding;
- Globally, there is a lot of funding for Data but this flows elsewhere, particularly to the USA and parts of Asia;
- There is a huge international initiative led by the G20 and the UN to address antimicrobial resistance (AMR), however, the UK does not access this effectively due to a lack of match funding, e.g. there is not enough specific funding for AMR translation work;
- With the emergence of UK Research and Innovation (UKRI) ISCF funding is changing;
- Businesses find it difficult to obtain growth and scale-up funding rather than start-up finance;
- The NHSA is working with partners to establish a Northern Life Science Growth Fund c£120m;
- Universities in Manchester, Leeds, and Sheffield are developing a 'Northern Triangle Initiative' (NTI). HEFCE endowed funding to work up a fund to leverage venture capital to support the growth of a shared intellectual property pipeline; and
- The European Development Fund (ERDF) is going to be replaced with the Shared Prosperity Fund.

Stakeholder views on research priorities in the North

1.33 Consultees highlighted the following broad research areas as strengths both in and for the North:

- Health economics and biostatistics;
- Clinical trials and real-world evidence;
- Digital Health, including Digital collaboration, such as the collaboration between Alder Hey Hospital, IBM Watson and the STFC Hartree Centre to create the UK's first 'cognitive' hospital by harnessing Big Data and the power of IBM's Watson technology platform;
- Companion Diagnostics;
- Pharma advanced manufacturing;
- Advanced therapy centres; and
- Devolution of health and social care in Greater Manchester.

Stakeholder views on Opportunities and Threats to Funding

1.34 When stakeholders reflected on opportunities and threats in the funding environment, they identified uncertainties in relation to Brexit – both in terms of the potential loss of funding streams and the potential loss of international collaborations, as well as the ability to maintain

attractiveness for inward investment. However, it was noted that organisations such as the NHSA are working to establish new Commonwealth based research, development and economic development partnerships in response to Brexit.

1.35 Reference was made to the potential for the Shared Prosperity Fund to support Life Sciences research in a more flexible manner than has been possible under the requirements of ERDF. In particular, the possibility of LEPs being given the freedom to fund validation research in NHS settings was highlighted as an opportunity to help support the R&D to FDI model of economic development in this sector. However, stakeholders also expressed concern that different LEPs placed different emphases on the Life Sciences, suggesting potential limits on collaborative working across different LEP geographies – which is the focus of this SIA.

1.36 Partners also highlighted the possibilities offered by the Industrial Strategy Challenge Fund, given the prominence of Life Sciences in the Industrial Strategy.

The Prize we offer

1.37 At its core, this SIA is seeking to exploit the potential to drive real-world clinical research across the North's population of about 16 million, drawing on the area's foremost expertise and knowledge in Health and Life Sciences. By working with place-based communities, supported by initiatives such as #Datasaveslives and Connected Health Cities, and pioneering assets such as the Great North and Leeds Care Records and the Salford Lung Study, the North is in prime position to diffuse and embed digitally-enabled Precision Medicine research and application at scale, for the benefit of UK citizens and the national economy.

The focus of this Science and Innovation Audit

1.38 The main hypothesis to be tested in this Science and Innovation Audit is that:

> Utilising the North of England's collective academic, clinical and business **strengths in Health Data** and **Precision Medicine** at a scale of up to 16 million people will have a greater impact on investment into, and the economic development of, the North of England and the UK than by utilising assets with smaller geographic and demographic footprints.

1.39 This hypothesis is tested across two highly complementary themes based on identified, purposefully selected, pan-regional health research capabilities as they provide an opportunity to increase research and secure industrial investment, and improve the quality and outcomes of patient care:

- **Theme One – Data for Better Health and Wealth**, for which there is a further sub-hypothesis:
  - The North of England is ideally placed to facilitate and catalyse the science and innovation required to establish Learning Health Systems; and
- **Theme Two – Precision Medicine**, for which there is also a sub-hypothesis:
  - Strategic investment in training will unlock a new uptake of **Precision Medicine** and will act as a model for other UK and international teams.

1.40 The evidence gathered through the SIA process – including evidence that contradicts our hypotheses – has helped us to develop five 'directions of travel' to inform our work, namely that the North of England:

- Be a globally recognised centre for applied Health Innovation with strengths in (i) Data for Better Health and Wealth, and (ii) Precision Medicine;
- Be one of the world's most connected and networked regions for Applied Health Innovation – attracting significant levels of public, private, and voluntary sector investment, based on a track record of excellence in applied Health Innovation;
- Will apply Health Innovation by bringing together unique combinations of assets and expertise with which to conduct research;
- Nurture locally applied Health Innovation talent in terms of research, clinical practice, entrepreneurship and business management, and attract and retain Health Innovation talent from around the world; and
- Will become a healthier and more economically productive place in which to live– narrowing the North's health and productivity gaps compared with the South of England.

1.41 The next Chapter provides more detail on the North's strengths that underpin our two themes.

2 Strengths in Science and Innovation

Headline Messages

- The North has significant academic, science, health and research assets: it provides 20 per cent of Russell Group universities and hosts one of the National Science and Innovation Campuses at Sci-Tech Daresbury, which is home to the Science and Technology Facilities Council (STFC) Daresbury Laboratory and the Hartree Centre – we need to build on these assets to strengthen economic clusters in the North;
- The scale of scientific production for the North is significant: 21 per cent of all submitted outputs, and full-time equivalent researchers, as reported in the REF 2014, were from our SIA area, along with 23 per cent of all doctoral degrees awarded in the period 2008-2012 – recent increases in medical school numbers for 2018-19 through to 2020-21 should further add to these figures;
- Our educational institutions deliver a strong talent pipeline – but we need to improve retention rates by offering good career development opportunities by growing our significant economic clusters around Leeds, Liverpool, Manchester, Newcastle and Sheffield and delivering improved transport links across the North;
- The North has a strong innovation footprint, accounting for around 22 per cent of UK patent applications in the Medical and Biological fields, which is above the North's average share of total patent applications; and
- The North has a strong business base, it is home to over 12,450 Core Biopharma companies (around 20 per cent of all UK Biopharma firms), employing 21,500 over people (18 per cent of all UK employment in the sector); and around 21,700 Medtech companies (around 22 per cent of all UK Medtech companies), employing over 28,500 people (23 per cent of all UK employment in the sector).[35]

Excellence in Science and Research

Academic Research

2.1 The North is home to 28 universities. Seven of these are a part of the Russell Group,[36] almost one-third of its total membership. It is also home to one of the National Science and

[35] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the data behind the charts, data,* Bioscience and health technology database: annual report 2017. **https://www.gov.uk/government/publications/bioscience-and-health-technology-database-annual-report-2017**

[36] A UK group of universities renowned for excellence in teaching and research.

Innovation Campuses at Sci-Tech Daresbury, which hosts the Science and Technology Facilities Council (STFC) Daresbury Laboratory and the Hartree Centre.

2.2 Our universities feature prominently on both national and international leader boards, with one in five of the UK's top twenty universities based in the North, and the Universities of Manchester[37] and Durham featuring in the top 100 universities in the Times Higher Education World University Rankings 2018.[38] The University of Sheffield joins them in the top 100 QS World University Rankings 2018.[39] The Times Higher Education Rankings for Pre-Clinical, Clinical and Health lists the University of Manchester, the University of Liverpool and the University of Sheffield in the top 100 universities in the world.

2.3 Lancaster University is also the 2018 Sunday Times University of the Year, an award given by a panel of experts for all-round academic excellence. The 2017 winner of this award was also in the North, the University of Leeds.

2.4 The 2014 Research Excellence Framework (REF)[40] [41] judged 30 per cent of the overall quality of UK submissions to be 4* or world-leading. Nine of the universities in the North have an overall average above this for submissions across all Units of Assessment: Durham University, Lancaster University, Liverpool School of Tropical Medicine, Newcastle University, Royal Northern College of Music, University of Leeds, University of Manchester, University of Sheffield and the University of York.

2.5 There are specific areas of excellence that are relevant to our SIA.[42] In 'Biological Sciences', 47 per cent of Newcastle University research outputs was judged to be world leading, second only to the Institute of Cancer Research, and compared to a national average across Biological Sciences of 29 per cent. Liverpool School of Tropical Medicine had the third highest percentage of 4* research outputs in 'Public Health, Health Services and Primary Care' across the UK, at 32 per cent compared to a UK average of 23 per cent. The University of Liverpool excels in 'Computer Science and Informatics' where over 39 per cent of research outputs was judged as 4* or world leading, and, the University of York had the second highest score nationally in 'Psychology, Psychiatry and Neuroscience' at 43 per cent compared to a national average of 26 per cent. Although the North doesn't have any research institutions who have an average of 4* research output activity at above the UK average for 'Clinical Medicine', there are still areas of excellence; with 22 per cent of 'Clinical Medicine' research outputs judged as 4* for the University of Manchester and 21 per cent at Sheffield University. Other examples of

[37] The UK's largest single-site university with over 35,000 full-time equivalent students.

[38] Times Higher Education World University Rankings, (2018), **https://www.timeshighereducation.com/world-university-rankings/2018/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats**

[39] QS World University Rankings®, (2018), **https://www.topuniversities.com/university-rankings/world-university-rankings/2018**

[40] 'The REF is a process of expert review carried out by expert panels for each of the 34 subject-based units of assessments (UOAs) under the guidance of four [expert] main panels'. REF Submissions are measured on output, impact and environment.

[41] Research Excellence Framework, (2014), **https://www.ref.ac.uk/2014/**

[42] We have highlighted the following REF subject-based UOAs as relevant to our SIA: 'Allied Health Professions', 'Biological Sciences', 'Computer Science and Informatics', 'Dentistry, Nursing and Pharmacy', 'Psychology, Psychiatry and Neuroscience', 'Public Health, Health Services and Primary Care'.

above UK average levels of world leading research outputs that are relevant to our SIA can be seen in Table 2-1.

2.6 There are significant centres of excellence and further enabling assets across the North that support these research themes shown in Figure 2-2, Figure 2-3, Figure 2-4 and Appendix 3.

2.7 The scale of scientific production for the North is significant: 21 per cent of all submitted outputs, and full-time equivalent researchers, as reported in the REF 2014, were from our SIA area, along with 23 per cent of all doctoral degrees awarded in the period 2008-2012. Recent increases in medical school numbers for 2018-19 through to 2020-21 should further add to these figures, with just over one-third of 1,500 additional medical school places being allocated to the North. Amongst those awarded, the University of Sunderland has been allocated 100 places, Hull York Medical School has been awarded 90 additional places, 60 more for Lancaster University and 69 additional spaces for the University of Sheffield.[43]

2.8 REF Power Rankings[44], which are used to help determine the total funding allocation each institution receives, placed two Northern universities in the UK top ten: the University of Leeds and the University of Manchester – and seven of the eight are in the top 25.

2.9 A breakdown of the research universities in the Northern Powerhouse and their relative strengths in relevant subjects is shown in Table 2-1. This includes some of the measurements highlighted above as well as other metrics, including the number of spinouts and start-ups since 2000. We have only looked at the 4* rating for the REF results for each university to focus on research excellence of a world-class standard.

Graduate Retention

2.10 In Table 2-2 we can see that almost three quarters of students who graduated from a Northern University in the 2010-2011 to 2014-15 period stayed in the North for employment on an all-subject average. This indicates a strong talent pipeline.[45] It shows the proportion of graduates who stay in the North for employment after graduation. This is broken down by LEP for subjects that are relevant to our two themes.

74 per cent of students who graduated from a Northern University stay in the North for employment

2.11 Reviewing the subjects that are relevant to our SIA, the overall retention of graduates in the North is eight percentage points lower at 66 per cent – which indicates that there is room for improvement in terms of retaining talent in the region. There are also pockets of strength, 'Nursing and Subjects Allied to Medicine' retains 84 per cent of graduates in the North, and

[43] HEFCE, (2018), Healthcare, Medicine and Dentistry, **http://www.hefce.ac.uk/lt/healthcare/**

[44] Power ratings were calculated by Research Fortnight through multiplying the percentage of research in each quality level – for example 4* or 3* – by the number of full-time equivalent staff. More credit being given to 4* research than 3* research. Totals were then divided by the total FTE staff at each institution. The figures were then used to produce the 'power ratings' with the top institution being rated as 100 and all others being a percentage of this total. These scores were then ranked.

[45] HEFCE, (2017), The geographical mobility of students, **http://www.hefce.ac.uk/analysis/maps/mobility/mobdata/**

'Sports Science', 'Psychology', 'Computer Science' and 'Pharmacology Toxicology and Pharmacy' also have a retention rate above 70 per cent.

2.12 However, when looking in more detail at graduate stayers and leavers, the North has difficulty retaining STEM graduates from N8 universities; around one-half of them move from the North to make their careers elsewhere. Furthermore, of the graduates retained in the North only 61 per cent achieved a first or upper second, compared to 68 per cent of those who left the North. More worrying for the UK economy, the data show that 36 per cent of those graduates moving South are over-qualified for the jobs they take, relative to 31 per cent in the North.[46] Graduates appear to accept a short-term reduction in their standard of living in order to develop their careers in the long term.

2.13 To retain graduates and deploy them in roles for which they are best suited, the North needs to develop its employment offer by growing current economic clusters and improving transport links to ensure a more efficient labour market.

[46] The Independent, (2015), *Too many smart northerners leave for London. The 'Powerhouse' must draw them back*. **https://www.independent.co.uk/voices/too-many-smart-northerners-leave-for-london-the-powerhouse-must-draw-them-back-a6677071.html**

Table 2-1: Northern Research University Dashboard

Research University	Russell Group	N8 Research Partners	Times UK Ranking	Times World Ranking	QS World Ranking	FTE Students	Intl Students	REF Power Ranking	4* Rating (REF, 2014)	Spinouts/ Start-Ups since 2000	Above UK average for % of 4* research outputs in relevant units of assessment (REF, 2014)
Durham University	✓	✓	5	97	=78	16,310	29%	18	32.6%	36/0	
Edge Hill University	-	-	61	-	-	-	-	96	7.2%	-	
Lancaster University	-	✓	6	=150	=135	11,637	38%	25	34.8%	24/2	• Allied Health Professions, Dentistry, Nursing and Pharmacy • Computer Science and Informatics • Psychology, Psychiatry and Neuroscience
Leeds Beckett University	-	-	123	601-800	-	20,122	14%	89	8.4%	-	
Leeds Trinity University	-	-	67	-	-	-	-	145	4.6%	-	
Liverpool Hope University	-	-	52	-	-	-	-	109	6.8%	-	
Liverpool John Moores University	-	-	70	501-600	-	18,268	13%	62	17.6%	4/0	
Liverpool School of Tropical Medicine	-	-	-	-	-	-	-	111	31.1%	-	• Public Health, Health Services and Primary Care
Manchester Metropolitan University	-	-	80	601-800	801-1000	26,686	15%	56	14.9%	1/0	
Newcastle University	✓	✓	26	=175	=161	20,952	30%	16	31.4%	43/12	• Biological Sciences • Computer Science and Informatics • Psychology, Psychiatry and Neuroscience
Northumbria University	-	-	66	501-600	751-800	22,176	16%	52	16.4%	2/0	
Royal Northern College of Music	-	-	-	-	-	-	-	133	36.0%	-	
Sheffield Hallam University	-	-	70	801-1000	-	24,627	14%	65	17.9%	3/2	

Research University	Russell Group	N8 Research Partners	Times UK Ranking	Times World Ranking	QS World Ranking	FTE Students	Intl Students	REF Power Ranking	4* Rating (REF, 2014)	Spinouts/ Start-Ups since 2000	Above UK average for % of 4* research outputs in relevant units of assessment (REF, 2014)
Teesside University	-	-	92	601-800	-	11,095	12%	102	8.8%	3/2	
University of Bolton	-	-	124	-	-	-	-	128	5.6%	1/0	
University of Bradford	-	-	75	601-800	601-650	9,636	30%	79	24.0%	2/2	• Allied Health Professions, Dentistry, Nursing and Pharmacy
University of Central Lancashire	-	-	93	601-800	801-1000	16,500	18%	74	8.5%	1/0	
University of Chester	-	-	61	-	-	-	-	107	5.5%	-	
University of Cumbria	-	-	125	-	-	-	-	142	6.4%	-	
University of Huddersfield	-	-	65	601-800	751-800	15,154	26%	69	14.6%	2/0	
University of Hull	-	-	75	-	601-650	13,482	19%	51	14.2%	7/0	
University of Leeds	✓	✓	10	139	101	27,995	26%	10	32.4%	51/5	• Allied Health Professions, Dentistry, Nursing and Pharmacy
University of Liverpool	✓	✓	42	=177	=173	19,815	35%	22	27.1%	23/1	• Computer Science and Informatics
University of Manchester	✓	✓	25	54	34	35,318	38%	5	35.3%	79/3	• Allied Health Professions, Dentistry, Nursing and Pharmacy • Computer Science and Informatics
University of Salford	-	-	88	601-800	751-800	15,790	26%	73	10.6%	8/1	
University of Sheffield	✓	✓	21	104	=82	24,581	36%	12	33.3%	36/5	• Allied Health Professions, Dentistry, Nursing and Pharmacy • Biological Sciences • Computer Science and Informatics
University of Sunderland	-	-	96	-	-	-	-	103	6.1%	-	

Research University	Russell Group	N8 Research Partners	Times UK Ranking	Times World Ranking	QS World Ranking	FTE Students	Intl Students	REF Power Ranking	4* Rating (REF, 2014)	Spinouts/ Start-Ups since 2000	Above UK average for % of 4* research outputs in relevant units of assessment (REF, 2014)
University of York	✓	✓	16	=137	=135	14,962	27%	24	35.3%	26/1	• Biological Sciences • Computer Science and Informatics • Psychology, Psychiatry and Neuroscience
York St. John University	-	-	118	-	-	-	-	122	6.3%	-	

Source: SDG-ED using The Times/The Sunday Times: Good University Guide 2018, Times Higher Education World University Rankings 2018, QS World University Rankings® 201, REF 2014 Power Rankings (Accessed at **http://www.telegraph.co.uk/education/universityeducation/11299261/League-tables-the-top-universities-for-research.html**), Spin Outs UK and REF data compiled by Technopolis

Table 2-2: Proportions of graduates who stay in the North for employment after graduation

Study LEP	Anatomy, Physiology and Pathology	Biological Sciences	Chemistry	Computer Science	Engineering and Technology	Mathematical Sciences	Medicine and Dentistry	Nursing and Subjects Allied to Medicine	Pharmacology, Toxicology and Pharmacy	Psychology	Sports Science	All North Study LEP Average for relevant SIA subjects
Cheshire and Warrington	-	38%	-	78%	29%	45%	-	87%	-	64%	63%	58%
Cumbria	38%	-	-	87%	96%	-	-	86%	-	66%	49%	70%
Greater Manchester	71%	72%	67%	79%	66%	64%	66%	85%	70%	78%	79%	72%
Humber		62%	58%	61%	57%		56%	76%	43%	61%	71%	61%
Lancashire	67%	75%	36%	82%	70%	61%	64%	94%	81%	81%	89%	73%
Leeds City Region	65%	61%	59%	75%	64%	49%	69%	83%	82%	76%	76%	69%
Liverpool City Region	52%	73%	61%	84%	66%	67%	71%	83%	79%	78%	73%	72%
North East	68%	64%	61%	76%	60%	48%	77%	87%	72%	76%	83%	70%
Sheffield City Region	50%	52%	48%	71%	52%	50%	73%	72%	-	66%	67%	60%
Tees Valley	68%	86%	47%	75%	85%	-	38%	94%	-	78%	84%	73%
York, North Yorkshire and East Riding	58%	49%	44%	37%	32%	42%	66%	79%	-	60%	80%	55%
All North Subject Average	60%	63%	53%	73%	62%	53%	64%	84%	71%	71%	74%	66%

Source: HEFCE, (2017), The geographical mobility of students, **http://www.hefce.ac.uk/analysis/maps/mobility/mobdata/**

2.15 Analysis of international patent data, conducted by Technopolis (Appendix 9), found that the NPiHR's footprint accounted for around 20 per cent of both England's patent applications and its unique applicants between 2004 and 2016 (Table 2-3).[47] It also found that patent applications in the Medical and Biological fields, relevant to our SIA, accounted for a slightly higher proportion than the average for all technologies, around 22 per cent. For IT and Data, the terms used to search for patents relevant to the Data for Better Health and Wealth theme, the analysis showed that the NPiHR's footprint accounted for around 13 per cent of unique applicants but only 6.5 per cent of applications.

Table 2-3: Profile of Northern Powerhouse patenting for Medical and Biological and for IT/Data & data related patent applications, 2004-2016

		Geo-located patents	Total patents (estimate)	Geo-located unique applicants	Unique applicants (estimate)	Geo-located unique inventors	Unique inventors (estimate)
All technology areas	NPiHR	14,330	104,093	2,902	21,080	18,351	133,302
	England	69,736	506,565	14,261	103,592	94,029	683,030
	% NPiHR	20.5%	20.5%	20.3%	20.3%	19.5%	19.5%
Medical and biological	NPiHR	3,949	28,685	679	4,932	6,129	44,521
	England	17,992	130,694	3,714	26,978	30,765	223,478
	% NPiHR	21.9%	21.9%	18.3%	18.3%	19.9%	19.9%
IT & data	NPiHR	770	5,593	257	1,866	976	7,089
	England	11,783	85,592	1,997	14,506	14,184	103,033
	% NPiHR	6.5%	6.5%	12.9%	12.9%	6.9%	6.9%

Source: Technopolis analysis of PATSTAT data as shown in Appendix 9, **https://www.epo.org/searching-for-patents/business/patstat.html**

2.16 The results for IT and Data show relatively low patent output for the NPiHR's footprint. This may be partially explained by a low tendency for patenting in these technology fields and a "headquarters' effect" with patent applications made from head offices in London. Nevertheless, it is fair to say that the SIA area is not a strong performer in terms of patent applications for IT and Data. However, partners in the NPiHR are strong in their *use* of data – for both health research and for the planning and delivery of health services – this is discussed in more detail in Chapter 3 on Theme 1: Data for Better Health and Wealth.

2.17 Disaggregated results for Medical and Biological patents show a slightly higher concentration of patenting activity in the North than the English average, which is due to activity in Medical Technologies and Organic Fine Chemistry technology (Table 2-4).

[47] Appendix 9 lists the inventors

Table 2-4: Geo-located patent applications in the Medical and biological topic, 2004-2016[48]

	NPiHR	England	% NPiHR	% England	LQ
Analysis of biological materials	272	1672	1.90%	2.40%	0.79
Biotechnology	601	3493	4.20%	5.01%	0.84
Medical technology	1424	5562	9.94%	7.98%	1.25
Organic fine chemistry	1448	6051	10.11%	8.68%	1.16
Pharmaceuticals	1007	6877	7.03%	9.87%	0.71
Total	3949	17992	27.56%	25.80%	1.07

Source: Technopolis analysis of PATSTAT data as shown in Appendix 9, **https://www.epo.org/searching-for-patents/business/patstat.html**

2.18 Furthermore, independent analysis conducted on behalf of the NHSA by Symbiosis Ltd (see Appendix 10)[49] showed that over the past 10 years the North has produced 386 Life Sciences (broadly defined) patents, by comparison, London produced 401, Oxford produced 214 patent applications, Cambridge 129. Over the past 10 years Scotland produced a similar number of Life Science patent applications (304) to Oxford and Cambridge combined. The research found that together the North and Scotland produce a number of Life Science patent applications to an equal size of the 'golden triangle' of London, Oxford and Cambridge. This suggests that collaboration between partners in the North and Scotland could provide a re-balancing effect in terms of innovation in the Life Sciences in the UK.

Innovation Strengths, Growth Points, and Assets

Industrial Specialisation

2.19 Reflecting the reality that specialisation can often fall away as geography increases, Figure 2-1 illustrates the relative specialisms for the North across the broad industrial classifications that are relevant to our SIA.[50] For each of these broad categories, we have selected relevant sub-categories that reflect our themes of **Data for Better Health and Wealth** and **Precision Medicine**. We can, therefore, compare the broader category, e.g., Manufacturing, with the collation of the specific elements of Manufacturing that are relevant to our SIA theme.[51]

2.20 We have done this by generating a Location Quotient that measures the specialisation of the North in these areas compared with the UK average. It maps business count on the vertical axis and employment on the horizontal axis. The subsectors reviewed are listed along the

[48] Patent applications can be assigned to multiple WIPO fields and the totals have been calculated taking this into account (so as to avoid double counting).

[49] The search was undertaken using Espacenet, the patents database created and maintained by the EPO. The search was undertaken on 21-22 March 2017. The database contains details of all published patent applications on those dates. There is an eighteen month time lag after filing before patents publish and become available for searching using this portal. It follows that the searching is representative of a 10 year window of patent filings that are at least 18 months old.

[50] We have used Standard industrial classification of economic activities (SIC) codes and have focused on 'Manufacturing', 'Human health and social work activities', 'Professional, scientific and technical activities' and 'Information and communication'. There are limitations in using SIC codes, as they do not capture the granularity of industrial structure, in particular, they are weak in relation to services. However, these data give a broad overview, which is then discussed in more detail in Chapters 4 and 5.

[51] All of the subsectors within 'Human health and social work activities' are relevant to our SIA, so there is no comparison for this category.

bottom of the chart. The 'bubble' size reflects the scale of employment. Bubbles above and to the right of 1 show relative specialisation in the North, bubbles below and to the left of 1 show under-representation in the North. This is a quantitative measure.

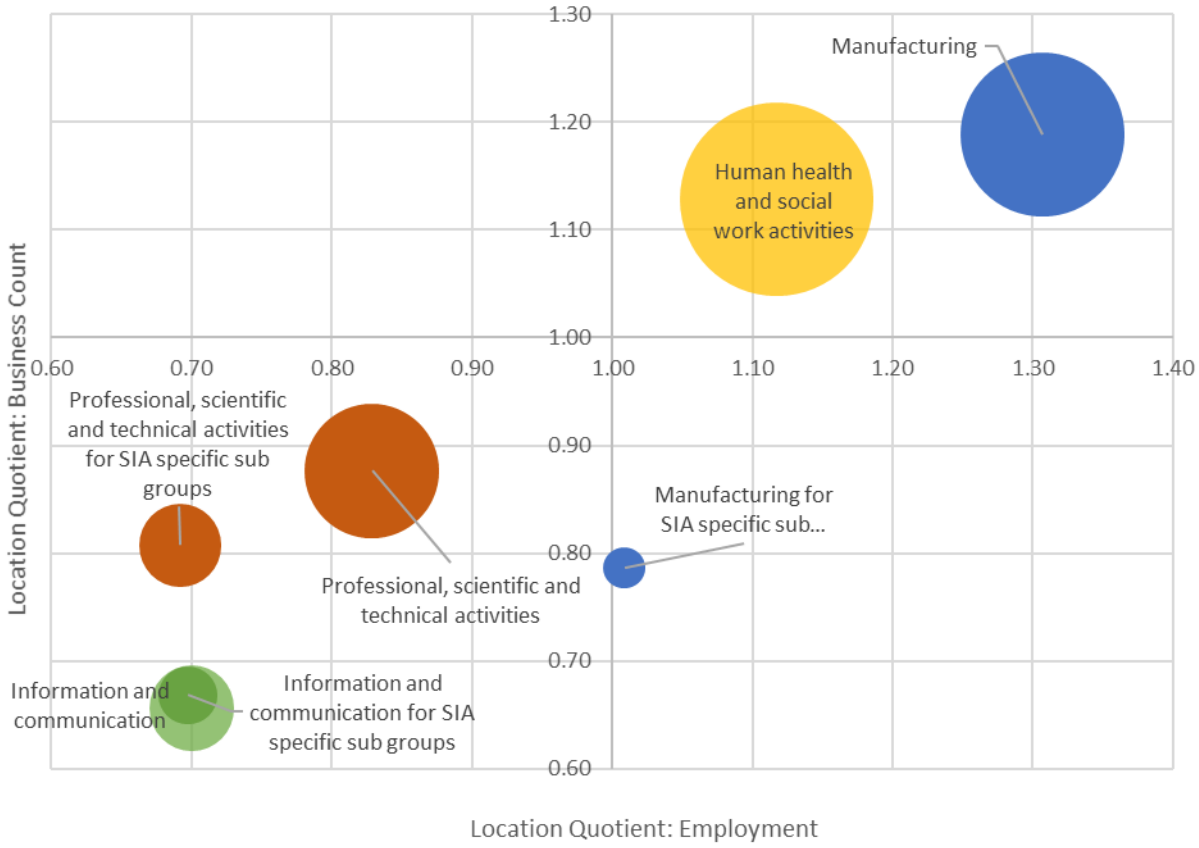
2.21 Figure 2-1 points to 'Human Health and Social Work Activities' as Northern strengths across employment and business count domains. This is relevant to the SIA area's offer both as a location for trials and the application of innovation in practice.

2.22 Manufacturing as a broad category is a strength for the region, however, the subsectors relevant to Manufacturing are relatively in line with the UK for employment and below in business count, indicating the importance of larger businesses in our theme areas.

2.23 'Professional, Scientific and Technical Activities' and 'Information and Communication' are less specialised than the UK average. 'Information and Communication for SIA specific subgroups' is an effective subset of the broader 'Information and Communication', and this shows that the aspects relevant to our theme are broadly in line with 'Information and Communication' across the region. 'Professional, Scientific and Technical activities' is slightly less specialised in the subset for both employment and business count – the SIA area's specific strengths in relation to **Data for Better Health and Wealth** and **Life Sciences/Precision Medicine** are addressed in more detail in Chapters 4 and 5.[52]

[52] These chapters also show a breakdown of the subsectors that we have used to create our SIA specific subgroups.

Figure 2-1: Location Quotient for relevant SIA theme areas in the North



Source: Business Register and Employment Survey (BRES) (2015), **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/businessregisterandemploymentsurveybresprovisionalresults/previousReleases**

2.24 Table 2-5 shows a breakdown of the North's share of Life Sciences businesses. It shows the North is home to over 12, 450 Core Biopharma companies (around 20 per cent of all UK Biopharma firms), employing 21,500 over people (18 per cent of all UK employment in the sector); and around 21,700 Medtech companies (around 22 per cent of all UK Medtech companies), employing over 28,500 people (23 per cent of all UK employment in the sector).[53]

[53] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the data behind the charts, data,* Bioscience and health technology database: annual report 2017. **https://www.gov.uk/government/publications/bioscience-and-health-technology-database-annual-report-2017**

Table 2-5: The North's contribution to the UK Life Science Sector

	No. of employees	% of UK total	Turnover	% of UK total	No. of sites	% of UK total
Biopharma core	12451	19.4%	3,792	11.4%	111	13.4%
Biopharma Service & Supply	8812	16.1%	1,498	10.1%	317	20.5%
Med Tech core	21698	22.3%	3,399	19.1%	632	21.6%
Med Tech Service & Supply	6838	27.9%	1,267	29.1%	214	20.9%
Total	**49799**	**20.7%**	**9,956**	**14.2%**	**1,274**	**20.1%**

Source: Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the data behind the charts.*
https://www.gov.uk/government/publications/bioscience-and-health-technology-database-annual-report-2017

Clusters

2.25 Success in the Life Sciences is further enabled through key regional clusters and innovation areas across the geography. These areas are further strengthened by the North's tech clusters.[54] Significant and relevant clusters include, but are not limited to:[55]

- **Manchester and Cheshire's Life Science corridors** contain world-class facilities including Alderley Park (which houses over 150 small biotech companies, and the Antimicrobial Resistance Centre), the Health E-Research Centre (HeRC), Sci-Tech Daresbury (in Liverpool City Region), Salford Lung Study, UK BioBank, Genomic Medicine Centres, NIHR BRC, the new Medicines Discovery Catapult, NIHR Greater Manchester Patient Safety Translational Research Centre and Life Science spin-offs from the University of Manchester;
- **Liverpool City Region's Health and Life Sciences cluster** is home to the Liverpool School of Tropical Medicine (LSTM), which is a global leader in infectious disease research, and the Centre for Experimental Infectious Disease and Research (CEIDR) which is a joint venture between LSTM and the University of Liverpool; it is also home to the Wolfson Centre for Precision Medicine, a Genomic Medicine Centre and the MRC Centre for Drug Safety Science as well as Knowledge Quarter Liverpool, which includes some of the world's most influential players in science, healthcare and technology, and Sci-Tech Daresbury and its emerging NW Medtech Cluster, supported by the Science and Technology Facilities Council's (STFC) High Performance Computer at the Hartree Centre[56]. Liverpool City Region is also home to Europe's largest biologic manufacturing cluster;
- **The North-East ageing, pharma, industrial and emerging photonics cluster** is animated by the universities of Newcastle and Durham. The pharma cluster is supported by 17 major pharmaceutical manufacturers in the region and a wealth of SMEs. Darlington also houses the CPI's Healthcare Futures Centre and the National Biologics Manufacturing Centre, as well as enabling-facilities such as Newcastle Helix. The National Innovation Centre for Ageing (NICA) and the National Innovation Centre for Data (NICD) and the Centre for Process Innovation (CPI) are key regional assets that animate and support this

[54] The North has Tech clusters in Hull, Leeds, Liverpool, Manchester, Newcastle & Durham, Sunderland, Sheffield & Rotherham (Tech North, The Digital Powerhouse: The Innovation Potential of Tech Clusters in the North, 2016).

