



CIDHR: Coalition for Innovation and Digital Health Research

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Executive Summary

The future sustainability and performance of health and social care systems will depend on the availability of patient information across the care pathway coupled with advanced digital technologies such as artificial intelligence, medical devices, human computer interaction and robotics. This process of increasing digitisation will transform public health, clinical diagnostics, self-health management and prevention, and operations management through a rich ecosystem of

An ecosystem where innovators in academia, industry, and health and social care provision can work together with patients and the public to make digitally enabled improvements to health and care.

connected institutions, people, devices, and data. Digitisation is changing healthcare, but it is also transforming how researchers and innovators create knowledge and build evidence for adoption within complex networks. These disruptions require a fundamental rethinking on how institutions collaborate, what infrastructures are needed and how transformation is led and governed.

CIDHR¹ aims to establish an open digital innovation ecosystem for the transformation of health and social care where innovators in academia, industry, health and social care can work together to explore new networked care opportunities that can improve health and care. CIDHR will combine clinical leadership with technology and social science to ensure decision making, diagnostics, screening and treatments can be augmented by digitisation in ways that improve the patient journey. CIDHR will redefine stakeholder relationships to accelerate how value is unlocked from digital technologies. In addition, as healthcare moves beyond the boundaries of acute care hospitals and into communities, further digital connectivity and data-driven relationships are fast approaching that will necessitate integration with regional government (i.e. Integrated Care System) and policies. The richness of information captured, processed and delivered will provide intelligence and mediate the highest quality care and interaction between healthcare professionals, patients and the wider population to enable long term regional health research, improvement and innovation. Innovators, healthcare funders and providers are recognising that real-world evaluation is key to building trust and move swiftly from trials to evaluation and on to rapid adoption. As such, institutions and partners that can collaborate to create such ecosystems for networked care will build national and global reputations, attract investment and industry, attract and retain the best people, and be the leaders (rather than followers) in the future of healthcare.

CIDHR proposes a pioneering end-to-end discovery and innovation pipeline that will accelerate adoption, build real-world evidence and manage risks associated with data governance, public trust and cost. Through acceleration methodologies, state-of-the-art infrastructures, advanced experimentation and trials platforms, and efficient data and intellectual property governance procedures, CIDHR will allow clinicians, industry, SMEs, academics and the public to work together through stages of design, demonstration and delivery of digital transformation. This will be achieved through a founding coalition that brings together regional players with world-class expertise, processes and the technology assets needed to translate scientific advances in healthcare technology into positive change. The vision is aligned with the ambition of the Hampshire and IoW STP “supporting agile innovation propositions to develop innovation in healthcare ecosystems through progressive digitalisation.”

The CIDHR Vision is a call to action. We must act quickly through a step change in strategy and commitment that moves beyond our competitors and establishes the region as a global leader in accelerated digital transformation and fit to deliver a 21st century service model of care.

¹ Renamed from AHEAD “A Healthcare Ecosystem Advanced by progressive Digitisation” in v1.5 due to existing initiatives in healthcare with similar name

Business Opportunity

Global healthcare growth is projected at 5.4% annually reaching \$10.1 trillion by 2022ⁱ, whilst according to the UK Life Sciences Industrial Strategy the global life sciences industry is predicted to be over \$2 trillion by 2023ⁱⁱ. Much of this growth will be driven by technology, a sector worth £184 billion in 2018 (a £14 billion growth in just two years) with growth 2.6 times faster than other parts of the economyⁱⁱⁱ. London is recognised as one of the best ecosystems in the world for technology start-ups with significant contributions from 'digital suburbs' like Portsmouth and Southampton, who can drive technology growth through strong links with academia^{iv}. Hall and Pesenti maintain that artificial intelligence (AI) is one of the most promising technologies and expected to add £630 billion to the UK economy by 2035 whilst highlighting healthcare as one sector with the biggest potential^v. It is well accepted that the future sustainability and performance of health and social care systems will depend on advanced technologies such as (AI), medical devices and robotics^{vi, vii, viii}.

