

# Improving the health of the public by 2040

**Optimising the research environment  
for a healthier, fairer future**

**September 2016**

The Academy of Medical Sciences is most grateful to Professor Dame Anne Johnson DBE FMedSci and other members of the working group for their contributions and commitment to this project. We thank the Academy's Council members, the external review group, the Academy's staff, workshop attendees, public dialogue participants and all other individuals who contributed to the report.

This report is published by the Academy and has been endorsed by its Officers and Council. Contributions by the working group were made purely in an advisory capacity. Working group members participated as individuals and not as representatives of their affiliated universities, organisations or associations.

All web references were accessed in July 2016.

This work is © The Academy of Medical Sciences and is licensed under Creative Commons Attribution 4.0 International.

# Improving the health of the public by 2040

## Contents

Executive summary .....	4
Recommendations .....	7
1. Introduction .....	11
2. A healthier, fairer future .....	25
3. Optimising research to improve the health of the public .....	55
4. Harnessing the digital revolution .....	65
5. Developing the next generation of researchers and practitioners .....	79
6. Working together to improve health and health equity.....	91
Annex I. Membership of working group, review group and secretariat .....	106
Annex II. Sources of input and contributors to the project .....	108
Annex III. Some recent UK initiatives in public health research .....	111
Annex IV. Previous reviews of UK public health research .....	113
Annex V. Some recent UK initiatives for the strategic coordination of research .....	114
Annex VI. Examples of the impact of population data .....	115
Glossary.....	116

# Executive summary

---

**Over the coming decades, the UK population will face a wide range of complex health challenges and opportunities, many of which can only be fully addressed through strategies to secure and improve the health of the public as a whole. This report explores how to organise our research environment to generate and translate the evidence needed to underpin such strategies.**

## Challenges and opportunities

The environments in which we live are already determining our health in 2040. Health is shaped by a confluence of myriad factors, including the air we breathe, the food we eat, the work we do, the taxes we pay, the places we live, and the people we know. We can anticipate ongoing improvements to the health of the UK public as a result of enhanced knowledge, technological developments, and innovation in health and social care. We can also expect rises in educational attainment, levels of employment and yearly earnings, all of which are likely to contribute to health gains.

Set against this are changes that present grave challenges to our health and to the sustainability of our health and social care systems, both nationally and globally. We face a growing and ageing population with multiple morbidities and more years spent in ill health, resource depletion, persistent inequalities, climate change, a rise in obesity and sedentary behaviour, and emerging and resistant infectious diseases.

Our aspiration for 2040, around a generation's time, is for health gains which significantly exceed those we might expect based on current trajectories; for a future in which the UK population experiences substantial and ongoing improvements in physical health, mental health, health-related quality of life and health equity, and in which the UK contributes to the global endeavour for similar improvements. Through public engagement activities we found widespread support for our assumption that this aspiration is of inherent societal value. To realise this, we must take a much broader view of the drivers of health and the types of evidence we need to intervene – now and in the future – for the promotion of health and the prevention of disease.

## 'Health of the public' research: a new paradigm

Public health research has provided fundamental insights into human health and how it can be improved. It has underpinned many major health achievements, such as identifying smoking as a major cause of cancer and cardiovascular disease. It has also been instrumental in developing the randomised controlled trials that guide the assessment of benefits and harms of a range of interventions, and in establishing epidemiological studies and models to identify social, environmental and genetic determinants of health and health inequalities.

Yet there remains much we do not know about the complex array of interlinking factors that influence the health of the public, and about how to prevent and solve the many health challenges we face as a population, including obesity, diabetes, dementia, depression, cancer and persisting and emerging infections. We do not yet have a robust understanding of the long-term impacts of many of the wider drivers of health that cut across local, national and global environments, from political and economic change to technological development and demographic shifts.

Biomedical research as currently conducted does not have the capacity to address these increasingly diverse and complex issues that transcend disciplinary, sectoral and geographical boundaries. We need to move towards a ‘health of the public’ approach, involving disciplines that would not usually be considered to be within the public health field; an approach integrating aspects of natural, social and health sciences, alongside the arts and humanities, which directly or indirectly influence the health of the public. We must drive forward an ambitious research agenda to realise the aspirations of successive policymakers and leaders of health and social care — aspirations to shift our focus to prevention and early intervention at scale, and to thereby optimise the use of resources.

Adopting a health of the public approach will require six key developments:

### **1. Rebalancing and enhancing the coordination of research**

There have been a number of funding initiatives for health of the public research in recent years, but they have been relatively small-scale and fragmented. We recommend creating a body to enable greater strategic coordination of research funding and delivery. Our proposed UK Strategic Coordinating Body for Health of the Public Research (SCHOPR) will drive population-level questions to be addressed in transdisciplinary ways, at scale, and embrace the range of interventions from the fiscal and legislative to the behavioural and biomedical. It will bring together a broad range of funders, from beyond the traditional biomedical sphere, to identify health of the public research priorities with practitioners and policymakers.

### **2. Harnessing new technologies and the digital revolution**

Novel computational approaches and the ability to link datasets across environments have the power to transform our understanding of the full spectrum of health determinants and to catalyse the adoption of new methods for evaluating the health impacts of individual- and population-level interventions. Innovative technologies, from sensors to wearable devices to artificial intelligence, will also present great opportunities to transform the delivery of health and social care, and to help us achieve the shift towards prevention and early intervention. However, we will need access to data generated by a wide range of individuals and public and private organisations if we are to capitalise on the digital revolution for health. It will also require us to collectively address issues associated with data access, ethics, trust, regulation and skills. We therefore call for ongoing efforts by research funders and key stakeholders to stimulate new research programmes and approaches, and to invest in the necessary transdisciplinary training, for the integration, manipulation and analysis of these data within appropriate ethical and regulatory frameworks.

### **3. Developing transdisciplinary research capacity**

The health of the public research leaders of 2040 are in education and training today. This means we must act now to develop a UK-wide transdisciplinary research capacity with a holistic understanding of the wide range of determinants of health, and the skills and approaches necessary to address them. We therefore describe how to reconfigure the current training pathways to provide the workforce we require for the future, through the development of joint modules for undergraduates and postgraduates between public and population health courses and other disciplines relevant to the health of the public.

### **4. Aligning perspectives and approaches**

Better alignment between public health and clinical practice is needed if we are to achieve the necessary shift to prevention. Our health and social care workforce must be equipped to understand the fundamental principles of ‘health of the public’ and the continuum of interventions from population to individual. We set out how to achieve this through changes to training and continuing professional development. Our recommendation on the establishment of regional hubs of engagement will catalyse more structured, long-term and effective connection between practitioners and researchers, and ensure that health and social care is based on best available evidence. We also set out how to support decisions on wider implementation of, or disinvestment in, interventions by recommending that all major policies and programmes which impact health and health equity should have independent effectiveness and economic evaluation built in from the start.

### **5. Working with all sectors of society**

The full societal value of research for the health of the public will not be realised until it is translated into improved health and health equity. This will require iterative and meaningful engagement with all sectors of society, including policymakers, the commercial sector and the public. We must ensure, for instance, that health is considered in all relevant policies through greater engagement of health of the public researchers in policy development and evaluation. Our proposed Health of the Public Policy Fellows, who would be embedded in Government departments to build reciprocal relationships, mutual understanding and long-term networks, will help achieve this aim.

### **6. Engaging globally**

While the focus of this report and our remit is on UK health of the public research, we believe this cannot be seen in isolation. Many of the drivers of our future health are global, and UK-funded research has had major global impact. Our recommendation for strategic coordination of future health of the public research must therefore take a global perspective and include the UK contribution to the challenge of global health sustainability and security.

## **A grand challenge**

Meeting our aspiration is a grand challenge. Securing the health of the public must build on but also go beyond public health as it is currently configured. We challenge all those working in fields that affect human health to come together with the public in pursuit of our aspiration for a future in which the UK experiences substantial, sustainable and ongoing improvements in health and health equity. A future that significantly surpasses current expectations.

# Recommendations

---

## **Recommendation 1**

We recommend the establishment of the UK Strategic Coordinating Body for Health of the Public Research (SCHOPR) to help meet our aspiration of substantially, continually and sustainably improving health and health equity by identifying research needs and coordinating research activities.

(Details of the proposed Coordinating Body can be found on page 58.)

## **Recommendation 2**

We recommend that key public and charitable research funders (such as Research Councils, the National Institute for Health Research and its devolved equivalents, the British Heart Foundation, Cancer Research UK and Wellcome) continue to work with relevant stakeholders (such as the Administrative Data Research Network, the Cabinet Office, NHS Digital, Involve, and the commercial sector) to maximise the potential of data generated within and outside the health system, within appropriate ethical and regulatory frameworks, for health of the public research. This should be linked to existing major health informatics investments such as the Farr Institute of Health Informatics Research.

In particular, we recommend that key research funders support a programme of research to better understand how society can best balance maximising social and health utility from data generated by new digital technologies with safeguarding citizen and commercial privacy.

### **Recommendation 3**

We recommend that higher education institutions and key research funders (such as Research Councils and Wellcome) further enhance training pathways in informatics for health that are open to a wide range of disciplines. The aim should be to build a critical mass of expertise in the UK to process and analyse the full range of available data now and in the future to understand and improve the health of the public.

### **Recommendation 4**

We recommend that higher education institutions:

1. Incorporate opportunities for learning about health in a wide range of disciplines relevant to the health of the public.
2. Incorporate these broader disciplines into public and population health courses.
3. Consider mechanisms for building joint modules between public and population health and these other disciplines to foster transdisciplinary approaches to learning and research.

### **Recommendation 5**

We recommend that, through education and training, health and social care practitioners are:

1. Better equipped with an understanding of the drivers and interventions that affect the health of the public and the relevance to their practice.
2. Able to engage with research, and evaluate and use evidence.

This should be taken forward by the relevant training and regulatory bodies for each of the professions, such as the Faculty of Public Health for public health professionals.

(Specific recommendations for clinicians can be found in Chapter 5.)

### **Recommendation 6**

We recommend that Public Health England, Health Education England and their equivalents in Scotland, Wales and Northern Ireland work with the research community to:

1. Develop regional hubs of engagement between practitioners and researchers to integrate health of the public research and health and social care delivery, building on existing national and regional public health structures, which together can form a UK-wide network.
2. Strengthen the mechanisms for obtaining and providing independent evidence on improving the health of the public, directed at all health and social care practitioners, and for reviewing the uptake of evidence-based practice guidance.

## Recommendation 7

We recommend that each Government department reviews how it obtains evidence and advice on health and health equity, in order to ensure that impact on health and health equity is incorporated in the development of all relevant policies within departments and across Government. These reviews could be led by the departmental Chief Scientific Advisers and supported by the Health of the Public Policy Fellowships we propose in recommendation 9. Working with departmental policymakers, the Fellows would identify evidence requirements and the mechanisms needed for the research community to provide this evidence and advice.

## Recommendation 8

We recommend that all major policies and programmes that address health and health equity, as well as those that affect the key drivers of health and health equity, should have independent effectiveness and economic evaluation of their short-, medium- and long-term impacts built in from the start. This will support decisions on wider investment or disinvestment, as appropriate, to promote optimum resource allocation.

## Recommendation 9

We recommend the development of ‘Health of the Public Policy Fellowships’ to build reciprocal relationships, mutual understanding and long-term networks between researchers and policymakers. These Fellows should be based in the most relevant parts of Government departments.

## Recommendation 10

We recommend that research funders (such as the Medical Research Council, Wellcome, the National Institute for Health Research and its devolved equivalents) consider mechanisms to explore joint working between health of the public researchers and the commercial sector.

## Recommendation 11

We recommend that key public and charitable research funders (such as Research Councils, the National Institute for Health Research and its devolved equivalents, the British Heart Foundation, Cancer Research UK and Wellcome) support research into:

1. Strengthening and developing methods of engagement between researchers and the public.
2. Strengthening and developing methods of communicating health messages that are appropriate to the values, culture and norms of different sectors of society.

In both cases, particular focus should be given to those groups that do not traditionally engage in research and those most at risk of poor health.



# 1. Introduction

---

## 1.1 Health of the public in 2040

**Public health research has formed the basis of many major health achievements, from identifying smoking as a major cause of cancer and cardiovascular disease to developing randomised controlled trials and establishing the epidemiological studies that identify the fundamental determinants of health and health inequalities, whether environmental, socioeconomic, behavioural, biological or otherwise. See Box 1.1.**

The health improvements that we have seen have arisen as much through impact on drivers outside of the traditional health sector – such as cleaner air, better housing and education, and changes to legislation and fiscal policies – as those within, such as vaccination, family planning, antenatal care, screening programmes, comprehensive healthcare, and advances in diagnosis and medical interventions. However, despite overall improvements in health, major inequalities in health outcomes, reflecting social and economic inequalities, persist.