[55] Raikes L (2016) *Health innovation: Breathing life into the northern powerhouse, IPPR North.*
http://www.ippr.org/publications/health-innovation-breathing-life-into-the-northern-powerhouse

[56] Liverpool's strengths in Infection and High Performance and Cognitive Computing is explored in greater detail in the Wave Two SIA for Liverpool City Region+.

cluster. The North East also has a growing cluster in Genomic and Precision Medicine, including NHS England Genomic Medicine Centres and a NIHR BRC. Further strengths such as the NIHR Innovation Observatory (IO) and the PPI resource VOICE (Valuing Our Intellectual Capital and Experience) add value to the region's collective offering to Industry via horizon scanning and "real time" consumer feedback. The North East has industrial strengths as it is home to a growing body of significant businesses including GKN, MSD, Piramal, Accord, Arcinova and Fujifilm Diosynth. The emerging healthcare photonics cluster is enabled through CPI's National Healthcare Photonics Centre (to be opened Autumn 2018), alongside a number of SMEs including Kromek, Ibex, Polyphotonix, and research strengths in Durham and Newcastle Universities; and

- **Yorkshire and Humber medtech and digital health cluster** with a strong regional asset base, including NHS Digital, NHS Data Spine, two NIHR BRCs, four NIHR Medtech and In-vitro diagnostics Co-operatives (MICs), NHS England Genomic Medicine Centres, the Leeds Institute of Data Analytics, bioinformatics, translational neuroscience and cancer therapeutics specialisms in Leeds, Bradford and Sheffield; the Advanced Manufacturing Research Centre (AMRC)[57] near Sheffield; Leeds and Bradford universities, which among other things work alongside medical equipment, prosthetics and tissue repair manufacturers in the region. With only 5 per cent of the UK population, Leeds has 22 per cent of its digital health jobs, 9 per cent of medical tech patents, and 8 per cent of research.[58] Leeds's regional strength in MedTech was explored and highlighted in the Wave Two SIA: Medical Technologies in the Leeds City Region. The cluster also operates the Translate programme, led by the University of Leeds, operated in partnership with the universities of Bradford, Huddersfield, York, and Leeds Beckett to enhance innovation and adoption of innovation.

Assets, Recent Investments and Pipeline Activity

Infrastructure to support Data for Better Health and Wealth and Precision Medicine

2.26 The NPiHR's footprint is home to significant 'hard' and 'soft' infrastructure, in other words, 'kit' and 'networks', including a network of world-leading sites and facilities that undertake significant research and innovation in health and data, e.g. the Health Innovation Park, based on the site of Sheffield's Olympic Legacy Park, which will bring together three research and innovation assets into a single, dynamic local geography. This will create the first health technology science and innovation park in the Sheffield City Region. It is led by Sheffield Hallam University (SHU), Sheffield Children's Hospital and Sheffield Teaching Hospitals, with these three anchor institutions drawing on their world-class track record in science and innovation. This also includes the Royal College of Physicians (RCP)'s RCP North, a major centre for clinical excellence in Liverpool.

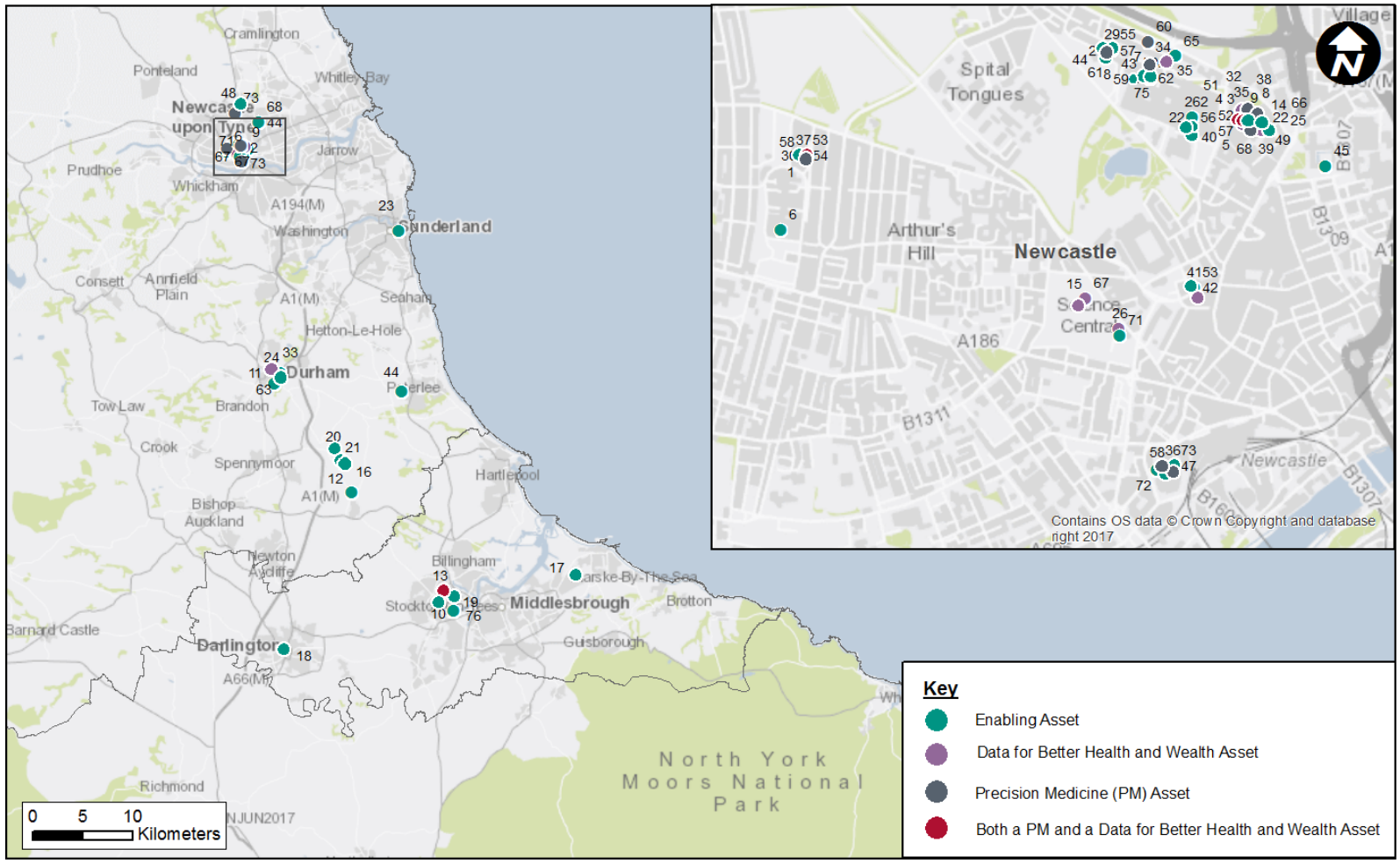
2.27 Figure 2-2, Figure 2-3 and Figure 2-4 provide (non-exhaustive) maps of significant infrastructure in the North East, North West, and Yorkshire and Humber respectively as they relate to our two SIA Themes. The component facilities are listed in Appendix 3.

[57] This asset is a key part of the Wave Two SIA for Sheffield City Region and Lancashire, *'Driving productivity growth through innovation in high value manufacturing'.*

[58] Tech Nation (2018), *How Leeds could become a world leader in healthtech*. https://technation.io/news/leeds-become-world-leader-healthtech/

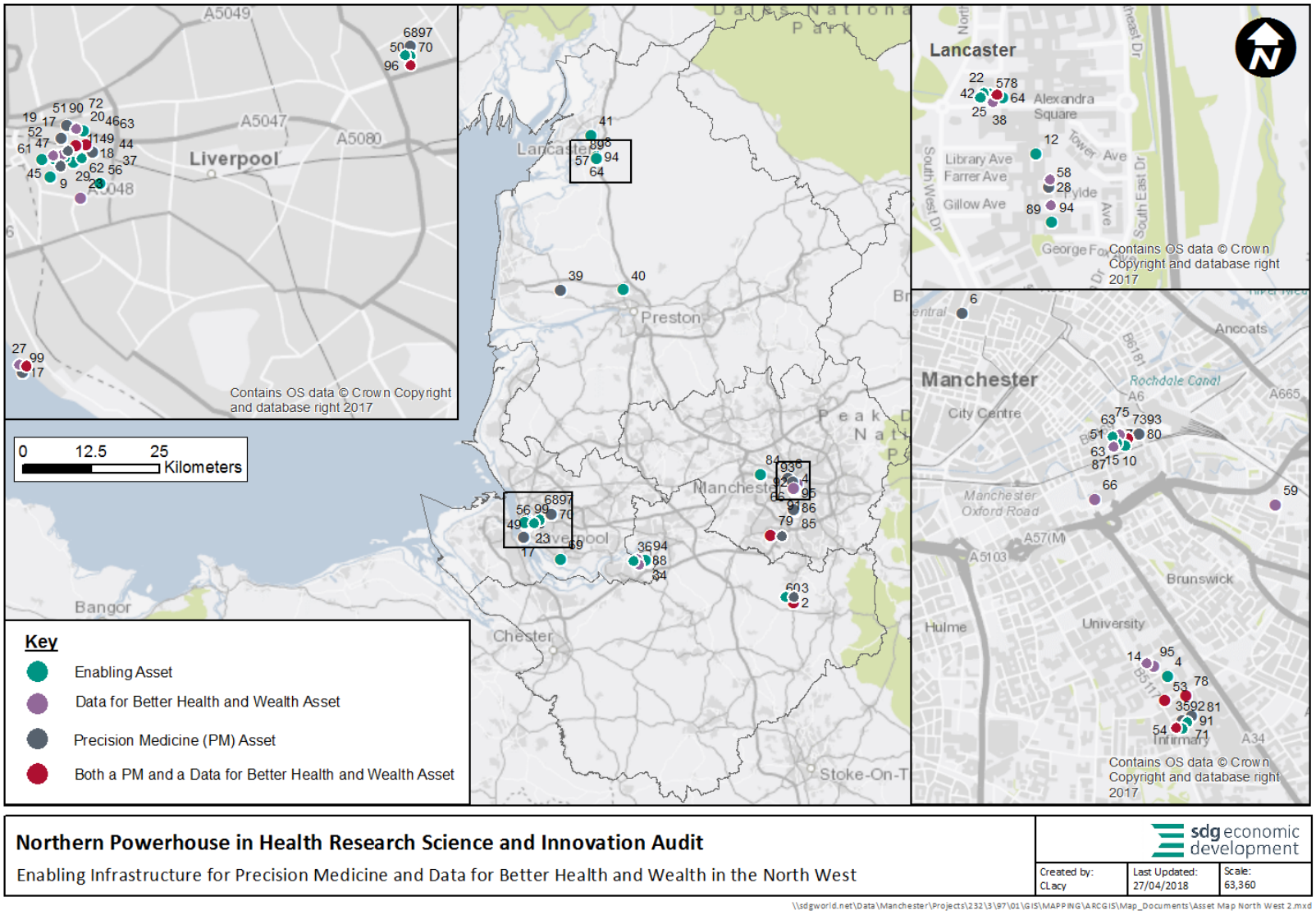
2.28 Similarly, a non-exhaustive list of businesses that work across our two Themes, the Northern NHS Foundation Trusts, and relevant incubators and science parks across the SIA area are also at Appendix 3.

Figure 2-2: Asset Map for the North East



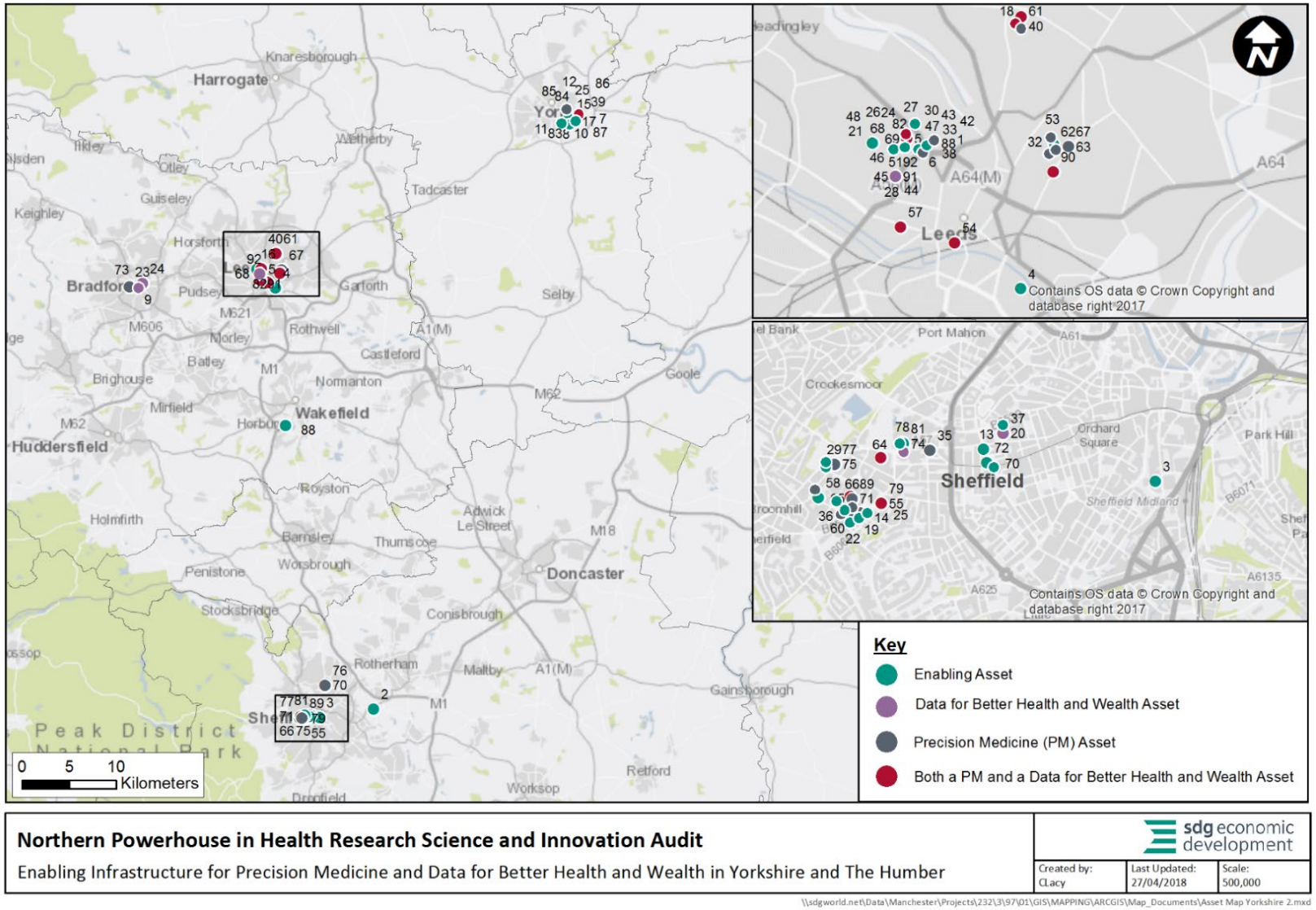
Source: SDG Economic Development

Figure 2-3: Asset Map for NPiHR: The North West



Source: SDG Economic Development

Figure 2-4: Asset Map for NPiHR: Yorkshire and The Humber



Source: SDG Economic Development

Recent and Proposed Pipeline Investments[59]

2.29 The NPiHR has been building momentum in **Data for Better and Health and Wealth** and **Precision Medicine** over recent years – along with acceleration of activity in the Life Sciences in general. Appendix 3 provides summaries or recent and pipeline investments. Three examples of flagship investments can be seen in Table 2-6 and Table 2-7.

2.30 The NHSA, working with its members, acts as an attractor of industry-led deals both from across the UK and from international hot spots in health technology and Life Sciences. NHSA aligns private sector requirements with HEI and NHS capabilities in the North. In 2016-17, the NHSA secured and delivered 30 projects.

2.31 In 2017-18 the NHSA handled 35 new private sector enquires. These were translated into 31 new projects and four secured deals (Table 2-8); with further projects potentially attracting funding during 2018/19.

2.32 As part of its proactive engagement with international markets, NHSA is in the process of signing a series of deals with Commonwealth partner nations, namely Singapore, Canada and Australia in health innovation and is a founding member of the Commonwealth Health Innovation Science Alliance (CHISA) which seeks to support Health Innovation deal flow between Commonwealth nations.

Table 2-6: Northern Alliance Advanced Therapies Treatment Centre and Innovate Manchester Advanced Therapy Centre Hub (iMATCH)

Innovate UK is funding three Advanced Therapies Treatment Centres (ATTCs) across the UK to facilitate the development, commercialisation, and adoption of Cell, Gene and Tissue Engineered Therapies in the UK. Two of these Centres are to be located in the North:

- The Northern Alliance Advanced Therapies Treatment Centre (NA ATTC) is one of three new AATC's which will develop advanced and emerging therapies based on genes, cells and tissues. Lead by Newcastle Hospitals NHS Foundation Trust (NUTH), the Centre it is a partnership of NHS hospitals and services, companies and universities and will be serving a population of 15 million in the North East, Yorkshire and Scotland. Recently awarded £9 million, the NA ATTC has been tasked with the delivery of advanced therapy to patients addressing issues around supply chain, manufacture and healthcare delivery.
- The iMATCH (Innovate Manchester Advanced Therapy Centre Hub) consortium, launched last December, was awarded £6.8m. The Manchester initiative, which will focus on advanced therapies for a wide range of illnesses including cancer, genetic and degenerative diseases, went live at the beginning of March.

Source: NHSA, University of Manchester and The Newcastle Upon Tyne Hospital NHS Foundation Trust

[59] The material presented here relates essentially to NHSA activity in the North of England. This work is augmented extensively by a range of other actors in the Health, Care, and Life Science domains, these including actors such as, for example, Bionow, Health Innovation Manchester and private sector businesses such as Bruntwood who see Health and Life Science as major growth areas.

Table 2-7: The Health Innovation Campus at Lancaster University

- Lancaster University is establishing an ambitious Health Innovation Campus on a 34,000 m^2 site adjacent to its main campus. The vision is to provide a distinctive, globally-recognised, interdisciplinary facility for co-developing, validating and driving innovative technologies and practices to support Health in Populations.
- The Health Innovation Campus will draw upon Lancaster University's outstanding strengths and capability in all academic disciplines, bringing together multidisciplinary teams to focus on the translation of world-class research into innovative products, processes, services and outcomes that will positively impact economic growth and contribute to society's adjustment to the ageing of the population. It will build upon its strong strategic partnerships with the NHS and a range of business, public and Third sector organisations, as well as with local communities. It aims to have a major impact on driving innovation to improve population health.
- In its three-phased entirety, the HIC will entail an eventual investment of nearly £170m with the ambition to provide innovative and flexible facilities that enable research and development, education, innovation and knowledge exchange in health, medicine and care, bringing together businesses, academics, health and social care providers, and the general population, to co-develop and co-create transformational products and services:
  - For Phase I, a £41m flagship innovation building will be developed to include co-location of businesses alongside academic staff to enable collaboration on Health and Care innovations. Phase 1 has been supported by the Lancashire Enterprise Partnership through the Local Growth Deal as well as through European Regional Development Funds and University funding.
  - Phase II will include the new NHS England funded NHS Pathology central facility for Lancashire and South Cumbria. This imaginative co-location and development aligns well with the University's plans for establishing laboratory-based facilities in Phase II, and will support and facilitate joint NHS/University/Business collaboration, for example around the theme of developing and evaluating population-focused systems and technologies for diagnosis and monitoring.
  - Phase III will be focused on the roll out of further facilities for business, to be developed with an appropriate private sector partner(s).

Source: Lancaster University

Table 2-8: NHSA Secured Deals in 2017-18

Beamline Diagnostics is a spin-out company from University College London. It has developed a new diagnostic test to determine, in real-time, whether a tumour is benign or malignant. It began as a study with Kings College, London, but required additional clinical trial sites and samples for its clinical validation study. The NHSA facilitated introductions to NHS Trusts in Manchester, Leeds and Newcastle who all expressed interest in the study. Progress moved forward with Manchester and recruitment started in January 2018.
Oncimmune is a UK company which has developed a test for early detection of lung cancer. Oncimmune approached the NHSA because it was interested in engaging with centres, which could support the validation of the new test, as well as support an application for a Small Business Research Initiative (SBRI) grant. The NHSA set up meetings with Leeds-based pathology experts and cancer leads, the bid for a SBRI grant was successful, and the study began in December 2017.
Meloq is a Swedish medical technology SME, which has developed a medical device for measuring the angle of joints and related spasticity during rehabilitation. The device has primarily been used within physiotherapy, but the company is interested in exploring alternative applications such as in neurological conditions. Last year the NHSA facilitated a research collaboration between Meloq and colleagues in Liverpool, Sheffield and Newcastle. A national study, led by Newcastle, is now taking place.
Grunenthal GmbH is a German mid-cap biopharmaceutical company with a portfolio of anti-analgesic products. Grunenthal approached the NHSA because it wished to expand its pipeline and portfolio into perioperative and emergency medical technology, as well as point-of-care diagnostics. Working with the NHSA, a senior team from Grunenthal visited centres in Leeds and Manchester and subsequently established a number of projects with Leeds and their medical technology group.

Source NHSA, March 2018

2.33 NHSA also has some pipeline projects with the potential to secure active deal status during 2018/19 (Table 2-9)

Table 2-9: NHSA Pipeline projects for 2018-19

The NHSA has worked with a Swiss, privately owned, mid-size pharma company, which has not conducted R&D or clinical development activity in the UK before but is keen to expand its geographical deployment.
Breath.me is an Israeli medical technology company, which has a device for measuring respiratory rates through a digital spirometer which attaches to a mobile phone. They are interested in connecting with clinical groups to undertake validation studies and look at data analytics, and the NHSA has introduced the technology to our members and is currently setting up meetings with interested parties and the company.
Matrixome is a Japanese biotechnology company which approached and engaged the NHSA through BioJapan 2017. The company has a unique cell substrate technology which is used for developing stem cells. A number of collaborations with HEIs, which have expressed interest, are anticipated in 2018-19.

Source NHSA, March 2018

Table 2-10: Commonwealth Pipeline projects for 2018-19

Singapore: The NHSA has secured a MoU with MedTech accelerators in Singapore that has seen Singaporean MedTech companies work with and validate technology in the UK.
Australia and Canada: Working with comparable organisations in these markets, the NHSA will later this year seek to establish a series of bi-lateral agreements which will focus on trade and investments between Commonwealth nations in health innovation.

Source NHSA, March 2018

Conclusions

2.34 This chapter has outlined our science and innovation strengths, in terms of assets, skills, business and research clusters, and infrastructure specific to **Data for Better Health and Wealth** and **Precision Medicine**. As our two themes are deeply affected by public policy – on health, research, innovation, and re-balancing the economy, Appendix 2 reviews the policy context in which our work operates.

2.35 The next two chapters look at the NPiHR's two themes, **Precision Medicine** and **Data for Better Health and Wealth** in more detail, providing evidence of our ability to deliver on these national and local policy priorities.

3 Theme 1: Data for Better Health and Wealth

For the purposes of this Science and Innovation Audit, our first theme – **Data for Better Health and Wealth** – focuses on the assets and capabilities which can promote Learning Healthcare Systems that will reduce the time lag between knowledge becoming available and its application in practice.

Headline Messages

3.1 In relation to **Data for Better Health and Wealth**, our SIA process has identified:

- Rising and ageing populations, with increasingly sedentary and unhealthy lifestyles, which are driving demand for healthcare around the globe;
- As a consequence, there is a worldwide appetite to control healthcare costs, while improving standards of care;
- This appetite for economy and effectiveness can be served by the speedy introduction of innovations into Learning Healthcare Systems;
- The efficient and effective use of data is essential to the development and introduction of these innovations;
- The North of England's combination of clinical and research assets, expertise, and networks means that it is placed ideally to drive the use of data to promote the speedy introduction of innovation;
- Our clinical assets, in relation to Data, include six Acute and two Mental Health Global Digital Exemplars, which are internationally recognised for their efficient delivery of exceptional care through world-class digital technology. Our digital maturity scores an average of 18 percentage points higher than the UK averages across the three main assessment areas: Capability, Enabling Infrastructure, and Readiness;
- Our research assets include, but are not limited to: the High Performance/Cognitive Computing facility at Hartree (including access to IBM's Watson engine); the University of Liverpool's Department of Biostatistics; the Liverpool Health Data Science Network; the Centre for Health Informatics, Computing and Statistics at the University of Lancaster; the Centre for Biostatistics at the University of Manchester's Faculty of Biology, Medicine and Health, the Health eResearch Centre in Manchester; University of York's expertise in Biostatistics and Computing science (including the York Cross-disciplinary Centre for Systems Analysis and the Biostatistics Research Group at Newcastle University's School of

Mathematics, Statistics and Physics); the National Institute for Smart Data Innovation in Newcastle; and the Leeds Institute for Data Analytics (LIDA);

- The Research Excellence Framework 2014, shows excellence in Computer Science and Informatics at the Universities of Lancaster, Liverpool (who was ranked first for 3* and 4* outputs), Manchester, Newcastle, Sheffield and York;
- Our research expertise, as measured by SciVAL, indicates that, while the *volume* of academic papers produced in the North has scope to grow, the *quality* of that research is already of international standard;
- Our networks include Connected Health Cities, which unites local health data and advanced technology to drive research and service provision, and has developed the necessary protocols and approvals to share health data at both volume and geographic scale;
- This combination of world-class assets, knowledge and networks, plus our excellent track record in recruitment to trials, means that the North plays a leading role in novel trial designs, including 'change of practice trials', for example, the world-leading Salford Lung Study and trials within cohort studies, such as the Born in Bradford Better Start Innovation Hub. The North is ideally placed to conduct Real-World Clinical Trials – clinical trials are already a regional strength for the North, with six major academic clinical trials units across the footprint, including one of the largest in the UK at Leeds;
- The North also has significant clusters of digital health businesses, particularly in city regions, such as Leeds, Liverpool, Manchester, Newcastle and Sheffield. The Leeds-Bradford area alone employs 22 per cent of the entire UK digital health workforce, houses NHS Digital, two major data companies (TPP, EMIS) with 75 per cent of the UK's current GP Electronic Health Record's and has two Research Council UK Digital Centres (MRC and ESRC) coming together through 30,000 sq. ft. of analytic capability housed in the Leeds Institute for Data Analytics (LIDA). Further to this, the Leeds Care Record[60] comprises data on 2.8 million patients and is the only UK-wide health record that spans primary, secondary and social care;
- Collaboration between business, clinicians and academics is growing. For example, Connected Health Cities is supporting the development of long-term, trust-based relationships between clinicians and researchers and over 70 businesses by establishing a Pre-Competitive Collaboration Consortium focused on data; and
- Earlier in 2018, NHS England invited regions to bid to become 'Local Health and Care Record Exemplars' (LHCRE) with potential funding of up to 7.5million being available for each LHCRE. It has recently been announced that the North has been successful in obtaining LHCRE status in two regions, Greater Manchester and Yorkshire and Humber. The award of two LHCRE to the North is a further strong independent endorsement of the health data strengths in the North and is a strong validation of this SIA. The LHCRE will form a positive force in helping galvanise other internationally leading health data assets highlighted in this SIA.

3.2 The issues to address, if we are to make the most of the opportunities arising from **Data for Better Health and Wealth**, are:

- Notwithstanding excellent strengths across the North, we have skill shortages in Bioinformatics (and the underpinning skills, such as Statistics and related Mathematical

[60] As part of the Yorkshire and Humber Local Health and Care Record Exemplar bid, Leeds developed 'Helm' (a handheld portal to the Leeds Care Record). This will help with patient consent for research as you will be able to directly ask a citizen if they want to get involved.

Sciences), Pathology, Microbiology, Genome Sequencing, Health Economics, and Clinical Trial Methodologists;
- The need to encourage more and deeper cross-discipline working, as a means of using skill and expertise sets in new and novel ways;
- Improving access to finance to enable firms to scale-up, as well as the need to build the management skills of growing businesses; and
- Optimising the synergies, linkages, and connections with other relevant SIAs elsewhere in the North and the wider UK (such as the emphasis given to High-Performance and Cognitive Computing and Infection in the Liverpool+ SIA, and Applied Digital Technologies in the Oxfordshire SIA).

Introduction

3.3 This Chapter focuses on assets and capabilities to promote Learning Healthcare Systems – that reduce the time lag between information that an action should be taken becoming available and the action being taken – known as Data Action Latency (DAL). It does this in the context of:

- Facilitating cost-control in healthcare systems;
- Informing new healthcare provision;
- Supporting research by providing data at scale and in real time; and
- Tackling health inequality through greater understanding of population need.

National and International trends and size of Global Markets

Scale of the Global Opportunity

> "Health spending in the US alone is up to $4 trillion, with 70 per cent spent on treating people in hospital and 30 per cent on prevention, the projection is that this will soon be 50:50, which will mean the use of diagnostics, sensors, computer science, machine learning, health analytics and algorithm development in health and social care is a Trillion Dollar opportunity.''[61]

Scale of the Digital Health Sector in the UK

3.4 The Department for Business, Energy and Industrial Strategy estimated that in 2017 the Digital Health sector:[62]

- Had 491 sites – the second highest number of sites in the Life Sciences industry;
- Employed 10,000 people – the fourth largest employer of all sectors in the Life Sciences industry and the largest segment in Med Tech by employment; and
- Generated revenues of c. £1.2 billion.

[61] Dr Hermann Hauser, CBE FRS FREng FInstP

[62] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: UK digital health segment. infographic***https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707079/digital-health-infographic-2017.pdf**

3.5 From 2016 to 2017 this has meant Digital Health has experienced an 11 per cent increase in employment and a 10 per cent increase in turnover. The largest segments of the market by employment were hospital information systems, e-health (e.g. software infrastructure to analyse data) and GP information systems. Together these three segments accounted for almost three-quarters of sector employment in 2017. The North accounts for 28 per cent of employment in Digital Health across the UK, with Yorkshire and Humber alone accounting for one fifth of UK employment in this sector.[63]

The challenges of cost-control and patient trust for healthcare systems

3.6 Demand for healthcare is rising due to many factors, including:

- Population growth;
- Increased life expectancy, often associated with multiple long-term health conditions;
- Increasingly sedentary and unhealthy lifestyles; and
- The consumerisation of technological advances which means that new treatment interventions are both more available and better understood by the public.