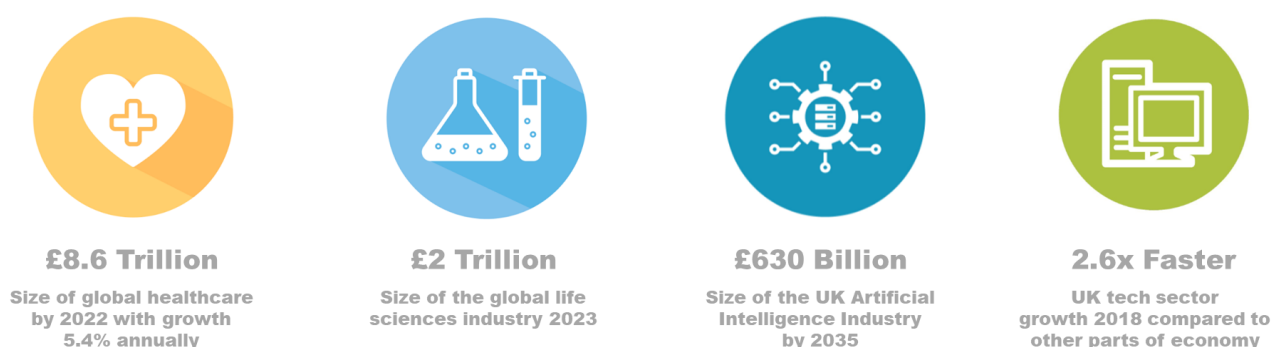
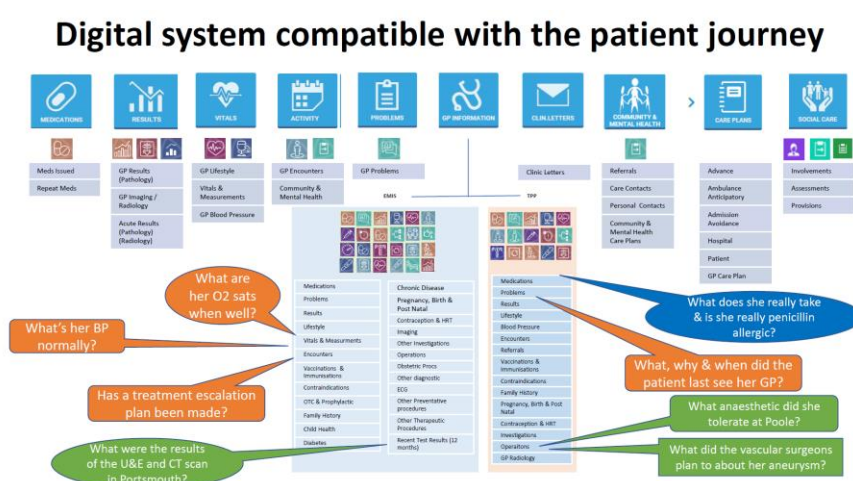


Figure 1: Global Opportunities in Health and Social Care

Digital transformation of healthcare will be achieved through progressive digitisation of organisations, business processes, social communities, and individuals². Digitisation will create new ways to deliver public health, clinical diagnostics, self-health management and prevention, and operations management through a rich ecosystem of connected institutions, people, devices, and data^{ix}. These trends will create a fundamental rethinking of health and social care systems, care delivery models and workforce capabilities that disrupts traditional functional business units within health systems ("the hospital", "the community trust", "the GP practice") and will require facilitation at a health system level in order to support adoption.

The process of digitisation will be guided by clinical experts, with advice on how decision making, diagnostics, screening and treatments can be augmented by digital technologies in ways that improve the patient journey. Increasingly systems will interoperate in real-time whilst effective and continuously evolving governance will ensure accessibility, safety,



² Progressive digitisation is the transformation of large and complex systems from analogue to digital form through incremental steps in different parts of the overall system.

effectiveness and acceptance by all healthcare staff and patients in all health settings. Distributed places of care will drive the need for interoperability and federation of clinical systems and foster the creation of “ecosystem services” supporting a network of service providers through shared historical information and powerful predictive models.

The Vision

Digitisation is not only transforming healthcare but also the networks of innovation, the processes of how knowledge is created and shared, and how new products and services emerge. Consequently, the end-to-end discovery and innovation pipelines will need to be restructured to mirror how clinical care occurs and real people live their lives. Such pipelines must offer real time, bidirectional access to health records in all care settings and enable the people, processes and systems necessary to co-create³ solutions and translate scientific advances in healthcare technology into positive change. Finally, trust by healthcare professionals, patients and the public must continuously be built through real-world evidence, responsible governance and continuous involvement and engagement. The opportunity is therefore to establish a vibrant healthcare ecosystem in the region where innovators in academia, industry, health and social care provision can work together to challenge existing systems and improve healthcare. Our collective vision is therefore simply:

“We are global leaders in accelerated digital transformation of health and social care systems driven by future analysis, innovation and research”

Delivering the Vision

We propose to deliver the vision through a founding regional coalition across Hampshire and IoW bringing together Hampshire and IoW STP (HISTP), Wessex Academic Health Science Network (WAHSN), University Hospital Southampton NHS Foundation Trust (UHS), Hampshire Hospitals Trust (HHT), Portsmouth Hospitals Trust (PHT), University of Portsmouth (UoP), University of Southampton (UoS) and a Public Trust Provider responsible for Public Patient Involvement (PPI). The coalition is ideally positioned considering the key assets of the regional health and social care networks and the research and innovation capabilities within the grouping.