Our lives and health are forever changing, for better or worse, reflecting the constant evolution of our many environments, whether through natural processes or human activity and innovation. In recent years, technological advances, including mobile communications and the internet, have reshaped how we work, learn and interact with one another; our natural and built environments have rapidly evolved. Such drivers, alongside changing patterns of the choices we make within these and other environments, have altered national and global burdens of disease. Such transformations are themselves heavily influenced by political, economic, and social spheres of life. Ultimately, the health consequences of these changes may be positive or negative.

Looking ahead, we will inevitably face many new health challenges and opportunities associated with the fundamental determinants of health. To address these challenges and opportunities, anticipated or otherwise, it is imperative that we have access to, and the ability to interpret and act on, the best possible evidence about the complex web of factors influencing the health of the public. It is crucial that the UK research environment has the right skills, transdisciplinary capacity, infrastructure, methods and networks to support the generation of this evidence and ensure that it is effectively translated into policy, practice, and societal benefit. Generating this evidence requires that action be taken now, to develop the necessary skills and to invest in research that builds upon, but goes well beyond, attempts already made in these areas.

To explore this, the Academy of Medical Sciences launched its 'Health of the public in 2040' project in November 2014, convening a working group of 17 experts from a wide range of areas reflecting the inherent complexity and transdisciplinarity of the task (Annex I). The group's expertise spans public health, urban design, political economy, behaviour change, innovation, informatics and environmental science.

## Box 1.1 Ten great public health achievements in the 20th century\*

- Vaccination.
- Motor vehicle safety.
- Safer workplaces.
- Control of infectious diseases.
- Decline in deaths from coronary heart disease and stroke.
- Safer and healthier foods.
- Healthier mothers and babies.
- Family planning.
- Fluoridation of drinking water.
- Recognition of tobacco use as a health hazard.

\*According to US Centers for Disease Control and Prevention<sup>1</sup>

### **Objectives and scope**

Tasked with developing recommendations regarding how the research environment can best support the health of the UK public by 2040, the working group agreed the terms of reference set out in Box 1.2.

While this report is primarily UK-focused, it also draws on international experience and knowledge, as well as the UK's contribution to global health, recognising that no country exists in isolation, but in an interconnected and interdependent world. It considers the research and mechanisms needed to support decisions about different efforts to reduce health inequalities and improve physical health, mental health and health-related quality of life across the population, but does not offer recommendations about specific interventions. Nor is it within the remit of this report to assess the strengths and weaknesses of current public health systems. This report deals with the full range of disciplines relevant to the population's health, from more distal disciplines such as politics and environmental sciences to more proximal disciplines such as biomedicine and other life sciences.

This report is aimed at research funders, policymakers, researchers at all levels, professional and regulatory bodies, public health service providers, commercial organisations, and the public. It is not limited to those with expertise or specific interest in health-related fields: the health of the public is affected by factors across a very wide range of disciplines and sectors.

## Box 1.2 The project's terms of reference

1. To recommend to relevant decision-makers the requirements for supporting the health of the UK population in 2040 – in terms of research evidence, research capacity, research infrastructure and the mechanisms for translating research into practice.

Specifically, the project considered how to:

- Capitalise on the opportunities created by advances in all areas of science and technology.
  - Bring together and ensure necessary research capacity across the full range of disciplines required to address future challenges.
  - Ensure an appropriate interface between researchers, policymakers and practitioners.
2. In pursuit of this aim, to address the following questions in the context of the future health of the UK population:
    - What are expected to be the main challenges by 2040, and what are the opportunities to address them?
    - What are the research and research infrastructure requirements to address these challenges and realise these opportunities?
    - How can we effectively train and link researchers and practitioners?
    - How can we ensure that the development of public policy and practice is informed by evidence (including from evaluation)?

### ***Conduct of the project***

The project was formally launched with a workshop that brought together a diverse mix of people to explore their aspirations for the population's health and the drivers likely to influence the direction of change over the next 25 years.<sup>2</sup> Building on the findings of the initial workshop and other research conducted by the working group, a call for input was launched, receiving over 50 submissions from a wide range of individuals and organisations. The Academy then hosted seven roundtable discussions to supplement the written input and explore particular topics of interest in greater depth, followed by a workshop to further discuss the working group's vision and provide an opportunity for stakeholders to support the development of recommendations. Throughout the project, the working group's activities were informed by a programme of public dialogue, entitled 'Health, lies and videotape', involving a combination of public health film screenings and discussion workshops. More information on these events and sources of input – including a list of individual and organisational contributors – can be seen in Annex II.

The report has been reviewed by an external panel appointed by the Council of the Academy of Medical Sciences (see Annex I), and approved by the Academy's Council.

### ***Structure of the report***

Following the Executive summary, this report comprises six chapters:

#### **1. Introduction**

This chapter sets out our rationale for undertaking this project, offers an overview of the past achievements of public health research and practice, outlines the current funding landscape for public health research, and summarises key terms.

#### **2. A healthier, fairer future**

Drawing on current forecasts and predictions from different sectors, this chapter summarises the ways in which a range of environments affect our health, how these environments might change over the next 25 years, and the associated evidence gaps to address the opportunities and challenges arising from these changes. This is followed by a description of a future towards which we aspire.

This chapter is therefore notably longer than the others: it provides the evidence base for the remaining chapters.

**3. Optimising research to improve the health of the public**

In light of our understanding of the research landscape and the drivers of health, this chapter explores how health of the public research might be enhanced through improved coordination and a rebalancing of priorities.

**4. Harnessing the digital revolution**

The rapidly increasing volumes of data that will be produced over the coming decades offer profound research opportunities alongside significant risks. This chapter considers how these data can be most appropriately harnessed for health of the public research, and the challenges that will need to be overcome.

**5. Developing the next generation of researchers and practitioners**

As tomorrow's research leaders are today's students, this chapter explores the skills and training the next generation of researchers will need to generate the necessary evidence to meet our aspirational future.

**6. Working together to improve health and health equity**

Achieving substantial and ongoing improvements in health and health equity will require stakeholders from all sectors of society to work together. The final chapter therefore considers how to improve researchers' engagement with practitioners, policymakers, the commercial sector and the public.

## 1.2 Successes and failures, opportunities and challenges

Public health measures have made major contributions to remarkable improvements in our health. Life expectancy at birth for England and Wales increased by around 20 years in the first half of the 20th century and in the last 50 years has increased by a further 10 years for a man and 8 for a woman.<sup>3,4</sup> Improvements in living conditions and large reductions in infant and child mortality were major contributors to this increase in the first half of the 20th century. Over the last 50 years, improvement has been greatest at older ages. The number of people dying from coronary heart disease, for example, in Great Britain more than halved between 1961 and 2009.<sup>5</sup> While improved treatments have had an important role, '*more than half of coronary heart disease mortality decrease between 1981 and 2000 is estimated to be attributable to reductions in major risk factors, principally smoking*'.<sup>6</sup>

Our understanding of health improvement and how to intervene is underpinned by research into the health of the public. This includes measuring changes in disease burden, understanding the drivers and causes of poor health and health inequalities, and undertaking experiments to evaluate the health impacts of a wide range of interventions. It covers the entire gamut of efforts and policies aimed at improving health, as well as interventions implemented without a focus on health but which ultimately affect it. The UK has a strong international reputation in public health research, and has made extensive contributions to this evidence base, nationally and globally (see Box 1.3).<sup>7</sup>

## Box 1.3 Some key successes of UK public health research

- Identifying smoking as a major cause of cancer and cardiovascular disease,<sup>8</sup> and evaluating the impact of resultant policy and legislative changes.<sup>9,10</sup>
- Identifying the developmental origins of health in later life.<sup>11</sup>
- Establishing the efficacy of bed nets on the control of malaria.<sup>12</sup>
- Developing the science of randomised controlled trials, complex interventions, systematic reviews and meta-analysis for evaluating both preventive and treatment interventions (the Cochrane Collaboration, for example).<sup>13,14,15</sup>
- Supporting an unparalleled collection of large-scale population cohort studies which provide a wealth of longitudinal phenotypic, biological and socioeconomic data for studying health, wellbeing and health inequalities throughout the lifecourse and across generations.<sup>16</sup>
- Working with geneticists to understand the role of genomics in health and disease in large population studies (for example, Case Control Consortium) and developing the field of genetic epidemiology.<sup>17</sup>

Despite overall improvements in health, there are major inequalities in health outcomes, reflecting social and economic inequalities. In England, for instance, average life expectancy in the poorest communities is seven years lower than in the wealthiest, and disability-free life expectancy is 17 years lower.<sup>18</sup> There are large systematic differences in health across several social characteristics, including education, occupation, income, wealth, area of residence, gender and ethnicity, all of which are affected by wider contexts, including the social, political, economic and cultural.<sup>19</sup> Health inequalities persist, despite various policies aimed at their reduction.<sup>20</sup>

We can anticipate that in the next 25 years many of the challenges and opportunities currently associated with the wider social, political, economic and cultural drivers of health will continue, alongside new challenges and opportunities. Generating the evidence necessary to act for a healthier, fairer future will require a shift in our approach to undertaking and organising research: an approach cognisant of the breadth and complexity of these drivers. Indeed, public health thinking is rapidly evolving.

Alongside initiatives such as the UN Sustainable Development Goals – which include focuses on health, health inequalities and many of the wider drivers of health<sup>21</sup> – a number of new ideas and concepts are emerging, including ‘fifth wave of public health’, ‘ecological public health’ and ‘planetary health’ (see Box 1.4).

## Box 1.4 Evolving concepts of public health

### **Fifth wave of public health**

The shifts in thinking about public health since it first emerged as a distinct concept during the 19th century has been characterised by Hanlon *et al* as four ‘waves’.<sup>22</sup> In this conceptualisation, the ‘first wave’, grounded in a need to deal with overcrowding, lack of clean water or sanitation, poor nutrition and a poor built environment, was an early attempt to apply science, public governance and political power to tackling issues of public health. These trends were continued in the ‘second wave’, roughly spanning 1890–1950, which saw the emergence of medicine as science. It was as part of this ‘second wave’ that ‘paternalist’ approaches to healthcare also gained precedence, and was institutionalised in the ‘third wave’ through the redesign of social institutions in the early 20th century and the birth of the welfare state. This was followed by the emergence of the ‘fourth wave’ in the 1960s, where the focus shifted to the risk theory of disease and the role played by lifestyle factors, including smoking, diet and physical activity, alongside nascent concerns with social inequalities of health. The recent concept of a ‘fifth wave’ is one defined by a ‘culture of health’, in which the value of health and incentives for healthy behaviour are maximised, healthy choices are promoted by default, and factors that create a culture and environment which promote unhealthy behaviour are minimised.<sup>23</sup>

### **Ecological public health**

The concept of ‘ecological public health’ focuses on the range of different environments through which health is influenced and the complex interactions between them.

Ecological public health thus reframes ill health as the result of a ‘*mismatch of bodies and environment*’, which can be alleviated by addressing a variety of factors across four environmental dimensions: the material dimension, the biological dimension, the cultural dimension and the social dimension.<sup>24</sup>

### **Planetary health**

Planetary health encompasses the interdependence of human health and that of the planet, recognising growing evidence that advances in human health have happened at the expense of exploiting our planet to the extent that support of human health by the environment will become unsustainable. This concept was explored in a joint commission by The Lancet and the Rockefeller Foundation, which defined planetary health as ‘*the health of human civilisation and the state of the natural systems on which it depends*.’<sup>25</sup> The global increase in life expectancy and decrease in poverty and child mortality rates over the past 50 years have coincided with a depletion of the Earth’s natural resources and increasing environmental impacts, including ocean acidification, deforestation, climate change and loss of biodiversity. These trends have led to the suggestion of an approaching ‘*Anthropocene epoch*’, reflecting the alteration of global systems by human impact. Planetary health acknowledges that as our population size and demands on the planet increase, maintaining the health of the planet on which we depend is vital to protecting future human health. It calls for suitable policies to apply interdisciplinary knowledge to strengthen planetary health, by ‘*promoting sustainable and equitable patterns of consumption, reducing population growth and harnessing the power of technology for change*.’<sup>26</sup> Specifically, it highlights failures such as not addressing the social and environmental drivers of ill health and the historical scarcity of transdisciplinary research and funding.