3.7 This means that around the world, health services are treating more people than ever before. For example, between 2003/4 and 2015/16, the number of admissions to NHS hospitals increased by 3.6 per cent a year.[64] This growth in patient numbers is putting a strain on NHS finances.[65] Thus, there is a growing appetite to find ways to control costs in healthcare systems, while improving, or at least maintaining, standards of patient care and safety. This is a trend we can see worldwide. Research in health economics in the North of England is world-leading, including the University of York's pioneering Centre for Health Economics and research teams at Leeds, Lancaster, Liverpool, Manchester, Newcastle and Sheffield. These research groups use health data analysis to increase the efficiency and equity of health services and improve population health.

3.8 There is also a need to reduce the harm and cost of medication errors and adverse drug reactions, which have been estimated by researchers at the universities of York, Manchester and Sheffield to cost around £100 million a year.[66]

3.9 Reduction in the time taken to introduce new knowledge into a healthcare system can help to reduce the use of inefficient treatments and practices for a given cohort, thereby reducing unnecessary cost. It also potentially increases the use of cost-effective treatments for a given cohort of patients, generating improved health outcomes. Thus, the promotion of Learning Healthcare Systems offers the potential to generate both short-term individual benefits as well as long-term gains in sustaining a more efficient health service.

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[63] ibid

[64] The King's Fund (2017) *Does the NHS need more money?* **https://www.kingsfund.org.uk/publications/articles/does-nhs-need-more-money**

[65] The King's Fund (2018) *The NHS in a nutshell: Trusts in deficit.* **https://www.kingsfund.org.uk/projects/nhs-in-a-nutshell/trusts-deficit**

[66] Policy Research Unit in Economic Evaluation of Health & Care Interventions [EEPRU] (2018) *Prevalence and Economic Burden on Medication Errors in the NHS in England.* **http://www.eepru.org.uk/prevalence-and-economic-burden-of-medication-errors-in-the-nhs-in-england-2/**

3.10 The provision of accurate, transparent, relevant and real-time data will also empower patients to manage their own care and to recognise the drivers behind diagnoses and treatments – building trust between patient and doctor and facilitating truly patient-centred healthcare.

The challenge of meeting medical research requirements – at scale and in time

3.11 Researchers are working to identify and test potential improvements in health and social care by developing and analysing large and complex, often linked datasets, for example:

- Omic data sets;
- Data extracted from medical imaging;
- Patient reported data;
- Cohort studies and administrative data;
- External environmental data; and
- Wearables and personal sensor data.

3.12 These complex datasets allow researchers to develop methods of efficient trial design (e.g. trials within cohorts or administrative datasets) as well as more personalised forms of care and medication. Data are collected as patients move along a care pathway,[67] providing researchers with an opportunity to capture and analyse real-time data as a large number of patients move through and interact with a healthcare system. The ability to track the impact of different approaches to establishing diagnoses, prescribing medication, and delivering treatments etc. in a real-world environment in real time is an essential part of modern medical research.

3.13 The Life Sciences Industrial Strategy states that: 'The UK's globally leading position in translational medicine is crucially important to the Industrial Strategy as it provides an important interface for industry in facilitating the development and demonstration of utility of a wide range of commercial products from global as well as smaller, UK-based organisations. The UK has clinical trial activity across all stages and is on par with comparator hubs for phase II trials. However, there still remains considerable room for improvement in translational science to enhance the UK's capability to attract more clinical trials from industry – a major source of inward investment in the Life Sciences space. The UK should focus particularly on novel trial designs and 'change of practice trials' to ensure it remains at the cutting edge of translational research'.[68] The Strategy goes on to say, 'Barriers, however, do still remain, including administrative burden, 'on-costs' (unfunded consequences of trials) and poor digital evidence collection infrastructure.'[69]

3.14 The report, *State of the Discovery Nation 2018*,[70] produced by the Medicines Discovery Catapult, highlights the need to develop novel informatics platforms, which 'humanise discovery' by using artificial intelligence to analyse large scale human data from Real-World cohorts including clinical and omic data. The Catapult will work both to develop and validate commercially ready algorithms, and to make large healthcare datasets available for medical

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[67] A care pathway sets out the process that should be followed to treat patients with specific needs.

[68] Office for Life Sciences [OLS] (2017) *Life sciences: industrial strategy.* **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/650447/LifeSciencesIndustrialStrategy_acc2.pdf**

[69] Ibid (p.25)

[70] Medicines Discovery Catapult (2018). *State of the Discovery Nation 2018* **https://md.catapult.org.uk/report-state-of-the-discovery-nation-2018/**

R&D. As noted in Chapter 2, the North has a good track record in recruiting to clinical trials. It also has a leading role in novel trial designs and 'change of practice trials'.

3.15 It has recently been announced that the North has been successful in obtaining 'Local Health and Care Record Exemplars' (LHCRE) status in two regions, Greater Manchester and Yorkshire and Humber. Earlier in 2018, NHS England invited regions to bid to become (LHCRE) with potential funding of up to 7.5million being available for each LHCRE. The award of two LHCRE to the North is a further strong independent endorsement of the health data strengths in the North.

3.16 Table 3-1, Table 3-2, Table 3-3 and Table 3-4 provide summaries of world-leading clinical trial studies led by the North. Table 3-5 is a description of an initiative to agree on a standardised set of outcomes for measuring and reporting clinical trials. Table 3-6 provides a summary of some of the care pathway projects which are currently being carried out in the North under the auspices of Connected Health Cities – discussed in more detail below.

Table 3-1: Salford Lung Studies

This ground-breaking study-type, sponsored by GSK and designed by NorthWest EHealth Ltd (NWEH), examined the safety and effectiveness of new treatments for Asthma and Chronic Obstructive Pulmonary Disease. Healthcare professionals from eight organisations across Greater Manchester collaborated to deliver the Salford Lung Studies which involved over 7,000 consenting patients, supported by 80 GP practices and 130 pharmacies in Salford and the Greater Manchester area. This was the world's first digitally enhanced Randomised Controlled Trial to include a broad population of patients in an everyday clinical-practice setting, embracing a novel approach to clinical trial design. It provided researchers with a breadth of clinical data that demonstrated the healthcare interactions of the everyday lives of patients and the way they use their medicines. These collaborative studies were placed in Salford because of the existing infrastructure of integrated electronic health medical records. They relied on software developed by NWEH, and securely hosted in the NHS network, which integrated the electronic medical records of consenting patients across all their everyday interactions with GPs, pharmacists and hospitals. This system allowed close monitoring of patients' safety in near real-time but with minimal intrusion. By securely collecting consented healthcare information quickly and efficiently, NWEH's system offers responsiveness to patient safety, high-quality data, and short timelines for studies. It is anticipated that the study methodology and underpinning technology will be used in future studies, not just in Greater Manchester but worldwide.

Source: NorthWest EHealth Ltd

Table 3-2: Introducing personalised risk-based intervals in Screening for Diabetic Retinopathy

This study, funded by NIHR, and designed and run by the University of Liverpool and the Royal Liverpool and Broadgreen University Hospitals Trust focuses on the implementation, safety, patient experience and cost-effectiveness of a personalised risk-based interval in the screening of sight-threatening diabetic retinopathy. The clinical trial involves over 4,500 consenting patients who attend the routine eye-screening programme in Liverpool, from more than 70 general practices. The clinical trial takes data feeds from both primary (EMISWeb) and secondary care (hospital systems) to calculate a personalised risk-based interval for the participant's screening appointment. The electronic systems and processes for the trial were designed and implemented by staff at the Clinical Trials Research Centre and Department of Eye and Vision Science, University of Liverpool, ensuring that the process had as low an impact as possible on the existing eye-screening programme. Data from GP and hospital systems are combined and pseudonymised on a secure server before being transferred to secure trial systems for storage and analysis. The trial systems interact with the risk engine and return data to the hospital systems (after re-identification) to enable the appropriate appointment letters to be sent as part of routine practice. The study design allows for minimal disruption to the normal patient pathway and burden on researchers in data collection. The methodology used for this study is innovative and cost-effective, and replicable.

Source: University of Liverpool

Table 3-3: Myeloma trials at the University of Leeds

The myeloma portfolio builds on a series of practice-changing late-phase studies, which have formed the basis of evidence for patient treatment in first- and second-line nationally and internationally (Myeloma VII, X, XI). The late phase portfolio has been supported by CRUK since 2006 with the award of Myeloma X (Relapse) study and followed up with the Myeloma XI study in 2009. In the past 5 years, we have been awarded 3 phase III trial grants from CRUK (Myeloma XII, XIV, and XV) with further support from pharmaceutical partners. These include innovative and flexible trial designs allowing adaptation to take account of emerging evidence, including the addition of arms, multiple randomisations, biomarker stratification (genetic- and response-adapted) and use of multi-arm multi-stage designs (MAMS) to allow new treatments to be added in at different stages from 2 of our ongoing early phase trials (MUK*Eleven* and MUK*Sixteen*) into Myeloma XV. Myeloma X has reported and results have been incorporated into NICE and International Myeloma Working Group Guidance. Myeloma XI closed to recruitment in 2016 with 4420 patients, this trial was successfully rolled into Myeloma XI+ to efficiently evaluate further novel treatments combinations in induction and maintenance treatment. The first results were presented at the 59th American Society of Haematology Annual Meeting and Exposition in 2016 have already led to the licensing of lenalidomide as a maintenance therapy post-transplant by the FDA (US Food and Drug Administration) and EMA (European Medicines Agency). Myeloma XI has shown further improvements on overall survival for younger-fitter patients with Leeds-delivered trials moving survival at 5 years from 20% in our first trial, Myeloma VII (7), to 61% at 5 years in Myeloma XI.

Source: University of Leeds

Table 3-4: Born in Bradford

Born in Bradford (BiB) is a world-leading cohort study supported by the NHSA. It is following over 13,000 children and their parents over the life course to investigate the early origins of ill-health and use this evidence to develop interventions to improve health and well-being. As part of the NHSA's Connected Health Cities project, researchers at the Bradford Institute of Health Research, supported by data infrastructure at the Leeds Institute of Data Analytics and epidemiological and health services expertise from the Unversity of York, have linked data across health, social care and education and demonstrated the power of this to help identify behavioural disorders early in life, support staff in predicting and intervening to prevent childhood obesity and demonstrate the impact of air pollution of birth weight and childhood asthma. As part of the £10million EU Lifecycle programme, it is collaborating with birth cohorts across Europe to harmonise data and cutting-edge genomics and metabolomics to develop novel biomarkers and early predictors of childhood illness. Working with QMUL and the Sanger Institute is has provided exome sequence data that is now supporting 11 bioscience companies to identify new drug targets. Most importantly BiB is an applied health research project that is demonstrating how innovation and research can lead to changes in practice and policy to prevent future ill-health and a whole systems, city-wide approach to prevention.

Source: Born in Bradford

Table 3-5: COMET

COMET is a global initiative, led from the University of Liverpool, that aims to improve the quality and relevance of health research, and thereby reduce waste leading to economic benefit, through the development and application of agreed standardised sets of outcomes, known as 'core outcome sets' (COS). COMET has successfully brought together the COS literature in an international publically available repository. COMET's work is seen as the essential point of reference by key organisations promoting COS uptake: trial funders (e.g. EC Horizon2020, AHRQ Canada, NIHR, HRB Ireland); protocol advisors (SPIRIT guidelines, UK Health Research Authority, NIHR Clinical Trials Toolkit); and regulatory bodies (EMA, NICE); **http://www.comet-initiative.org/cosuptake**. Since its launch in 2011, the website has received 71,661 unique visitors from 182 countries, with 20,997 searches of the COMET database. COMET is a partner in the IMI Big Data for Better Outcomes (BD4BO) consortium, a programme of research to link outcomes measured in trials to routine care to facilitate the collection of Real-World evidence about health care interventions. The BD4BO toolkit for the identification, selection, and measurement of outcomes including in real-world settings draws heavily on the COMET Handbook and other COMET resources.

Source: COMET Consortium

Table 3-6: Connected Health Cities novel trial design and 'change of practice trials'

Connected Health City	Care pathway projects
Connected Yorkshire	*Supporting community care and reducing demand on A&E services* • By linking together patient data from different hospitals and services across Yorkshire, researchers build a detailed picture of how accident and emergency services in the region function. The anonymous data helps scientists to understand A&E services across an entire city and suggest improvements, managers compare A&E departments to one another, allow hospitals to learn from each other, and help researchers to plan ahead and forecast disease outbreaks. *Urgent care for childhood asthma* • Asthma is one of the commonest reasons for urgent admissions to secondary care among children in Bradford, accounting for around 30% of the total. The project uses linked, routine electronic healthcare data to help improve the urgent care pathway for paediatric asthma so that more care is provided in the community and unplanned hospital admissions are reduced.
Greater Manchester	*Using technology and data to improve the diagnosis and treatment of stroke* • Analyses data from different stroke services to develop a comprehensive overview of how stroke patients pass between primary, secondary and community care in Manchester and Salford to improve recognition of stroke by paramedics to: (1) maximise the proportion of acute stroke patients taken directly to a specialist stroke centre for timely expert care and minimising the number of non-stroke; (2) ensure timely and focused referral to neurosurgery for patients with stroke caused by brain haemorrhage; and (3) ensure patients get all the right treatments to reduce the risk of another stroke. *Building Rapid InTerventions to reduce anti-microbial resistance and overprescribing of anti-biotics (BRIT)* • By accessing anonymised records from GPs, A&E departments and out-of-hours clinics, researchers can compare prescribing patterns. Prescriptions for antibiotics for people with cold symptoms varied from 10% to 80% of patients in different GP practices.

North East and North Cumbria	*Predictive modelling for unplanned care in the North East and North Cumbria* • A collaboration to produce statistical models that can be routinely used to produce daily forecasts up to six months in advance with the pertinent associated uncertainties and variations in Urgent and Emergency Care. As more health, local authority and other relevant data become available, the models will be enhanced to track 'at-risk' cohorts coming through unplanned care. The project's initial focus is on the frail elderly with an emphasis on dementia, and on alcohol-related attendances. *SILVER: Smart Interventions for Local VulnERable families* • The project links data across multiple agencies, including, health (physical and mental), social care, criminal justice, housing and education. It explores issues of consent of personal data from the user perspectives and is developing sustainable interventions that can be used by key workers across agencies.
North West Coast (Lancaster and Liverpool).	*Development of learning system for unplanned care* • Focusing on data related to care pathways for patients with epilepsy and chronic obstructive pulmonary disease, the project aims to enable better-coordinated health and social care, to improve patient outcomes and efficiency, reduce emergency department attendances, and hospital admissions and shorten the duration of stay. *Development of learning system for alcohol* • There are more than 60 diverse conditions linked to alcohol misuse; these involve multiple pathways and place a major burden on the NHS. Alcohol misuse often associated with 'environmental factors' including social and economic issues, such as reliance on benefits, poor housing, domestic violence and crime. The project aims to improve data collection and analysis and data sharing between agencies and service users, so that frontline teams have access to better, more timely information to inform point-of-care decisions and service planning.

Source: Connected Health Cities

The challenge of health inequality

3.17 There are distinct health inequalities based on location, as well as other markers. For example, in the UK, Manchester, Blackpool, Liverpool and Salford have the highest early mortality rates in England. Furthermore, as noted above, the chance of dying under the age of 75 is more than 20 per cent higher in the North than in the South of England.[71] Thus, there are social and political, as well as economic imperatives to improve understanding of the drivers of health outcomes, the efficacy of treatments, and the processes required to halt the use of ineffective or inefficient treatments and practices and promote adoption of treatments and practices that have proven to be more effective.

3.18 To do this we require appropriate access to data, at the level of the individual and for defined cohorts with shared characteristics. Furthermore, we need to be able to study the impact of socio-economic status and environmental and civic factors to understand the actual (or potential) efficacy of a given treatment in a place-based context. There is currently a gap in our infrastructure in relation to developing our understanding of environmental and civic factors, which we aim to fill, but additional support and investment are needed to make this a reality.

Local Science and Innovation Assets

Health data research assets and capabilities

3.19 The North has many significant best-in-class assets and pioneering capabilities in public, private and not-for-profit sectors, as well as significant partnerships. Appendix 4 includes

[71] Public Health England, (2014-2016) *Mortality Rankings*, **http://healthierlives.phe.org.uk/topic/mortality/comparisons#are//par/E92000001/ati/102/pat/**

several maps that illustrate the location and share of digital health assets across the UK – it shows key assets, e.g., Farr Institute, and growth nodes, e.g., Digital Health Enterprise Zones. Appendix 4 also provides more detail on the specific relevant heath-and-data-related assets and capabilities of the North's universities and in particular an overview of the N8 supercomputer and its plans for 2018. One of the North's greatest digital assets, The Hartree Centre, is included in Table 3-7.

Biostatistics in the North of England

3.20 Biostatistics, the application of statistics to medicine and biology, is a key skills area where the North of England has particular strengths. Biostatisticians across the North have a strong tradition of working together in methodological areas of relevance to both the themes of **Data for Better Health and Wealth** and **Precision Medicine**.

Data for Better Health and Wealth

3.21 Statisticians in four of the Northern Universities (Liverpool, Lancaster, Manchester, Newcastle) work together in the MRC Hub for Trials Methodology Network (chaired by Liverpool). More widely, statisticians and trialists (Leeds, Liverpool, Manchester, Newcastle, Sheffield, York) work together in the UKCRC Registered Clinical Trials Unit Network. Areas of expertise of particular relevance include the design and analysis of trials in stratified medicine and e-trials.

3.22 Statisticians in the Connected Health Cities programme work with front-line clinicians across the North, supporting co-production of clinically-validated analytics and data visualisations for defined patient pathways. Areas of expertise of particular relevance include spatial statistics, joint modelling of longitudinal and survival data, and Bayesian inference.

Table 3-7: Hartree Centre Case Study

• The Hartree Centre was established in 2012 at Sci-Tech Daresbury to support UK industry in the effective adoption of High-Performance Computing, Big Data and Cognitive Technologies. The Hartree Centre is part of the Science and Technology Facilities Council (STFC) one of seven UK Research Councils and one of Europe's largest multi-disciplinary research organisations.
• The Centre has been the focus for three linked and reinforcing rounds of government funding so far:
  • An initial UK Government investment of £37.5 million, largely derived from the national Infrastructure fund (2011);
  • A further £19 million of capital investment (in 2013) to address two further 'forces of change' in the HPC arena: first, the growing need for large-scale data and analytics competence (recognising the exponential increases in the volume and variety of data being created); and second, to pursue advances in the energy efficiency of HPC machines, and
  • Some £115.5 million of investment (in June 2015, running out over five years) to establish Hartree as the UK Centre of Excellence in Cognitive Systems and Big Data. With a clear focus on developing new approaches, this investment allows Daresbury to deliver computing capability to a range of industrial users and partner organisations. Moreover, it also delivers a transformational capacity for UK industry to extract value from the vast and readily available array of big data, so accelerating development and adoption processes by industry.
• Alongside Government investment, this last phase is being co-funded by IBM in the form of access to its global IP (including IBM Watson) and onsite expertise. This is valued at £200 million and involves establishing an IBM Research base of around 30 staff at Hartree. The facility is IBM's only R&D facility in the UK. IBM's presence will add to the existing Hartree headcount of 50 data scientists and specialists.
• By combining its world-class facilities with access to its specialists and computational scientists, Hartree enables organisations of all sizes to produce better outcomes, products and services more quickly and cost-effectively than they can through conventional R&D workflows. It is unique in the range and power of its facilities and specialist staff, sitting between the academic-facing supercomputing facilities at universities like Edinburgh and companies like Amazon or Microsoft, who rent access to their cloud-based systems by the hour.
• The Hartree Centre has recently acquired a new supercomputer, the UK's first Bull Sequana X1000, one of the most powerful supercomputers in the world, capable of performing 3.4 x10^{15} (petaflop) calculations per second. This comes through a new strategic partnership with Atos UK&I.

Source: Liverpool City Region+ A Science and Innovation Audit Main Report (2017, p.48) **https://www.liverpoollep.org/wp-content/uploads/2017/09/LCR-SIA-full-report-and-appendices-FINAL-September-2017.pdf** (Accessed 02/03/2017)

Table 3-8: Academic Capability across the North in Biostatistics for Data for Better Health and Wealth

Location	Capability
Liverpool	The University of Liverpool's Department of Biostatistics has 46 academic staff and 48 PhD students (20 co-supervised between biomedicine and biostatistics) undertaking cutting-edge research in statistical genetics, pharmacogenetics, joint modelling of longitudinal and time-to-event data, multivariate data analysis, stereology, multi-sourced evidence synthesis and clinical trials. It has a long-established track record of high-profile funded research with funding from the Medical Research Council (MRC), Wellcome, National Institutes of Health (NIH), Horizon 2020 and National Institute for Health Research. High-impact research includes methodologies for the analysis of genome-wide association and sequencing studies have been developed and applied across international collaborative efforts, advancing understanding of the molecular and pathophysiological basis of common diseases including type 2 diabetes, resulting in publications in *Nature;* identification of a pharmacogenetics-guided warfarin dosing protocol for improved anticoagulation control, shown to reduce hospital admissions in the international EU-PACT trial; development and application of methods for joint modelling of longitudinal dose and competing risks time-to-event data has influenced anti-epileptic drug prescribing practice with publication in the *Lancet*. It also leads the North West Hub for Trials Research Methodology (partnership including the universities of Lancaster, Manchester and Bangor).

Location	Capability
Lancaster	The University of Lancaster Medical School hosts the Centre for Health Informatics, Computing and Statistics, which currently has 10 full-time equivalent academic staff, three full-time equivalent post-doctoral staff, and 11 full-time PhD students. Over the last 3 years, CHICAS has undergone a rapid expansion, employing six new academic staff members. CHICAS also has honorary members from across Lancaster University, and Columbia and Yale Universities. It has a good track record of funding through organisations including the MRC, NIH and the Wellcome Trust. The group is known internationally for its research in spatial and spatiotemporal statistical methods in epidemiology, infectious disease modelling, statistical genetics, and data informatics, geographical information systems, and visualisation of complex data. High impact outputs include work in schizophrenia genetics (*Nature*), the effectiveness of Ebola screening (Lancet) and spatial modelling of emergency service response time (Journal of the Royal Statistical Society). Mathematical Sciences at Lancaster was ranked fifth in the most recent Research Excellent Framework (third for impact), with 91% of its submission being of internationally excellent or world-leading standard. It is one of the largest statistics groups in the UK with expertise in a wide range of areas. The group has an active postgraduate and post-doctoral programme, runs an MSc in Statistics with a specialised stream in medical statistics and has around fifty PhD students. The Medical Statistics group in the department provides an excellent environment for collaborative interdisciplinary research and is home to the Medical and Pharmaceutical Statistics Research Unit (www.mps-research.com). The research ethos of the group is firmly based at the interface of theory and practice; all staff are experienced in, and committed to, collaborative research. Funding for the group is provided by industry, EC Horizon 2020 and UK research councils and its members routinely act in advisory capacity to the pharmaceutical industry and the WHO. High impact outputs include analysis of malarial drug trials or a per clone or per individual basis. (Stats in Medicine) and work on dose ranging in trials (BMJ Open). Staff in both CHICAS and the Medical Statistics unit are part of the Data Science Institute which aims to set the global standard for a truly interdisciplinary approach to contemporary data-driven research challenges.
Manchester	The University of Manchester's Faculty of Biology, Medicine and Health hosts the Centre for Biostatistics, which undertakes methodological research that is primarily focussed on modern statistical and econometric approaches to causal inference. These are applied in the interpretation of routinely collected medical records (e.g. e-Health), formally designed epidemiological studies and quasi-experiments, and, in particular, inferences concerning treatment-effect mechanisms (mediation) in randomised controlled trials and their application to the development of personalised (stratified) health care.
Newcastle	Newcastle University's School of Mathematics, Statistics and Physics houses an internationally recognised Biostatistics research group. They work collaboratively with the Faculty of Medicine and the Clinical Trials Unit. Their active research areas include nonparametric curve fitting and prediction as well as working on missing data problems for longitudinal analysis, which is being extended to missing data in clinical trials (particularly crossovers and meta-analyses with missing confounders). Newcastle is also home to the National Lead for Training in the NIHR Infrastructure, NIHR Infrastructure National Training Forum Chair and NIHR Rare Disease Training Lead.
York	The University of York's Trials and Statistics Research Group, in the Department of Health Sciences, has around 50 research staff and 15 research students working on designing and implementing scientifically rigorous trials in health care, but also in other areas including education and criminal justice. The Epidemiology and Cancer Statistics Group works with clinicians and laboratory scientists in the Haematological Malignancies Research Network, exploring the determinants, prognosis and treatment of haematological cancers. Researchers in the Centre for Health Economics (CHE) (around 60 economists) conduct extensive data analysis using often innovative methods. Within CHE, the Health Econometrics and Data Group provides expertise in development and application of cutting-edge quantitative research methods. Statisticians work in other areas of health research at York including evidence synthesis, public health, mental health and health policy, and across the University, including the fundamental sciences and Departments of Computer Science and Electronic Engineering, as well as the York Cross-disciplinary Centre for Systems Analysis.

Source: SDG-ED with information from the University of Liverpool, Lancaster University and various sources in the public domain

3.23 As well as centres of individual excellence, stakeholders in the North, operating through partnerships such as the N8 and Northern Health Science Alliance and four Northern AHSNs, have developed strong and effective projects and partnerships – essential to the collection, analysis, and operational deployment of health data, including:

- **The Connected Health Cities programme**, which unites local health data and advanced technology to improve health services for patients in Northern England; and
- **Global Digital Exemplars**, which are internationally recognised NHS providers delivering exceptional care, efficiently, through the use of world-class digital technology and information. There are six Acute and two Mental Health Global Digital Exemplars in the North of England (Table 3-10).

Connected Health Cities

3.24 Connected Health Cities (CHC) is a £20m pilot programme funded by the Department of Health, via the Northern Health Science Alliance, which operates in four city-regions:

- Connected Yorkshire (Bradford, Leeds and Sheffield);
- Greater Manchester – which in addition hosts the Coordinating Hub;
- North East and North Cumbria; and
- North West Coast (Lancaster and Liverpool).[72]

3.25 Its aims are to:

- Develop a system that will continually improve care services and health;
- Work with and gain the public's trust e.g. via citizen's juries and a citizen forum in each CHC; and
- Stimulate the UK's digital health economy by encouraging new technologies to be developed and new services to be created.

3.26 In seeking to achieve its aims, CHC operates to common principles:

- Engaging and involving the public to build public trust and civic partnerships;
- Working with data custodians and existing infrastructure at a local, regional and national level to create linked-data critical masses for a deeper understanding of health in defined populations;
- Developing at the heart of each city region an Ark – a secure, combinatorial data analytics facility, with state-of-the-art data management and analysis tools, underpinned by research, education and training; and
- Bringing people from academia, NHS and industry into deep collaboration with the Ark, working in partnership to create new knowledge that will inform decision-making at levels.[73]

3.27 The CHCs operate within and between their local governance and administrative systems:

- Connected Yorkshire provides a population data laboratory that links data from Bradford, Leeds and Sheffield. The University of Leeds provides analytical and warehouse

[72] Connected Health Cities (n.d.) **https://www.connectedhealthcities.org/**

[73] NHSA (2016) *Connected Health Cities* **http://www.thenhsa.co.uk/app/uploads/2016/04/Connected-Health-Cities.pdf**

infrastructure through the Leeds Institute for Data Analytics. The University of York provides epidemiological and health services research expertise;
- The Greater Manchester CHC sits within Health Innovation Manchester (HinM), which provides the data-engine that powers health devolution in Greater Manchester. It utilises the Trustworthy Research Environment (TRE) facility at the University of Manchester's Health eResearch Centre (HeRC) and incorporates information from the Datawell (a software platform that enables the exchange of NHS patient record information electronically);
- North East and North Cumbria CHC operates from The Core in Newcastle and involves Newcastle University, Durham University, Newcastle upon Tyne Hospitals NHS Foundation Trust, South Tees Hospitals NHS Foundation Trust, and the Academic Health Science Network for the North East and North Cumbria; and
- North West Coast CHC has a programme of activity, including putting in place the permissions and systems needed to enable novel uses of data to transform care and the development of information models and algorithms for frontline staff, delivered by a core group of organisations: The Innovation Agency North West Coast, AIMES Grid Services (a community interest company providing a data centre), the University of Liverpool, Lancaster University; plus, clinical colleagues.

3.28 As part of the initial phase of CHC each area is specialising in specific care pathways:

- Greater Manchester (GM)
  - Using technology and data to improve the diagnosis and treatment of strokes;
  - Using data to tackle antibiotic resistance; and
  - Using technology to improve the treatment of pressure ulcers in the community;
- Northwest Coast (NWC)
  - Development of a Learning Health System for unplanned care (COPD);
  - The Northwest Coast CHC Epilepsy Care Pathway Project; and
  - Development of a Learning Health System for alcohol misuse;
- Connected Yorkshire (cY)
  - Promoting healthier child growth;
  - Empowering independence in older people; and
  - Supporting community care and reducing demand on A&E services;
- North East and North Cumbria (NENC)
  - Dementia and Frailty;
  - Forecasting Emergency Unplanned Care; and
  - A Learning Health system for Vulnerable Families.

3.29 CHC NENC has also delivered a regional integrated digital care record project –The Great North Care Record (GNCR). This builds upon and supports the established North East Trials Capability. Phase one established data sharing agreements across the region for 350 GP practices, all out of hours services, 13 Acute Trusts and 3 Mental Health Trusts. The inclusion of social care is currently underway.

3.30 The Hub, based in Manchester, has been engaging industry, particularly in the initial stages the Information Communication and Technology (ICT sector), via 'think tanks', 'webinars'). It has also undertaken a series of activities, including citizen's juries and attendance on leisure events, to engage the public – to raise awareness, test willingness to participate and identify potential risks. It also operates six working groups: technical, patient and public involvement, capacity building, evaluation, information governance, and citizen's empowerment. These

activities are all focused on improving the environment for research, whether that be in terms of data sharing and analysis, research collaboration involving academics, practitioners and business. Appendix 4 provides a summary of CHC delivered activities to date and Table 3-9 provides a case study of how data-sharing infrastructure has been put in place.

Table 3-9: Bradford Connected Yorkshire

• CHC colleagues in Bradford undertook professional stakeholder engagement liaising with the local medical committee, senior management, clinicians, and general practitioners as well as other key professionals across the three Clinical Commissioning Groups (Bradford City, Bradford Districts and Airedale, Wharfedale & Craven). There are agreements with all 88 GP Practices in the three areas, to provide pseudonymised data. • Bradford Institute for Health Research has approval from Bradford Teaching Hospitals NHS Foundation Trust and signed data sharing agreements from Bradford District Community Trusts and Airedale Hospitals, Bradford Council's Health & Wellbeing Department and Sue Ryder. • The North of England Commissioning Support Unit has an agreement with the Bradford Teaching Hospitals NHS Foundation Trust to provide the encryption key to Caldicott Guardian's / Designated Officers to share with those organisations that have signed a data sharing agreement enabling data to be replaced, removed and encrypted at source demonstrating the highest standards of information governance and security.