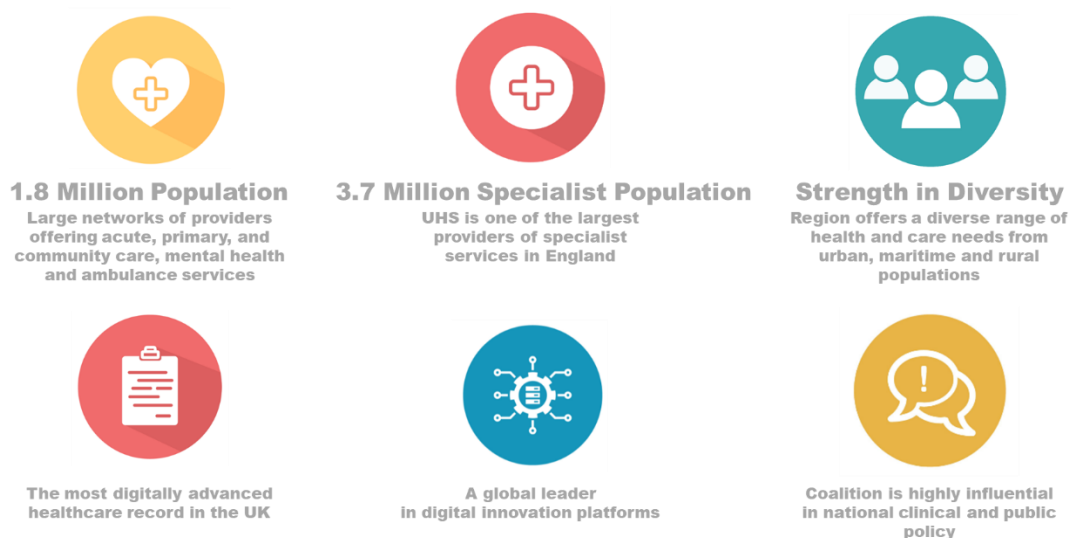


Figure 2: Assets of the Regional Coalition

³ Co-creation is a process of design that brings together people from different disciplines (including patients and citizens) to discover solutions

The founding coalition are institutions engaged at the time of writing and we are open to other institutions joining. The expectation is that following establishment of the founding coalition, membership will be expanded to include other service providers, industry and higher education institutions as the programme is scaled up.

Regional Health System

From 2020, Hampshire and Isle of Wight will have a shadow Integrated Care System (ICS) with formal status from April 2021⁴. The ICS create closer collaboration between all NHS bodies (primary care, acute care, community services, mental health services, etc.) in the region serving the 1.8 million population. The provider sector includes HHT, Isle of Wight NHS Trust, PHT, Solent NHS Trust, Southern Health NHS Foundation Trust, South Central Ambulance Service NHS Foundation Trust, UHS and 28 newly established Primary Care Networks. UHS is positioned within the wider health system as a large general hospital with a diversity of acute care services that is unique outside London and other larger metropolitan areas. In addition, UHS is one of the biggest providers of specialised services in England serving a 3.7M population as a specialist centre. The geographic region and environmental conditions are highly diverse and includes urban, maritime and rural economic activities and large permanent/transient populations presenting a wide range of health and care needs. The health service and population factors make the region highly attractive for discovery and evaluation of new healthcare technologies including those that extend care into new settings beyond traditional hospitals.

Sphere of Influence

UHS, as a teaching hospital, has a long strategic partnership with the University of Southampton (UoS) across medical disciplines, health informatics, operations research, medical devices, AI and beyond. As a top UK university, and a member of the Russell group, UoS has world class, research-intensive faculties in medical, social, physical and engineering sciences. Together, the UHS and UoS is highly influential within complementary networks necessary to influence transformation: while the UHS is influential within key NHS networks (Adrian Byrne - Chair of the NHS CIO Network, Chair of InterOpen Board and Christine McGrath - Chair of NHS R&D Network), the UoS is influential in public policy (Dame Wendy Hall - Government Advisor on AI and Anneke Lucassen - ethico-legal aspects of data raised by new genomic technologies).