## 1.3 The current research landscape

Here, we briefly outline the current UK public health research landscape from a review commissioned as part of this project.<sup>27</sup>

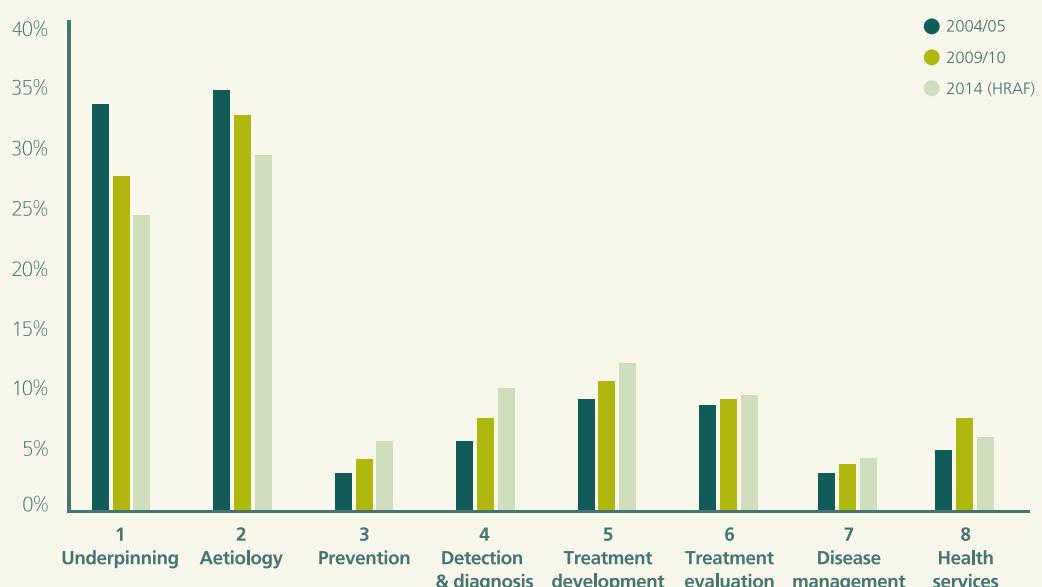
The UK has a very strong and diverse portfolio of high-impact public health research, with a particular strength in large, longitudinal population studies, some of which began decades ago. From 1995 to 2004 the UK had the highest numerical output of publications in public health research of all European countries.<sup>28</sup>

The Research Excellence Framework (REF) 2014 sub-panel report acknowledged that '*the UK is a world leader in the inter-linked and complementary disciplines of public health, health services and primary care research*', noting that a large proportion of research in these areas is conducted by collaborative, multidisciplinary teams. Almost 23% of the research outputs submitted to unit of assessment 2 (public health, health services and primary care) were judged to be of world-leading quality and a further 49% to be internationally excellent. Of the total submissions, 68% were judged to be world-leading in terms of impact.<sup>29</sup> The UK also hosts several globally recognised centres of excellence for public health research.<sup>30</sup>

### Funding

Major UK funders in public health research currently include the Medical Research Council (MRC), the Economic and Social Research Council (ESRC), the Department of Health (DH) via the National Institute for Health Research (NIHR), the Chief Scientist Office in Scotland and their equivalents in Wales and Northern Ireland, Wellcome and other major research charities such as Cancer Research UK. The UK also receives significant funding from non-UK funders such as the European Union, the US National Institutes of Health and the Gates Foundation, particularly for global public health research. From a low base, public investment in these fields, by 12 large funders of public and charitable health research in the UK, has increased in recent years, particularly in prevention research: between 2004 and 2014 spend on prevention research increased threefold from £29.6 million in 2004/05 (in real terms) to £102 million in 2014.<sup>31</sup>

**Figure 1. Health research spend**



Proportion of combined health research analysis spend (real terms) by research activity for 12 Health Research Analysis Forum funders for 2004/05, 2009/10, and 2014.<sup>32</sup>

There have also been a number of initiatives aimed at supporting research and the development of interventions aimed at improving public health. Alongside major continued investments by the MRC, Wellcome and Cancer Research UK (in the UK and overseas), significant capacity and coordinating investments include the following (see Annex III for details):

- The National Prevention Research Initiative (NPRI).
- NIHR's School for Public Health Research (SPHR), Public Health Research Programme, and Collaborations for Leadership in Applied Health Research and Care (CLAHRCs).
- The DH Policy Research Programme.
- The UK Clinical Research Collaboration (UKCRC) Public Health Research Centres of Excellence.

Major investments such as UK Biobank and 34 large UK cohort studies underpin much of our current understanding of the impact of interacting socioeconomic, environmental and biological factors on health. Funders outside of biomedicine such as the Engineering and Physical Sciences Research Council (EPSRC) have also made significant investments and commitments, including to harness the opportunities for health application of new technologies,<sup>33</sup> and with the inclusion of '*improving prevention and public health*' as an ambition in their delivery plan.<sup>34</sup> With regard to international health, the Department for International Development (DFID), Wellcome, the MRC and the NIHR have made significant joint investments in global health trials. In the field of planetary health, Wellcome last year announced its '*Our planet, our health*' initiative (see Annex III).

Despite these positive changes to the public health research landscape, the field continues to receive relatively little investment in the UK, in absolute terms and as compared with other fields of biomedical research: spending on prevention research accounts for just 5.4% of the total public spending on health research (see Figure 1).<sup>35</sup> Successive reports have emphasised the need to shift the balance of funding from treatment of illness to primary prevention,<sup>36,37</sup> requiring not only a shift of resources for service delivery but a concomitant commitment to the associated research and knowledge base. There is also less clarity on funding the costs of public health interventions that are part of research projects, compared to clinical interventions, despite recent publication of information to rectify this issue.<sup>38</sup>

Fields from medical humanities and health-related social sciences that contribute to improvements in the health of the public – social statistics, environmental planning, economics, human geography, law, psychology, ethics, sociology and social policy, to name but a few – also receive relatively little funding compared with the biomedical sciences.<sup>39</sup> Of the research funding spent on understanding causes of disease, only 20% is attributed to studying the environmental, psychological, social and economic factors, while the remaining 80% funds research into biological and endogenous factors.<sup>40</sup> This has led to a number of specific evidence gaps and a lack of research capacity in key areas relevant to the health of the public.

### **Workforce**

Public health research is an interdisciplinary endeavour, as reflected by the variety of disciplines and backgrounds making up the workforce. While it is therefore difficult to estimate the size of the workforce, a recent public health academic review by the Centre for Workforce Intelligence (CfWI) reported approximately 300 public health academics in active practice in England (see Table 1).<sup>41</sup> The CfWI also mapped the core public health workforce in Scotland where, looking at a wider range of academic roles, it identified at least 360 public health academics.<sup>42</sup> However, these approximations are likely to underestimate those engaged in relevant work: there will be many more working in public health research outside these settings.

## Table 1. Summary of the public health workforce in England: academics and scientists

Role	Summary description	Estimated numbers (headcount)
Public health academics	<p>Lecturers, researchers and teachers employed in higher or further education sectors, whose primary focus is public health.</p> <p>May also be consultants/specialists, most likely regulated by the General Medical Council or the UK Public Health Register.</p>	<p>200–300.</p> <p>Numbers primarily relate to senior academics based at universities with medical and dental schools; therefore actual numbers may be higher.</p> <p>Source: Medical and Dental Schools Council; Faculty of Public Health.</p>
Public health scientists	<p>Generally employed by Public Health England (PHE) or the NHS.</p> <p>Perform scientific roles in support of public health objectives, at all grades.</p> <p>May be regulated by the Health and Care Professions Council depending on scientific speciality and protected title (Biomedical or Clinical Scientist).</p>	<p>1,500–2,500.</p> <p>Numbers based primarily on staff working previously for the Health Protection Agency and currently working within Public Health England; numbers may therefore be higher.</p> <p>Source: Health and Social Care Information Centre and PHE.</p>

Source: CfWI (2014) N.B. figures for public health academics in medicine include only professors and lecturers.<sup>43</sup>

This is reinforced by data from the REF 2014, which highlights that submissions to unit of assessment 2 (public health, health services and primary care) included over 1,350 full-time equivalent staff (an increase of 13% since the 2008 Research Assessment Exercise), with 1,678 doctoral degrees awarded between 2008 and 2013. However, other data show that the number of clinical academics in medical schools working in public health decreased by 20% between 2000 and 2013, while the number of clinical academic lecturers in public health decreased by 71%.<sup>44</sup>

### **Coordination**

For many years, reviews have highlighted the need for improved coordination of UK health research, including in clinical and public health research, a theme reinforced by the evidence received by the working group (see Annex IV). In response, several coordinating bodies have been established. Partnership organisations such as the Office for Strategic Coordination of Health Research (OSCHR), the UKCRC and the National Cancer Research Institute (NCRI) have made progress in providing the UK with a more strategic approach to health research, most particularly in funding opportunities, with cross-committee membership ensuring some consistency between initiatives (see Annex V).

These structures, however, have largely focused on delivery of clinical research and have not benefited from an overarching strategic perspective for the health of the public. Funding agencies have taken some steps towards a more holistic approach, with, for example, the establishment of Health Protection Research Units (HPRUs) in some higher education institutions (research partnerships between universities and PHE),<sup>45</sup> the development of CLAHRCs in some areas of the UK (whose remit includes public health),<sup>46</sup> and the creation of the Scottish Collaboration for Public Health Research and Policy.<sup>47</sup> But there remains no overarching strategic view of research in the context of the health of the public.

## 1.4 Summary of key terms

We outline here several of the key terms used in this report. A full list can be seen in the glossary on page 116.

### **Health**

Throughout the report we consider 'health' to include mental health, physical health and health-related quality of life.

### **Health of the public research**

Health of the public research is transdisciplinary: it works across traditional discipline boundaries, integrating aspects of natural, social and health sciences, as well as the arts and humanities, which directly or indirectly influence the health of the public. We favour the use of this term in the report, over public health and population health research, as it includes disciplines that would not usually be considered to be within the public health field but which ultimately shape population health.

### **Health inequalities**

In common with many authors, we use the term health inequalities to refer to:

*'Unfair and avoidable differences in people's health across social groups and between different population groups...unfair because these health inequalities do not occur randomly or by chance, but are socially determined by circumstances largely beyond an individual's control. These circumstances disadvantage some people and limit their chance to live a longer, healthier life. Health inequalities are avoidable because they are rooted in political and social decisions. There was a substantial narrowing of health inequalities in the UK and USA between the 1920s and 1970s, the period in which welfare states were constructed and income inequalities declined'<sup>48</sup>*

### **Intervention**

We use the term intervention throughout the report to refer to any effort or strategy aimed at improving the health of the public and/or reducing health inequalities. Interventions may include any combination of policies, campaigns or changes to our environments.



## References

1. Centres for Disease Control and Prevention (2013). *Ten great public health achievements in the 20th Century.* <http://www.cdc.gov/about/history/tengpha.htm>
2. Academy of Medical Sciences (2014). *Workshop report: aspirations and drivers of change.* <http://www.acmedsci.ac.uk/download.php?f=file&i=30963>
3. Longevity Science Advisory Panel (2013). *Life expectancy: past and future variations by gender in England and Wales.* 8-10 [http://www.longevitypanel.co.uk/\\_files/life-expectancy-by-gender.pdf](http://www.longevitypanel.co.uk/_files/life-expectancy-by-gender.pdf)
4. Office for National Statistics (2010). *Mortality in England and Wales: average life span.* <http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/mortalityinenglandandwales/2012-12-17>
5. British Heart Foundation (2011). *Trends in coronary heart disease 1961-2011.* 11-30 <https://www.bhf.org.uk/publications/statistics/trends-in-coronary-heart-disease-1961-2011>
6. Unal B, Critchley JA, Capewell S (2004). *Explaining the decline in coronary heart disease mortality in England and Wales between 1981 and 2000.* Circulation **109**, 1101-1107.
7. Gray S, et al. (2006). *Public health in the UK: success or failure?* Journal of the Royal Society of Medicine **99(3)**, 107-111.
8. Doll R & Hill AB (1950). *Smoking and carcinoma of the lung.* BMJ **2(4682)**, 739-748.
9. Pell JP, et al. (2008). *Smoke-free legislation and hospitalisations for acute coronary syndrome.* New England Journal of Medicine **359**, 482-491.
10. Levy DT, Chaloupka F & Gitchell J (2004). *The effects of tobacco control policies on smoking rates: a tobacco control scorecard.* Journal of Public Health Management **10(4)**, 338-353.
11. Barker DJ (1997). *Maternal nutrition, fetal nutrition and disease in later life.* Nutrition **9**, 807-813.
12. Alonso PL, et al. (1991). *The effect of insecticide-treated bed nets on mortality of Gambian children.* The Lancet **337(8756)**, 1499-14502.
13. Stolberg HO, Norman G & Trop I (2004). *Randomised controlled trials.* American Journal of Roentgenology **183**, 1539-1544.
14. Chalmers I, Dickersin K, Chalmers TC (1992). *Getting to grips with Archie Cochrane's agenda.* BMJ **305**, 786.
15. Bhatt A (2010). *Evolution of Clinical Research: A History Before and Beyond James Lind.* Perspectives in Clinical Research **1(1)**, 6-10.
16. <https://www.mrc.ac.uk/research/facilities/cohort-directory>
17. Wellcome Trust Case Control Consortium (2007). *Genome-wide association study of 14,000 cases of seven common diseases and 3,000 shared controls.* Nature **447(7145)**, 661-678.
18. The Marmot Review (2010). *Fair society, healthy lives.* <http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review>
19. World Health Organization Commission on Social Determinants of Health (2008). *Closing the gap in a generation: health equity through action on the social determinants of health.* [http://www.who.int/social\\_determinants/thecommission/finalreport/en/](http://www.who.int/social_determinants/thecommission/finalreport/en/)
20. Newton JN, et al. (2015). *Changes in health in England, with analysis by English regions and areas of deprivation, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013.* The Lancet **386(10010)**, 2257-2274.
21. <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>
22. Hanlon P, et al. (2011). *Making the case for a 'fifth wave' in public health.* Public Health **125(1)**, 30-36.
23. Davies SC, et al. (2014). *For debate: a new wave in public health improvement.* The Lancet **384(9957)**, 1889-1995.