Source: Connected Health Cities

Global Digital Exemplars

3.31 Global Digital Exemplars are part of the wider Driving Digital Maturity Programme. This is a programme that aims to improve patient outcomes whilst delivering the highest quality care through supporting effective decision-making.

3.32 More effective decision-making is achieved through a paper-free service at the point of care, as dependence on error-prone paper records is a risk to patients. This programme is delivered through:

- Digital Maturity Assessments (utilised to assess the extent of how effectively digital technology is used at the point of care by healthcare providers);
- Local Digital Roadmaps (a source of information to be used as the justification for investment and national policy); and
- Transformation Support (a programme for support for Clinical Chief Information Officers (CCIOs) and Chief Information Officers (CIOs) including the delivery of the Global Digital Exemplars).

> 'A Global Digital Exemplar is an internationally recognised NHS provider delivering exceptional care, efficiently, through the use of world-class digital technology and information. Exemplars will share their learning and experiences to enable other trusts to follow in their footsteps as quickly and effectively as possible'.

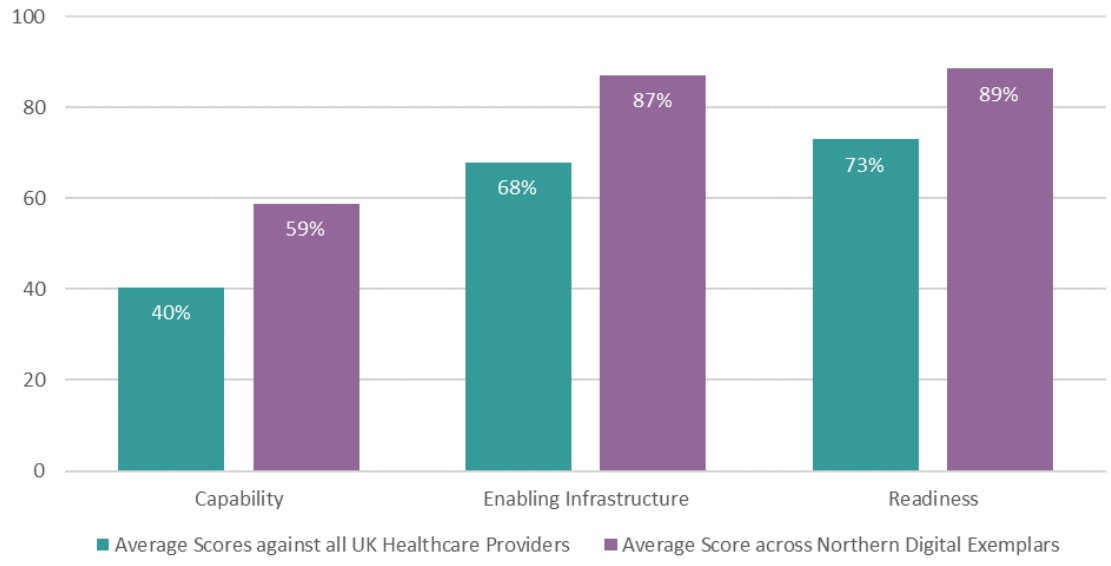
Table 3-10 Global Digital Exemplars in the North of England

Acute Global Health Digital Exemplars in the North	Mental Health Digital Exemplars in the North
• Alder Hey Children's Hospital NHS Trust • City Hospitals Sunderland NHS Foundation Trust • Newcastle upon Tyne Hospitals NHS Foundation Trust • Royal Liverpool and Broadgreen University Hospitals NHS Trust • Salford Royal NHS Foundation Trust • Wirral University Teaching Hospital NHS Foundation Trust	• Mersey Care NHS Foundation Trust • Northumberland Tyne and Wear NHS Foundation Trust •

Source: NHS England (n.d.) *Global Digital Exemplars* **https://www.england.nhs.uk/digitaltechnology/info-revolution/exemplars/**

3.33 The Digital Maturity Assessment Scores for 2015/2016 data show Northern-based Global Digital Exemplars are true centres of excellence with digital maturity scores an average 18 percentage points higher than the UK averages across the three main assessment areas; Capability, Enabling Infrastructure and Readiness. The highest scoring healthcare provider of the Northern Based Global Digital Exemplars is Salford Royal Hospitals NHS Trust with scores of 99 out of 100 for Readiness, 83 out of 100 for Capability and 98 out of 100 for Enabling Infrastructure.

Figure 3-1: Digital Maturity Assessment Scores, comparing UK averages with Northern Digital Exemplars



Source: NHS England (2015-2016) *Digital Maturity Assessment 2015/2016*
https://data.england.nhs.uk/dataset/digital-maturity-assessment-2015-2016

3.34 A further example of world-class digital innovation in the Northern NHS Foundation Trusts can be found in the pioneering multi-year collaborative programme at Alder Hey Children's Hospital Foundation Trust. In collaboration with the Science and Technology Facilities Council's (STFC) Hartree Centre and with support from IBM Watson, Alder Hey's Children NHS Foundation Trust is set to become the UK's first 'cognitive' hospital using an artificial

intelligence programme. This is the first time that Watson technology will be applied to improve patient experience in the United Kingdom.

3.35 After data is securely and voluntarily provided by patients, the patient experience will be improved by:

- Identifying patient anxieties and providing information and reassurance on-demand;
- Reminding young patients and their parents about appointments and about aftercare; and
- Providing insightful feedback to clinicians based on the tone and sentiment of these interactions.[74]

Business base and capabilities

3.36 Figure 3-2 uses Standard Industrial Classifications (SICs) to identify Location Quotients for the ICT sector in the North. We note that SICs have their limitations, especially for new technology areas, and the SIC codes used cover a much broader category than simply Health Data alone. The figure maps business count on the vertical axis and employment and the horizontal axis. The subsectors reviewed are listed along the bottom of the chart.

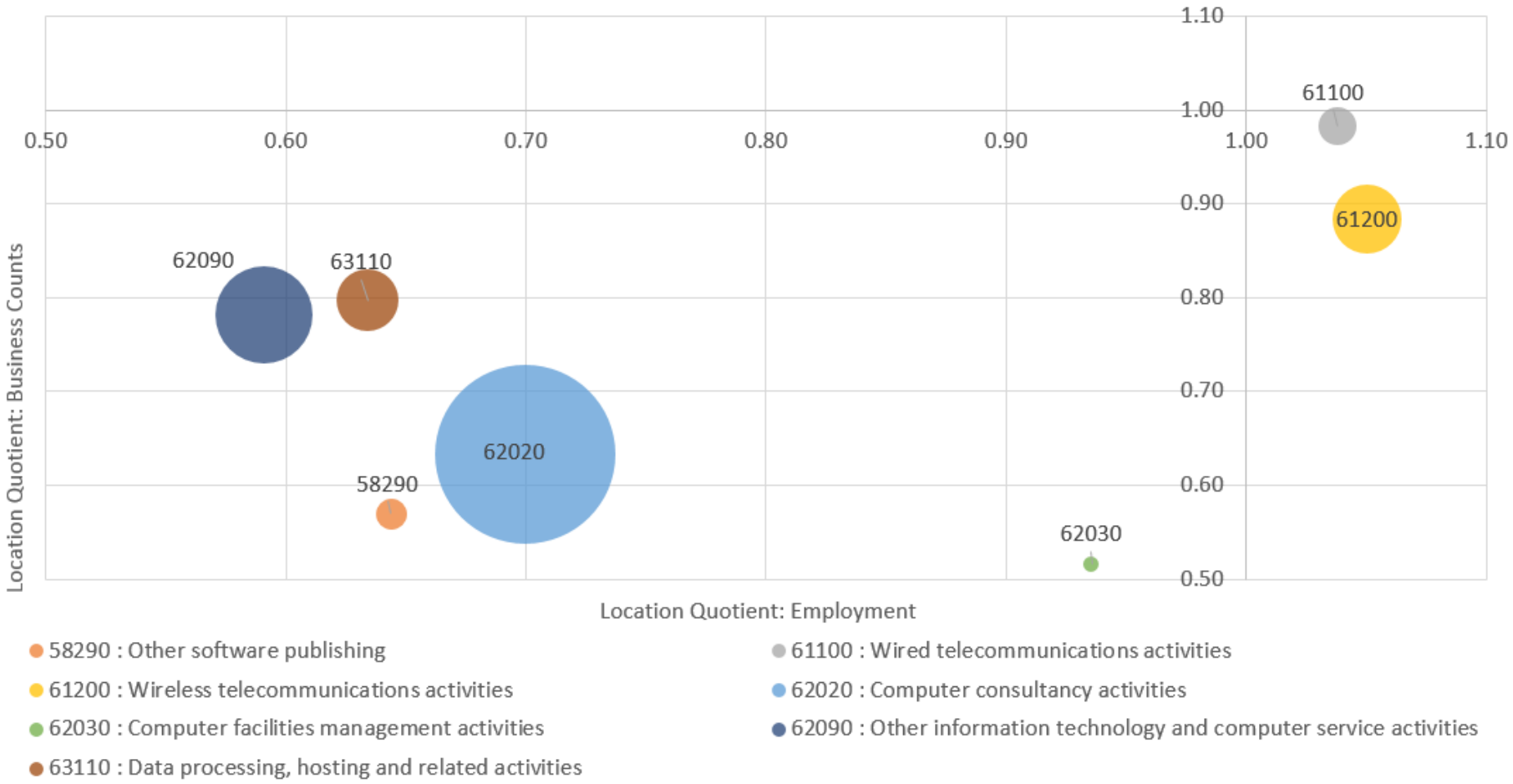
3.37 The 'bubble' size reflects the scale of employment. Bubbles above and to the right of 1 show relative specialisation in the North, bubbles below and to the left of 1 show under-representation in the North. The figure shows a relative strength in relation to wired and wireless telecommunications, but no specialisation in other sub-sectors. However, the health data space is a niche in these broad categories and the North has particular strengths in this area.

3.38 Appendix 4 provides a non-exhaustive summary of Life Science and Health Data businesses in the North. SIA partners aim to undertake further work in mapping supply chains and the potential for growth as part of the follow-up work to the SIA, subject to additional resources being made available (e.g. via Sector Deals at national or Northern levels).

3.39 The **Data for Better Health and Wealth** offer, at the level of the North, is founded on the interaction between digital businesses/providers and the infrastructure. Appendix 4 also provides a 'heat map' based on the combined digital health infrastructure and business base in the UK. It shows a particularly strong arc running from Liverpool City Region to the Manchester City Region.

[74] NHS Alder Hey Children's NHS Foundation Trust (2016), *Alder Hey Children's Hospital Set to Become UK's First 'Cognitive' Hospital*, **https://alderhey.nhs.uk/contact-us/press-office/latest-news/alder-hey-childrens-hospital-set-become-uks-first-cognitive-hospital** (Accessed 02/03/2018)

Figure 3-2: Location Quotient for Information and Communications in the North



Source: Business Register and Employment Survey (BRES) (2015), **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/businessregisterandemploymentsurveybresprovisionalresults/previousReleases**

Business and academic partnerships

3.40 Researchers and clinicians in the North have not only identified and responded to the need to streamline access to health data to facilitate and accelerate research, but they have identified the importance of establishing and developing long-term, trust-based relationships with business. To that end, Connected Health Cities is establishing a Pre-Competitive Collaboration Consortia (PCCC). The first consortium, as noted above, focuses on data. An event (held at CityLabs, Manchester) in May 2017 was attended by 41 companies to discuss terms/heads of agreement, including the approach to Intellectual Property, as well as data security. A follow-up webinar was held with 31 companies which had been unable to attend the event. The PCCC aims to be self-sustaining via in-kind as well as cash contributions. The PCCC includes some or all of the following businesses:

- Quaenam;
- Red Ninja Studios;
- Aridhia;
- GE
- Orcha
- Gendius;
- North West eHealth;
- Rescon Technologies;
- MDSAS;
- Cisco Systems;
- Intel;
- UK Cloud;
- CSC;
- Microsoft;
- InterSystems; and
- Telefonica.

3.41 The work on the PCCC for Health ICT demonstrates the business appetite for engagement and the effectiveness of the 'soft' infrastructure that CHC provides. There is scope for the approach to be developed for other themes, for example, pharmaceuticals.

Local Science and Innovation Talent

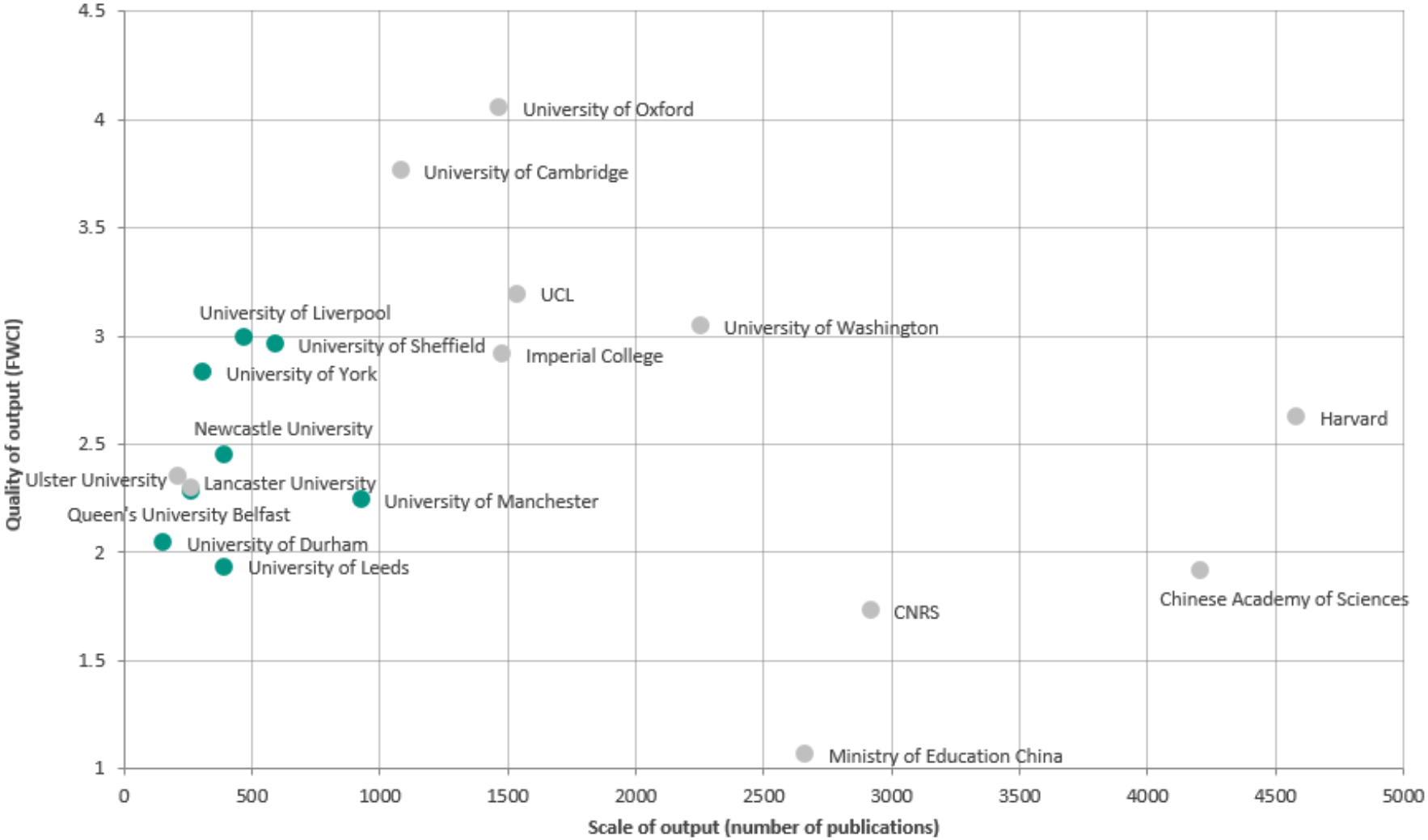
3.42 The attraction and retention of talent is vital for the North to retain its leadership position Health ICT, and to build on the assets and skills that it has, to establish a world-leading role.

Current research talent as indicated by academic metrics

3.43 The Research Excellence Framework 2014, referenced in Chapter 2, showed, excellence in Computer Science and Informatics in the Universities of Lancaster, Liverpool, Manchester, Newcastle, Sheffield and York. This level of evidence, however, is not sufficiently granular to show relative strength in particular specialisms. SciVAL bibliometric data are more effective at providing a granular and more up-to-date picture of excellence. (See Appendix 7 for further information on SciVAL and the methodology applied, including the keyword search strings used).

3.44 Figure 3-3 plots the scale of publications output on the horizontal axis and the quality of this output, as reflected in Field-Weighted Citation Index (FWCI) on the vertical axis. These results compare our output with that of top-ranked institutions highlighted by the search and tell us that while the quantity of output is not as great as some of our larger national and international peers, Northern research performance in advanced medical informatics – a particularly important part of the data offer for **Precision Medicine** – compares favourably in terms of quality as measured by the Field-Weighted Citation Index (FWCI) to that of leading institutions both in the UK and world-wide.

Figure 3-3: Research output versus research quality for advanced medical informatics, 2012-18



Source: SDG Economic Development of Scopus SciVAL data jointly provided by the NHSA and Queens University Belfast

Talent pipeline as indicated by data on graduates

3.45 As noted in Chapter 2, the North retains around three-in-four of its Computer Science graduates, a similar share to the overall graduate retention rate at the level of the North. This recognised, it only retains around one-in-two of its Mathematics graduates. A detailed picture of graduate retention and attraction between study and employment LEP is in Appendix 4.

Talent pipeline evidence from stakeholder consultations

Skill shortages and skills gaps

3.46 Stakeholders working in the NHS, universities and the commercial sector were consulted on skills, and recruitment and retention issues via workshops and steering group sessions. They highlighted the following areas as ones which are suffering from skills shortages (i.e. insufficient supply to meet demand):

- Bioinformatics, pathology, microbiology and genome sequencing – which are subject to worldwide shortages;
- Health economists and data scientists – in part due to the higher salaries offered by other sectors, particularly in the case of data scientists who can work in finance and the media; and
- Staff with a strong understanding of both **Precision Medicine** and Digital.

3.47 One of the symptoms of these skills shortages is poaching in the system, for example, data analysts and data managers have moved from local NHS trusts to NHS Digital and NHS England.

3.48 Stakeholder consultations also highlighted two related issues in relation to the talent pipeline. First, job roles are likely to change over time, which requires ongoing scanning of skill requirements and a recalibration of forecasts of skill requirements to inform development and delivery of programmes of Continuing Professional Development (CPD) to address skills gaps (i.e. shortfalls in the skills of the existing workforce). Second, stakeholders need to unpack the challenges faced to determine whether requirements are best addressed by upskilling individuals or through better use of team-based working. The latter may make demands on management skills and generic team-working and communication skills, rather than require training programmes for individuals.

3.49 Consultees also noted a skills shortage of entrepreneurship and a skills gap in management. Three explanations of the shortage and gap were identified:

- A lack of scale-up funding for SMEs in the North means entrepreneurs are drawn southwards, where venture capital is more readily available;
- The greater mass and density of Life Science business in the Golden Triangle of Oxford, London, Cambridge means that the potential risks of failure are mitigated, as an individual has more opportunities to pick up a career in the same sector and geography; and
- The lack of an established programme or route by which academics who specialise in research could handover the operation of a spinout business to someone with business management expertise.

Action to be taken

3.50 Stakeholders identified a number of steps to be taken at the level of the North to address skill shortages and skill gaps, including:

- Working to promote STEM subjects in schools and working with specialist schools such as the Liverpool Life Sciences University Technical College and the Health Sciences UTC Sheffield to develop the talent pipeline;
- Establishing a coordinated approach to graduate appointments and internships by reducing red tape and thereby making it easier to start a career in the North;
- Identifying measures to reduce the loss of international graduates from the North, once courses are completed;
- Developing a twofold 'returners programme' to attract people who have left the sector, e.g., data specialists who switched fields, to return to it, and people who migrated away from the North to return;
- Increasing the availability of a year in industry as part of undergraduate and post-graduate studies, to improve retention rates but also enhance the ability for cross-sector collaboration;
- Developing a national/regional skills academy to enable workers to passport skills from one sector to another – in order to ease attraction of much-needed skills from other sectors;
- Building on current offers, such as, MRC Skills Development Fellowships for postgraduates with quantitative skills wanting to apply them in medicine, and Lancaster University's MSc in Medical Statistics, which is one of only a handful in the UK; and
- Developing a national/regional academy of clinical or life science entrepreneurship.

National and International Engagement

Scale of international collaboration on research

3.51 Table 3-11 provides the SciVAL data obtained for advanced medical informatics. It shows the scale of activity and the scale of research collaborations in the Northern universities relative to the top-ranked institutions identified using our search terms. Figure 3-4 plots the relationship between national and international collaborations, as reflected in the proportion of papers with a national or international co-author. This demonstrates that the NPiHR universities have a strong international focus in their collaborations in advanced medical informatics – only slightly below the international collaboration emphases of the top-ranked UK universities. International collaboration in research is a powerful indicator of research standing – and also has a strong impact on the quality of the research – so these data show both the quality of research and the strength of international ties that will enable the North to stay ahead in its key research fields.

Research quality and international collaboration

3.52 Figure 3-5 confirms the frequently observed association between international collaboration and research quality for advanced medical informatics research. This association comes about because cutting-edge research often relies on bringing together complementary competencies, distinctive research assets, and (increasingly) datasets – for which the North is ideally placed. It is usually the case that the larger the multinational scope of a collaboration the greater its prominence in terms of citations. The NPiHR institutions perform relatively well in terms of this relationship.

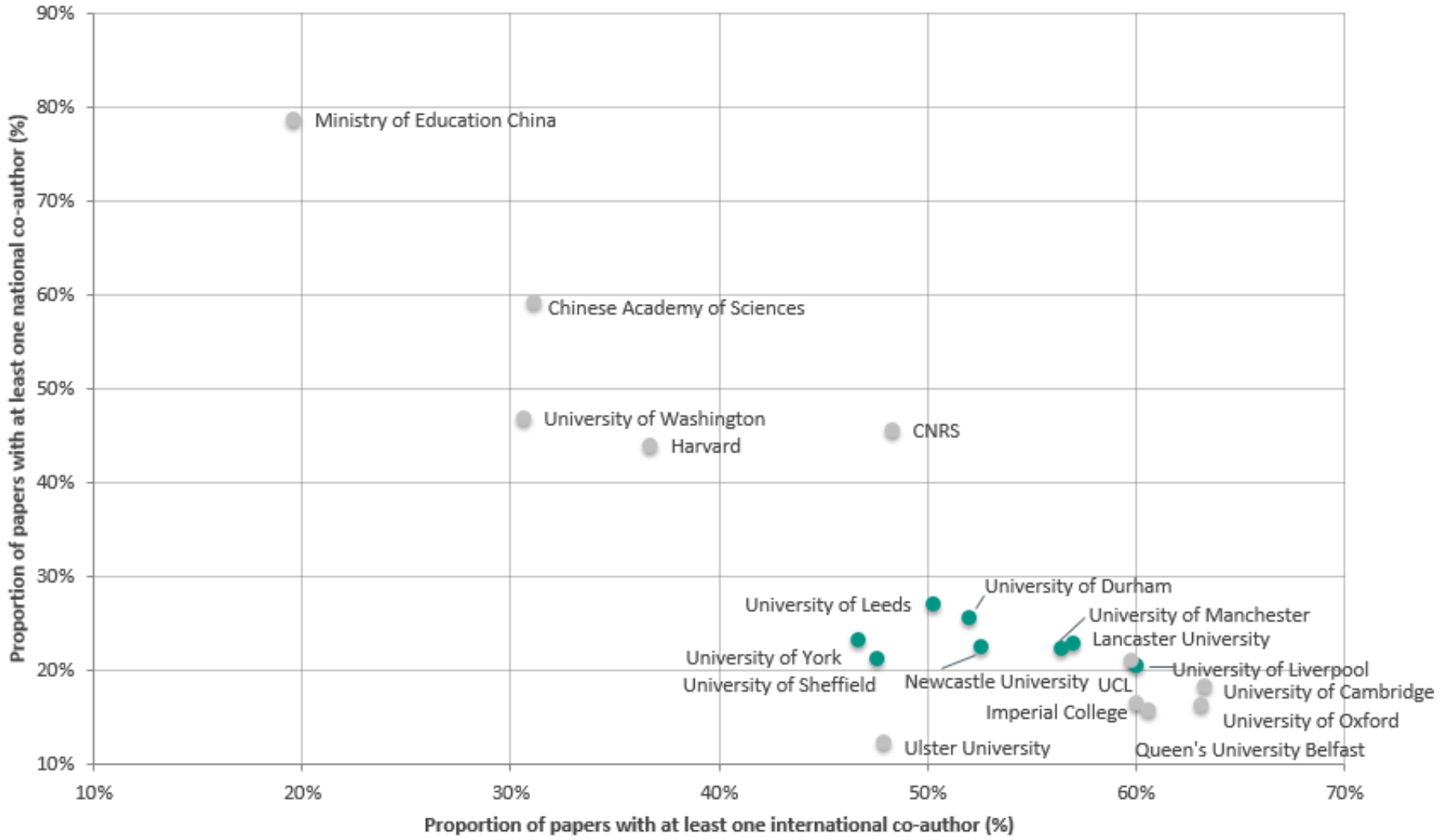
Table 3-11: Bibliometric data for advanced medical informatics, 2012-18

Institution	Number of publications	Number of citing countries	Number of papers with at least one national co-author	Proportion of papers with at least one national co-author	Number of papers with at least one international co-author	Proportion of papers with at least one international co-author	Number of publications in Top 10% Journal Percentiles (using SCImago Journal Ranking)	Proportion of publications in Top 10% Journal Percentiles (using SCImago Journal Ranking)	Field-weighted citation impact	Number of papers in Top 10 citation percentile - field-weighted	Proportion of papers in Top 10 citation percentile - field-weighted	Citation Count
University of Leeds	398	122	102	25.6%	207	52.0%	149	43.6%	1.93	87	22.3%	3,860
University of Manchester	930	137	210	22.6%	489	52.6%	311	38.8%	2.24	200	22.2%	8,693
University of Sheffield	594	165	126	21.2%	283	47.6%	182	40.4%	2.96	132	22.4%	7,926
University of Liverpool	475	162	98	20.6%	285	60.0%	139	37.4%	2.99	118	25.3%	6,749
Newcastle University	398	115	91	22.9%	227	57.0%	146	43.6%	2.45	94	24.6%	3,913
University of York	313	142	73	23.3%	146	46.7%	111	43.4%	2.83	67	22.2%	4,337
University of Durham	159	86	43	27.0%	80	50.3%	53	40.8%	2.04	38	24.4%	1,313
Lancaster University	264	95	59	22.4%	149	56.4%	77	41.8%	2.28	61	23.6%	1,761
University of Cambridge	1,085	193	198	18.3%	687	63.3%	474	53.8%	3.76	337	31.7%	20,598
University of Oxford	1,472	193	241	16.4%	929	63.1%	526	44.2%	4.05	482	33.4%	29,380
Imperial College	1,484	177	246	16.6%	891	60.0%	554	44.8%	2.91	380	26.1%	20,966
UCL	1,541	180	323	21.0%	921	59.8%	566	44.1%	3.19	409	27.1%	22,429
Chinese Academy of Sciences	4,208	156	2,497	59.3%	1308	31.1%	982	30.1%	1.91	734	17.9%	26,810
CNRS	2,922	167	1,332	45.6%	1412	48.3%	712	33.3%	1.73	526	18.3%	19,582
Harvard	4,587	201	2,016	44.0%	1682	36.7%	2,002	47.2%	2.62	1,129	25.3%	67,017
Ministry of Education China	2,666	139	2,097	78.7%	522	19.6%	546	23.8%	1.06	278	10.7%	11,048

Institution	Number of publications	Number of citing countries	Number of papers with at least one national co-author	Proportion of papers with at least one national co-author	Number of papers with at least one international co-author	Proportion of papers with at least one international co-author	Number of publications in Top 10% Journal Percentiles (using SCImago Journal Ranking)	Proportion of publications in Top 10% Journal Percentiles (using SCImago Journal Ranking)	Field-weighted citation impact	Number of papers in Top 10 citation percentile - field-weighted	Proportion of papers in Top 10 citation percentile - field-weighted	Citation Count
University of Washington	2,258	187	1,060	46.9%	691	30.6%	815	43.0%	3.04	545	24.7%	34,830
Queen's University Belfast	264	100	42	15.9%	160	60.6%	76	37.4%	2.29	61	23.1%	n/a
Ulster University	217	143	27	12.4%	104	47.9%	34	21.1%	2.35	20	9.2%	n/a

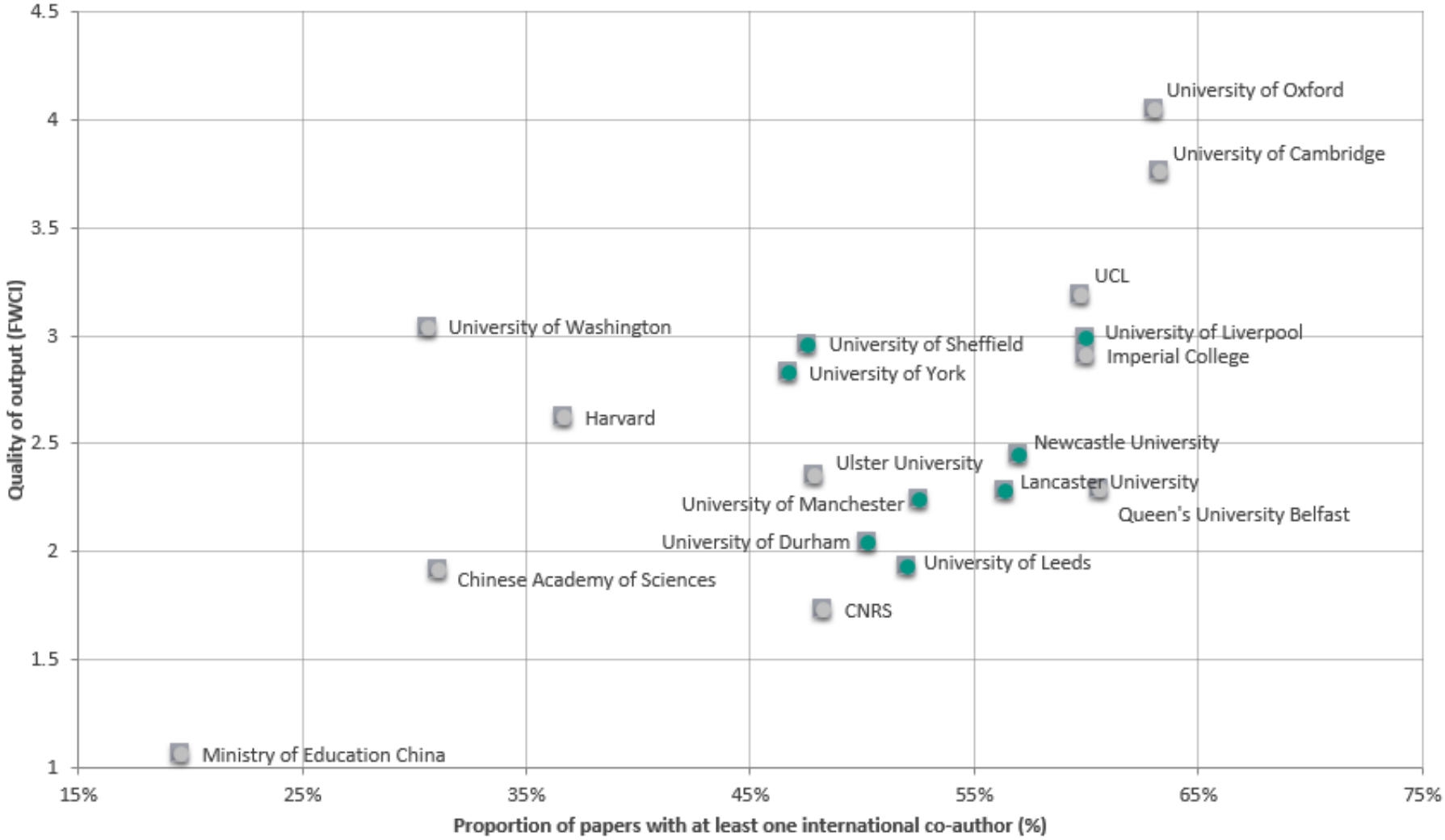
Source: SciVAL data jointly provided by the NHSA and Queens University Belfast

Figure 3-4: The relationship between national and international collaboration emphases for advanced medical informatics, 2012-18



Source: SciVAL data jointly provided by the NHSA and Queens University Belfast

Figure 3-5: The relationship between international collaboration and quality of output for advanced medical informatics, 2012-18



Source: SciVAL data jointly provided by the NHSA and Queens University Belfast

Conclusions

3.53 Our original hypothesis in relation to **Data for Better Health and Wealth** was that:

- The North of England is ideally placed to facilitate and catalyse the science and innovation required to establish Learning Health Systems.