Technical Base

The Hampshire and IoW STP has developed a five-year plan with digital services and digitisation, the long-term vision is for a data infrastructure and governance arrangements that can act as a blueprint for health and social care systems whilst promoting the region nationally and internationally. UHS and HHT Trust are global digital exemplars (GDE)⁵ aiming to become paperless digital trusts encompassing all healthcare settings, including the patients homes, involves social care as well and occurs over a life time, whilst Hampshire Hospitals NHS Trust and South Coast Ambulance Service are both GDE fast followers, whilst the Hampshire Health Record (CHIE) brings together key electronic healthcare record (EHR) data from NHS bodies in the Hampshire and IoW region and is nationally recognised as best in class. CHIE is

⁴ In 2016, NHS organisations and local councils came together to form sustainability and transformation partnerships (STPs) covering the whole of England, and set out their proposals to improve health and care for patients. In some areas, a partnership will evolve to form an integrated care system, a new type of even closer collaboration.

⁵ A NHS Global Digital Exemplar is a globally recognised NHS provider delivering improvements in the quality of care, through the world-class use of digital technologies and information.
<https://www.england.nhs.uk/digitaltechnology/connecteddigitalsystems/exemplars/>

a major regional interoperability asset offering population scale and potential for highly networked linked data. Ongoing work is exploring how a real-time CHIE could underpin deterioration bowtie⁶ models to produce predictors of outcomes on a population level at acute presentations and over a lifetime. Machine learning applied at the knot could be used to ascertain signals of clinical phenotype, acute presentation data, assessment & pathology data, treatment choices on outcomes. UHS's MyMedicalRecord is the most digitally advanced in the UK and UHS have a technical strategy based on interoperation rather than a single vendor solution. The ability to interoperate through exchange of data using open protocols and standards is a fundamental requirement for progressive digitisation. Interoperability allows for different parts of an overall system to be evolved flexibly at different speed and by different solution providers. A key investment in 2020 will be the UHS data warehouse⁷ that will bring together clinical, financial, operational, estates, workforce and wider public service and environmental data assets as a data source for research, innovation and business intelligence.

UoS is a leader in digital innovation platforms delivering in healthcare, social care, smart cities and more widely into technology areas of data science, future networks, cloud computing and the Internet of Things (IoT). Such platforms establish co-creation environments where multi/inter-disciplinary teams design, test and evaluate new technologies for performance, viability and acceptability in a variety of laboratory and real-life settings. UoS has extensive experience in developing high Technology Readiness Level (TRL) software and clinical systems that can translate technologies into practice. It also possesses the expertise and credibility to deliver data discovery and analysis platforms (Platform-as-a-Service) on current and future infrastructures (Infrastructure-as-a-Service). The EDGE Clinical Trials Platform^x has been deployed in 90%+ of all NIHR Clinical Research Networks, the LifeGuide platform^{xi} (2008-2022) supports public health interventions and illness management interventions, The FLAME platform^{xii} has driven the development of 3GPP standards and 5G adoption by establishing an accelerated innovation pipeline for 5G services. This has included a seamless transition from desktop, lab and urban deployments (Bristol, London, Barcelona). EXPERIMEDIA^{xiii} established real-life testbeds to translate ideas from lab to live environments including non-invasive connected devices for high performance sports and sports science, FED4FIRE^{xiv} has established the largest federation of networking and IoT testbeds in Europe. DataPitch and Data Market Service^{xv,xvi} platforms have been established where public sector and corporate data problem owner can work with innovative SMEs and entrepreneurs on data science solutions. UoS also provides core opportunities to develop and advance analytics and visualisation of complex inter-related data through activities in mathematics and machine learning. Collaborations, such as QBio (Quantitative Biology), are already working with health-related data and well positioned to fill a critical role in CIHDR. Seamless access to Trust data will empower collaborative groups and provide significant return for health and operational approaches. The Business School offers a further opportunity to drive adoption, innovation education and CPD in digital applications within health and social care. The combination of capabilities in future infrastructure, data infrastructures, data analytics and their application in health and social care ideally positions UoS to deliver the necessary technical environment for accelerated research and innovation.

Finally, the region is an attractive place for public investment with opportunities for growth. NIHR have funded the Biomedical Research Centre (BRC) which at £14M over 5 years is modest in comparison to other national BRC's. With increased activity and an improved innovation environment there is opportunity to increase the scope and funding for Southampton's BRC (award to UHS but led by UoS Academic Staff). Contracted by the Department of Health and Social Care, the Wessex Institute NETSCC

⁶ The Bowtie method is a risk evaluation method that can be used to analyse and demonstrate causal relationships in high risk scenarios.