24. Lang T & Rayner G (2012). *Ecological public health: the 21st century's big idea?* BMJ **345**, e5466.
25. Horton R & Lo S (2015). *Planetary health: a new science for exceptional action.* The Lancet **386**, 1921-1922.
26. The Lancet (2015). *Planetary health: a new science for exceptional action* [http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736\(15\)61038-8.pdf](http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(15)61038-8.pdf)
27. Norman Freshney Consulting (2016). *UK research landscape for population health research and public health practice* <http://www.acmedsci.ac.uk/phlandscapemapping>
28. *Ibid.*
29. Research Excellence Framework 2014 (2015). *Overview report by main panel A and sub-panels 1 to 6.* <http://www.ref.ac.uk/media/ref/content/expanel/member/Main%20Panel%20A%20overview%20report.pdf>
30. Norman Freshney Consulting (2016). *UK research landscape for population health research and public health practice.* <http://www.acmedsci.ac.uk/phlandscapemapping>
31. *Ibid.*
32. UK Clinical Research Collaboration (2015). *UK health research analysis 2014.* <http://www.hrcsonline.net/pages/uk-health-research-analysis-2014>
33. <https://www.epsrc.ac.uk/research/ourportfolio/themes/healthcaretechnologies/>
34. Engineering and Physical Sciences Research Council (2016). *EPSRC Delivery Plan 2016/17-2019/20. Science for a successful nation.* <https://www.epsrc.ac.uk/newsevents/pubs/epsrc-delivery-plan-2016-17-2019-20/>
35. Norman Freshney Consulting (2016). *UK research landscape for population health research and public health practice.* <http://www.acmedsci.ac.uk/phlandscapemapping>
36. Wanless D (2004). *Securing good health for the whole population.* [http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/D/3/Wanless04\\_summary.pdf](http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/D/3/Wanless04_summary.pdf)
37. NHS England (2014). *Five Year Forward View.* <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
38. The Association of Directors of Public Health (2016). *Position statement: funding costs of public health interventions which are part of research projects.* <http://www.adph.org.uk/wp-content/uploads/2016/05/ADPH-position-statement-on-excess-treatment-costs.pdf>
39. <http://www.acmedsci.ac.uk/mhssreport>
40. Norman Freshney Consulting (2016). *UK research landscape for population health research and public health practice.* <http://www.acmedsci.ac.uk/phlandscapemapping>
41. Centre for Workforce Intelligence (2015). *Mapping the core public health workforce.* <http://www.cfwi.org.uk/our-work/public-health/mapping-the-core-public-health-workforce>
42. NHS Health Scotland (2015). *Mapping the core public health workforce in Scotland.* <http://www.healthscotland.com/documents/25602.aspx>
43. Norman Freshney Consulting (2016). *UK research landscape for population health research and public health practice.* <http://www.acmedsci.ac.uk/phlandscapemapping>
44. *Ibid.*
45. <http://www.nihr.ac.uk/funding/health-protection-research-units.htm>
46. <http://www.nihr.ac.uk/about/collaborations-for-leadership-in-applied-health-research-and-care.htm>
47. <http://www.scphrp.ac.uk/>
48. <http://www.healthscotland.com/equalities/health-inequalities/index.aspx>



## 2. A healthier, fairer future

---

We aspire to a future with substantial and ongoing improvements in health equity, mental health, physical health and health-related quality of life across the UK population, far beyond levels we might expect based on current trends. Achieving this will require a transdisciplinary research environment which appreciates and responds to the full range of factors that drive the health of the public.



## Introduction

To determine the research requirements for improving the health of the UK public by 2040, we sought to describe a probable future, drawing on current trajectories, to compare with our vision of an aspirational, preferable future. Using forecasts and predictions from different sectors, we explored factors with known and possible influence on the health of the public over the coming decades, as well as associated uncertainties, and categorised them under eight ‘environments’ and two cross-cutting themes.

Sections 2.1 to 2.10 describe how each of these environments and cross-cutting themes affect health, how they are likely to change over the next 25 years, and the gaps in our knowledge to address the opportunities and challenges that arise from these changes. Responding to these drivers and uncertainties, we outline our vision for the health of the public in 2040 in section 2.11.

We recognise that this is not an exhaustive overview of the drivers of health of the public, and that environments overlap and interact in myriad complex ways. These exercises are necessarily limited and bound by current context and understanding. It is therefore difficult to anticipate the exact nature of major shocks, policy changes and unexpected events that could drastically alter any forecast for better or worse. We conducted this exercise not in an attempt to predict the future but to identify the research needed to help direct ourselves towards a healthier, fairer, more desirable future.



### 2.1 The natural and built environment

Many aspects of our physical surroundings, whether natural or built, contribute to our health. For example, ambient air pollution caused an estimated 3.7 million premature deaths worldwide in 2012.<sup>49</sup> In the UK, around 40,000 deaths each year have been attributed to exposure to outdoor air pollution, which has been linked to cancer, asthma, stroke and heart disease, diabetes, obesity, and changes linked to dementia. The associated costs add up to more than £20 billion every year in the UK.<sup>50</sup>

Other drivers identified within this environment include climate change,<sup>51</sup> access to green space,<sup>52</sup> chemical and other pollutants,<sup>53</sup> water quality,<sup>54</sup> urban population growth,<sup>55</sup> urban design,<sup>56</sup> housing quality,<sup>57</sup> transportation systems,<sup>58</sup> communications infrastructure<sup>59</sup> and the extent to which the built environment promotes or discourages health-related behaviours.<sup>60</sup>

#### **Climate change**

The 2015 Lancet Commission on Health and Climate Change argues that, given the potential of climate change to reverse the health gains seen from economic development, and that future projections represent a potentially catastrophic risk to human health, tackling climate change should urgently be seen as the most significant global health opportunity of the 21<sup>st</sup> century.<sup>61</sup> Moreover, many climate change mitigation policies are likely to have immediate and potentially large effects (co-benefits) on population health.<sup>62</sup>

Globally, climate change is expected to directly cause around a quarter of a million additional deaths per year between 2030 and 2050.<sup>63</sup> Its direct effects include increased floods, heat stress, drought, and increased frequency of intense storms. Indirect effects of climate change also threaten population health through adverse changes in air pollution, the spread of disease vectors, food insecurity and under-nutrition, displacement, and mental ill health.<sup>64</sup>

Although trajectories will depend to an extent on mitigation measures, it is expected that the global mean surface temperature will increase by 0.3–0.7°C between 2016 and 2035. According to the InterGovernmental Panel on Climate Change, *‘it is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales’*.<sup>65</sup> Even if fully implemented, current commitments to reduce emissions, such as those made by 195 nations in the 2015 Paris Agreement,<sup>66</sup> will still lead to an estimated 2.7°C increase in global temperatures.<sup>67</sup> In the UK, it is estimated that all areas will warm between now and 2080, with changes in mean summer temperatures of up to 4.2°C in parts of southern England.<sup>68</sup>

The impact of environmental change on global migration is expected to increase in the future, although we do not know whether this will make migration more or less likely. The direct impact of environmentally-driven migration on the UK is therefore uncertain, although the geopolitical effects of either mass migration or ‘trapped populations’ could be significant.<sup>69</sup>

### ***The natural environment***

Natural environments can provide three generic health benefits:<sup>70</sup>

- Direct positive effects for mental and physical health.
- Indirect positive effects by facilitating nature-based activity and social engagement, which positively influence health, and by catalysing the adoption of healthier lifestyles.
- Reducing the incidence of pollution and disease vectors via a variety of purification and control functions, such as local climate regulation and the scavenging of air pollutants.

The term green exercise indicates the synergistic benefits arising from activity in green places,<sup>71</sup> and a dose of nature has been shown to have a positive effect on mental health for a wide range of activities, from walking to gardening, for all age groups, for every habitat, and for the already healthy and the mentally ill.<sup>72</sup> Greener environments may also help reduce social and health inequalities.<sup>73,74</sup>

However, people will only derive the mental or physical health benefits nature provides if they are able to engage with the natural world, either physically or by observation. Such choices are themselves affected by factors including location of dwelling, proximity of and access to nature, and individual choices and environmental behaviours.<sup>75</sup>

Access to nature can vary according to cohort demographics as well as by urban and rural settings. For example, wealthier individuals are able to access certain places more readily because they own a car (it is common for the most biodiverse ecosystems not to be served by public transport).

Natural environments are also a direct source of threats to human health, including infectious agents and vector-borne diseases; physical threats from animals, pollutants or contaminants from industrial plants; and elemental threats through extremes of temperature, extreme weather events or UV radiation.

### ***The built environment***

Worldwide, at present, almost 50% of the urban population reside in relatively small settlements of less than half a million inhabitants, while nearly one in eight live in mega-cities with populations of at least 10 million people. By 2030, 41 such mega-cities are expected to exist.<sup>76</sup> Given rises already occurring and with increased urban wealth discrepancies, homelessness is likely to rise.<sup>77</sup>

Within the UK, current growth rates suggest an additional 5.2 million city dwellers can be expected by 2037, and a further 4.1 million by 2062.<sup>78</sup> To accommodate this growth, the Greater London Authority, for instance, predicts that an extra 1.5 million homes will be needed in London by 2050, with 600 additional schools and a 50% increase in transport capacity required to accommodate the population.<sup>79</sup> It is worth noting, however, that there is likely to be differential ageing between urban and rural areas and uneven distribution of age groups across the UK. Of the 8.4 million population, 197,000 people moved into London and 252,000 moved out in 2013. Those moving in were mostly young adults for work purposes, while families with children, retirees and students moving to universities and colleges were mostly those moving out.<sup>80</sup> The growth of cities is also likely to be uneven, with some places seeing declining populations.<sup>81</sup>

### ***Evidence gaps***

While the likely trajectory of climate change in relation to carbon emissions is well known, we need more evidence on the impact of anticipated consequences of climate change on health and the relationship between planetary and population health. For instance, there are knowledge gaps around the impact on health of environmental adversity, such as repeated flooding; of medium- to long-term shortage of water and food supply; and of changes to pollution patterns in a warming climate. We also need to understand net changes likely to result from climate change, such as a possible reduction in excess winter deaths but an increase in heat stress. And while it is widely acknowledged that effects of climate change are likely to be unequally distributed, the potential patterns of distribution, at both global and national level, are not well understood.

With increasing urbanisation, more evidence is required on the physical designs and policies of cities, in different settings, that bring about health gains. Given many cities suffer from the effects of ageing infrastructure, which are unlikely to be resolved soon, we need a greater understanding of the likely medium-term impact on health.

Location is an important modifier of choice for travel. The average Londoner, for instance, walks 292km a year while the average rural resident in the UK walks 122km.<sup>82</sup> While recent evidence indicates that the physical activity benefits of active travel (walking or cycling) outweigh the harm caused by air pollution in all but the world's most extreme air pollution concentrations,<sup>83</sup> the complexity of factors affecting urban health outcomes needs to be better understood.<sup>84</sup> In this regard, we note that the Lancet Healthy Cities Commission recommends that '*policymakers at national and urban scales would benefit from undertaking a complexity analysis to understand the many overlapping relations affecting urban health outcomes.*'<sup>85</sup> Evidence on health co-benefits of climate mitigation, for instance, needs to be incorporated into future design of cities.