3.54 The SIA process has shown that we have the necessary physical assets – including but not limited to: six Global Digital Exemplars, the National Innovation Centre for Data in Newcastle, the Health eResearch Centre and the High Performance Cognitive Computing Facility at the Hartree Centre – to support the operation of effective Learning Health Systems in the North.

3.55 It has also shown that we have significant expertise, of international calibre, in Biostatistics and Data, with leading teams in Lancaster, Leeds, Liverpool, Manchester, Newcastle and Sheffield. This extensive expertise already has established significant international collaborations – providing an excellent platform from which to build further collaborations to exploit growing international markets.

3.56 Our review of evidence on businesses shows that we have a growing digital health business sector. Businesses in this sector are collaborating effectively with clinicians and researchers across the North. Our 'soft' infrastructure supports these collaborations, in particular, but not exclusively, by developing the protocols and agreements that are necessary to enable research to happen at scale, with relative speed, and with minimum bureaucracy.

3.57 Thus, the SIA has found that we have the necessary conditions to facilitate and catalyse the science and innovation required to establish Learning Health Systems in the North.

3.58 Stakeholders identified constraints on our ability to realise fully the opportunities offered by **Data for Better Health and Wealth**, including skill shortages in vital specialisms such as Bioinformatics and weaknesses in the business support environment to support the development of scale-up business in the Life Sciences in general, for example, access to finance and succession planning.

3.59 Given the above findings and our over-arching objectives, we will:

- Build on our digital assets, and networks, such as Connected Health Cities, to exploit the power of **Data for Health and Wealth** by delivering multiple Real-World Clinical Trials at scale and combining cohort data and civic data through the application of large connected data sets across the North to increase the efficacy and to reduce the costs of treatments; and
- Work with LEPs and other business support agencies to identify support for Life Science businesses in general.

4 Theme 2: Precision Medicine

For the purposes of this SIA, **Precision Medicine** is broadly defined as: the search for, and application of, the right treatment (Diagnostic, Digital, Drug and Device) to the right patient (given gender, age, location, socio-economic characteristics and Omic background) at the right time (in terms of Prevention, Intervention and Management) and at the right dosage.

A narrower definition applied by clinicians is that **Precision Medicine** is where a strong understanding of the molecular pathophysiology of disease enables the design of therapies/interventions to target and repair directly the underlying defect, and the targeting of that therapy to patients most likely to benefit.

The SIA's approach to **Precision Medicine** applies the principle of 'P4 Medicine', that is medicine that is Predictive, Preventative, Personalised, and Participatory.

Headline Messages

4.1 In relation to **Precision Medicine**, we find:

- **Precision Medicine** offers a route to 'smart' utilisation of existing and novel drugs and other therapies. It can broadly be defined as: the search for, and application of, the right treatment (Diagnostic, Digital, Drug and Device) to the right patient at the right time (in terms of Prevention, Intervention, and Management) and at the right dosage;
- It offers the possibility of more effective diagnoses, treatments, and interventions, and collaborative research between patients and clinicians;
- With appropriate support, **Precision Medicine** could produce improved health outcomes and reduce healthcare costs by lowering the incidence of ineffective or inappropriate treatments/procedures;
- The critical next step of the **Precision Medicine** revolution is to translate the scientific vision and commercial promise into practical reality – it is in such applied research that SIA partners excel;

- The NPiHR's footprint's assets include, but are not limited to: the Genomic England's NHS Genomic Medical Centres (in Leeds, Liverpool, Manchester, Newcastle and Sheffield); the National Institute for Health Research; four NIHR Biomedical Research Centres; NIHR Medtech and In-Vitro diagnostics co-operatives (in Leeds, Manchester, Newcastle and Sheffield); InnovateUK's Medicines Discovery Catapult and the Antimicrobial Resistance Centre at Alderley Park; the UK Pharmacogenetics and Stratified Medicine Network; the Wolfson Centre for Personalised Medicine; the Medical Research Council's Centre for Drug Safety Science; The Centre of Excellence in Infectious Disease Research (Liverpool); expertise in economic evaluation at the University of York's Centre for Health Economics and other groups in the region; the Stoller Centre in Manchester; and the Medical Research Council's Stratified Medicine Consortia (n3) (in Manchester and Newcastle). We also benefit from two (of three) InnovateUK-funded Advanced Therapies Treatment Centres (ATTCs), which are facilitating the development, commercialisation, and adoption of Cell, Gene and Tissue Engineered Therapies (Innovate Manchester's Advanced Therapy Centre Hub (iMatch), and the Northern Alliance Advanced Therapies Treatment Centre (NAATTC);
- Further strengths such as the NIHR Innovation Observatory (IO) and the PPI resource VOICE (Valuing Our Intellectual Capital and Experience) add value to the regions collective offering to Industry via horizon scanning and "real time" consumer feedback;
- In terms of specific areas of expertise, the Research Excellence Framework 2014 shows academic excellence in: (1) Allied Health Professions, Dentistry, Nursing and Pharmacy at the Universities of Lancaster, Bradford, Leeds, Manchester, and Sheffield; (2) Psychology, Psychiatry and Neuroscience at the Universities of Lancaster, Newcastle, Sheffield and York; and (3) Public Health, Health Services and Primary Care at the Liverpool School of Tropical Medicine and University of Sheffield;
- International collaboration is a vital part of innovation in Precision Medicine. Universities in the NPiHR's footprint demonstrate high levels of international collaboration with over 60 per cent of papers containing at least one international partner, a rate comparable to the UK's best research institutions;
- Collaborative working (between sectors as well as across borders) is vital to the success of innovation in Precision Medicine, such collaboration is supported by multidisciplinary centres that complement our themes e.g. the EPSRC-funded Centre for Maths in Healthcare at Liverpool, the recently funded £2 million EPSRC grant for new approaches to Data Science at Lancaster, and EPSRC investments in Anti-Microbial Resistance at Liverpool, York and Sheffield; furthermore, the NPiHR's 'soft' infrastructure supports collaboration within the North, and between the North and the rest of the world;
- In terms of business, the NPiHR's footprint has nationally significant and complementary clusters of Life Sciences businesses. The North is home to over 12,450 Core Biopharma companies (around 20 per cent of all UK Biopharma firms), employing 21,500 over people (18 per cent of all UK employment in the sector); and around 21,700 Medtech companies (c.22 per cent of all UK Medtech companies), employing over 28,500 people (23 per cent of all UK employment in the sector).[75]

[75] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the landscape of the medical technology and biopharmaceutical sectors in the UK*, Annual report 2017.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707072/strength-and-opportunity-2017-bioscience-technology.pdf

- The North West is strong in therapeutics at Alderley Park and has a core Biopharma and Medtech service and supply chain; Yorkshire and the Humber is strong in core Medtech and Digital Health; and the North East, which has a significant cluster of 17 major pharmaceutical companies including Sanofi and GSK, is strong in Biopharmaceutical service and supply, and core Biopharmaceutical; and
- There is growing diagnostics cluster in the North, including the Abtek Biologicals Mast Group in Liverpool, QIAGEN in Manchester, and Mids Medical at Sci-Tech Daresbury.

4.2 The issues to address, if we are to maximise the health and economic benefits of the North's potential in Precision Medicine, include:

- A lack of pan-regional joined-up infrastructure to conduct real-world precision trials at scale;
- Insufficient funding and support for scale-up businesses in Precision Medicine (notwithstanding the good work already being done e.g. at Alderley Park);
- The slow adoption and application of innovation in the NHS. This arises from a range of causes, including conservative procurement processes, cultural issues, and crucially a lack of engagement by clinicians (often due to wider NHS pressures), with the latter meaning that researchers and companies tend to push products from a technology perspective, and in ways which are not always aligned with the patient pathway/Health and Care system;
- A workforce that has not been sufficiently trained in the skills required fully to exploit the opportunities offered by Precision Medicine, this including cross-team working and entrepreneurial and business management skills; and
- Optimising the synergies, linkages, and connections with other relevant SIAs elsewhere in the North and the wider UK (such as Scotland's SIA focused on Precision Medicine Innovation, and Medical Technologies in the Leeds City Region SIA).

Introduction

Understanding the challenge

4.3 **Precision Medicine**[76] is and will remain, a continuous work-in-progress, it seeks to optimise the diagnosis and treatment of individual patients rather than broad, often diverse, disease groups. This is because patient responses to a given drug treatment, therapeutic intervention, and standard of care can vary widely within a given population; for example, only 20-30 per cent of patients respond positively to the standard of care for oncology treatments.[77]

4.4 Adverse drug reactions cost over £1 billion a year. Drug safety is a major cause of drug attrition either during drug development or after a drug is launched onto the market. **Precision Medicine** represents the route to 'smart' utilisation of existing and novel drugs and other therapies, targeting the right drug to the right patient at the right time and in the right dose. It also offers the possibility of more effective diagnoses, treatments, and interventions, collaborative research between patients and clinicians, resulting in improved health outcomes and reductions in healthcare costs associated with the use of ineffective or inappropriate treatments and procedures.

[76] Also, sometimes referred to as Personalised Medicine or Stratified Medicine.

[77] UK Stratified Medicine (2013) Unlock Your Global Business Potential, **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/301775/UK_Stratified_Medicine.pdf**

Understanding the different elements of the development process

4.5 Based on stakeholder consultations, the following stages and processes for developing and applying **Precision Medicine** treatments can be identified:

- Understanding the clinical unmet need;
- The research to commercialisation cycle;
- The clinical cycle; and
- Exploitation of different market domains.

4.6 The research to commercialisation cycle includes the following stages:

- Discovery (basic research);
- Applied research;
- Experimental development;
- Demonstration of proof-of-principle;
- Commercial viability assessments;
- Commercialisation;
- Certification and clinical approval;
- Market introduction; and
- Service monitoring and improvement.

4.7 The clinical cycle includes:

- Understanding the patient cohorts that will benefit;
- Prediction and risk mitigation;
- Diagnosis and evaluation of treatment options;
- Treatment and interventions; and
- Monitoring, evaluation and clinical learning.

4.8 And work in different market domains includes but is not limited to:

- Drug (Pharma and Biotech);
- Diagnostics;
- Devices;
- Digital & data; and
- Delivery treatment services.

The NPiHR's role in these spaces

4.9 The NPiHR does not claim a pan-Northern world-leading position in basic research and discovery, yet many of its individual centres do have capacity in this domain. However, it does possess internationally competitive assets and expertise in all the other aspects of the research to commercialisation and clinical cycles, along with significant assets and expertise in relevant market domains, which provide a firm foundation for future growth.

The scope of the work

4.10 The North's work to develop **Precision Medicine** treatments is and will continue to help to improve the cost-effectiveness of healthcare by:

- Reducing the likelihood of incorrect clinical diagnoses (and associated wasted intervention costs) – known as false positive clinical test results;

- Increasing the likelihood of correct clinical diagnoses – known as true positive clinical test results;
- Ensuring that prescribed treatment interventions are cost-effective; and
- Increasing the rate of diffusion and adoption of innovations in diagnosis, devices, drugs and treatment services.

Challenges to address

4.11 According to consultees, there are several 'road blocks' to gaining the full benefits of **Precision Medicine**, some of which are shared with **Data for Better Health and Wealth**, including:

- Lack of capacity to conduct real-world precision trials at scale, e.g. due to lack of eHealth infrastructure and resource constraints in the NHS and constraints on funding provided to and by LEPs;
- Lack of funding and support for scale-up businesses in **Precision Medicine**;
- Slow adoption of innovation into the NHS, due to procurement processes and cultural issues; and
- A workforce that has not been sufficiently trained in the skills required fully to exploit the capabilities offered by **Precision Medicine** – including cross-team working and entrepreneurial and business management skills.

The NPiHR's role in tackling these challenges

4.12 Based on consultations and discussions conducted for this SIA, the NPiHR aims to build on its strengths to accelerate the pace of the research to commercialisation cycle and promote diffusion and adoption of innovation in **Precision Medicine** in the NHS, in particular:

- Developing the ability to run real-world precision clinical trials at scale across the North of England;
- Working with LEPs and other business support agencies to pool funding to support health innovation and to support scale-up businesses;
- Working in the NHS to support innovation through procurement and organisational development programmes; and
- Developing professional development programmes to skill-up the workforce, including the provision of support for cross-team working;
- Developing entrepreneurship and business management programmes to support the growth of **Precision Medicine** businesses.

National and International Trends and size of Global Markets

Economic and technological trends

National and international trends

4.13 **Precision Medicine** is part of a wider set of technological and clinical trends pushing convergence of sectors, including:

- Next Generation Pharmaceutical Products;
- Engineering and Life Sciences;
- Diagnostics;
- Data Science and Computing; and

- Connected Devices.[78]

4.14 The UK has an established industrial base and associated supply chains to support the development of **Precision Medicine** through established capabilities in:

- Drug discovery and Development;
- Biomarkers;
- Informatics;
- Imaging;
- Diagnostic and Genomic technologies; and
- Product design and manufacture.[79]

4.15 With ageing populations putting pressure on healthcare systems around the world and new treatments becoming available, healthcare costs have been and are set to continue to rise. The global **Precision Medicine** market is forecast to grow at a compound annual growth rate of 11.23 per cent between the years 2017 and 2026, to reach a value of US$141.7 billion.[80] The take-up of **Precision Medicine** should increase the effectiveness of treatments and help to contain healthcare costs.

4.16 The UK Government, the research community, and clinicians are committed to ensuring the UK is a global leader in **Precision Medicine**.[81] This applies equally to the attraction of investment and talent and the growth in the export of goods and services.

Commercial, inward investment and export opportunities

4.17 A few years ago, the then UKTI, separated the general commercial, inward investment, and export opportunities on offer to businesses in the UK into several categories, including:

- The development and consumption of research tools, platform technologies and informatics solutions – building on research programmes in translational science, genomics and stratified and Personalised Medicine;
- The provision of test-beds for products and services – drawing on access to patients and NHS data and records;
- An appetite for new business and regulatory models – in particular, to reduce Data Action Latency;[82]
- The search for better patient outcomes and/or reduced costs to the NHS;
- Pursuit of excellence in health technology assessment and health economics – driven by the National Institute for Health and Care Excellence; and

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[78] McKinsey&Company (2013) Disruptive technologies: Advances that will transform life, business, and the global economy **https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies**

[79] UK Stratified Medicine (2013) Unlock Your Global Business Potential, **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/301775/UK_Stratified_Medicine.pdf**

[80] BIS Research (2017) Global Precision Medicine Market –Analysis and Forecast (2017-2026) **https://bisresearch.com/industry-report/global-precision-medicine-market-2026.html**

[81] Ibid

[82] Data Action Latency is the time lag between data being available indicating that an action should be taken and the action being taken in practice – the development of Learning Health Systems helps to overcome DAL.

- An enabling infrastructure, e.g., legal and financial advice, for generators of Intellectual Property, and exporters with established links to the mainland Europe, the USA, Japan, China, India, and the Middle East.[83]

4.18 A commitment to building and maintaining effective partnerships between the public and private sectors in the UK underpins work to maximise the economic returns to the UK of these commercial, investment and export opportunities. The critical next step of the **Precision Medicine** revolution, and where the UK can benefit from its work to date, is to translate its scientific vision and commercial promise into practical reality for patients – it is in this applied research that the North excels. The North's offer in this area is explored below.

Local Science and Innovation Assets

The importance of operating at scale

4.19 No single country, city or region successfully delivers the complex supply chain needed to develop, evaluate, regulate and commercialise a **Precision Medicine** product. Scale and connectedness are vital. The North's c. 16 million population, with a steady high burden of disease, provides a unique setting to rollout **Precision Medicine** at scale, and the North has the companies, e-health infrastructure and expertise essential to moving from theory to application in real-world health settings.

The scale, diversity and quality of Precision Medicine assets

4.20 The NPiHR's footprint has significant public and private sector **Precision Medicine** capabilities, disease-specific academic and clinical assets and clinical trials, e-health, diagnostics, bioinformatics and health economics expertise. Lists of these assets and capabilities can be found in Appendix 5. Appendix 5 also includes a non-exhaustive overview of the North's asset base for **Precision Medicine**. These assets are underpinned by multi-disciplinary research teams across the North, including the Bioeconomy and Health and Integrated Social Care research teams at Northumbria University.

4.21 The North is also home to the Leeds and Newcastle NIHR Medtech and In vitro diagnostics Co-operatives (MICs), formerly known as NIHR Diagnostic Evidence Co-operatives (DECs). These are outlined below:

- The NIHR Leeds MIC facilitates the generation of high-quality evidence on in-vitro diagnostic medical devices (IVD) for the NHS nationally, including evidence of analytical and clinical validity, clinical utility and cost-effectiveness. Focused on oncology, urology, liver, musculoskeletal and colorectal diseases, the MIC has assembled an outstanding multi-disciplinary team of methodologists in trial design, health economics, health informatics and IVD performance evaluation. This MIC is industry facing and has established relationships with more than 60 commercial companies (informatics, diagnostics and pharma/**Precision Medicine**), including 16 SMEs, and has engaged stakeholders from over 90 non-commercial organisations. Additionally, for protein biomarkers, validating new diagnostic tests is an integral part of R&D lab activity in the Trust prior to the introduction of any new tests to clinical practice. At an academic research level, through the NIHR Biomarker Programme and bridging to the Proteomics group, assessment of the clinical utility and validation studies of

[83] UK Stratified Medicine (2013) Unlock Your Global Business Potential, **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/301775/UK_Stratified_Medicine.pdf**

several biomarker assays have been carried out, particularly in the areas of renal diseases and in some cases highlighting flaws in commercially available assays.

- The NIHR Newcastle MIC has a specific remit to evaluate IVDs, and to develop better methodologies to do this. Furthermore, Newcastle has an MRC Molecular Pathology Node which will provide additional capacity for upstream test evaluation. The MIC specifically looks at pathway design and how this may be (or is) altered by new IVDs. Included in the MIC is the Newcastle University's health economics expertise. Newcastle University Teaching Hospital also has a NICE EAC which evaluates new devices and has a relationship with York Health Economics Consortium who provide health economics expertise. Both the EAC and MIC have attracted funding from the North East and North Cumbria AHSN to provide bespoke advice to SMEs for the development, analysis, NHS readiness and health economic evaluation of IVDs. The Institute of Health & Society in Newcastle University has extensive capacity in health economics and the University's Joint Research Office has expertise in regulatory approvals.

4.22 An example of how NIHR MICs collaborate to exploit physical and knowledge-based assets is provided in Table 4-1.

Table 4-1 North of England Genetic Epidemiology Group

The North England Genetic Epidemiology Group (NEGEG) is made up of epidemiologists primarily from seven research centres: Sheffield, Manchester, Leeds, Leicester Liverpool, Lancaster and Newcastle. NEGEG organises 2-3 meetings each year focusing on current topics in genetic epidemiology. These meetings are open to anyone interested in the field. Researchers from the seven institutes are involved in developing a wide range of statistical methods (for example methods for aggregation of Genome-Wide Association (GWA) Studies from multiple ethnic groups, or aggregation of functional and statistical data types). They are also involved in the leadership of international workshops in Statistical genetics (e.g. Advanced Topics in GWA Studies, Toronto). Finally, they work together in international analyst teams such as the International Consortium on Blood pressure.

Source: NHSA

4.23 An example of how this combination of assets attract businesses is provided in Table 4-2, Table 4-3 demonstrates how the North is utilising precision medicine approaches to prevent adverse drug reactions and Table 4-4 is the long-term biobank study based near Manchester – UK BioBank.

Table 4-2: Oxford Nanopore Case Study

Background

- The NHSA began working with Oxford Nanopore Technologies as the company was interested in looking at clinical applications of their MinION device; a portable, real-time, long read and low-cost device that has opened up DNA sequencing to researchers who would never normally have access to this kind of technology.

NHSA support

- The NHSA was able to get clinical pathologists and researchers across the North to meet with the company to discuss this technology. This included the University of Liverpool Wolfson Centre for Personalised Medicine, Newcastle University, Sheffield Teaching Hospitals, Lancashire Teaching Hospitals Teaching Trust and Hull & East Yorkshire Teaching Hospital. All these centres agreed that it would be particularly useful in helping provide rapid identification of infectious agents and identify genes involved in AMR from clinical samples.

Results

- Initially, the test needed to be optimised for use on clinical samples and the University of Liverpool was successful at being awarded a grant from the Medical Research Council to support the pilot work.
- With coordinating support from the NHSA, the other four centres are providing thoughts and insight on which clinical samples and bacterial strains to look at; the overall aim of which will be to scale up and implement the use of the technology across the five centres and eventually into standard NHS practice to fight anti-microbial resistance.

Source: NHSA

Table 4-3: A genomic HLA biomarker panel to prevent serious adverse drug reactions

Serious adverse drug reactions (ADRs) are a major clinical problem. Since the beginning of this century, at least 24 different HLA alleles have been shown to predispose to ADRs with a number of drugs. The MRC Centre for Dug Safety Science has worked with MC Diagnostics, using funding from NIHR i4i, to develop a HLA biomarker panel for commercialisation. This panel will have a turnaround time of less than 48 hours (current turnaround time in the NHS is 1-2 weeks), will be cheaper than single locus tests, and will be linked to a web-based clinical decision support system.

Source: University of Liverpool

Table 4-4: UK Biobank (located in Stockport, 20 minutes from Alderley Park)

The coordinating centre for UK Biobank is based in Cheadle, Manchester. This national resource contains DNA, plasma, serum, urine, saliva, buffy coat from 500,000 UK individuals aged 40-69 years at the time of recruitment. In addition to health, lifestyle, diet and occupational data and basic clinical phenotype measurement (height, weight, hip measurement, blood pressure, spirometry) at time of venesection, major subsets have been further characterised for hearing and eye test, activity monitoring. Linkage with a range of longitudinal clinical data sets (e.g. HES and general practice data) is ongoing as is linkage to disease registries (e.g. cancer) and flagged for time and cause of death. Access to these samples is through UK Biobank's own access committee and valid requests are routinely granted. The main dataset is being enhanced through MRI and ultrasound/densitometry imaging in 100,000 participants with c.2/3 of those being resident in the Northern region. Extension to longitudinal imaging in a subset of 10,000 being developed by Dementias Platform UK as a deeply phenotyped clinical trial ready cohort is equally biased towards participants in the North, establishing this population as an important international resource.

In terms of storage, there is capacity for around 100,000 samples (1-2ml Matrix tubes) at -80C (automated) and 30-45,000 in liquid nitrogen in Cheadle. There are also a number of manual -80C freezers that can hold about 50,000 samples each and these can be increased as needed. The national Biosample Centre in Milton Keynes is also run by UK Biobank. Here they have fully automated sample processing for multiple sample types and can process around 500 samples per day/per platform. UK Biobank has the capacity to extract, measure and normalise 7,000 DNA and 5,500 RNA samples per week. They also have extensive re-formatting capacity. UK Biobank provides extensive QC infrastructure to support this and routinely transfer samples between Cheadle and Milton Keynes.

Source: NHSA

Business base and capabilities

4.24 Figure 4-1 uses Standard Industrial Classification (SIC) data, which has its limitations, to provide location quotients for 'Human and health and social work activities'. It shows that the North has relative specialisation in care, general medical practice and hospital activities – indicative of a strong population base for tests.

4.25 Figure 4-2 provides location quotients for 'Professional, scientific and technical activities'. It shows a relative specialisation in Technical testing and analysis.

4.26 Figure 4-3 covers location quotients for Theme-relevant manufacturing activities.[84] Figure 4-3 shows relative specialisation in the 'Manufacture of medical and dental instruments and supplies', and specialisation in employment terms, in the 'Manufacture of pharmaceutical preparations'.

4.27 As **Precision Medicine** is not in data terms a formally defined sub-sector of Life Sciences, it can be difficult to ascertain precise and consistent data. Therefore, figures and definitions are often inconsistent. **Precision Medicine** activity is embedded across the two more routinely defined subsectors of Life Sciences, namely Biopharmaceuticals and Medical Technology. The development of precision therapeutics and the areas which surround this (e.g. pharmaceuticals, biotechnology, genomics etc.) reside in the Biopharmaceuticals classification whilst diagnostics and analytical techniques such as imaging reside in the Medical Technology classification.

4.28 BEIS has undertaken a more fine-grained analysis of the business landscape of the Life Sciences, Medical Technology and Biopharmaceutical sectors. The analysis shows 6,048 businesses in the

[84] OLS defines Biopharmaceuticals as 'Manufacture of pharmaceutical products' and 'Manufacture of pharmaceutical preparations', and defines Medical Technology as 'Manufacture of irradiation, electromedical and electrotherapeutic equipment' and 'Manufacture of medical and dental instruments and supplies'.

UK in 2016 (up from 5,633 in 2015), of which 1,221 (c. 20 per cent) are in the North of England (up from 1,165 in 2015).[85]

4.29 Appendix 4 includes maps on employment in Life Sciences as a whole and Medtech and Biopharma. The maps show distinct employment clusters in the North East, North West and West Yorkshire. In terms of national significance, the North West is strong in Core Biopharma and Medtech service & supply, Yorkshire and the Humber is strong on Core Medtech and Digital Health. While in terms of significance within a region, Biopharmaceutical service and supply and Core Biopharmaceutical are significant for the North East.[86] These data do not focus on **Precision Medicine** as a distinct category but they provide an indication of scale.

4.30 Appendix 5 provides a (non-exhaustive) list of **Precision Medicine** businesses located in the North. As mentioned in the previous chapter, SIA partners aim to do further work in mapping supply chains and the potential for growth for both Data for Better Health and Wealth and Prevision Medicine as part of the follow-up work to the SIA, subject to additional resources being made available e.g. via Sector Deal.

4.31 Many of the UK's large pharmaceutical companies have a base, including R&D units, in the North with a distinct cluster in the North East (Table 4-5).

4.32 Recent significant investments in the North include: 4D Pharma, raised £50m in the last 12 months; Premaitha, a reverse takeover, raising £7.2m and C4X Discovery floated on AIM in 2014 raising £11m. Also, Seqirus (Table 4-7) and Fujifilm Diosynth in Stockton-On-Tees.

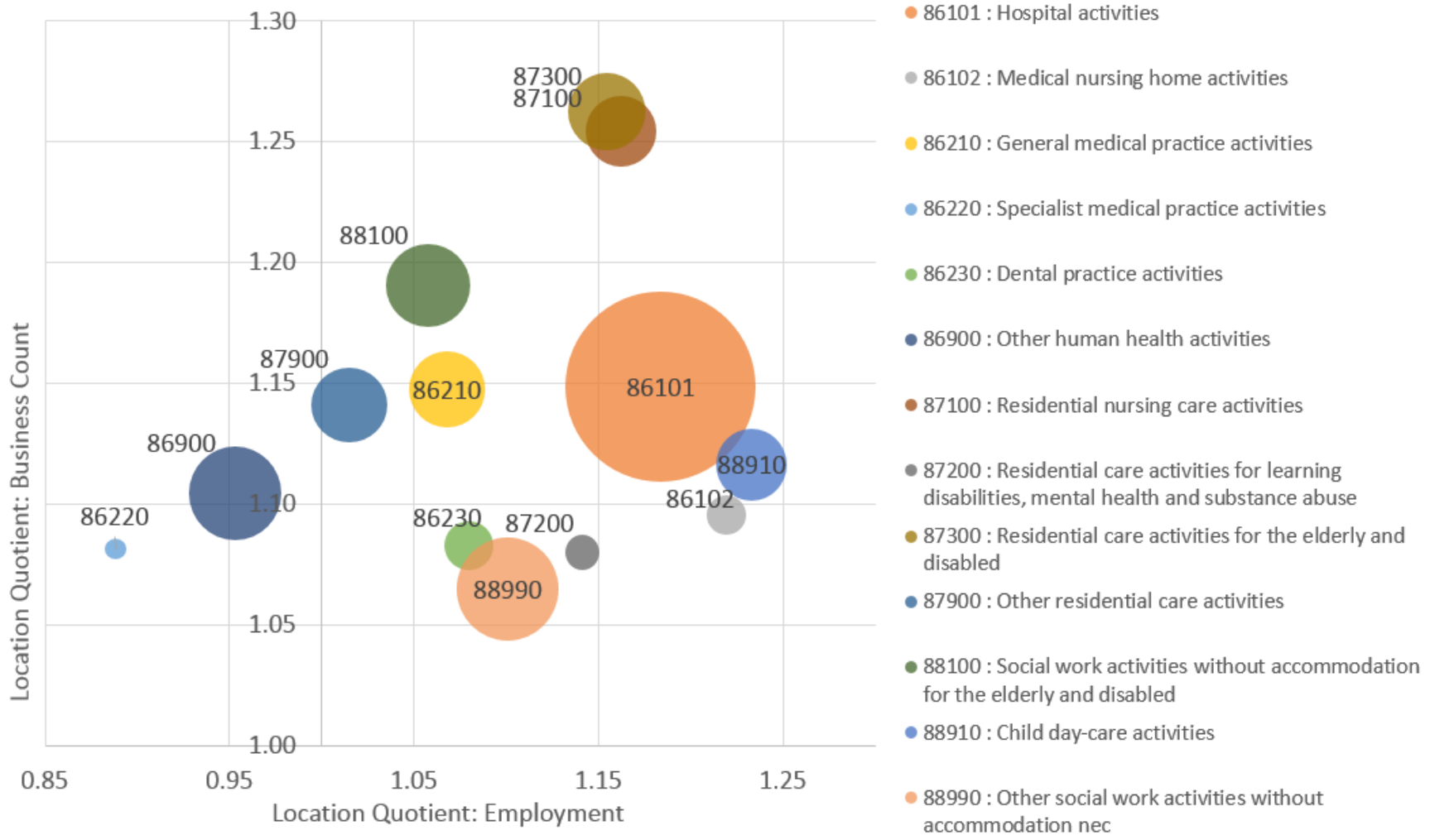
4.33 There is also a well-established and growing diagnostics cluster in Yorkshire and across the North, including Abtek Biologicals Mast Group in Liverpool, Qiagen in Manchester and Mids Medical at Sci-Tech Daresbury.