⁷ A data warehouse is a system that pulls together data from many different sources within an organization for reporting and analysis.

manages evaluation of research programmes and activities as part of the research work strand of the NIHR. The Applied Research Collaboration for Wessex (ARC: £9M 5years) is part of the NIHR mission to improve outcomes for patients and public; improve quality, delivery and efficiency of health and care services; and increase the sustainability of health and care systems locally and nationally. The region attracts significant grants from Charities (Cancer Research UK) and research councils (MRC, EPSRC, BBSRC, NERC) based on pioneering research. Whilst more generally, UoS has recently signed a data sharing agreement with Hampshire County Council for access to public service data^{xvii}. Such data provide the socio-economic and environmental contexts often missing from medical datasets and research.

The consequence of these important sector and technological trends is that institutions must substantially redefine their stakeholder relationships to create a Healthcare Ecosystem that accelerates “unlocking value from digital technologies”. As the future of healthcare moves beyond traditional healthcare settings and into communities, further digital connectivity and data-driven relationships are fast approaching that will necessitate integration with regional government and policies. The region has an opportunity to establish itself as a global pioneer for replication by others nationally and internationally.

Building the Partnerships

Although there is increasing data on health and multiple systems and devices to collect those data, bringing them together is essential if we are to capitalise on the potential of digitisation. Researchers and innovators need open digital innovation⁸ ecosystems where they can experiment, trial and evaluate healthcare technologies across the continuum of TRLs and in consideration of

We must act quickly as the opportunities to establish the region as global leaders are significant and important

complex social and economic factors. The safe, secure, efficient and continuous integration of technologies into health systems is the critical success factor for digital transformation. Globally, innovators, healthcare funders and providers are recognising that real-world evaluation environments are key to move swiftly from trials to evaluation and on to rapid adoption. ***Institutions and partners that can collaborate to create such ecosystems will build national and global reputation, attract investment from public bodies and industry, attract and retain the best staff, and be the pioneers (rather than followers) in the future of healthcare.***



Figure 3: Healthcare Ecosystem Stakeholder Journeys

⁸ Open Digital Innovation is the intersection of innovation studies, information systems, and data sciences based on the idea that knowledge is widely distributed and where no institution can innovate effectively on their own.

Industry sectors (pharma, medical device providers, mobile application providers, analytics providers, software vendors, etc.), service providers, academics and policy makers all need to explore technologies and impacts within the context of care pathways and cohorts of citizens, patients and clinicians. Specific stakeholder journeys are required that clearly communicate how to engage and get involved, whilst public and patient involvement throughout all stages will be critical for trust.

Nowhere has this been “cracked”, but within the UK and globally a small number of higher education institutions and health systems are beginning to put down the foundations through innovation hubs for healthcare transformation. Government funding is increasingly based on a hub-and-spoke model. For example, NHS Global Digital Exemplars received £10m in funding and their associated fast followers £5m. Another example is the pathology and radiology AI centres that received £50m and now have a closed competition for further funding to work with others. Evidence demonstrates that the region has yet to establish itself as a player in the health data research landscape ^[xviii, xix, xx]. Other innovation initiatives have emerged such as DRIVE at Great Ormond Street, the Innovation Hub in Coventry focusing on Population Health Management and AI, Oxford Big Data Institute, HDR UK players and emerging data hubs.

Recent important regional proposals such as the Biomedical Informatics Centre and Innovation Space and HDR-UK Digital Innovation Hub were not supported by all necessary investors. In addition, a critical University of Southampton asset, ADRC England, lost funding in 2018, the only national Centre to do so. The use of ARDC Wales in Swansea by Edinburgh’s winning HDRUK Respiratory Digital Innovation Hub is an example of the importance of research infrastructure and innovation environments for attracting investment from both public and private sources. ***If we do not act quickly through coordinated action, we will struggle to establish innovation hubs and at best we will become a “follower spoke” on someone else’s wheel.***

A step change in strategy, action and commitment is needed to move the region beyond our competitors in ways that create a compelling shared vision for digital transformation and implements this by building on regional strengths and existing investments. The recent focus on data-driven healthcare is important, but it does not address the critical aspect of inherent localisation in health and social care systems. Health and social care systems exist in physical space with each healthcare institution (processes, resources, policies, etc.) and region (population, socio-economic, environment, etc.) having unique properties. The localisation (process, culture, etc.) of solutions are a considerable barrier to adoption within clinical and social settings, especially with care settings to grow beyond traditional hospitals. The recent launch of HDR-UK “data hubs” with the shift from their previous name of digital innovation hubs can be considered recognition that data does not equate to digital. This is important as our step change goes beyond what has currently been funded.