Better evidence in these areas, however, should not be at the expense of generating similar evidence in rural environments; as cities grow, rural communities may become increasingly impoverished and disadvantaged because of the preponderance of an elderly and dependent population.<sup>86</sup>



## 2.2 The demographic, social and cultural environment

Society not only shapes its own health but also that of future generations. Specific drivers in this environment include population growth and population ageing; the culture and religious structure of society; family structures, roles and relations; and societal values, including their divergence and convergence across demographic groups.

The global population is expected to grow significantly over the next 25 years to 8.8 billion by 2040, with the developing world accounting for the majority of population growth. Conversely, some areas of Europe, Japan, China and Latin America are likely to face an ageing and declining population despite recent growth due to immigration.<sup>87</sup> If current trends continue, the UK population will reach 74.3 million by mid-2039 from an estimated 64.6 million in mid-2014, 49% of which is attributable to projected natural increase (more births than deaths) and 51% due to assumed net migration.<sup>88</sup> The current median age of the UK population is 40 years, the highest ever estimated.<sup>89</sup> By mid-2039, 1 in 12 of the population is projected to be aged 80 and over.<sup>90</sup> Changing demography and the prevalence of multiple morbidities in older age will place changing demands on treatment and prevention services (see section 2.6).

Black and minority ethnic communities currently represent 14% of the UK population, a figure that is estimated to increase to 20–30% by 2051. In this time it is expected that ethnic minorities will move out of deprived inner city areas and into suburbs and surrounding towns.<sup>91</sup> The religious profile of the population is changing globally. Over the next four decades, it is estimated that Christians will remain the largest religious group, but Islam will grow faster than any other major religion.<sup>92</sup> In the 2011 Census, the number of people who reported that they did not have a religion reached 14.1 million people, an increase of 6.4 million (from 15% to 25% of the population).<sup>93</sup>

Changes to household structures, including higher separation rates, more single parents, more same-sex partnerships and more cohabitation, are expected to continue. The number of one-person households is expected to grow along with a rise in sole-parent households and the proportion of couples without children.<sup>94</sup> The number of sole-parent households in the UK is expected to increase by 22% by 2030.<sup>95</sup>

### **Evidence gaps**

There are uncertainties about many aspects of demographic change, such as changes over time in the make-up of each generation, the demography of social groups in part through intra and international migration, and how these are likely to influence social structures, population risk and health profiles, and demand for (and types of) health and social care.

We need more evidence on the role of social interactions, customs, values, religion, social cohesion and public participation, and how they contribute to differences in health outcomes. Similarly, there are evidence gaps around the impacts of changing social structures, cultural values and new means of communication on human development and psychological resilience. This includes better measures of ‘wellbeing’ and quality of life. Relationships are another area requiring more evidence. For example, what types of relationships are important to health and when? What determines isolation and loneliness and how can we tackle their health impacts?

The potential of social media, patterns of communication, and public empowerment leading to changes – for better and worse – should be further explored. For instance, an approach to behaviour change might involve community initiatives or social movements such as the emergence of an inclusive healthy eating movement spread via social media. We also need to find effective ways of encouraging public support and demand for changes to environments to make healthier behaviours more likely.



## 2.3 The political, economic and commercial environment

The drivers of health under this environment include the societal impact of national and international fiscal policy; international trade agreements; rates of economic growth; levels of employment, welfare benefit and national debt; prevailing political climate; levels of public trust in authority; approaches to foreign policy (such as isolationism or interventionism); approaches to health and social care policy; investment in education and research infrastructures; interactions between Government and private corporations; and the extent to which we assess, understand and influence the health outcomes of business decisions.<sup>96</sup>

Macroeconomic decisions and trade-offs on factors such as taxation, interest rates, budget deficits, export policies and international trade agreements have a profound impact on health behaviours and social drivers of health, including levels of poverty, unemployment, wages, and the cost of living, as well as social expenditures on cradle-to-grave supports from early childhood development to pensions.<sup>97</sup> Similarly, legislative interventions, such as clean air,<sup>98</sup> seat belt,<sup>99</sup> and smokefree legislation,<sup>100</sup> can have profound impacts on health and will remain mechanisms for interventions in the future.

Real GDP growth is generally associated with higher standards of living,<sup>101</sup> depending, however, on how economic growth is distributed. In recent years, the mean wage of workers has been stagnant, reflecting a decline in construction and manufacturing sectors, superimposed on rebounding rates of activity in financial and services sectors. Much recent growth has been distributed inequitably, giving rise to widening social and income inequality.<sup>102</sup>

Looking to the future, UK GDP is forecast to grow by 2.4% annually until 2020,<sup>103</sup> while the global economy is expected to grow at a rate of around 3% per annum, with a tripling in size predicted by 2050.<sup>104</sup> Further increase in income inequality by 2040 seems likely, potentially fuelling increased socioeconomic inequality and instability.<sup>105</sup> The UK can expect to see greater numbers of children in relative poverty (3.3 million by 2020/21 compared with 2.6 million in 2009/10) while the number of working-age adults in relative poverty is forecast to rise from 5.7 million to 7.5 million. This is likely to lead to increasing health inequality.<sup>106</sup> That said, much uncertainty surrounds the political, economic and commercial environment, particularly in light of disruptive events (such as the UK’s recent decision to leave the European Union).

### **Evidence gaps**

More evidence is needed on how macroeconomic decisions, such as taxes and Government spending, impact on health and health equity and potential ways in which these decisions might be shaped for the benefit of the health of the public.

Evidence is also needed on the influence of UK politics on health, including possible changes in the UK’s international relations through further global integration, departure from the EU, and changes in migration policy, as well as the impact of international trade agreements. Greater evidence is needed on the effectiveness of legislation and regulation.

Finally, there is limited information on how best to address health effects of corporate influence on public policy and of the introduction of new goods and technologies where the impacts on health have not been evaluated.



## 2.4 The digital and technological environment

The past decade has seen rapid development and adoption of technologies that have driven substantial societal change, scientific progress and healthcare improvement. There is greater connectedness between people through social media, greater access to previously inconceivable amounts of information, and greater mobility. The extent of these changes, however, differs across sectors of the population, most notably across age groups. In the biomedical arena, increased computational power is at the heart of advances in many areas such as genome sequencing technology and imaging.

We can expect the technological and digital environment to continue to shape major changes to society, and hence human health, over the next 25 years. For instance, aided by pocket-sized devices with continuously increasing computational power and an abundance of services available online, people's lives in 2040 are likely to be defined and shaped by their connectedness, as well as by the technologies and organisations providing this connectedness.

Indeed, the confluence of a wide range of technological developments – big data, artificial intelligence, the internet of things, wearable devices and other sensors – could not only reshape some of the key determinants of health, but also our understanding of these determinants and the impact of interventions. They can contribute to the realisation of the prevention agenda and to transforming the delivery of health and social care. Box 2.1 provides a brief overview of several emerging technologies and how they might affect human health.

### Box 2.1 Examples of emerging technologies

This box summarises several technologies that could transform our lives. The list is non-exhaustive, omitting many technologies that may also be considered game-changers, such as synthetic biology, geoengineering, virtual reality, and others that may be currently unimaginable.

#### **Additive manufacturing**

Additive manufacturing, or 3D printing, describes processes used to synthesise a three-dimensional object through successive addition of layers of material under computer control. This technology has already been applied to make replacement limbs, jet plane parts<sup>107</sup> and sweets.<sup>108</sup> 3D-printed buildings are likely to become common in the future, with concrete already established as a 3D-printable material.<sup>109</sup> This could vastly reduce construction time and allow much greater variety in building design, potentially generating more nature-inspired and aesthetically-pleasing homes.<sup>110</sup> There is also great potential for this technology to advance the medical industry, in making surgical instruments, implants, 3D matrices for cell culture and potentially whole organs, using cells as the 'ink'.<sup>111</sup>

#### **Artificial intelligence**

Artificial intelligence (AI) is a rapidly advancing field. Present day AI is capable of performing narrow tasks, such as playing chess, and is considered 'weak'. The move towards 'strong AI', capable of outperforming humans at every intellectual task, has transformative implications, including for research and delivery of health and social care.<sup>112,113,114</sup> However, as computers become more involved in healthcare, the extent to which AI should be allowed to make or contribute to decisions is an area of debate.<sup>115</sup> There is also a growing body of research exploring the existential risks associated with AI.<sup>116,117</sup> The field of AI may itself be transformed by the possible development of quantum computing, where data operations are performed using quantum-mechanical phenomena. Such a development could lead to increases in computational power that would far exceed current projections.<sup>118</sup>

### **Autonomous vehicles**

An autonomous vehicle is one capable of sensing its environment and navigating without human input.<sup>119</sup> Autonomy in vehicles has already advanced significantly in the past decade, with autonomous emergency braking and lane-assist technologies, for example.

Fully autonomous transport is likely to be prevalent by 2045.<sup>120</sup> These vehicles could free up to 50 minutes a day for their users,<sup>121</sup> and have the potential to provide huge economic benefit, dramatically increase road safety, reduce pollution and congestion, and increase independency of the elderly and disabled.<sup>122</sup> They are also likely to create an estimated 320,000 additional jobs in the UK by 2030.<sup>123</sup>

### **Bespoke nutrition**

Nutritional supplements intending to provide a ‘nutritionally complete’ meal in the form of powder are becoming more common and advanced.<sup>124,125,126</sup> If such food becomes cheaply available it could help to reduce hunger and malnutrition globally.<sup>127</sup> Combined with the increasing availability of genome sequencing,<sup>128</sup> this industry could develop to provide personalised diets, according to an individual’s genetic background, to improve health and fitness, and potentially to prevent onset of disease.<sup>129</sup> Responses to such a diet could be monitored (through apps and wearable technologies, for example).

### **Digital health technologies**

Digital technologies have the potential to transform the delivery of health and social care, reducing costs, increasing access and improving health outcomes.<sup>130,131</sup> Many technologies sit under the canopy of digital health, including genome sequencing, remote sensing, implantable drug delivery, algorithms that optimise care and identify potential treatments, and the development of new electronic care pathways.<sup>132,133</sup> The Nuffield Trust highlights that important developments can be seen in *‘the increasing intelligence and reach of devices supported by the ‘internet of things’ and sensor technology, which will open up new possibilities for better resource management, patient self-care, improved prevention and remote monitoring.’*<sup>134</sup> The concept of digital health is discussed further on page 32.

### **Internet of things**

Some 20 billion devices are already connected to the internet, and this number is growing rapidly, with predictions that 50 trillion devices could be connected by 2045.<sup>135</sup> This marrying of the physical and virtual worlds is known as the internet of things. According to a report by the UK Government Chief Scientific Adviser, this so-called ‘second digital revolution’ could have significant societal and health implications: *‘In the future we will carry sensors that measure our health and how we move around the environment in which we live. These will help us to socialise and navigate the world in ways that we can barely imagine.’*<sup>136</sup> The internet of things could produce over \$11 trillion per year in economic value by 2025.<sup>137</sup>

### **Robotics**

Unmanned systems, or robotics, are already emerging as useful tools in various aspects of healthcare. This is almost certain to expand,<sup>138</sup> potentially easing the strain on health and social care workers. Future application is likely to include service provision in hospitals,<sup>139,140</sup> enhancing communication to the elderly,<sup>141</sup> remote care,<sup>142</sup> improving prosthetic limb design,<sup>143</sup> robotic therapy for children,<sup>144</sup> movement assistance in paralysis,<sup>145</sup> and microbots for technical use in surgery.<sup>146</sup> By 2040, surgical robots are likely to overtake humans in their ability to respond to fast-moving and microscopic environments.<sup>147</sup> But robotics will not just have profound implications for the delivery of health and social care. Robots are likely to be as prevalent in 2045 as computers are today, and human-robot interaction will become more and more complex. Robots will also increasingly replace people in work, rendering some types of employment obsolete, and can be expected to change the nature of warfare across the globe.<sup>148</sup>

### ***Understanding and improving health***

Large-scale cohort studies have been fundamental to the measurement of the drivers of health, and can now incorporate larger amounts of data on environmental, social, economic, behavioural and other exposures over time, alongside genetic data, biomarkers and health outcomes. This will enable us to better understand the relationship between these external drivers and their impact on biological processes including epigenetic phenomena. In the future, data systems will have the potential to build ever-larger and more powerful electronic cohorts to better understand competing risks and guide interventions along the causal pathway for individuals and populations, allowing the possible convergence of population prevention strategies and personalised medicine. Harnessing the potential of big data for health of the public is discussed further in Chapter 4.