[85] Department for Business, Energy and Industrial Strategy and Office for Life Sciences [BEIS and OLS] (2017) *Strength and Opportunity 2017: the data behind the charts, data,* Bioscience and health technology database: annual report 2017. **https://www.gov.uk/government/publications/bioscience-and-health-technology-database-annual-report-2017**

[86] Ibid

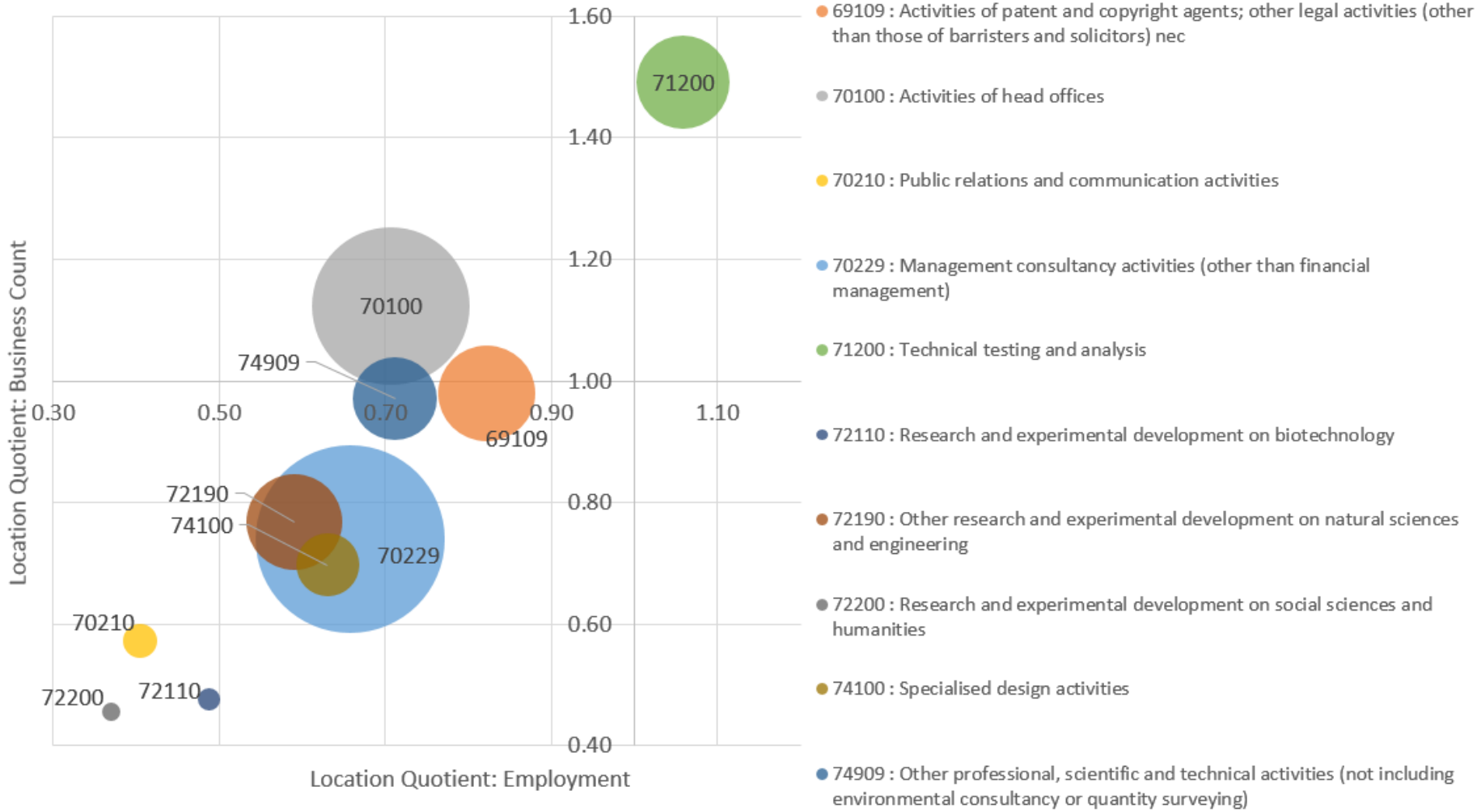
4.34 Figure 4-4 is a breakdown of the Leeds Precision Medicine structure, largely based around their capability in diagnostics and medical-surgical technology. This model could be emulated in other cities across the North.

Figure 4-1: Location Quotient for Human Health and Social Work Activities in the North



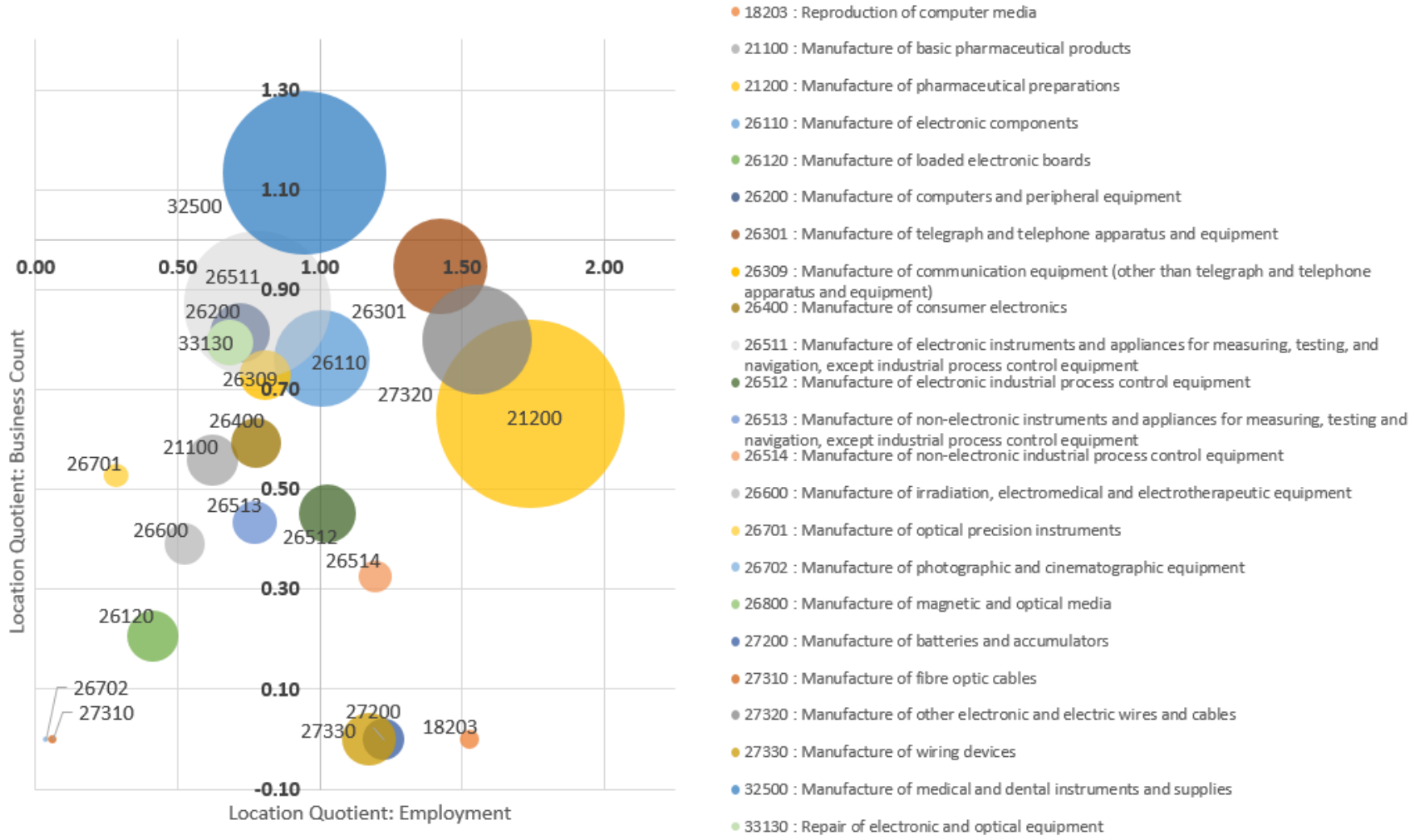
Source: Business Register and Employment Survey (BRES) (2015), **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/businessregisterandemploymentsurveybresprovisionalresults/previousReleases**

Figure 4-2: Location Quotient for Professional, Scientific and Technical Activities in the North



Source: Business Register and Employment Survey (BRES) (2015), **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/businessregisterandemploymentsurveybresprovisionalresults/previousReleases**

Figure 4-3: Location Quotient for Manufacturing in the North



Source: Business Register and Employment Survey (BRES) (2015), **https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/businessregisterandemploymentsurveybresprovisionalresults/previousReleases**

Table 4-5: North East Pharmaceuticals Cluster

The growth of the North East pharmaceutical and chemicals manufacturing sector is a strong example of successful Government industrial policy and investment from the late 1960s and early 1970s. Today, there are 17 major pharmaceutical manufacturers in the region plus a larger number of SMEs, contract development and manufacturing companies. The region exports £2.7 billion of pharmaceutical and other chemical products to the EU alone, comparable to the £2.9 billion of cars and other transport products. A recent survey of manufacturing site directors indicates that they are expecting to recruit an additional 7% of their current workforce in 2017 but at the same time many raised concerns over two aspects of Brexit a) the future of the UK's excellent manufacturing regulation systems which currently help support investment decisions and b) the need for tariff-free or low-tariff trade because many companies import raw materials and export products with very high added value. Including large pharmaceutical players such as Sanofi and GSK with significant site operations in Ulverston (Table 4-6) and Barnard Castle, and MSD at Cramlington.

Source: http://firstforpharma.co.uk

Table 4-6: GSK in Ulverston

In 2012 GSK announced it was developing a new state-of-the-art biopharmaceutical manufacturing facility in Ulverston, Cumbria. Approximately £350m has been earmarked for its construction. Four existing GSK sites across the UK were assessed – Barnard Castle and Ulverston in the North of England, and Irvine and Montrose in Scotland – with an examination of factors such as sterile processing skills, technical capability and existing links with local suppliers and academic partners. In 2014 the company secured approval from local planners for the development which will create more than 700 jobs in Cumbria as well as supporting more than 400 construction roles.

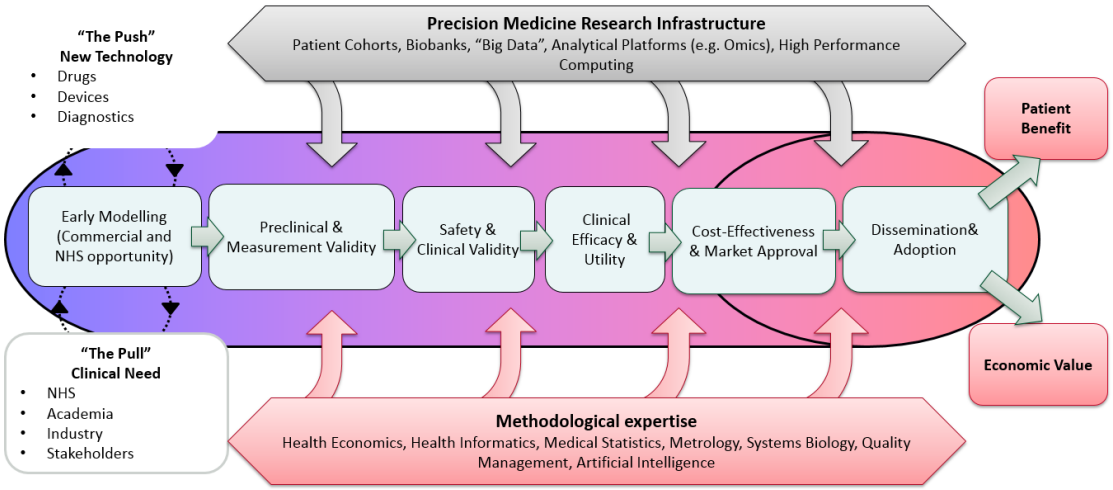
Source: NHSA

Table 4-7: Seqirus in Liverpool

Seqirus's site in Liverpool is a Centre of Excellence for egg-based influenza vaccine manufacturing. It is one of the biggest biotechnology sites in Europe and the only injectable influenza vaccine manufacturer in the UK. It also produces the only licensed adjuvanted seasonal influenza vaccine.

Source: http://www.seqirus.com/about

Figure 4-4: Leeds Precision Medicine Structure



Source: University of Leeds

Local Science and Innovation Talent

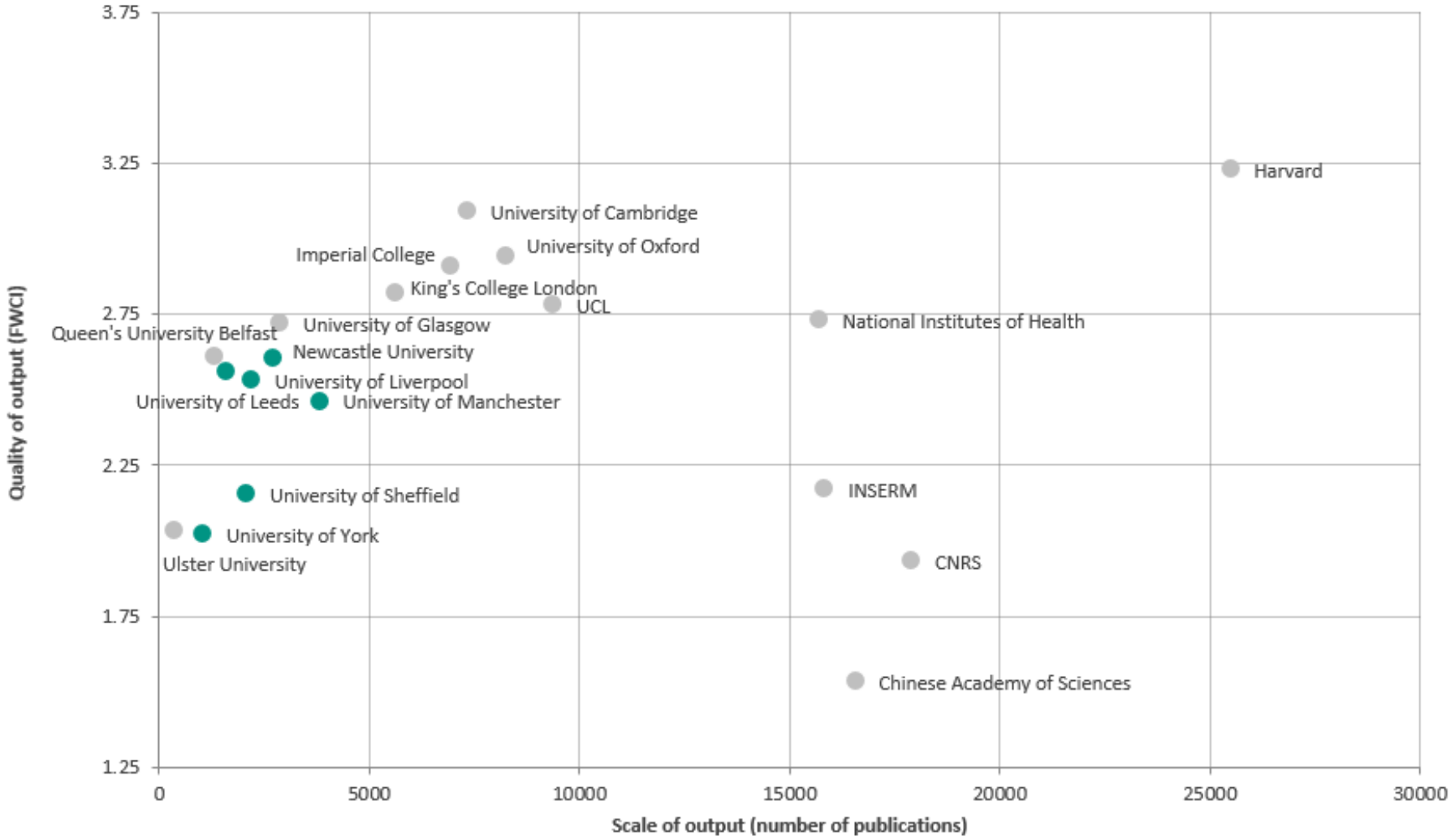
4.35 The attraction and retention of talent is vital for the North to retain its leadership position in **Precision Medicine**, and to build on the assets and skills that it has, to establish a world-leading role.

Current research talent as indicated by academic metrics

4.36 The Research Excellence Framework 2014, referenced in Chapter 2, showed, excellence in Allied Health Professions, Dentistry, Nursing and Pharmacy at the universities of Lancaster, Bradford, Leeds, Manchester, and Sheffield. It also showed excellence in Psychology, Psychiatry and Neuroscience at the universities of Lancaster, Newcastle, Sheffield and York, and excellence in Public Health, Health Services and Primary Care at Liverpool School of Tropical Medicine and The University of Sheffield. This level of evidence, however, is not sufficiently granular to show relative strength in particular specialisms. SciVAL data is more effective at providing a granular and more up-to-date picture of excellence. (See Appendix 7 for further information on SciVAL and the methodology applied).

4.37 Figure 4-5 plots the scale of publications output on the horizontal axis and the quality of this output, as reflected in Field-Weighted Citation Index (FWCI) on the vertical axis. Note, given the institutional research foci there are no results available for the University of Durham and the University of Lancaster in the **Precision Medicine** data. These results tell us that research performance in **Precision Medicine** in the NPiHR's footprint compares favourably with that of leading institutions both in the UK and world-wide. Whilst the scale of output over this time period is lower, the quality of that output (measured by the FWCI) is above 1.75 and not far below the larger UK research-intensive universities of Cambridge, Oxford, Imperial College and Kings College. Whilst the leading overseas institutions have much higher scales of research output this is not of a higher quality in FWCI terms. Thus, as with Data, while universities in the North do not match the scale of research conducted by its international peers, they do match the quality.

Figure 4-5: Research output versus research quality for Precision Medicine, 2012-18



Source: SDG Economic Development of Scopus SciVAL data provided by NHSA and Queens University Belfast

Talent pipeline as indicated by data on graduates

4.38 As noted in Chapter 2, the North retains 74 per cent of all graduates. Retention levels in Chemistry, Biological Sciences, and Medicine and Dentistry are respectively 21, 11, and 10 percentage points below this average – a disparity which needs to be addressed.

4.39 Appendix 5 provides a more detailed breakdown of graduate retention for Anatomy, Physiology and Pathology; Biological Sciences; Chemistry; Medicine and Dentistry; Nursing and Subjects Allied to Medicine; Pharmacology and Toxicology and Pharmacy by Local Enterprise Partnership, that is, the proportion of graduates from the 2010/11 to 2014/15 cohort (inclusive) that found employment in the LEP area in which they studied.

4.40 There is relatively strong retention in Nursing and Subjects Allied to Medicine with around one-half of graduates being retained in a number of categories. Cheshire and Warrington LEP is a major 'importer' of graduates, as are Cumbria and the Humber. This suggests a functioning labour market for undergraduates at the level of the North with LEP areas, which do not provide certain undergraduate and postgraduate courses attracting employees into their LEP area from other areas in the North. However, as noted in Chapter 2, there is a need to improve transport and communication links to support the more efficient functioning of northern labour markets, in order to enable high-performing graduates to build their careers in the North.

National and International Engagement

Scale of international collaboration on research

4.41 Table 4-8 provides the SciVAL data for **Precision Medicine**. It shows the scale of research and the scale of collaboration for those institutions that are top ranked in our searches.

4.42 Figure 4-6 plots the relationship between national and international collaboration for research in **Precision Medicine**. This exhibits the same profile as for advanced medical informatics – with NPiHR universities demonstrating high levels of international collaboration alongside the leading UK universities active in this field. As noted for advanced medical informatics, the emphasis on international collaboration in a strong indicator of excellence and also a driver of research impact.

Quality of research outputs and international collaboration

4.43 Table 4-8 provides the SciVAL data obtained for **Precision Medicine**. It shows the scale of activity and the scale of research collaborations.[87]

4.44 Figure 4-6 plots the relationship between national and international collaboration for research in **Precision Medicine**. This exhibits the same profile as for advanced medical informatics – with NPiHR universities demonstrating high levels of international collaboration only just below those of the leading UK universities active in this field. As noted for advanced medical informatics, the emphasis on international collaboration is a strong indicator of excellence and also a driver of research impact.

4.45 Figure 4-7 confirms the frequently observed association between international collaboration and research quality for **Precision Medicine** research. This association comes about because cutting-edge research often relies on bringing together complementary competencies, distinctive research assets and (increasingly) datasets – for which the NPiHR's footprint is

[87] Note: Durham and Lancaster do not appear in this table.

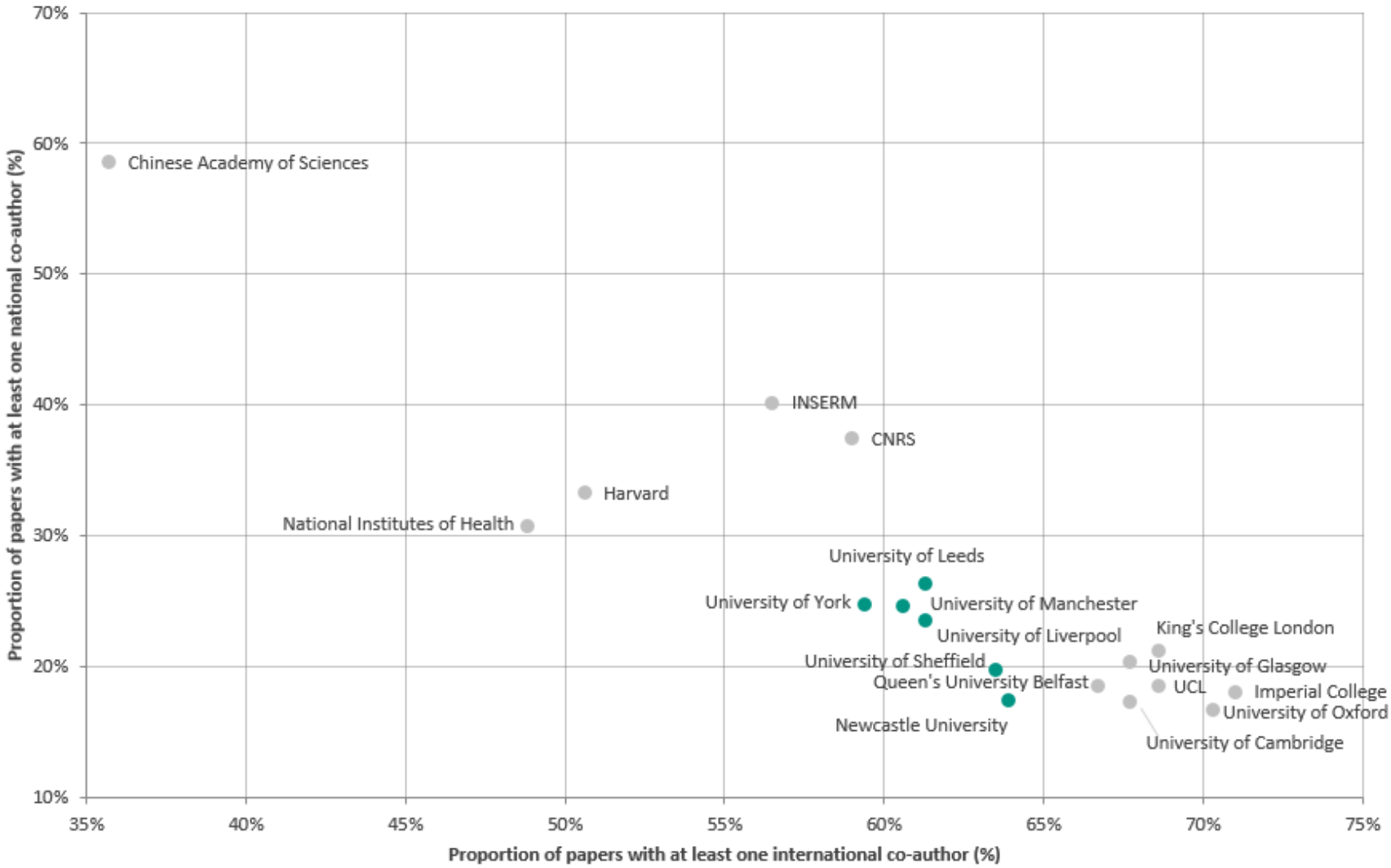
ideally placed. Indeed, it is usually the case that the larger the multinational scope of this collaboration the greater the prominence of the research. The NPiHR institutions perform relatively well in terms of these relationships.

Table 4-8: Bibliometric data for Precision Medicine, 2012-18

Institution	Number of publications	Number of citing countries	Number of papers with at least one national co-author	Proportion of papers with at least one national co-author	Number of papers with at least one international co-author	Proportion of papers with at least one international co-author	Number of publications in Top 10% Journal Percentiles (using SCImago Journal Ranking)	Proportion of publications in Top 10% Journal Percentiles (using SCImago Journal Ranking)	Field-weighted citation impact	Number of papers in Top 10 citation percentile - field-weighted	Proportion of papers in Top 10 citation percentile - field-weighted	Citation Count
University of Leeds	1,636	174	431	26.3%	1,003	61.3%	900	57.7%	2.56	365	22.9%	31,285
University of Manchester	3,838	185	948	24.7%	2,326	60.6%	2,046	55.6%	2.46	953	25.3%	73,662
University of Sheffield	2,099	170	415	19.8%	1,332	63.5%	1,076	54.5%	2.15	485	23.6%	33,889
University of Liverpool	2,216	185	520	23.5%	1,359	61.3%	1,166	55.6%	2.53	541	24.9%	41,701
Newcastle University	2,739	170	477	17.4%	1,749	63.9%	1,423	55.4%	2.60	711	26.7%	49,586
University of York	1,061	169	263	24.8%	630	59.4%	550	55.2%	2.02	245	23.6%	16,146
University of Glasgow	2,893	194	590	20.4%	1,958	67.7%	1,707	61.7%	2.72	794	28.3%	61,344
University of Cambridge	7,349	204	1331	18.1%	5,214	71.0%	4,676	65.8%	3.09	2217	30.7%	191,643
University of Oxford	8,257	214	1376	16.7%	5,804	70.3%	5,109	64.4%	2.94	2408	29.7%	196,148
King's College London	5,638	195	1196	21.2%	3,867	68.6%	3,318	61.5%	2.82	1614	29.3%	128,629
Imperial College	6,959	204	1288	18.5%	4,774	68.6%	3,949	59.4%	2.91	1844	27.0%	151,416
UCL	9,395	206	1626	17.3%	6,359	67.7%	5,118	56.9%	2.78	2600	28.2%	200,276
Chinese Academy of Sciences	16,587	200	9718	58.6%	5,914	35.7%	7,844	49.8%	1.53	2496	15.4%	185,388
CNRS	17,929	215	6722	37.5%	10,580	59.0%	9,585	56.0%	1.93	3542	20.2%	272,508
Harvard	25,518	218	8504	33.3%	12,919	50.6%	15,480	63.0%	3.23	7801	31.2%	713,561
INSERM	15,864	206	6373	40.2%	8,956	56.5%	8,270	53.8%	2.17	3491	22.5%	276,169
National Institutes of Health	15,723	211	4831	30.7%	7,676	48.8%	9,145	60.2%	2.73	4097	26.5%	379,667
Queen's University Belfast	1,341	172	249	18.6%	895	66.7%	770	59.3%	2.61	469	35.0%	n/a
Ulster University	373	156	58	15.6%	214	57.4%	153	44.7%	2.03	79	21.2%	n/a

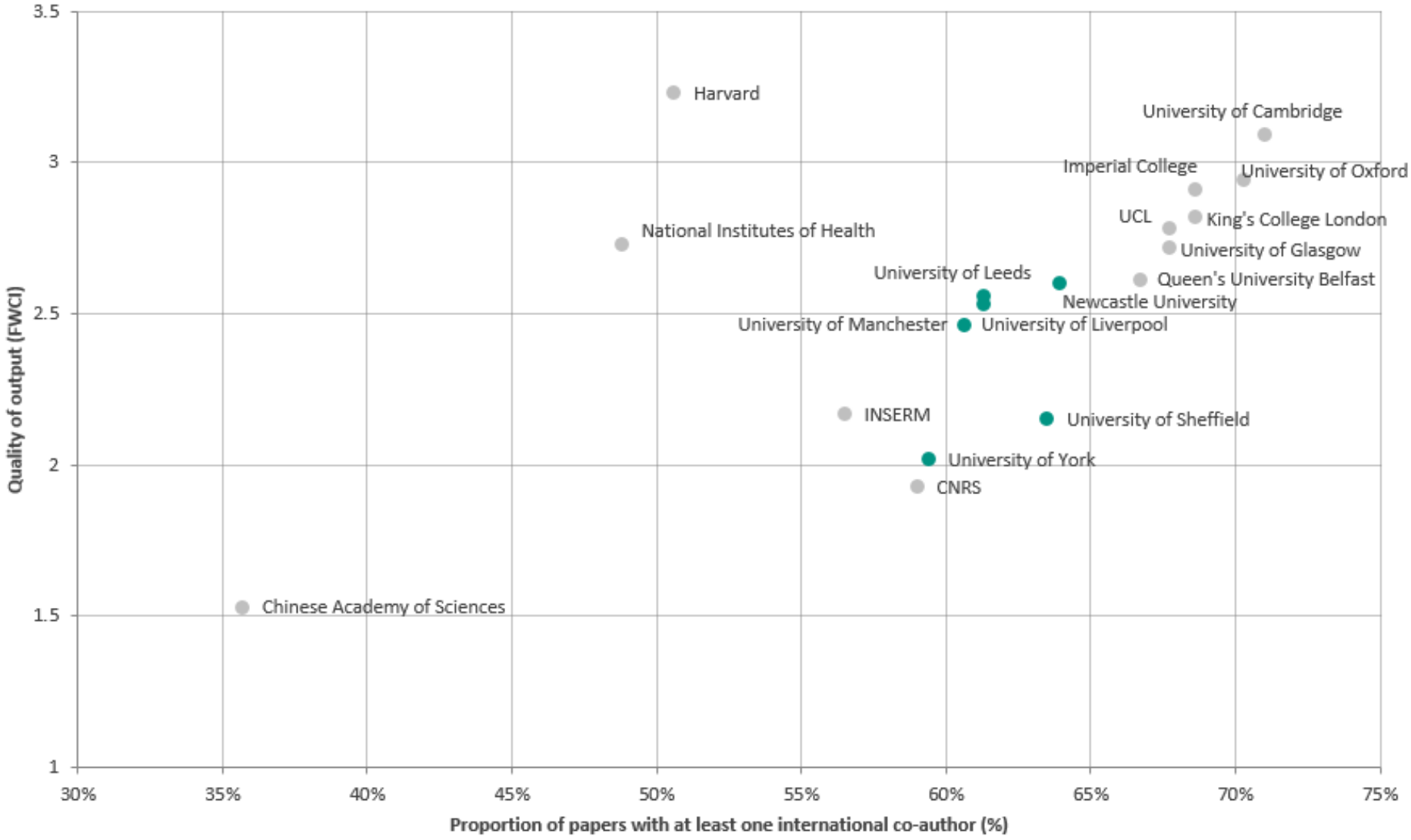
Source: SciVAL data jointly provided by the NHSA and Queens University Belfast

Figure 4-6: The relationship between national and international collaboration emphases for Precision Medicine, 2012-18



Source: SDG Economic Development of Scopus SciVAL data provided by NHSA and Queens University Belfast

Figure 4-7: International collaboration versus FWCI performance for Precision Medicine, 2012-18



Source: SDG Economic Development of Scopus SciVAL data provided by NHSA and Queens University Belfast

Conclusions

4.46 Our original hypothesis in relation to **Precision Medicine** is that:

- Strategic investment in training will unlock a new uptake of **Precision Medicine** and will act as a model for other UK and international teams.

4.47 The SIA process has shown that the NPiHR's footprint has significant assets and strengths in **Precision Medicine** – including national centres of excellence, the necessary networks and groups to facilitate and maintain vital collaborations between sectors and across national borders, and growing business clusters in medtech, biopharma and diagnostics.