HDR-UK has recently shifted emphasis away from digital innovation hubs to simple data hubs. Data does not mean digital, it seems. Instead, digital is fundamentally about creating virtual representations of physical systems to support both human and machine agency in health and social care. Digital encompasses the full continuum of edge devices offering sensing (i.e. medical devices, wearables, IoT, etc.) and actuation (i.e. robotics), processing and communications infrastructure, and platforms with business processes and decision guidance including discovery, visualisation and business intelligence. Digital has data at the core but unless data is integrated into socio-technical systems including their physical and socio-economic environments the translation into practice will be considerably inhibited and restricted.

We therefore conclude that prospective innovators seeking to change and improve healthcare systems must be offered an open digital innovation ecosystem that includes physical “places of care” where healthcare technologies can be designed, implemented, integrated, tested and evaluated to build real-world evidence in context. The ecosystem must be localised in physical space but supported by replication processes allowing generalisation, portability and scaling to different places of care.

Approach

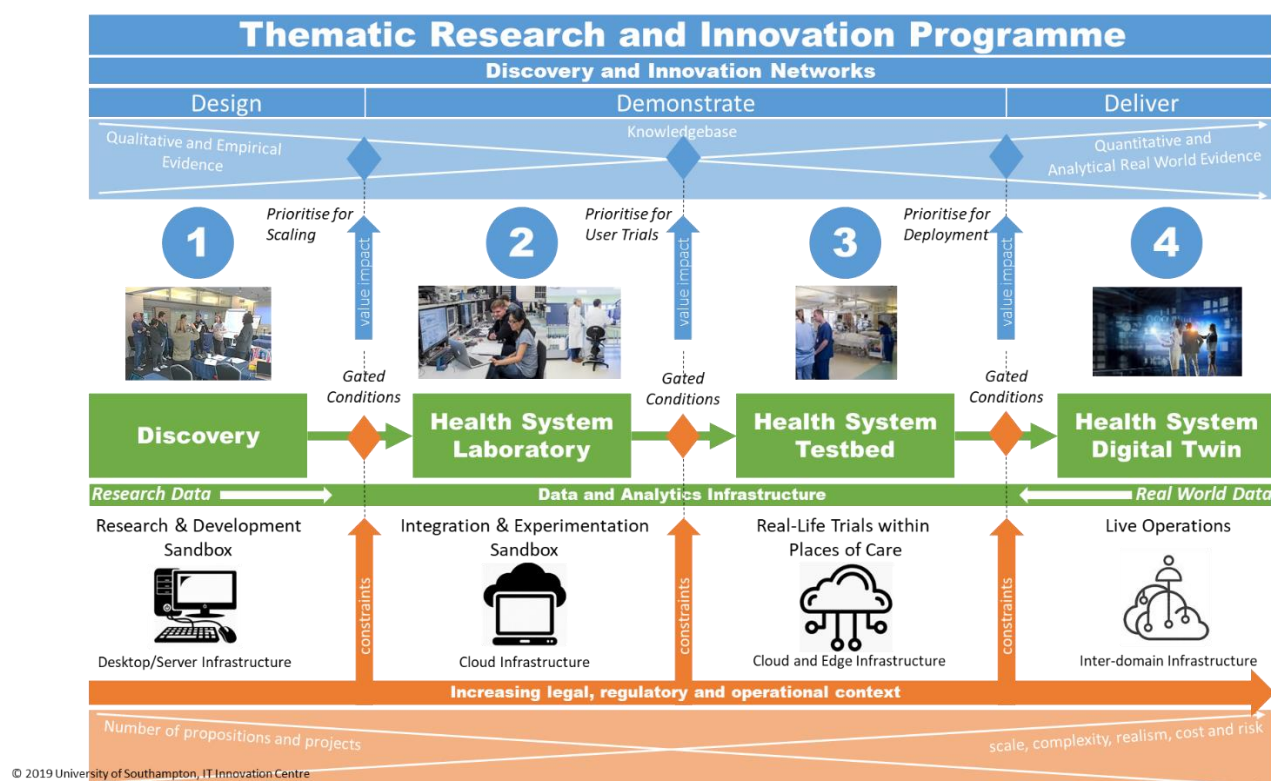


Figure 4: CIDHR Discovery and Innovation Pipeline

CIDHR aims to establish an open digital innovation ecosystem for the transformation of health and social care where innovators in academia, industry and health and social care can work together to change healthcare for the better. Through acceleration methodologies supported by state-of-the-art infrastructures, discovery and innovation pipelines, advanced trials platforms, and efficient data and intellectual property governance procedures, CIDHR will allow clinicians, industry, SMEs, and academics to co-create digital transformation from desktop discovery through to laboratory and real-life healthcare testbeds. CIDHR will ensure the region is a trailblazer offering best practice for sustainability, governance, citizen/patient/clinician engagement models, and platform/infrastructure standards and specifications that is replicated nationally and internationally. In summary the CIDHR goals are to:

- Establish the region as a global leader in **accelerated digital transformation** of health and social care for the benefit of everyone
- Establish a **process of replication** that allows the ecosystem to be extended towards different localised care settings regionally, nationally and internationally
- Facilitate **world-leading interdisciplinary teams** drawing on expertise from clinical informatics, social sciences, artificial intelligence, devices and human computer interaction in academic, industrial and public sector
- Design considering **human-centric principles** for digital transformation and its adoption
- Operate with the **highest standards of ethics**, integrity, transparency and governance
- Champion the ecosystem through marketing and influential internal and external **advocates within academia, government and industry**
- **Sustain the ecosystem** through a combination of public and private funding underwritten by institutional investment.

The ecosystem will be constructed through a series of incremental and connected co-creation spaces that allows researchers and innovators to build evidence for efficacy, performance, viability and acceptability through increasingly realistic operational contexts. The clinical interaction is arguably the most important element as the analytic potential will be a by-product of systems that are interconnected, fit for purpose and well used. Digital discovery (Stage 1) and subsequent stages should be informed and guided by clinicians and intelligence (Stage 4). Although the diagram shows a pipeline, there are networks of data-driven interdependencies each stage and between stages representing increasing levels of complexity. The feedback and connection between Stages creates a circular and often non-linear process, although stages are needed to manage risks. The discovery and innovation pipeline will consider virtual and physical infrastructure and governance needed to translate small scale ideas from an innovator's desktop through to adoption in healthcare systems via distinct stages. Each stage has digitally represented systems, repositories of knowledge and data, along with optimally dimensioned resource constraints (i.e. cost control) and governance frameworks (i.e. ethical constraints, risk assessment) that allows tests to be conducted and evidence to be obtained necessary to continue to subsequent stages through gated conditions. Each stage will be supported by methodologies (co-creation, design in theory vs design in practice, etc.) and tools appropriate to experiment and study design. The ecosystem will be operated on the principles of open digital innovation with non-linear design and evaluation processes which dynamically integrate or split different ideas, tools, or actors and where there is no single innovator.

Stage 1 starts with a "Discovery" where multi-disciplinary teams use analogue (white board, paper prototypes) and digital mediums (dataset exploration, small models, digital prototyping, etc) to explore, design, validate initial assumptions along with the development and testing of code. The infrastructure in Stage 1 involves real and virtual meeting rooms and individual developer machines. Stage 2 "Health System Laboratory" is primarily a clone of component parts of a health system to support technology integration, functional testing and some performance tests. Laboratories may be technology specific supporting experiments related to data, devices and human computer interaction. Stage 2 will include tools supporting emulation and simulation of behaviour including service demand, and pseudonymisation of datasets acquired from real systems in addition to synthetic data where needed. Stage 2 includes no real-life citizens or patients but may involve other end-users (i.e. clinicians and managers) in the evaluation of Quality of Experience. Stage 2 infrastructure would be scaled beyond an individual desktop allowing larger and more representative datasets to be considered and for integration of critical systems components. Reconfigurable design spaces may also form part of stage 2. Stage 3 "Health System Testbed" would deploy and evaluate the systems within real-life places of care under controlled conditions and based upon traditional PPI principles. Stage 3 offers a fully functional system including live data and real users for qualitative and quantitative acceptance, adoption, feasibility and performance tests. The testbed will constrain resources to a specific experiment or trial and would incorporate privacy mechanisms for the pseudonymisation of data if needed. Stage 3 may consider both backend and frontline situations. Backend would consider technical testing for systems integration prior to digital twin whereby frontline would involve dedicated spaces representative of care situations such as emergency department, acute care ward, care home or home care. The provision of places of care along with digital systems allows for real-life trials to consider distinct experience to be enhanced along with providing temporal and spatial constraints associated with the activity location, social-cultural constraints with users, and local infrastructure constraints. Stage 4 "Health System Digital Twin" offers a long-term vision of virtual near real-time digital (computer) models of healthcare systems including physical assets, processes, and people^[xxi,xxii]. Digital Twins are created through connected devices, IoT and ML/AI that allows clinicians and managers to understand, plan, predict, and optimise use of assets. Stage 4 is a source of real-world data providing periodic historical datasets for earlier pipeline stages, whilst offering live APIs for the purpose AI/ML shadow trials.