The convergence of digital and genomic advances with health is often described as ‘digital health’ (see Box 2.1).<sup>149</sup> It empowers individuals to manage, track and potentially improve their own and others’ health,<sup>150</sup> and it is likely to become increasingly common. It includes health IT, wearable devices, remote diagnostics, telemedicine and personalised medicine, and is being developed to reduce inefficiencies and improve access to quality healthcare, with apps and social networking providing innovative platforms for this work.<sup>151</sup> The commercial sector is increasingly advancing in this area with initiatives such as Google DeepMind Health<sup>152</sup> and IBM Watson Health.<sup>153</sup>

As a natural extension of online health and social networks, crowdsourcing has become more common: the practice of obtaining participants, services, ideas or content through participation with large groups of people, often via the internet.<sup>154</sup> Crowdsourced studies can be researcher- or participant-organised. Researchers crowdsource from health social networks for traditional studies, for example through PatientsLikeMe<sup>155</sup> and 23andMe,<sup>156</sup> while participants organise their own studies for the purpose of self-experimentation and investigation of shared health concerns, for example through Genomera<sup>157</sup> and DIYgenomics.<sup>158</sup> Although the level of scientific rigour must be taken into account, crowdsourcing has the potential to allow a rapid increase in understanding of disease, with large cohort sizes and rapid data gathering. It also illustrates the potential for technological advances to open up new avenues of dialogue and foster meaningful user engagement and the communication of health messaging.

However, we are only beginning to understand the potential for data available from social media, industry and many non-health areas as sources of information on the health of the public, and as tools for communicating, or mis-communicating, health messages. These are explored further in Chapters 4 and 6, respectively.

### ***Evidence gaps***

There are significant gaps in our knowledge of the potential impact of technology on individuals, populations and on health and social care. For instance, we currently have limited understanding of how technologies are taken up by different age groups and their effects across these groups. It is not clear how individual behaviours are ultimately affected by digital experiences, and we know little about how best to capitalise on digital opportunities to improve health and health equity.

We need more evidence on the potential of integrated data from health and linked records, and the role of digital data outside the formal health system for health intelligence and intervention. These will be key to the practice of personalised medicine and personalised prevention, as well as to understanding the impacts of health systems on the health of the public. More information is required on how best to work with technology and data industries to build effective governance and measures of effectiveness.

We need more evidence on the potential of clinical innovations, such as genomics, gene editing, nanotechnology and infectious disease detection, and our improved understanding of biological processes, to collectively improve the health of the public. More information is also needed on the impact of changes to care and preventive pathways, as well as new models of care such as mobile health, on the health of the public as well as on individual health outcomes. Further evidence gaps regarding innovative methods of care delivery – including remote diagnosis and robotisation – are outlined in section 2.6.



## 2.5 The educational and occupational environment

### ***Education***

Education is a key factor influencing health through the lifecourse,<sup>159,160,161,162</sup> and is a driver of, and potential solution to, both social and health inequality.<sup>163,164</sup> Lifelong learning begins from birth, with the home learning environment and early years education providing foundations for achievement in school and beyond.<sup>165</sup> Learning is also linked with healthy ageing, with evidence that incidence of dementia might be reduced through improved access to education.<sup>166</sup>

Universal, publicly-funded early education has been available since 1998, but has since increased in availability, uptake and quality: in 2015, 96% of three and four year olds attended some form of funded early education. However, children from disadvantaged backgrounds are still entering school less ready to benefit from compulsory education than their more advantaged peers.<sup>167</sup>

Since the late 1990s, the rate of participation in higher education among young people in the UK has increased from 30% to 38%, and this is predicted to remain relatively stable.<sup>168</sup> Estimates in England suggest that young women are at present 22% more likely than young men to progress into higher education.<sup>169</sup> Trends indicate that educational attainment is likely to continue increasing over time.

### ***Occupation***

Work and employment have a significant impact on health and health equity. The factors contributing to poor health include unemployment, income inequalities, poor working conditions, and adverse psychological environments that arise from the changing nature of employment and work and the shifting demands of the labour market. Furthermore, health-adverse employment and working conditions leave people in lower socioeconomic positions at higher risk of experiencing poor health.<sup>170,171,172</sup>

In the UK, increased income inequality is likely to be seen alongside an increase in the rate of employment over the next five years.<sup>173</sup> The nature of employment and work are likely to continue to change with ongoing disruption to existing business models and creation of new markets from global mobility of workers and new technologies. The role of women in the UK labour market will continue to increase, with projections indicating that women will take two-thirds of net growth in higher-skilled jobs over the next ten years; and jobs can be expected to become increasingly time-flexible as we move towards a 24-hour society.<sup>174</sup> Automation of specific tasks and activities is also likely to increase, potentially redefining the vast majority of jobs and occupations.<sup>175</sup> Historically, technological development has led to more long-term employment, but some believe the impact on employment rates may reverse in the future.<sup>176</sup> The health implications of many of these trends are currently uncertain and dependent on the balance of competing factors. Increased employment could yield health benefits, but this is likely to depend on the nature of work and the benefits associated with it.<sup>177</sup> Similarly, changes to the labour market could result in diminished income and job insecurity<sup>178</sup> with associated adverse health impacts, but policy responses, such as an adequate living wage, could ameliorate this.<sup>179</sup>

### ***Evidence gaps***

Although a number of trials of health promotion interventions have taken place in schools, there is less evidence on the general effect on health and health inequalities of different types of education and education policy during school years.

There is limited information on the health impacts of continuing changes to employment levels and practices, or evidence on the effectiveness of interventions to facilitate health-promoting and health-protective work despite evidence gained from natural experiments such as the evaluation of health consequences of the UK's Work Capability Assessment.<sup>180</sup>



## 2.6 The health and social care environment

Provision of comprehensive and high-quality health and social care has clear positive impact on the health of the public. Evidence suggests, however, that the UK system as it is currently organised is unsustainable, particularly in the face of anticipated changes to treatments, technologies, care delivery, funding growth, demography, and patients' needs and preferences.<sup>181</sup> The NHS 'Five Year Forward View' notes that the sustainability of the health system is dependent on a '*radical upgrade in prevention and public health*'.<sup>182</sup>

### **The changing nature of populations and patients**

In the future, more people will be highly educated, which will contribute to further improvements in population health.<sup>183</sup> Patients' preferences are also changing with more people wishing to be better informed and involved with their own care.<sup>184</sup>

Healthy life expectancy has improved in many countries recently but mostly at a slower pace than improvements in total life expectancy. The number of years lived in ill health has therefore also increased: globally, over the past 20 years, each one-year increase in life expectancy at birth has been associated with a 0.8-year increase in healthy life expectancy.<sup>185</sup> In the UK, life expectancy with cognitive impairment has declined over the last two decades but that with physical disability has increased.<sup>186</sup> While many people are staying healthy and independent well into old age, people are progressively likely to live with complex multiple morbidities, disability and frailty as they age.<sup>187</sup> Some of this increasing morbidity, at least for mental health, dementia, vascular disease and cancer, is due to earlier diagnosis. There is also a significant concern about increasing mental health problems, particularly among young people.<sup>188,189</sup>

Long-term health conditions now take 70% of the health service budget,<sup>190</sup> and higher life expectancy is assumed to lead to a greater demand for health services, which is particularly high towards the end of life.<sup>191</sup>

### **Technological and biomedical innovation**

Technological and biomedical developments and innovation have hugely advanced our ability to predict, diagnose and treat diseases, and improvements in medical care have contributed to extensions in life expectancy.<sup>192,193</sup> These improvements are likely to continue, but their effects on population health may be mixed. For example, opportunities for screening and real-time health monitoring are expected to expand, which may help avoid advanced disease and death, but will also increase the number of people with a medical diagnosis requiring support and healthcare. In the future, surgical robots could overtake humans in their ability to respond to fast-moving and microscopic environments, and robots may also be employed for care provision (see Box 2.1). The potential for remote diagnostics and monitoring of new electronic pathways provides significant opportunities for healthcare while also increasing people's access to health information. The potential for greater patient participation in decision-making will change the nature of care delivery (see section 2.4). A wide range of clinical approaches based on new biological understanding, genomics, precision medicine and regenerative medicine are likely to be seen, although their contribution to overall health improvement is uncertain. A major challenge is how they may be most effectively deployed in a health system that not only identifies and reduces competing risks of disease long before the patient reaches the clinic but also ensures consistent implementation of preventive and treatment interventions based on clear evidence of benefit.

### **Funding**

In all, the above trends are likely to produce an upward pressure on health and social care costs. Over the last 50 years, public spending on the NHS has risen from roughly 3.4% of GDP to 8.2%, which is equivalent to seven times more in real terms.<sup>194</sup> Projections for healthcare spending in the UK show a wide range of possible futures, from a quarter of UK wealth in 50 years' time to 7.8–16.6% of GDP in 2061.<sup>195</sup> What is clear, however, is that using current models of health and social care provision, the cost is likely to increase more than available funding. If projected rises in the cost of healthcare and management of multiple morbidities is realised, redressing the balance of expenditure between prevention, treatment and palliation to maximise healthy lifespan and optimise quality of life will become ever more important.

Modelling of known risk factors suggest that greatest health gains will come from preventive interventions across the population, and that such interventions can reach those at highest disease risk who may also be the most difficult to reach with other effective interventions; greater adoption of high-cost individual interventions may not only put pressure on the sustainability of the health and social care system, but widen health inequalities as access and uptake are less likely among the socioeconomically disadvantaged.<sup>196,197,198,199,200,201</sup>

### Evidence gaps

Greater focus on health systems research is needed to design economically and environmentally sustainable and integrated models of health and social care that place a greater focus on prevention and have the capacity to manage multiple morbidities and end-of-life care in an increasingly aged population.<sup>202</sup> To realise the gains to be made from an integrated approach to treatment and prevention, we need to enhance and bring together our understanding of biological, behavioural and social determinants of health at individual and population levels.

We need more information on how to maximise the cost-effectiveness of funding provided to the care system, including a better understanding of the appropriate balance of investment into primary prevention, early detection, and treatment and support of illness and disease. In addition, more evidence is required on how to support the development of innovative methods and approaches such as remote diagnosis and care delivery, robotisation, as well as how to use and scale-up existing applications like smartphones in prevention and care pathways.



## 2.7 The behavioural environment

Non-communicable diseases (NCDs) are the leading causes of death and premature mortality across the globe, and many of these diseases can be prevented by tackling their main behavioural determinants: tobacco consumption, excessive consumption of alcohol, physical inactivity, and unhealthy diet.<sup>203,204,205</sup>

A 30-year cohort study of men that tracked the effect of five ‘positive’ behaviours (non-smoking, acceptable body mass index, high fruit and vegetable consumption, regular physical activity and low-moderate alcohol intake) on health and lifespans showed that those who engaged in four of five of these positive behaviours delayed vascular disease events by up to 12 years and lived up to six years longer.<sup>206</sup> There is also evidence that smoking, obesity and physical activity are strongly associated with the gap in life expectancy between the rich and the poor in the US.<sup>207</sup> See Box 2.2 for more examples of the impact of behavioural risk factors.