4.48 Stakeholders identified five significant constraints on our ability to maximise the North's potential in relation to **Precision Medicine**:

- Lack of capacity to conduct real-world precision trials at scale, e.g. due to lack of eHealth infrastructure and resource constraints in the NHS and constraints on funding provided to and by LEPs;
- Lack of funding and support for scale-up businesses in **Precision Medicine**;
- Under-developed methods of economic evaluation of **Precision Medicine**, limiting the capacity to demonstrate its value;
- Slow adoption of innovation into the NHS, due to procurement processes and cultural issues; and
- A workforce that has not been sufficiently trained in the skills required fully to exploit the capabilities offered by **Precision Medicine** – including cross-team working and entrepreneurial and business management skills.

4.49 Given the above findings, we believe that the original hypothesis for **Precision Medicine** should be amended to include the following statements:

- Strategic investment in team-based working will help address skill shortages and skill gaps, as well as acting as a model for UK and international teams; and
- Strategic investment in the development of Life Science Entrepreneurs, management development programmes and processes for transferring businesses management from academics leading start-ups to managers with scale-up expertise will help address skill shortages and skill gaps, as well as acting as a model for UK and international teams.

4.50 In the light of our findings, as well as addressing constraints to growth, such as skills gaps and shortages, we will seek to:

- Build on our experience of gaining consent, recruiting to trials, and conducting Real-World Clinical Trials at scale to help deliver key elements of the Life Sciences Industrial Strategy by providing a platform for applied research to move from 'moonshot' research to practice, and by building capacity in the analysis of health data to promote the application of Precision Medicine; and, in line with the Life Science Industrial Strategy target, increase the number of clinical trials undertaken in the North by 50 per cent over the next 5 years.

5 Understanding the Synergies - Data for Better Health and Wealth & Precision Medicine, together

The two previous Chapters have set out two themes where the SIA will have its core focus. These are the **areas where we want to 'stay ahead'**. But we also recognise that by looking at how these two areas overlap and deliver synergy, we can identify '**new routes to excellence**'. This Chapter sets out this potential.

Headline Messages

5.1 As is clear from the above, the North of England has internationally competitive and globally connected clinical, research, and business assets and capabilities in relation to **Data for Better Health and Wealth** and **Precision Medicine** as separate domains. But if our two themes combined effectively, their assets and strengths can form a uniquely attractive offer to researchers, clinicians, and businesses working on the effective use of data to drive innovation in **Precision Medicine** and its application.

5.2 A wide body of stakeholders across our SIA's footprint were asked to think creatively about how such combinations of assets and expertise generate synergies. The following areas were suggested:

- **Real-World Clinical Trials** – building on the platform developed by North West EHealth (as well as strong capabilities across the wider Northern footprint), which has 1.4 million patient records, and a unique, secure, and safe method for managing pseudonymisation and re-identification for Real-World Evidence, and from which the North can establish a novel, world-leading unique platform. Furthermore, Liverpool and Leeds Clinical Trials Unit have established e-trial platforms and experience across multiple studies, including comprehensive strengths in clinical trial design. Utilising the combined strengths of real-world data and adaptive clinical trial design, the NPiHR SIA partners are positioned to conduct robust and unbiased evaluations of Precision Medicine technologies and methods, with prior consent, and to being monitored pre-disease to enable longitudinal

studies – recruiting people for clinical trials using live data for identification and accessing data at the point of care would underpin this work;
- **Ageing** – Ageing Society has been identified by the Government as one of four Grand Challenges in the UK Industrial Strategy, the NPiHR partners can build on their age-related assets, such as the National Innovation Centre for Ageing (NICA) and the MRC Arthritis Research UK Centre for Musculoskeletal Ageing, a collaboration of three N8 Universities, with a number of pan-Northern population health-based initiatives, including scaling the activities of the five Active and Healthy Ageing (AHA) Reference Sites, which are now working together through the AHA North initiative on areas such as Falls Prevention, Frailty, and Bone Health;
- **Anti-Microbial Resistance** (AMR) – building on assets and expertise, particularly those in the North West, the North is well-placed to lead Precision Medicine research into AMR which, posing a significant threat to current treatment practice, has huge market potential. The key area for development here is both the support for a dedicated AMR cluster in the North West, as well as a national clinical trials platform for AMR that could be established first in our SIA geography; and
- **Predicting future health needs in the population** – linking such findings to (a) the most effective treatments; and (b) preventive measures/treatments.

Introduction

5.3 Given the assets, networks and expertise mapped in the previous two chapters, and the 'soft' infrastructure which convenes, coordinates and animates partnership working in the North, this Chapter focuses on the synergies between **Data for Better Health and Wealth** and **Precision Medicine**. It:

- Provides a conceptual framework within which to understand interactions between the two themes, highlighting five enabling factors:
  - Clinical and academic excellence in knowledge, research, & translation;
  - Hard and soft enabling and supporting infrastructure;
  - Arrangements for large-scale consent;
  - Skills and understanding of Precision Medicine to support Learning Health Systems as a part of Data for Better Health and Wealth; and
  - NHS procurement to support the adoption and diffusion of innovation.
- Discusses current intersections and interactions between the two themes – highlighting the North's unique offer based on the combination of its current strengths, particularly in relation to:
  - Real-World Clinical Trials;
  - Ageing;
  - Anti-Microbial Resistance; and
  - Highlights some challenges to effective exploitation of the synergies highlighted by stakeholders.

Conceptual Framework for understanding synergies

5.4 Figure 5-1 is a conceptual representation of the interaction between the two themes. It shows a large 'set' representing **Data for Better Health and Wealth** – which includes data for research, civic data for public health, data for planning and managing health care provision, as well as data for **Precision Medicine** – and a smaller 'set' representing **Precision Medicine**, which, apart from the development and production of medical technology and devices is almost wholly reliant on Data.

5.5 Figure 5-1 also shows five 'enabling factors', where the North has established strengths but where there is also room for improvement:

- **Clinical and academic excellence in knowledge, research, and translation** to support international academic and business collaboration, which, as demonstrated above, is strong but requires additional investment, particularly trials, which may require freedoms and flexibilities for partners, e.g., LEPs, to achieve maximum impact;
- **Hard and soft enabling and supporting infrastructures** with which to share data, knowledge, and good practice and facilitate collaborations, e.g., AHSN and local health partnerships to facilitate collaboration and knowledge transfer, a proposed centre for the analysis of civic/environmental data to enhance capability to analyse environmental factors in Real-World Clinical Trials, and business support to assist business growth;
- **Arrangements for large-scale consent** to support Real-World Clinical Trials, e.g., assets developed for the Salford Lung Study and the Information Sharing Gateway established in the North East and shared across the North;
- **Skills and understanding of Precision Medicine to support Learning Health Systems** supported by existing networks, course and programmes but with skill gaps to fill, particularly in Bioinformatics and in the development of multidisciplinary teams and team working; and
- **NHS procurement to support the adoption and diffusion of innovation** – procurement is a vital element in supporting the adoption of innovations in Precision Medicine, however, NHS procurement in the North currently has few freedoms and flexibilities with regard to powers to support and promote innovation in Precision Medicine at the level of the North.

Interactions and synergies between Data for Better Health and Wealth and Precision Medicine

5.6 Through the process of entrepreneurial discovery undertaken as part of this SIA (involving Universities, NHS partners, and businesses) a range of current interactions and synergies between **Data for Better Health and Wealth** and **Precision Medicine** in the NPiHR's footprint were identified (Table 5-1). Three of these were judged to be particularly convincing:

- Real-World Clinical Trials;
- Ageing; and
- Anti-Microbial Resistance.

5.7 While not being the sole areas of strength in the North, these strengths illustrate of the scope and scale of new routes to excellence, in a sense providing the 'next agenda' items above and beyond the work we need to do to stay ahead in our core **Data for Better Health and Wealth** and **Precision Medicine** themes. These opportunities are discussed in more detail below.

Real-World Clinical Trials

5.8 Global Health and Care systems are under pressure to reduce costs while improving outcomes. In response payors are moving to pricing models that are linked to value and patient outcome rather than cost per intervention. To do this they need to evaluate medicines based on reimbursable outcomes, as such the ability to conduct precision trials and economic evaluation based on data is a necessity.

5.9 The standard randomised control clinical trials do not provide mechanisms to truly evaluate the cost-effectiveness of **Precision Medicine**s in a Real-World setting. Indeed, very few trials are able to:

- Demonstrate clinical and cost effectiveness in parallel to inform value based pricing; and
- Access longitudinal data for long-term outcomes.

5.10 In addition, historic trial set-up issues remain, including:

- Access to granular data for feasibility and recruitment;
- Designing protocols that will recruit appropriate numbers of patients;
- Recruiting to time and target; and
- Managing safety in phase II/III clinical trials.

5.11 Solutions offered by pragmatic, precision electronic health record (EHR) driven trials include:

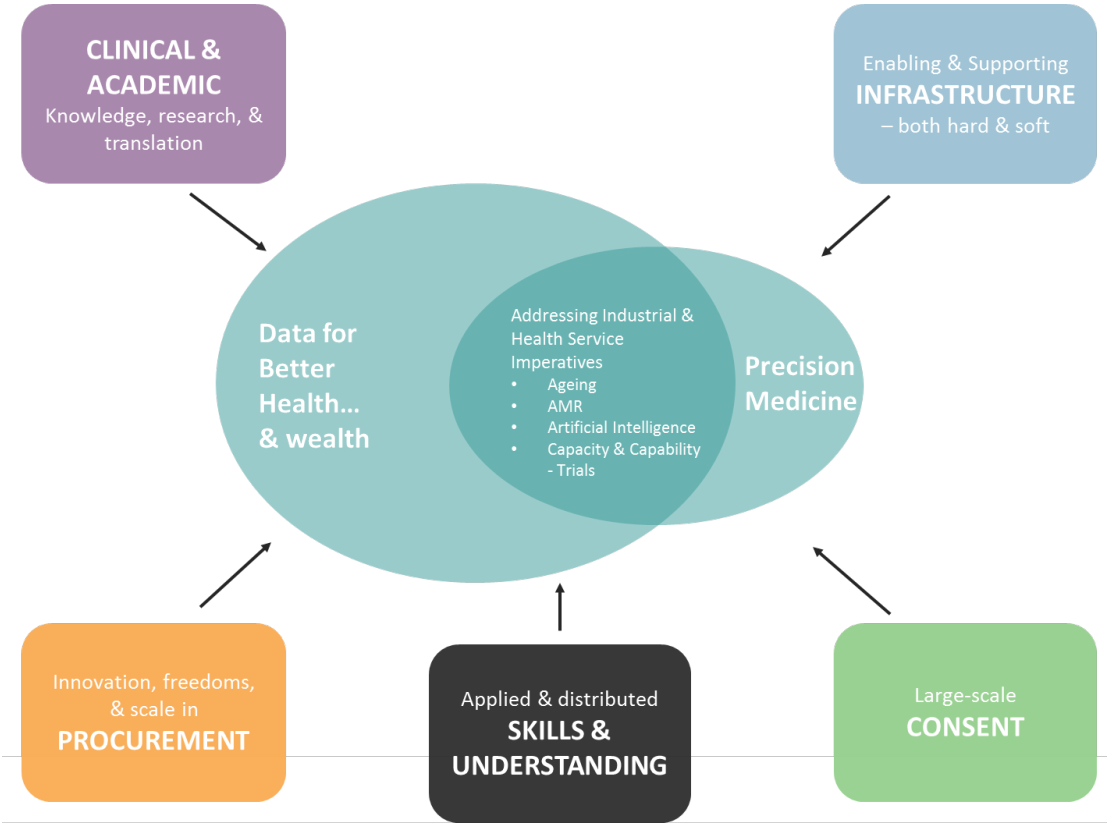
- Capability for fast, accurate feasibility across patient populations;
- Capability for efficient recruitment to trials via primary care providers;
- Capacity to design trial protocols which will deliver studies in the right locations and within timescales to meet commercial demands;
- Longitudinal data to track patient populations over time and across disease areas;
- Near real-time safety monitoring and reporting, setting a new standard for clinical trials;
- Trial outcome monitoring, enabling adaptive trial design; and
- Health Resource Utilisation analysis demonstrating the real total cost of care.

5.12 The North of England, home to the Salford Lung Study as well as a number of other real-world evidence studies (RWE), is ideally placed to meet these requirements. The team at NorthWest EHealth (NWEH), which ran the Salford Lung Study, has 1.4 million patient records, a unique, secure and safe method for managing pseudonymisation and re-identification for RWE. It also has established integrated consented data from two hospitals, 80 GP practices, 140 community pharmacies, out-of-hours and emergency care, national data feeds for moves and deaths and out of area care. This represents a platform from which the North can build and establish a novel, world-leading unique real-world platform.

5.13 The Clinical Trials Units at the Universities of Liverpool and Leeds have demonstrated expertise in the delivery of efficient value for money studies that utilise the Electronic Health Record. For example, the ISDR project (Table 4-2) accesses >5M records from >20,000 people including prescribing data, of which more than 4,500 have participated in a clinical trial. These Units are also leading the way in the innovative use of patient registries to undertake clinical research; the CF-START trial being the first registry-based randomised trial in a paediatric setting, for example. The methodologies used are innovative and cost-effective, and can be reproduced in other settings in the North.

5.14 The Life Sciences Industrial Strategy states that the UK should 'Establish two to five regional innovation hubs providing data across regions of three to five million people'. The North is well positioned to bid for securing these as part of the on-going Life Science Industrial Strategy.

Figure 5-1: Enabling factors, interactions and synergies between Better Data for Health and Wealth and Precision Medicine



Source: SDG-ED

Table 5-1: Summary of current interactions between Data for Better Health and Wealth and Precision Medicine identified stakeholders

• The linking up of samples from clinical datasets to bioinformatics, e.g. the Leeds Institute for Data Analytics' work on lung cancer screening data; • Big Data and Health Data combined and applied to genomics; • Analysis of healthcare data in the development of healthcare pathways (currently being carried out by CHC); • National Institute for Health Research is funding research that combines service data with personal data, using standard NHS data fields, e.g. risk, with trail results in 2019; • The work in the antibiotic world, using the right drugs for the right pathogen for the right disease fits in this section, but there is scope to do more, for instance showing the savings in the system as well as the importance of timing, e.g. Data Action Latency[88] in infection.

Source: Stakeholder workshop, Bradford, 6 February 2018

Ageing

5.15 Ageing populations are a global trend: female life expectancy has been increasing by five hours a day in the best performing countries through the nineteenth and twentieth centuries, and there are around 15 million people over 60 in the UK – forecasts indicate that this is likely to rise to around 30 million by 2040, approximately 25 per cent of UK population.

[88] As noted above, Data Action Latency is the time lag between data indicating that an action should be taken becoming available and the action being taken.

5.16 Societies, including the UK, experience the costs of ageing in terms of lost societal participation, productivity, and rising health and social care demands. Furthermore, products and services are not fully addressing needs and opportunities.

5.17 Demand is likely to grow for new goods and services that enhance lives and promote independence in later life, increase social participation and productivity, and provide affordable health and social care that meets citizens' needs. Those working in the domains of **Data for Better Health and Wealth** and **Precision Medicine** are at the forefront of the innovative work responding to these challenges and opportunities – in improving diagnoses, medical devices (such as wearable and mobile technology), drugs and treatment services. There are a lot of opportunities to further develop the North's offer in ageing, an example of this is Newcastle's ambition to develop a 'Healthy Ageing Research Test Bed' on their Campus for Ageing and Vitality (Spectrum of Independence model).

5.18 The North has world-leading assets in relation to ageing. Appendix 6 provides a non-exhaustive list of ageing-related assets in the North. In particular, the National Innovation Centre for Ageing (Table 5-2) based in Newcastle, which has been founded in response to the challenges and opportunities presented by global societal ageing; and the Active and Healthy Ageing Reference Site (Table 5-3).

Table 5-2: National Innovation Centre for Ageing

The National Innovation Centre for Ageing is a £20 million capital investment co-located in Newcastle with the National Innovation Centre for Data.

Its objectives are to:

- Foster citizen, academic, business, public sector and third-sector collaboration to maximise translation and commercialisation of ageing opportunities based on sound research, by identifying the commercial potential of ideas/propositions in an economic, effective and efficient manner.
- Drive public involvement in the conception, design, introduction and evaluation of goods/services that contribute to flourishing lives and improve independence in later life.
- Catalyse engagement of academia, business, public sector, third sector and citizens on ageing issues, to raise awareness of, and capability to address the needs of an ageing society.
- Lead development of internationally-recognised ageing cluster focused on Newcastle Science Central, driving commercialisation, innovation and growth.
- Establish NICA as a viable self-sustaining organisation by 2025.

It is to achieve these objectives by:

- NICA for Business. This will include activities such as innovation programmes, space for firms to co-locate and base themselves at the Centre, building collaborations between citizens, university, business and other agencies to enable effective identification, translation, evaluation and market development of innovations that enhances lives and promote independence in later life.
- NICA Insights for Ageing. This set of activities will focus on delivering citizen-led insights into needs and opportunities, as well as catalysing co-innovation of appropriate goods and services to meet these identified demand areas.
- NICA Knowledge Exchange, Learning and Dissemination. This final set of activities will focus on wider citizen engagement in NICA's work and national debate around the wider ageing agenda. Specific activities will include awareness and training courses, public exhibitions and promotions, and debates realised via physical and digital channels.

NICA aims to achieve the following benefits:

- Enhance UK competitiveness in relation to ageing innovation, e.g. via piloting/testing;
- Have NICA occupying a national and international leadership role in citizen engagement in innovation that enhances lives and promote independence in later life;
- Increase engagement between citizens, academia, business and third sector to reduce barriers to identification of needs and opportunities and subsequent translation and commercialisation;
- Bring forward a flourishing innovation cluster centred on Newcastle Science Central, contributing to a dynamic and resilient UK sector;
- Establish sufficient markets for business services in ageing innovation, and/or insights for ageing, and/or knowledge exchange, learning and dissemination to enhance ageing innovation in the UK, and ensure the long-term viability of NICA.

Source: SDG-ED

Table 5-3: Active and Healthy Ageing Reference Site

- In January 2016, the North of England's AHSNs with strategic guidance from the Northern Health Science Alliance (NHSA) applied for 'Reference Site' status in the Second Call from the European Innovation Partnership on Active and Healthy Ageing (EIP-AHA). This alignment ensured each organisation could contribute their individual expertise at local level, whilst offering a 'similar but different' narrative on their suitability for trans-Northern joined up capabilities, in addition to the trans-European collaboration expected of the AHA Reference Site.
- This opportunity afforded the creation of a structured collaboration and alignment in older adult health between the four North of England Academic Health Science Networks (AHSNs).
- All four applications were successful, and in December 2016 the four organisations received international recognition for their excellence in active and healthy ageing.
- An Active and Healthy Ageing reference site is defined as 'ecosystems which comprise different players (including regional and/or local government authorities, cities, hospitals/care organisations, industry, SMEs and/or start-ups, research and innovation organisations and civil society), that jointly implement a comprehensive, innovation-based approach to active and healthy ageing, and can give evidence and concrete illustrations of the impact of such approaches on the ground'.

Source: NHSA

5.19 As well as a cluster of ageing-related businesses in the North East, the Leeds City Region has over 250 businesses specialising in medical technologies (including some of the leading medical device manufacturing and digital health companies in the UK, e.g. the Global Development and Technology Centre for DePuy Synthes, a Johnson & Johnson company, RSL Steeper, Brandon Medical, TPP and EMIS);[89] and more than 200 digital and technology businesses operating in the health and social care space, which are positioned to respond to the opportunities in the market for ageing-related treatments. Table 5-4 highlights work at the University of Leeds's Institute of Medical and Biological Engineering cited in the Leeds City Region SIA on Medical Technologies.

Table 5-4: 50 years after 50 Case Study

A £50 million research initiative, aimed at giving people '50 active years after 50' at the University of Leeds, working on developing new medical devices and regenerative therapies to encourage and enable activity in later life.

Driven by clinical challenges, they undertake solution-focused pioneering research and education in medical technology. They innovate and translate novel therapies into practical clinical applications.

Their capabilities include deceulluarised scaffolds for Tissue (Re-)engineering, computational modelling of tissues, devices and interventions, and experimental evaluation of tissues, devices and interventions.

Source: SDG-ED using Leeds City Region MedTech SIA and Leeds University website

Anti-Microbial Resistance

5.20 One of the most significant challenges to be faced in relation to prevention is anti-microbial resistance (AMR)[90]. The North is well-placed to respond to this challenge (Table 5-5) housing the National AMR Centre and undertaking data driven analysis to tackle over-prescribing (Table 5-6). Furthermore, the Wave Two SIA from the Liverpool City Region+ highlights AMR as

[89] As noted above, Data Action Latency is the time lag between data indicating that an action should be taken becoming available and the action being taken.

[90] Jim O'Neill et al, Tackling Drug-resistant infections globally Final Report and Recommendations, May 2016, **https://amr-review.org/** and Annual Report of the Chief Medical Officer, Volume Two, Infections and the rise of antimicrobial resistance, 2011.

a significant component of its Infection Theme. This brings together internationally significant assets, including the Liverpool Life Sciences Accelerator (which (a) provides access to a fully staffed Category 3 anti-microbial/parasitology/insectary provision and rapid biological screening facility), (b) co-locates SMEs with academic specialists, and (c) the Centre of Excellence in Infectious Diseases Research (CEIDR)), which might be emulated more widely across the North of England as a cost-effective solution to anti-microbial resistance and antibiotics development. The interaction between **Data** and **Precision Medicine** – and in particular the work to reduce the time taken for data to be used in informing antibiotic treatment – is a vital element of work to tackle infection.

5.21 One of the actions from the Liverpool City Region+ Wave Two SIA is to develop an Open Innovation Hub for 3D monitoring by linking the work of academic groups in Liverpool with the high-speed computing abilities at Daresbury/Hartree, to reduce the time taken to integrate the tracking of movement of various disease agents and their human and secondary hosts. Speeding up this process will make the most of assets in the North and increase collaboration with business to develop products for the prevention of vector-borne diseases.

5.22 Furthermore, the North's strength in the development of new materials, means that it is well-placed to develop new anti-microbial surfaces to fight the spread of infection. The Liverpool City Region+ SIA notes that antimicrobial coatings on medical devices surfaces are likely to see significant market growth faced and cites research by Global Market Insights into the antimicrobial coatings market that the market is set to treble over the next 20 years to approximately US$7 billion. This focus could link more generally to the acknowledged research strength in biomaterials at Leeds, Liverpool, Manchester and Sheffield and device industries and wound-dressing industries in the North/North West (e.g. Smith and Nephew, Depuy), with 'health materials' perhaps being a key component of the AMR agenda proposed by this SIA.

Table 5-5: Antimicrobial Resistance Cluster in the North

Our SIA area is also home to the largest cluster of Antimicrobial Resistance (AMR) R&D activity in Europe. This comprises of the following:

- **Non-profit and private sector organisations** including diagnostic companies Qiagen, MAST Diagnostics and QuantumDX;
- **World leading accelerators** (Antimicrobial Resistance Centre (AMRC), Alderley Park, Centre of Excellence in Infectious Diseases Research (CEIDR), Liverpool, and the Medicines Discovery Catapult (MDC), Alderley Park);
- **A cluster of biotech activity** with 6 based in the North, compared to 2 in Cambridge, 2 in Oxford, 2 in Sandwich and 6 others at single locations around the UK;
- **The Contract Research Organisation Evotec,** a drug discovery alliance and development partnership company focused on rapidly progressing innovative product approaches with leading Life Science organisations has sites at Alderley Park and supports over 20 international AMR projects;
- The UK's leading AMR-focused conference **'**BioInfect**'** is hosted at Alderley Park and organised by Bionow;
- **The most AMR programmes in the pipeline** with 14in the North, compared to 5 in Cambridge, 4 in Oxford and 3 in Sandwich; and
- Extensive academic and clinical expertise found in our universities and NHS.

Source: SDG-ED

Table 5-6: BRIT – Using data to tackle antibiotic resistance

The issue

- Antibiotics are used to kill bacteria when patients get an infection or to protect patients whose immune systems are vulnerable.
- There is a crisis in public health, as bacteria have been and are becoming more resistant to antibiotics and as a result they are becoming less effective, and they might stop working altogether.

The cause

- One of the reasons for the growth in resistance is over-prescription. Antibiotics are being given out too often and the bacteria are becoming immune to them.

The response

- This project, delivered by the Greater Manchester CHC, applies a tech-savvy solution to help understand and tackle the problem by making better use of health data.
- The BRIT team accesses anonymous GP records, data from A&E departments and out-of-hours clinics to understand which services are prescribing the most antibiotics.
- Data are kept in medical records and sent to a secure environment to be analysed. The results of analyses can be displayed in an easy-to-understand dashboard so that GPs can understand how their surgery compares to their peers. The system will also allow GPs to access more detailed information about symptoms and guidance to target the prescription of antibiotics.

Source : Connected Health Cities (n.d.) *BRIT – Using data to tackle antibiotic resistance*
www.connectedhealthcities.org/research-projects/using-data-tackle-antibiotic-resistance/

Making the most of these new routes to excellence

5.23 With its unique combination of assets, and 'soft' infrastructure, the North is ideally placed to identify and exploit the healthcare and market possibilities to be found at the intersection of **Data for Better Health and Wealth** and **Precision Medicine**. Furthermore, stakeholders also identified areas with potential for future collaboration (Table 5-7).

Table 5-7: Potential synergies between Data for Better Health and Wealth and Precision Medicine identified by stakeholders

- Utilising the power of **Data for Better Health and Wealth** and **Precision Medicine** to predict future health needs in the population and linking the findings to: (a) the most effective treatments; and (b) preventive measures/treatments;
- The recruitment of people into clinical trials using live data for identification and accessing data at the point of care – notwithstanding the complexity of this for secondary care environments;
- Consent to being monitored pre-disease to enable longitudinal studies;
- Development of a programme of diagnostics to attract researchers, clinicians and businesses to the region;
- Greater partnerships with the NHS in the innovation process would mean more ease in bringing products through;
- There needs to be softer adoption models to prove new products use before buying – the NHS may need an adoption fund;
- An awareness that just as drugs are adopted more easily at the sites of the trials, so is technology; and
- An improvement in the skills required to get something adopted and to progress adoption.

Source: Stakeholder workshop, Bradford, 6 February 2018

Challenges and barriers to growing Data for Better Health and Wealth and Precision Medicine synergy

5.24 The barriers to growth at the interface between **Data for Better Health and Wealth** and **Precision Medicine** have been raised in the preceding two chapters but bear repeating in light of the scale of the opportunities to be exploited.

5.25 Skill shortages and gaps will restrict the scale of growth and the pace at which innovation in Learning Health Systems can be introduced. Stakeholders report skills shortages in:

- Bioinformatics, pathology, clinical trial methodologies, microbiology and genome sequencing – which are subject to worldwide shortages;
- Health economists and data scientists – in part due to the higher salaries offered by other sectors, particularly in the case of data scientists who can work in finance and the media; and
- Staff with a strong understanding of both **Data** and **Precision Medicine**.

5.26 Furthermore, to date, stakeholders reported curricula for Healthcare professionals (including Doctors) have not focused sufficiently on **Precision Medicine.** The Health workforce is thus ill-equipped to deal with the opportunities it affords, and to drive **Precision Medicine** into Health and Care.

5.27 To address these skill shortages and skill gaps, stakeholders propose:

- New undergraduate and postgraduate modules and programmes to support Continuing Professional Development, these to be channelled through a focused and expert **Applied Precision Medicine Academy**. The practical form of the Academy is yet to be explored, but this might take the form of a multi-site facility, building on and extending the North's existing Health training and learning infrastructure centres;
- Targeted programmes to attract skilled professionals who have left the North and/or the sector to return (emulating the successful 'Make it back Home' programme which was used in Northern Ireland following the Good Friday Agreement to attract back to the Province expert workers); and
- Lobbying for improved connectivity across the North, including HS3, in order to improve the functioning of the North's labour markets and to assist the work being done to establish the North of England as a Life Science, Health, and Care cluster of global renown.

5.28 As noted in previous Chapters, stakeholders highlighted a lack of venture capital and lack of business management skills as constraints to business growth. They suggested a **Northern Life Sciences Venture Capital Fund** – on which steps have already been taken outside the SIA process – and work to support LEPs to provide a more supportive business environment for Life Science businesses, e.g., through the development of tailored support to bring products to market.

5.29 Finally, as noted above, procurement rules in the NHS do not incentivise the speedy adoption and deployment of innovation, and LEPs' funding scales and requirements limit their ability to support research in the NHS – for example LEPs struggle to support the NHS to conduct novel technology validation. In order to address these constraints, stakeholders requested freedoms and flexibilities to enable NHS procurement to incentivise the speedy adoption of health innovation and freedoms and flexibilities for LEPs to fund health innovation where it is a local priority.

Conclusions

5.30 This chapter has focused on the potential impact of the interaction between **Data for Better Health and Wealth** and **Precision Medicine**.

5.31 It finds that the NPiHR's footprint has a significant potential to combine its assets in **Data for Better Health and Wealth** and **Precision Medicine** to become an international centre for Applied Health Innovation, particularly relating to Real-World Clinical Trials, Ageing, and Anti-Microbial Resistance.

5.32 It highlights the NPiHR's 'soft' infrastructure in ensuring that the North is ideally placed to identify and exploit the healthcare and market possibilities to be found at the intersection of **Data for Better Health and Wealth** and **Precision Medicine**.

5.33 It identifies five enabling factors: Clinical and Academic Excellence in knowledge, research, and translation; 'Hard' and 'Soft' Enabling and Supporting Infrastructures, Arrangements for Large-Scale Consent to support Real-World Clinical Trials; Skills and Understanding of Precision Medicine to support Learning Health Systems and thus Data for Better Health and Wealth, and NHS procurement freedoms to support the adoption and diffusion of innovation.

5.34 It also identified a series of challenges – as highlighted in previous Chapters – in particular, skills gaps and shortages, access to finance for business, LEP funding criteria, which limit both cross-border working and financial support to the NHS, and cultural and procurement barriers to the adoption of innovation in the NHS.

5.35 Given the findings from this SIA process, we believe that our original overarching hypothesis should now read:

> Utilising the North of England's collective academic, clinical and business strengths in **Health Data** and **Precision Medicine** at a scale of up to 16 million people will have a greater impact on investment into, and economic development of, the North of England and the UK than through utilising assets with smaller geographic and demographic footprints – *provided enabling and supporting activity is undertaken by LEPs and other partners to attract and grow businesses and talent*.

5.36 Furthermore, given the discussion in this chapter, we believe that the hypothesis for Better Data for Health and Wealth should now read:

> The North of England is ideally placed to facilitate and catalyse the science and innovation required to establish Learning Health Systems – *provided organisational development, investment and culture change programmes and freedoms and flexibilities in procurement process are implemented*.

6 Conclusions

Introduction

6.1 This Chapter provides:

- A summary of our findings against our hypotheses;
- A logic model that sets out the case for a programme of activity to address opportunities, barriers and gaps (Table 6-1);
- A number of targeted project proposals; and
- A summary of our proposed governance arrangements for taking the SIA forward.

Reviewing and revising our Hypotheses

6.2 Table 6-1 sets out the initial hypotheses, the findings and lessons learned through the production of this SIA, and finalised revised hypotheses.