CIDHR will be governed through the principles and values of open digital innovation, ethics, integrity and fairness in full consideration of digital inclusion (i.e. literacy and innovation opportunities), social inclusion, and gender equality, whilst considering incentive structures supporting multidisciplinary and multi-

motivational teams. Patient and Public Involvement (PPI) will be considered throughout all stages of the pipeline. Public as well as data subject (patient) and beneficiary (clinician and researcher) trust is important and much of the research around the use of patient data indicates that people accept use if it's transparent, secure and not linked primarily to industry and organisational profit. As such, CIDHR will consider the relationship between resourcing and public trust through clear value propositions, distribution of risk and benefits within the ecosystem and what happens with the value that is created. This is especially important when considering a global leadership positioning. Therefore, CIDHR will be developing/co-creating new directions and purposes of investigation and potentially markets from data, innovation development and real-world application across research, industry and implementation support. This takes CIDHR beyond just supporting others to answer their questions towards being a driver and developer of innovation and joint value creation.

Built initially on existing institutional and regional investments (cash and in kind) from the regional coalition, CIDHR will establish a coherent ecosystem thereby overcoming the current fragmentation in digitisation research, innovation and governance. This will also involve engaging key stakeholders in to establish a thematic programme based on current projects. Our vision depends on the region which is ideally positioned in terms of resources, people and networks to drive the digital transformation of healthcare. With institutional buy-in, there's no doubt that the region can become a nationally and internationally recognised trailblazer, attracting investment and building the partnerships necessary to deliver enhancements to public health and to the sustainability of the health and social care system.

ⁱ An Investing Megatrend: How Demographics and Social Changes are Shaping the Future, <https://www.visualcapitalist.com/investing-megatrend-how-demographics-social-changes-shape-the-future/>

ⁱⁱ Life sciences: industrial strategy: <https://www.gov.uk/government/publications/life-sciences-industrial-strategy>

ⁱⁱⁱ Tech Nation 2018 report: UK tech expanding faster than the rest of the economy: <https://www.information-age.com/tech-nation-2018-report-uk-tech-faster-economy-123471982/>

^{iv} Connection and collaboration: powering UK tech and driving the economy: <https://35z8e83m1ih83drye280o9d1-wpengine.netdna-ssl.com/wp-content/uploads/2018/05/Tech-Nation-Report-2018-WEB-180514.pdf>

^v Growing the Artificial Intelligence Industry in the UK:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652097/Growing_the_artificial_intelligence_industry_in_the_UK.pdf

^{vi} "Thinking on its own: AI in the NHS" - <https://www.wiltonpark.org.uk/wp-content/uploads/Thinking-on-its-own-AI-in-the-NHS.pdf>

^{vii} Hampshire and IoW Health & Care System STP Delivery Plan" - <https://www.hampshireccg.nhs.uk/download.cfm?doc=docm93jjm4n593.pdf&ver=813>

^{viii} Sizing the prize: "What's the real value of AI for your business and how can you capitalise?", PWC <https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf>

^{ix} Untapped potential: Investing in health and care data analytics <https://www.health.org.uk/sites/default/files/upload/publications/2019/Untapped%20potential.pdf>

^x EDGE Clinical Trials Platform, <https://edgeclinical.com/>

^{xi} LifeGuide Platform <https://www.lifeguideonline.org/>

^{xii} FLAME Platform <https://www.ict-flame.eu/>

^{xiii} EXPERIMEDIA <https://sportperformancecentres.org/sites/default/files/Michael%20Boniface-EXPERIMEDIA-ASPC-2015-v1.0.pdf>

^{xiv} FED4FIRE <https://www.fed4fire.eu/>

^{xv} DataPitch <https://datapitch.eu/>

^{xvi} Data Market Services <https://www.datamarketservices.eu/>

^{xvii} <https://www.southampton.ac.uk/news/2019/10/hampshirecc-uos-agreement.page>

^{xviii} HDRUK strategy: <https://www.hdruk.ac.uk/wp-content/uploads/2019/04/HDR-UK-One-Institute-Strategy-compressed-1.pdf>

^{xix} HDRUK sites: <https://www.hdruk.ac.uk/news/54-million-funding-to-transform-health-through-data-science/>

^{xx} HDRUK data hubs: <https://www.hdruk.ac.uk/news/pioneering-data-research-centres-to-enable-cutting-edge-research-and-innovation/>

^{xxi} National Infrastructure Commission's (NIC's) National Digital Twin programme, <https://www.nic.org.uk/wp-content/uploads/Data-for-the-Public-Good-NIC-Report.pdf>

^{xxii} <https://www.cdbb.cam.ac.uk/news/dt-hub-blog-vision-national-digital-twin>