If current trends continue, by 2025, global obesity prevalence is expected to reach 18% in men and surpass 21% in women; severe obesity will surpass 6% in men and 9% in women. By 2025, the UK is predicted to have the highest obesity among both men and women in Europe, at 38%.<sup>208</sup> During the next 20 years, modelling suggests that obesity will add an excess of 544,000–668,000 cases of diabetes, 331,000–461,000 of coronary heart disease and strokes, and 87,000–130,000 of cancer in the UK.<sup>209</sup>

### Box 2.2 Impact of behavioural risk factors

- Physical inactivity is responsible for one in six deaths in the UK.<sup>210</sup> A third of men and half of women do not get enough physical activity.<sup>211</sup>
- In 2013, 21% of male deaths and 13% of female deaths were estimated to be attributable to smoking in England.<sup>212</sup>
- In 2014, there were 8,697 alcohol-related deaths registered in the UK. This represents a fall since 2008, but the rate in 2014 is still higher than that observed in 1994.<sup>213</sup>
- There were 3,346 drug poisoning deaths registered in 2014 in England and Wales, the highest since comparable records began in 1993. Of these, 2,248 (or 67%) were drug misuse deaths involving illegal drugs.<sup>214</sup>
- More than 4 in 10 cases of cancer could be prevented by lifestyle changes.<sup>215</sup>
- The incidence of HIV in men who have sex with men remains unchanged and STI rates are increasing, despite the availability of antiretroviral therapy and testing.<sup>216</sup>

### **Evidence gaps**

We have a growing body of evidence on individual behaviours that adversely affect our health, but limited understanding of which aspects of our environments – singly and together – are most important in driving unhealthy behaviours, often without awareness. We know even less about how to create environments – physical, economic, social and digital – to enable healthier behaviours from the early years and allow them to flourish across the lifecourse. In its report on Behaviour Change, the House of Lords Science and Technology Select Committee concludes that while much is understood about human behaviour from basic research, there is relatively little evidence on how this could be applied in practice to change the behaviour of populations. The report recommended that more should be done to improve the evaluation of interventions as it ‘would help to build a body of research that could inform effective policies targeting population-level behaviour change’.<sup>217</sup>



## **2.8 Biology across the lifecourse**

The biological processes that determine health and disease throughout life result from the genetic make-up of individuals and innate characteristics such as sex, as well as from the cumulative impact of a wide range of environmental exposures (such as through social environments, the shaping of our immune response through exposure to infection and vaccination, influences on the microbiome, nutrition and brain development, and the role of epigenetic effects on disease outcomes). Health inequalities may arise due to epigenetic effects in childhood and impact on future health outcomes,<sup>218,219</sup> regardless of immediate changes in health-related behaviours. Undernutrition of the foetus during pregnancy, for example, is an early origin of adult cardiac and metabolic disorders that permanently shape the body’s structure, function and metabolism.<sup>220</sup> Evidence also highlights the importance of early life experiences and social circumstances in shaping later health.<sup>221</sup>

As population exposures change, so will the distribution of biological markers – blood pressure, cholesterol, acquired immunity – in populations. For example, between 2003 and 2013, the proportion of the population with controlled hypertension increased from 6% to 10% among women and 5% to 9% among men.<sup>222</sup> Reduction of salt exposure in diet, on the other hand, has contributed to national reductions in blood pressure profiles.<sup>223</sup>

It follows that changes in environmental and other exposures may have lifelong biological and health impacts on current and future populations. Biology and health of the public are therefore not discrete disciplines, but are part of a continuum in our understanding of diseases, including their causation and how they can be addressed. Understanding the competing and inter-related associations between environmental, genetic and biological factors in disease causation (and therefore its prevention) requires transdisciplinary investigation in very large populations. These in turn provide insights for further investigation of biological mechanisms. The study of genetic and epigenetic association with disease relies on the methods of population sciences from which mechanisms of disease can be studied in the context of populations.

Increasing recognition of the interrelationship between genetics, biology and wider environments can be seen in various emerging concepts, such as ‘precision public health’ and ‘personalised prevention’. Considering biological risk as a function of the combined effects of genetic and wider environmental factors, these concepts broadly seek to improve the health of specific populations by capitalising on advances in technology and genetic understanding for a more delineated view of health over the lifecourse and across communities and environments.<sup>224,225,226</sup>

### **Evidence gaps**

We need to understand further how to most effectively promote lifelong health through investment in early years, including before birth, and to understand the socioeconomic determinants and biological process of ageing across the lifecourse, particularly at key transition points in life – childhood, puberty, starting a family, retirement – to develop effective interventions.

We still have a relatively limited understanding of the drivers of longevity, and how to prevent and limit the impact of multiple morbidities. We need better understanding of how to break the link between disease and disability to ensure that projected increase in life expectancy is through the addition of healthy years. More evidence is also needed to understand how health changes across generations and between populations.

Much of our understanding of the drivers of health and disease in populations comes from large-scale cohort studies, with birth, occupational and disease cohorts all playing crucial roles. Cohort studies using data on the full spectrum of determinants of health and disease – as explored throughout this chapter – alongside genetics, biomarkers, infectious disease exposure and the microbiome will help address gaps in our knowledge outlined above. These studies are expensive, resource intensive and require considerable commitment by participants.<sup>227,228</sup> They are long-term international resources for health and other disciplines, requiring shrewd and imaginative investment to ensure that the future benefits associated with large, integrated and increasingly electronic datasets are realised.



## 2.9 Cross-cutting theme: health inequalities

Health inequalities are found by individual or household measures of socioeconomic status, and by residence in areas of deprivation, which may overlap. Health inequalities can also be seen across other social determinants, including gender and ethnicity.

In England in 2011–2013, men in the most deprived tenth of areas had a life expectancy of 71.4 years, 70.5% of which was spent in good health. Men in the most affluent tenth of areas, on the other hand, had a life expectancy of 83.1 years, 84.9% of which was spent in good health. Similarly, women in the most deprived areas spent 66.2% of their 79.1 years in good health, compared to 82.9% of 86 years in the most affluent areas. But inequality is not just a matter of differences between the top and bottom social groups; there is a steady gradient across all social groups with health and life expectancy becoming progressively better with increasing affluence.<sup>229</sup> See also Box 2.3.

### Box 2.3 Life expectancy in Glasgow

Male life expectancy at birth is 63.7 years in Bridgeton, a deprived area of Glasgow, compared to 78.0 years in Jordanhill, a more affluent area; for females the equivalent difference is 72.1 years versus 83.8 years.<sup>230</sup> Approximately 91% of baby boys in East Dorset and 94% of girls in Purbeck will reach their 65th birthday, if 2010–12 mortality rates persist throughout their lifetime. The comparable figures for Glasgow City are 75% for baby boys and 85% for baby girls.<sup>231</sup>

Inequalities are observable from the beginnings of life, being manifest in rates of low birth weight, infant mortality, and breastfeeding rates. For example, babies born of parents who live in areas of high deprivation are more likely to be of low birthweight compared to babies born of parents who live in areas of average and low deprivation: 8% compared to 5–6% in Scotland in 2010.<sup>232</sup> In 2013, in England and Wales, infant mortality rates were highest for the lowest socioeconomic groups (describing routine and manual occupations) with 5.4 deaths per 1,000 live births. In contrast, there were 2.2 deaths per 1,000 live births for the highest groups (higher managerial, administrative and professional occupations), and 3.2 deaths per 1,000 live births for intermediate occupations.<sup>233</sup> In 2011/12, 15% of mothers in the most deprived areas exclusively breastfed their child for six to eight weeks compared to 40% of mothers in the least deprived areas.<sup>234</sup>

Although there have been overall improvements in many health indicators and in mortality rates, health inequalities remain and have in some cases widened. In England and Wales, for example, the life expectancy gap at birth between the top and bottom social groups was wider in 2007–2011 than in 1982–1986 for both males and females.<sup>235</sup>

Inequalities by income and education are also well documented, and it is generally agreed that the distributions of income, wealth, power, and employment are key drivers of inequalities in health.<sup>236,237</sup> Education, for instance, provides literacy and numeracy, as well as analytical and communication skills,

which increase people's employability and ability to cope with health and other issues. Employment builds on these skills and provides income, which in turn provides access to health-promoting resources, from housing to heating to food.<sup>238</sup>

Although the trend for most health indicators is positive, with a continuing upward trend in life expectancy, there is no evidence that this will lead to a reduction in health inequalities, since more privileged sectors of society are most able to benefit from improvements in social determinants of health and health-related behaviours.

There are some suggestions that information-based approaches, such as nutrition labelling and anti-smoking adverts, can increase inequalities because advantaged groups in society are more likely to take up health promotion advice and change behaviour. Interventions at higher regulatory or environmental levels appear more likely to reduce inequalities in health.<sup>239</sup>

### **Evidence gaps**

Although there is a large body of evidence on the magnitude of health inequalities and likely explanations for their creation and continuance, there is much less evidence on the effectiveness of different interventions to reduce such inequalities.<sup>240</sup> One reason is that the evaluation of health promotion interventions or public health policies often focuses on the effect on the population in general rather than the effect on inequalities. Trials of interventions often have the statistical power only to examine overall effects on the target population, rather than differential effects, and trials with the power to examine such differential effects would need to be considerably larger scale and therefore either much more expensive or sometimes unfeasible.

There is often a lack of willingness on the part of policymakers or public authorities to subject public health policies to systematic evaluation, including their effects on inequalities.<sup>241</sup> More evidence is needed from evaluation of the effects of local and national policies which are likely to affect health and health inequalities, whether by using larger scales and innovative trial designs or by using routine data to monitor natural experiments.<sup>242,243</sup> Evaluation is discussed further in Chapters 3 and 6.



## **2.10 Cross-cutting theme: the global context**

While this report is focused on the UK, many future health challenges will be global in nature – such as climate change, conflicts, the rise of mega-cities, emerging infectious diseases, food and water security, and inequalities in access to health and social care. These challenges will require international responses and a commitment to global partnerships.<sup>244,245</sup> To date, many gains in global life expectancy have been achieved through improved socioeconomic conditions and infectious disease control but now around two-thirds of deaths globally are due to NCDs, with 80% occurring in low and middle income countries.<sup>246</sup> Globally, deaths from NCDs are projected to more than double by 2060 and halve from infectious disease,<sup>247</sup> although we are likely to continue to face challenges from new and emerging infectious diseases. Increasing migration and travel means infectious diseases are able to spread at a faster rate than ever.<sup>248</sup> An influenza pandemic, which tops the UK's National Risk Register, could potentially result in up to 750,000 additional deaths and significant social and economic disruption.<sup>249</sup> Recent outbreaks of Ebola and Zika viruses have highlighted the weaknesses in the global humanitarian and research response.

Antimicrobial resistant (AMR) pathogens could be widespread by 2045,<sup>250</sup> leading to resistance to treatment and potentially increasing global mortality.<sup>251</sup> There is a projected loss of \$10 billion to global GDP from antimicrobial resistance and 10 million deaths per year by 2050.<sup>252</sup> Global health is a particular strength of the UK research community. Positive examples include tackling malaria, HIV and other infectious diseases; vaccine delivery; reducing infant mortality; addressing global mental health; and continuing investment from Research Councils, charities and the DFID, including in large overseas centres and intervention trials.

### Evidence gaps

More evidence is required on interventions to reduce the growing global burden of NCDs, working in equitable partnerships with researchers and practitioners in low- and middle-income countries. The Global Alliance for Chronic Diseases is an example of a consortium of national research agencies working together to prioritise and fund initiatives in this area.<sup>253</sup>

We need evidence on how to increase the number of new antimicrobial agents, reduce levels of resistance, and minimise dependence on antimicrobials in animals and humans. The global profile of AMR has increased substantially in recent years and several streams of work aimed at mitigating this threat are underway.<sup>254,255,256</sup>

As global outbreaks of infectious diseases have demonstrated, more evidence is needed from disaster risk and resilience research so that the UK is highly prepared and can respond rapidly to shocks and disruptive events at a local, regional, national and international level, and contribute to global health security and planetary health. Evidence is also required on how best to develop civic structures that facilitate effective response. We need to better understand, for instance, the drivers and outcomes of community decisions that affect the progression of epidemics.

Furthermore, the UK needs a permanent and flexible workforce that can be rapidly mobilised for research and investigation in an epidemic outbreak, as well as funding mechanisms that can be deployed rapidly to support research on early detection of outbreaks, clinical trials and vaccine development, and rapid epidemiological, anthropological and environmental research.<sup>257</sup> This could build on initiatives such as the NIHR-supported UK Rapid Response Team and PHE's Field Epidemiology Training Programme linked to academic training.<sup>258,259</sup>

## 2.11 A preferable future: our aspiration

This chapter has highlighted significant opportunities for and threats to the population's health by 2040. It is probable that by then our planet will be warmer, our air more polluted and our natural resources more depleted than ever. Our population will be larger, older and more densely concentrated, with increasing social, economic and health inequalities potentially fuelling tension within and across national borders. There is a risk that these changes will offer new opportunities for infectious diseases to thrive, at a time when our arsenal of effective antimicrobials is on the wane and the burden of NCDs is already threatening the sustainability of many of our health and social care systems.

Emerging data, knowledge and technologies offer new opportunities to tackle some of these issues, although they may also introduce new harms and will require global coordination if they are to provide solutions to global problems. Developments in novel treatments and advances in health-related technologies may lead to notable improvements in individual health, although they are unlikely to reduce health inequalities without major political shifts.

We believe that a desirable future for 2040 is one in which people have significantly more equitable opportunities to live longer, healthy lives, and in which health substantially and continually improves across the population. We therefore adopted this as our 'primary aspiration' and developed a vision for how it might be delivered. Specifically, the primary aspiration is supported by five areas in which change is critical: environments, empowerment, values, sustainability and resilience. Beneath the primary aspiration and these five supporting ambitions is one underpinning requirement, describing the need for appropriate research capability, infrastructure, evidence, interventions and people. These are shown in Figure 2.