- It shows that while the SIA process found evidence in favour of our initial hypotheses, it also showed that additional factors need to be taken into consideration, if we are to achieve maximum health and economic impact. In particular, the process identified the need for more work to:
  - Develop a supportive business environment, if the North is to capitalise on its strengths in **Data for Better Health and Wealth** and **Precision Medicine**, including support to develop entrepreneurs and business managers in the Life Sciences;
  - Bring changes in the way that the NHS procures, if innovation is to have maximum impact on health and economic outcomes; and
  - Support team-based working as well as individual upskilling to maximise the benefits offered by **Precision Medicine** and **Data for Better Health and Wealth** – this is one of the main ways that our SIA will contribute to reducing adverse drug reactions, as it will ensure staff apply precision medicine in their everyday practice.

6.3 It also demonstrated that there are a number of areas where the North can capitalise on the intersection of the two SIA research themes, particularly, but not exclusively, Real-World Clinical Trials, Ageing, and Anti-Microbial Resistance.

6.4 These findings have informed our approach to identifying the gaps in our current assets and strengths that need to be filled and the targeted opportunities that need to be taken to ensure that the potential of **Precision Medicine** to deliver better health and wealth in the North is fully realised.

6.5 We recognise this SIA as an important, but nonetheless still initial, attempt to define Health, Care, and Life Science activity across the North. Recognising this**,** partners to this SIA intend to map more fully the supply chains and potential for wider sectoral growth as part of follow-up

work, subject to additional resources being made available (e.g., via Sector Deals at national and/or Northern levels).

Logic for a Programme of Action at the level of the North

6.6 Table 6-2 sets out a logic-model framework that makes the case for a programme of targeted opportunities in relation to **Data for Better Health and Wealth** and **Precision Medicine** at the level of the North. It looks at the context for the work, the rationale for intervention, the objectives of intervention, the inputs required, and the outputs, outcomes, and impacts anticipated.

Table 6-1: Initial hypotheses, findings and lessons, and finalised hypotheses

Initial Hypotheses	Findings and Lessons	Finalised hypotheses

• Utilising the North of England's collective academic, clinical and business strengths in Health Data and **Precision Medicine** at a scale of up to 16 million people will have a greater impact on investment into, and economic development of, the North of England and the UK than through utilising assets with smaller geographic and demographic footprints.	• The SIA process identified significant academic, clinical and business assets in **Data for Better Health and Wealth** and **Precision Medicine**, particularly in the translation space, along with significant research networks, academic and business clusters, and international collaborations. The assets, clusters, and networks collaborate at different spatial scales depending on the issue/topic under consideration. Thus, we identified the North has one of the necessary conditions for achieving greater economic impact by operating at the scale of the North.
	• We found that partners in the North have developed and fully validated the necessary protocols and data sharing arrangements to facilitate clinical trials across defined and representative geographies – in line with the Life Sciences Industrial Strategy. However, the infrastructure in place requires scaling to the level of the North's c16m population. The North is already on-track in using this infrastructure to attract interest from overseas businesses, but much more could be secured with additional support.
	• We also found that there are localised clusters of expertise and business activity with sufficient density to drive innovation, particularly, but not solely, in the use and re-use of data, Real-World Clinical Trials, Anti-Microbial Resistance and Ageing.
	• However, stakeholders also identified that supporting actions are required if we are to realise the full economic potential of the North's offer, in particular:
	  • Strategic pan-Northern investment is required to enable the North to continue to leverage its assets and act at scale that could be used to improve the health and wealth of the North.
	  • LEPs and other partners need to coordinate their inward investment and business support activity alongside research in **Data for Better Health and Wealth** and **Precision Medicine** to ensure potential economic impact is realised in growing clusters of international significance;
	  • The talent pipeline needs to be developed from school age and the North's transport infrastructure needs to be improved so that its labour markets are of sufficient scale and accessibility to ensure that graduate-level workers feel able to build careers in the North;
	  • Universities and the NHS need to ease the bureaucratic burden of organising placements and secondments for students both to support innovation and to attract international talent.
		• Utilising the North of England's collective academic, clinical and business strengths in Health Data and **Precision Medicine** at a scale of up to 16 million people will have a greater impact on investment into, and economic development of, the North of England and the UK than through utilising assets with smaller geographic and demographic footprints – *provided enabling and supporting activity is undertaken by LEPs and other partners to attract and grow businesses and talent*.

Initial Hypotheses	Findings and Lessons	Finalised hypotheses

• The North of England is ideally placed to facilitate and catalyse the science and innovation required to establish Learning Health Systems.	• The SIA process found that the North is ideally placed to conduct translation/commercialisation work – taking ideas and making them work in practice – given its established assets, infrastructure, networks, and partnerships, and protocols developed by organisations like the Academic Health Science Networks, Local Health Partnerships and the NHSA.
	• We identified two issues that need to be addressed, if innovation is to be adopted at scale and speed:
	  • Changes in NHS procurement requirements, so that innovation can be adopted more quickly; and
	  • Organisational development programmes to tackle cultural issues and established working practices that limit the diffusion and adoption of innovation in practice.
	• The North should act as a pilot for freedoms and flexibilities in NHS procurement, building on lessons from Health Devolution in Greater Manchester.
		• The North of England is ideally placed to facilitate and catalyse the science and innovation required to establish Learning Health Systems – *provided organisational development, investment and culture change programmes and freedoms and flexibilities in procurement process are implemented*.

• Strategic investment in training will unlock a new uptake of **Precision Medicine** and will act as a model for other UK and international teams.	• Stakeholder consultations indicated widespread support for this hypothesis. Skills shortages were identified in Bioinformaticians, Pathologists, Microbiologists, and Genome Sequencing, Health Economists, and Data Scientists; and skill gaps were identified in a shortage of staff with a strong understanding of both **Precision Medicine** and Data.
	• However, stakeholders identified:
	  • The speed at which role descriptions are changing, implying the need for monitoring and review of under-graduate and post-graduate courses, as well as Continuing Professional Development programmes to ensure **Precision Medicine** is embedded in education and training;
	  • The role of team-working in the field and the need to develop team-based responses to the demand for skills to manage Data and **Precision Medicine**;
	• Stakeholders also identified:
	  • A shortage of Life Sciences entrepreneurs, limiting the flow of start-ups in the sector; and
	  • A lack of management expertise in scaling-up early-stage businesses, limiting company growth.
	• Thus, we found that strategic investment in training in **Precision Medicine** was a necessary but not a sufficient condition for the effective exploitation of the opportunities offered by **Precision Medicine** in the North.
		• Strategic investment in training will unlock a new uptake of **Precision Medicine** and will act as a model for other UK and international teams.
		• Strategic investment in team-based working will help address skill shortages and skill gaps, as well as acting as a model for UK and international teams.
		• Strategic investment in the development of Life Science Entrepreneurs, management development programme and processes for transferring businesses management from academics leading start-ups to managers with scale-up expertise will help address skill shortages and skill gaps, as well as acting as a model for UK and international teams.

Source: SDG-ED

Table 6-2: Logic-model for a programme of action at the level of the North

Element of the logic model	Key points in the logic model for a programme of action to promote Data for Better Health and Wealth and Precision Medicine in the North of England
Context	• The North has lower life expectancy than the UK average. • Poor health outcomes in the North contribute to relatively low labour productivity and drive high health and social care costs. • Much of the hard and soft infrastructure to conduct real-world trials at scale is in place in parts of the North, but activity has yet to reach critical mass. • The pace at which innovations are adopted by the NHS in the North faces challenges, linked to skills/knowledge/awareness of **Precision Medicine**, NHS procurement rules and cultures, and silo-based funding requirements for a number of partners, including Local Enterprise Partnerships. • There is a lack of finance and management expertise to promote indigenous business growth in **Data for Better Health and Wealth** and **Precision Medicine** in the North.
Rationale	• Research and trials should be conducted in the populations that most need treatments for reasons of equity, efficacy of research, and evidence suggesting innovation adoption rates are higher in places engaged in research. • An increase in the scale and quality of work on **Data for Better Health and Wealth** and **Precision Medicine** will drive health improvements that will in turn raise workforce productivity. • The North's research capacity and capability requires investment in order to generate and coordinate hard and soft innovation assets to attract and conduct multiple trials and verification work at scale and to attract international investors and collaborators. • To facilitate adoption of **Precision Medicine** in a Learning Healthcare System, action needs to be taken to raise awareness, knowledge, and individual skills, and to support cross-team working. • NHS culture, structures, and practices need to change in order to enable the development and adoption of innovative approaches based on **Data for Better Health and Wealth** and **Precision Medicine**. • A critical mass of businesses in **Data** and **Precision Medicine** won't be reached in optimal time in the absence of business support intervention.
Investment objectives	• The development of more effective treatments to reduce the cost of adverse drug reactions, drive health improvement, and increase workforce health and productivity. • To develop the hard and soft infrastructure required to ensure a consented population of c.16m. • Ensure capacity for the North to deliver Real-World clinical trials at scale at the level of the North. • Enhance Learning Health Systems to reduce delays in adopting innovations in **Precision Medicine**. • Develop clusters of businesses and expertise for **Data for Better Health and Wealth** and **Precision Medicine**.

Element of the logic model	Key points in the logic model for a programme of action to promote Data for Better Health and Wealth and Precision Medicine in the North of England
Inputs	• Research funds to conduct trials in the populations which are most in need. • Infrastructure to support the North to deliver Real-World clinical trials at scale at the level of the North. • Resources to fund clinicians to conduct verification work in partnership with UK and international industry. • Flexibility in NHS procurement to adopt innovation in **Precision Medicine** at the level of the North. • Resources for the development of, and recruitment to, education and training modules on **Precision Medicine**, and culture charge to effect the introduction of innovations linked to **Precision Medicine**. • Access to business finance support and a Northern VC Fund, plus entrepreneurial and business management skills to support the growth of business clusters.
Activities	• Develop and implement protocols on data exchange and ethics, plus national/regional exemplars. • Undertake trials to tackle poor health outcomes in the North. • Awareness, education and training on **Precision Medicine** to promote adoption among health professionals. • Culture Change programmes to overcome cultural and institutional barriers to the adoption of innovations in **Precision Medicine**. • Development of freedoms and flexibilities in NHS procurement to promote the adoption of innovation in **Precision Medicine**. • Support for start-up and scale-up businesses in Health Data and **Precision Medicine**.
Outputs	• Comprehensive protocols and partnerships between business, researchers and clinicians to support research in **Precision Medicine**. • More trials at scale and more trials of relevance to the health needs of the North. • Number of awareness/education/training programmes and modules. • Number of change programmes to promote adoption of PM/Data innovations. • Number of businesses supported to start-up and/or scale-up.

Outcomes	• Increase in the number of new treatments trialled with increased funding for research.
	• Research and innovation capability in **Precision Medicine** approaches critical mass.
	• Adoption times of **Precision Medicine** innovations fall due to:
	  ◦ More NHS staff being trained to apply **Precision Medicine** innovations; and
	  ◦ NHS procurement and management processes supporting the adoption of health innovation.
	• Clusters of **Data for Better Health and Wealth** and **Precision Medicine** businesses developed.

Impacts	• The North is a world-leading site for real-world trials. • The North has well-established clusters of businesses and research expertise in Data for Health and **Precision Medicine**. • The North is a preferred location for inward investment in Data for Health and **Precision Medicine**. • Increased life expectancy. • Increased labour productivity. • More efficient provision of health and social care, e.g. as a result of reductions in adverse reactions to drugs.

Source: SDG-Economic Development

Targeted Opportunities

Extending Connected Health Cities

- The Health North/Connected Health Cities (CHC) initiative is creating a world-leading partnership using large-scale data to drive public sector reform in health and social care;
- The original CHC funding was for the pilot of the project, and was linked to potential future scale-up capital;
- An extension to CHC will enable the development of almost 16 million consented population based on the Great North Care record, and its various sub-regional equivalents, that will complement the UK Life Sciences Industrial Strategy. The latter seeks, among other things, to improve the speed and efficiency of UK clinical trial capabilities and to support collaboration between the NHS and industry for the benefit of patients;
- CHC also has significant export potential, with existing requests from Australia, USA, Canada, Brazil, Turkey and Singapore for international relationships based on the platform being demonstrated through CHC; and
- The funding requirement over the next five years is estimated at **£25 million capital, and £75 million revenue**.

Extension of the Northern Health Science Alliance (NHSA)

- The NHSA performs a vital animateur and coordinating role working with Universities, Academic Health Science Networks and NHS Teaching Hospitals, plus engaging with business;
- It currently handles around 35 private sector enquires a year, translating around 90 per cent of these into formal R&D projects; and
- The funding requirement for NHSA over the next five years is estimated at **£3-5 million revenue.**

Development of a Centre/Collaborative for Civic Computation

- This will involve co-locating physical and digital facilities with the CHC data analytic centres at regional science parks across our SIA geography. The latter can accommodate industry partners, so optimising the opportunities for clustering, as well as ensuring activity is visible to the public, thereby helping to build public trust in the increasingly sensitive and high-profile 'personal data' domain;
- The CCC will drive regional and national growth by working closely with CHC, entrepreneurs, and existing businesses to develop digital health products and services. It will establish a programme in Civic Data Science research alongside a Centre for Doctoral Training, addressing an acute need in the rapidly expanding Digital Health and allied Digital Civic segments, and develop a cohort of Computing and Mathematics Fellows;
- The precise form of the asset needs to be worked through, but it could take the form of a single facility for the North, a network of nodes across the North, or the North leading as part of a national collaboration in civic computation. Links to, and synergies with, Health Data Research UK will be key;
- This centre will be able to draw upon the lessons and expertise from the EPSRC Centre for Doctoral Training (CDT) in Digital Civics at Newcastle University, which aims to train 55 doctoral students between 2014 and 2022;
- The CCC will drive regional and national growth by working closely with CHC, entrepreneurs, and existing businesses to develop digital health products and services. It will establish a programme in Civic Data Science research alongside a Centre for Doctoral

Training, addressing an acute need in the rapidly expanding Digital Health and allied Digital Civic segments; and develop a cohort of Computing and Mathematics Fellows;
- The precise form of the asset needs to be worked through, but it could take the form of a single facility for the North, a network of nodes across the North, or the North leading as part of a national collaboration in civic computation. Links to, and synergies with, Health Data Research UK will be key; and
- The funding requirement over seven years is estimated at **£10-15 million capital and £25-40 million revenue** – based on benchmarking with other Centres.

Development of a Precision Medicine Academy

- An **Applied Precision Medicine Academy** (APMA), focussed on delivering coordinated training and knowledge transfer across the North, will build on partners' outstanding track record in innovative clinical academic training – this includes the Modernising Scientific Careers Programme under Health Education England, the NIHR National Dean for Training (Liverpool), and the National Lead for Training in the NIHR Infrastructure, NIHR Infrastructure National Training Forum Chair and NIHR Rare Disease Training Lead (all in Newcastle); and
- Further work is required to determine the scale of the Academy and the breadth of Allied Health Professional courses that it will cover. Initial estimates indicate **annual running costs of around £2-4 million a year**. In the first instance, an **estimated £75,000 is required for a Concept Feasibility Study**.

Development of Real-World Clinical Trials

- The NHSA and the team at North West eHealth (NWEH), which ran the Salford Lung Study, plus the wider Northern platform, will scale-up the North's offer on Real-World Clinical Trials. Wider expertise will be drawn in from other centres of specialist clinical trials expertise, such as the UKCRC's Clinical Trials Research Centre (Liverpool) and Clinical Trials Research Unit (Leeds). Similarly, the recent Wolfson Centre for Applied Health Research Medicine is seeking to research Health Inequalities in the Leeds-Bradford area;
- This opportunity is complementary to, and supportive of, the Life Sciences Industrial Strategy, which aims to establish two to five regional innovation hubs providing data across regions of three to five million people; and
- The funding requirement for this is estimated at **£20 million over five years, which will unlock at least twice as much in private sector investment**.

Freedoms and flexibilities in Procurement and Funding

- The NHSA, working in partnership with NHS Trusts, AHSNs, and the newly developing NHS Northern Procurement Hub will explore fresh ways for the North of England to procure innovation at scale, with the aim of identifying any procurement barriers to the introduction of pan-Northern innovation procurement. The estimated cost of a **Scoping Study for this opportunity will be £100,000**; and
- The NHSA will work with researchers, businesses and LEPs to prepare a Business Case for LEPs which have prioritised the Life Sciences to have the freedom to support work to develop and validate new products, processes, and services delivered to the NHS. The **estimated cost of this case-making activity is a further £140,000**.

Table 6-3: Expansion of Health North Connected Health Cities (CHC) to Create Data for Better for Research, Health and Wealth

Question	Description				
Rationale: Why should money be invested?	The Health North: Connected Health Cities (CHC) initiative is creating a world-leading partnership using large-scale data to drive public sector reform in health and social care. The CHC project sees the North assemble data, experts, and technology to generate new information that shapes health and social care services to deliver better outcomes for patients and communities. Companies seeking to develop, test and validate technologies in this market require relationships with trusted third parties. The NHSA seeks to build an economic and investment rationale for anticipated follow-on investment into Health North: Connected Health Cities and new investment into additional programmes of industry orientated research and implementation such as the use of health data analytics required to power a transformation in healthcare by exploiting the explosion in digital health data, for patient, public and economic benefit. Such programmes will directly complement the Alan Turing Institute (the UK's national centre for data science) of which connections have already been made through the Farr Institute, by providing user-pull and a translational pathway for more fundamental methodological work. The NHSA, through the reach of its member organisations and institutions, is in an enviable position to explore how the funding allocation of £20m thus far for Health North: Connected Health Cities, currently a three-year pilot programme, could be scaled so the benefits and commercial partnerships developed in the programme can benefit a wider patient population across the UK and a greater number of companies. For the UK to fully realise the benefits of the programme, it will require regional scale up investment as well as investment in the national rollout of the outputs from the pilot study. The UK Government has already committed to supporting the CHC concept, there are no tangible barriers to the expansion of this project and it already covers the whole Northern Powerhouse geography.				
Actions: How this could be achieved?	The NHSA and CHC project are already developing an industry-based pre-competitive consortium which includes companies from the eHealth and ICT sectors which will work to build a market place for these companies whilst also implementing new standards for the use of data in health and social care. Additionally, we would have opportunity to benchmark the CHC programme as a national asset to international investors and existing UK companies. The CHC leadership is in discussion with Singapore, Australia and other global health partnerships to explore the export potential of the programme. This opportunity will also directly complement the UK Life Sciences Industrial Strategy that seeks to underpin 21st century health research with well annotated clinical data to inform research whilst also impacting healthcare delivery. CHC has significant export potential with existing requests from Australia, USA and Singapore for international relationships based on the platform being built through Health North: Connected Health Cities.				
Timeframe and resources[91]	Next 5 years	Estimated total cost	£100m	Estimated annual running cost (if applicable)	£5m per year in Capital. £15m per year in Revenue *Capital requirements decrease over time, figured quoted here is the mean over five years.

Source: SDG-Economic Development, 2018

Table 6-4 Extension of support for the Northern Health Science Alliance

Question	Description				
Rationale: Why should money be invested?	The North's health innovation assets are shared between multiple partners and geographies. Without a mechanism for bringing key players together and a central animateur to coordinate activities, these assets will not achieve full health and economic impact. The Northern Health Science Alliance performs a vital animateur and coordinating role working with Universities, Academic Health Science Networks and NHS Teaching Hospitals, plus vital networking and brokering with businesses. It has been cited as an exemplar for wider pan-Northern working as part of Innovation North, a project led by Innovate UK and the 11 Northern LEPs. It currently handles around 35 private sector enquires a year, translating around 90 per cent of these into projects, and over 10% into secured deals.				
Actions: How this could be achieved?	Re-contracting of NHSA with a five-year funding deal will facilitate its work to: • Support **Data for Better Health and Wealth** via the application of large connected data sets across the North; • Provide a platform for applied research to move from 'moonshot' research to practice; • Support programmes to support ageing well and innovation for ageing; • Build on the North's ability to attract 20 per cent of private sector funding in Life Sciences R&D by moving from 13 per cent to 20 per cent of public sector R&D funding; • Work with regulators and industry, via Connected Health Cities, to use digital healthcare data and systems to evaluate the safety and efficacy of new interventions and modernise Good Clinical Practice regulations; • Build capacity in the analysis of health data to promote the application of **Precision Medicine** e.g. via a **Applied Precision Medicine Academy**; • Increase the number of clinical trials undertaken in the North by 50% over the next 5 years – as identified in the LSIS; • Work with NHS Digital and NHS England to set out clear and consistent nationwide approaches to data and interoperability standards and requirements for data access agreements; • Streamline legal and ethical approvals for access to datasets; and • Act as a coordinator of data in the North to work with academia, charities and industry to engage with all health data programmes.				
Timeframe and resources	Next 5 years	Estimated total cost	£3-5 million	Estimated annual running cost	£500,000-£600,000 a year

Source: SDG-Economic Development, 2018

Table 6-5: Development of a Centre/Collaborative for Civic Computation Centre (CCC) aligned to Connected Health Cities and complimentary to HDR UK

Question	Description				
Rationale: Why should money be invested?	The North of England has already begun the deployment of the pilot Connected Health Cities. This £20m pilot is seeding the world's first civic data partnerships that can: (1) Drive regional and national economic growth by enabling industry and public sector organisations to work together over civic data in ways that are supported by local communities and that develop new digital health products and services; and (2) Drive public sector reform for better Health and Care by providing actionable information to Patients, NHS commissioners, NHS and social care providers and their partners, Public health professional and local authority planners, and Researchers (leveraging and feeding RUK investments). Healthcare can't be optimised without coordinating other interdependent services that are inherently place-based, such as social care, transport, education etc. Here, the UK has potential exports in how healthcare can 'learn' from wider civic data, where our competitors in the US and many other countries have insurmountable barriers to connecting the necessary data. We propose developing a Centre/Collaborative for Civic Computation (CCC) using the NHSA-convened focus on health data analytics to create regional critical masses of activity around a powerful networked infrastructure. The infrastructure would comprise physical and digital facilities co-located with the CHC data analytic centres in regional science parks able to accommodate industry partners, especially SME growth. Each CCC node would be highly visible to public visitors, nurturing the vital public trust and civic pride in how local data are being used to improve local public services and provide new jobs/prosperity nearby. Specifically, the Centre would: • Drive regional and national growth by working closely with the CHC pilots, entrepreneurs and businesses to develop digital health products and services; • Build a national programme in civic data science research alongside a centre for doctoral training, addressing an acute need in the rapidly expanding digital health and allied digital civic sectors; • Develop a cohort of computing and mathematics fellows at the interface between data science and health informatics, creating capacity to translate ideas into new products; and • Develop new civic data analytic methodology, powering learning civic systems and accelerating progress through secure access to real challenges, with a ready set of targets and activities from the CHC pilots.				
Actions: How this could be achieved?	We will recruit and retain a skilled workforce to service CCC at lower cost and faster pace than anywhere else in the UK. Effective collaboration is already in place, and there are significant strengths in computing and mathematics, with five of the top ten computer science and informatics centres in the North. In health data analytics alone, over the past two years the North has led the formation of a national network of excellence alongside the Farr and Alan Turing Institutes, drawing over 450 members from academia, industry, NHS and government. The next step is to create a critical mass of activity which would support wider economic growth, embedding data scientists in an environment where they interact with translational health informaticians, economists, social scientists, clinicians, NHS commissioners and providers, and industry.				
Timeframe and resources	Next 7 Years	Estimated total set up cost	£35m-£55m	Estimated annual running cost	£1.5m-£2m Capital over five years £3-5m-£6m revenue per year

Source: SDG-Economic Development, 2018

Table 6-6: Development of an Applied Precision Medicine Academy

Question	Description				
Rationale: Why should money be invested?	Precision Medicine is an acknowledged future, delivering a bespoke approach to each patient's disease. For the purpose of this proposal we include Genomic Medicine within Precision Medicine. The UK is already in a leading international position in the science of Precision Medicine. The critical next step of the Precision Medicine revolution, where the UK can benefit from its position of advantage, is to translate its scientific vision and commercial promise into practical reality for patients. We know that drugs do not work effectively in all patients. It is estimated that >90% of drugs work in only 30-50% of people. The current 'one-drug, one-dose fits all' paradigm inevitably leads to enormous waste, adverse effects and cost. Adverse drug reactions cost over £1bn pa. Drug safety is a major cause for drug attrition either during drug development or after a drug is launched onto the market. Precision Medicine represents the route to 'smart' utilisation of drugs and other therapies, targeting the right drug to the right patient at the right time and in the right dose. To date, curricula for healthcare professionals (including doctors) have not focused on Precision Medicine, and the workforce is thus ill-equipped to deal with the opportunities afforded, and implement Precision Medicine into healthcare. Thus, there is a need for better education and training to facilitate the uptake of Precision Medicine into the NHS, through the development of an **Applied Precision Medicine Academy (APMA**), thus providing a solution which will be available to the whole of the UK. A better trained, more skilled workforce will facilitate interactions between the current and future shape of the Genomics England Genomic Medicine Centres, Medicines Discovery Catapult, industry and NHS professionals generating the evidence of clinical validity and clinical utility; and better liaison with commissioners to evaluate the utility of Precision Medicine approaches in the NHS, facilitating speedier adoption.				
Actions: How this could be achieved?	An APMA training programme will substantially increase international competitiveness and attractiveness to industry. The programme will build on the outstanding track record of the NHSA member institutions and partners in clinical academic training innovation and on the existing Modernising Scientific Careers programme under Health Education England. The NHSA members host the NIHR National Dean for Training (Liverpool) and the National Lead for Training in the NIHR Infrastructure, NIHR Infrastructure National Training Forum Chair and NIHR Rare Disease Training Lead (all in Newcastle). Our collective training links with NIHR, Wellcome Trust and MRC put us in a strong position to lead for the systematic development of PM in the UK and to link with our partners to make our training content available across the UK (through NIHR Infrastructure and utilisation of the e-learning approach in which we have significant expertise). In addition, expertise and training would both be opened to and sought from the global diagnostics, medtech and pharmaceutical sectors.				
Timeframe and resources	Next 5 years	Estimated total cost	£10-20m	Estimated annual running cost £2-4m a year	Further work is required to determine the scale of the academy and breadth of allied health professional that courses are offered to.

Source: SDG-Economic Development, 2018

Table 6-7: Development of Real-World Clinical Trials

Question	Description
Rationale: Why should money be invested?	The Life Sciences Industrial Strategy states that the UK should be at the forefront of Real-World clinical trials. Global Health and Care systems are under considerable pressure to reduce costs while improving outcomes. In response payors are moving to pricing models that are linked to value and patient outcome rather than cost per intervention. **Current clinical trial protocols do not provide mechanisms to truly evaluate cost effectiveness.** Few trials are able to: a) Access granular, longitudinal data for feasibility and recruitment; and b) Demonstrate clinical and cost effectiveness in parallel to inform value based pricing. **Solutions offered by pragmatic electronic health record (EHR) driven trials:** • Capability for fast, accurate feasibility across patient populations; • Capability for efficient recruitment to trials via primary care providers; • Capacity to design trial protocols which will deliver studies in the right locations and within timescales to meet commercial demands; • Longitudinal data to track patient populations over time and across disease areas; • Near real-time safety monitoring and reporting, setting a new standard for clinical trials; • Trial outcome monitoring, enabling adaptive trial design; and • Health Resource Utilisation analysis demonstrating the real total cost of care.
Actions: How this could be achieved?	The future of Life Sciences R&D and innovation in healthcare is being driven by a convergence of biology, computing and data. Together with access to cloud-based data analytics and machine learning technologies this presents a new way to develop 21st century medicines. In the future, clinical trials will be required as standard to generate both clinical and cost effectiveness data to support value/outcomes based pricing. However, delivering data driven trials has so far proven difficult. The NWeHealth Team based in Manchester is the only team globally to have delivered a real-world clinical trial in the form of the GSK sponsored Salford Lung study. This study was a world-first data-enhanced real-world randomised control trial. This is an example of what can be achieved when the health system works together with industry partners. NHSA Ltd is working with NWeHealth Ltd as well as the real-world clinical trial infrastructue in Liverpool and Leeds to develop a pan-regional approach to establishing a real-world trials platform with the view to establish a global platform for real-world trials. Starting in the North and scaling internationally, this methodology will take the North's Real-World trials offering, including software and services, to a position where we can link consented information between countries, ensuring patients get earlier access to innovative medicines and bringing in investment.

Timeframe and resources	Next 5 years	Estimated total cost	£20m	Estimated annual running cost	Will become self-sustaining from revenue generation

Source: SDG-Economic Development, 2018

Table 6-8 Developing freedoms and flexibilities in NHS procurement and funding

Question	Description
Rationale: Why should money be invested?	In 2016 the *Accelerated access review* and *Carter review* identified that: • *The approach to accessing innovation in the NHS has become increasingly challenging; creating frustration for innovators who see the NHS as an interesting environment for demonstrating the value of their products, for patients who often have to wait long periods of time before life-saving therapies are available, and for clinicians who are frustrated by the multiple barriers to both approval and adoption.* ***Accelerated access review, 2016*** • *'whilst there have been excellent improvements by some trusts, most still don't know what they buy, how much they buy, and what they pay for goods and services. Very few trusts are able to demonstrate even a basic level of control or visibility over total inventory or purchase order compliance that is common practice in other health systems and industrial sectors such as retail... For example, a sample of 22 trusts covering approximately 16% of nhs spending revealed that in one year they used 30,000 suppliers, 20,000 different product brands, more than 400,000 manufacturer product codes with more than 7,000 people are able to place orders'.* ***Carter review 2016*** More recently the pivotal report from Public on Health Tech noted that **'***Technology is changing healthcare in ways that were scarcely imaginable only a few years ago. The changes that innovations such as cloud computing, VR, 3D printing, genomics and artificial intelligence are bringing to the NHS cannot come too soon. They represent one of the few ways that the NHS can sustainably relieve the demographic and financial pressures it faces. Without major reform, the NHS may see a £30 billion funding gap open up over the next three years alone (Public, 2018')* Stakeholders from across the NPiHR repeatedly suggested that they be given the opportunity to explore new models to access and uptake innovation such as: • Freedoms and flexibilities to enable NHS procurement to incentivise the speedy adoption of health innovation; and • Freedoms and flexibilities for LEPs to fund health innovation where it is a local priority.
Actions: How this could be achieved?	• The NHSA, working in partnership with NHS Trusts, AHSNs, and the newly developing NHS Northern Procurement Hub will explore new ways for the North of England to procure innovation at scale, with the aim of identifying any procurement barriers to the introduction of pan-Northern innovation procurement. • The NHSA will work with researchers, businesses and LEPs to prepare a Business Case for LEPs which have prioritised the Life Sciences to have the freedom to support work to develop and validate new products, processes, and services delivered to the NHS.

Timeframe and resources	Next 5 years	Estimated total cost	£145,000	Estimated annual running cost	The estimated cost of the NHS procurement study is £75,000 The estimated cost of case-making activity for LEP freedoms and flexibilities to fund health innovation is £70,000.

Source: SDG-Economic Development, 2018

Governance and Delivery Arrangements

6.7 The Northern Health Science Alliance is structured as a limited independent not-for-profit company limited by guarantee. Its governance structure includes the eight-leading research-intensive NHS teaching hospitals the N8 universities and the four northern Academic Health Science Networks. The NHSA therefore already contains a significant proportion of the NPiHR ecosystem. In the initial phases of delivering the recommendations and suggested outcomes from this SIA the NHSA will act as the governing body in the first instance. However, to reflect the full breadth of the North's health innovation economy the NPiHR will establish a Leadership Steering Group to support the implementation and delivery of the SIA's recommendations and next steps. The NPiHR joint leadership steering group which will involve members from the NHSA, regional trade bodies, such as BioNow and LEPs, as well as directly involving the senior leadership from relevant companies to guide and inform the implementation of the SIA outputs. The NHSA is in the process of agreeing the governance model for the NPiHR SIA Leadership Steering Group with relevant stakeholders.