Throughout our public dialogue activity, we heard widespread support for these aspirations. In general, we also have seen, across various initiatives and reports, a movement towards new measures of societal success and progress, in alignment with the working group's aspiration for a future in which health and health equity are valued more highly across society.<sup>260,261</sup>

## Figure 2. Our vision for 2040

### Primary aspiration

Substantial and ongoing reductions in health inequalities, and improvements in mental health, physical health and health-related quality of life across the UK population.

### Five supporting ambitions



#### Environments

*All elements of the UK environment support healthy living for everybody.*

- Decisions regarding our many environments are guided by a robust understanding of how to most effectively support and improve the health of the public and allow healthy behaviours to flourish.
- A better understanding has been gained of how to create and deliver conditions conducive to improved health equity, and everyone has the opportunity to reach their full potential throughout the lifecourse.



#### Empowerment

*People are empowered to actively contribute to their own and other people's health.*

- The public is meaningfully consulted and engaged in all decisions likely to affect population health, particularly those sectors of society most vulnerable to poor health outcomes.
- Health information is communicated in a way that empowers people to make informed decisions about their health, and everybody receives an education that allows them to access and use this information.
- Patient care is shaped by shared decision-making, in which the views and values of patients and their loved ones are discussed and used to inform treatment.



#### Values

*All sectors of society value health and health equity, and they are indicators of societal success.*

- All parts of government, at all levels, are equipped and incentivised to act in ways that support health and health equity, with all policies having to demonstrate the impact on health.
- The UK health and social care systems support the health of the public and deliver outcomes valued by the population.
- Health is valued by industry, both in its role as an employer and a provider of goods and services.
- Health, health-related quality of life and health equity are consistently and accurately measured, monitored and reported.



#### Sustainability

*Improvements to UK health are gained in ways that are economically, environmentally and socially sustainable.*

- The relationship between planetary and population health is explicitly recognised and reflected in national decision-making, and is supported by a relevant, robust and accessible evidence base.
- Financial and other resources are allocated more proportionately to preventive interventions which have the potential to benefit whole populations, compared with therapeutic interventions which aim to treat specific individuals.
- Economic, environmental and social sustainability are taken into account in the formulation of all relevant policies.



#### Resilience

*The UK has developed resilience to potential health crises and is a major contributor to global health security.*

- The UK Government displays high levels of preparedness and adaptability to respond to shocks and disruptive events at local, national and international levels.
- The UK acts as a leader in initiatives to increase global health security and implements national policies and practices that support global health.
- The UK population possesses qualities that facilitate national resilience, such as high levels of social cohesion, education, health and empowerment.

### Underpinning requirement

The UK has the transdisciplinary research capacity, capability and infrastructure to generate evidence to improve the health of the public.

## 2.12 Research objectives

To address the evidence gaps identified in this chapter, we propose a number of broad research objectives. Meeting these objectives, which align closely with our primary aspiration and supporting ambitions, will be crucial for working towards a healthier, fairer future. How to take forward these objectives is discussed further in Chapter 3.

- **Reducing health inequalities and addressing social gradients.** Research conducted at all levels, from individuals to global, that aims to improve our understanding of how to create and deliver conditions conducive to improved health equity.
- **Delivering progress sustainably.** Research that explores how to deliver health improvements in ways that are environmentally, economically and socially sustainable.
- **Harnessing digital and technological developments.** Research that enables us to maximise the benefits of technology and data for good health and improved and sustainable health systems delivery within appropriate ethical and regulatory frameworks.
- **Improving health outcomes from the early years.** Research that helps us to understand how best to promote lifelong health through investment in the early years.
- **Creating societies in which older people experience the best possible health for as long as possible.** Research that equips us to support an ageing population and maximises health-related quality of life across the lifecourse, including appropriate approaches to care towards the end of life.
- **Supporting positive behaviours and maintaining good health.** Research that helps us to develop and design enabling environments, policies and methods of communication that support maintenance of good health and make healthier behaviours easy to adopt.
- **Improving global security.** Research that enables us to develop resilience to potential health crises at the international level, particularly those related to infectious diseases and environmental change, and the establishment of a rapid response research capacity to address global health emergencies.

## 2.13 Conclusions

The world is changing in ways that offer great opportunities as well as severe threats to the health of the public. Opportunities are expected to arise from the digital revolution, which offers an unprecedented chance to understand and influence the myriad factors that affect human health. At the same time, there are great potential benefits from rapidly emerging health-improving technologies and treatments. If the projected overall rise in educational levels, employment levels, yearly earnings and improved material conditions are realised, along with digital and technological developments, we could see continued improvements to the health of the public. On the other hand, global warming, resource depletion, a growing and ageing population with multiple morbidities, a more obese and sedentary public, increasing inequalities in wealth and health, and the problems of emerging and resistant infectious diseases present serious challenges to our health and to the sustainability of our health and social care systems.

Our aspiration for 2040 is for improvements in health which far exceed those we might expect based on current trajectories; for a future in which the UK experiences ongoing improvements in physical health, mental health, health-related quality of life and health equity across the population. To help achieve this, there is a critical need for a paradigm shift in several key areas:

- **Environments:** All elements of the UK environment must support healthy living for everybody based on a robust understanding of how to create a health-promoting society and conditions conducive to improve health equity.
- **Empowerment:** People – particularly those who are most vulnerable to poor health outcomes – must be empowered to actively contribute to their own and other people's health through meaningful and iterative engagement; effective communication of health information; and shared decision-making over their care.
- **Values:** All sectors of society – including all policymakers, health and social care practitioners and commercial bodies – should value health and health equity and these should be treated as indicators of success.

- **Sustainability:** Improvements to UK health must be gained in ways that are economically, environmentally and socially sustainable through greater focus on preventive intervention at the population level. The relationship between planetary and population health should be explicitly recognised.
- **Resilience:** The UK must develop resilience to potential health crises – with all levels of Government having high levels of preparedness and adaptability – and be a major contributor to global health security.

Meeting this aspiration will require a future in which the UK possesses a transdisciplinary research capacity, capability and infrastructure to generate evidence to improve health and health equity.



## References

49. World Health Organization (2014). *Fact sheet No313: Ambient (outdoor) air quality and health.* <http://www.who.int/mediacentre/factsheets/fs313/en/>
50. Royal College of Physicians (2016). *Every breath we take: the lifelong impact of air pollution.* <https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution>
51. World Health Organization (2016). *Fact sheet No266: Climate change and health.* <http://www.who.int/mediacentre/factsheets/fs266/en/>
52. White MP, et al. (2013). *Would you be happier living in a greener urban area? A fixed-effects analysis of panel data.* Psychological Science **24(6)**, 920-928.
53. Briggs D (2003). *Environmental pollution and the global burden of disease.* British Medical Bulletin **68(1)**, 1-24.
54. *Ibid.*
55. World Health Organization (2014). *Cities for Health.* [http://www.who.int/kobe\\_centre/publications/cities\\_for\\_health\\_final.pdf](http://www.who.int/kobe_centre/publications/cities_for_health_final.pdf)
56. Global Research Network on Urban Health Equity (2010). *Improving urban health equity through action on the social and environmental determinants of health.* <http://www.bvsde.paho.org/texcom/cd045364/GRNUHEreport2010.pdf>
57. Parliamentary Office of Science and Technology (2011). *POSTnote: housing and health.* [http://www.parliament.uk/documents/post/postpn\\_371-housing\\_health\\_h.pdf](http://www.parliament.uk/documents/post/postpn_371-housing_health_h.pdf)
58. World Health Organization (2000). *Transport, environment and health.* [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0003/87573/E72015.pdf](http://www.euro.who.int/__data/assets/pdf_file/0003/87573/E72015.pdf)
59. Rimal RN & Lapinski MK (2009). *Why health communication is important in public health.* Bulletin World Health Organization **87**, 247.
60. Glasgow Centre for Population Health (2013). *The built environment and health: an evidence review.* [http://www.gcpch.co.uk/assets/0000/4174/BP\\_11\\_-\\_Built\\_environment\\_and\\_health\\_-\\_updated.pdf](http://www.gcpch.co.uk/assets/0000/4174/BP_11_-_Built_environment_and_health_-_updated.pdf)
61. Watts N, et al. (2015). *Health and climate change: policy responses to protect public health.* The Lancet **386(10006)**, 1861-1914.
62. Haines A, et al. (2009). *Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers.* The Lancet **374(9707)**, 2104-2114.
63. World Health Organization (2016). *Fact Sheet No266: Climate change and health.* <http://www.who.int/mediacentre/factsheets/fs266/en/>
64. Watts N, et al. (2015). *Health and climate change: policy responses to protect public health.* The Lancet **386(10006)**, 1861-1914.
65. InterGovernmental Panel on Climate Change (2014). *Climate change 2014 synthesis report summary for policymakers.* [http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5\\_SYR\\_FINAL\\_SPM.pdf](http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf)
66. European Commission Climate Action. *Paris agreement.* [http://ec.europa.eu/clima/policies/international/negotiations/paris/index\\_en.htm](http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm)
67. Committee on Climate Change (2016). *UK climate change risk assessment 2017 synthesis report: priorities for the next five years.* <https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf>
68. Met Office (2010). *UK climate projections science report: climate change projections.* <http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87893&filetype=pdf>
69. Foresight (2011). *Migration and global environmental change.* [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/287722/11-1115-migration-and-global-environmental-change-summary.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/287722/11-1115-migration-and-global-environmental-change-summary.pdf)
70. UK National Ecosystem Assessment (2011). *Technical Report Chapter 23: Health Values from Ecosystems.* <http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=S901pJcQm%2fQ%3d&tabid=82>

71. Pretty J, et al. (2005). *The mental and physical health outcomes of green exercise*. International Journal of Environmental Health Research **15(5)**, 319-337.
72. Barton J & Pretty J (2010). *What is the best dose of nature and green exercise for improving mental health? A multi-study analysis*. Environmental Science & Technology **44(10)**, 3947-3955.
73. Mitchell R & Popham F (2008). *Effect of exposure to natural environment on health inequalities: an observational population study*. The Lancet **372(9650)**, 1655-1660.
74. Mitchell RJ, et al. (2015). *Neighborhood environments and socioeconomic inequalities in mental well-being*. American Journal of Preventive Medicine **49(1)**, 80-84.
75. Pretty J, et al. (2016). *Improving health and well-being independently of GDP: dividends of greener and prosocial economies*. International Journal of Environmental Health Research **26(1)**, 11-36.
76. United Nations (2014). *World urbanization prospects*.  
<http://esa.un.org/unpd/wup/highlights/wup2014-highlights.pdf>
77. KPMG (2014). *Building the homes we need*. [http://www.shelter.org.uk/\\_data/assets/pdf\\_file/0019/802270/Building\\_the\\_homes\\_we\\_need\\_-\\_a\\_programme\\_for\\_the\\_2015\\_government.pdf](http://www.shelter.org.uk/_data/assets/pdf_file/0019/802270/Building_the_homes_we_need_-_a_programme_for_the_2015_government.pdf)
78. Foresight (2014). *People in cities: the numbers*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/321814/14-802-people-in-cities-numbers.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321814/14-802-people-in-cities-numbers.pdf)
79. Business in the Community (2015). *The United Kingdom in 2030. Key trends for the built environment*. [http://www.bitc.org.uk/system/files/bitc\\_future\\_trends\\_document\\_-\\_final.pdf](http://www.bitc.org.uk/system/files/bitc_future_trends_document_-_final.pdf)
80. Whitty C (2015). *The shape of things to come: future demography around the world*.  
[http://www.youtube.com/watch?v=Z7S\\_fJv-NgA](http://www.youtube.com/watch?v=Z7S_fJv-NgA)
81. Foresight (2014). *The evolving economic performance of UK cities: city growth patterns 1981-2011*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/358326/14-803-evolving-economic-performance-of-cities.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/358326/14-803-evolving-economic-performance-of-cities.pdf)
82. Pretty J, et al. (2016). *Improving health and well-being independently of GDP: dividends of greener and prosocial economies*. International Journal of Environmental Health Research **26(1)**, 11-36.
83. Tainio M, et al. (2016). *Can air pollution negate the health benefits of cycling and walking?* Preventive Medicine **87**, 233-236.
84. <https://lsecities.net/media/objects/articles/urban-age-cities-compared/en-gb/>
85. Rydin Y, et al. (2012). *Shaping cities for health: complexity and the planning of urban environments in the 21st century*. The Lancet **379(9831)**, 2079-2108.
86. Whitty C (2015). *The shape of things to come: future demography around the world*.  
[http://www.youtube.com/watch?v=Z7S\\_fJv-NgA](http://www.youtube.com/watch?v=Z7S_fJv-NgA)
87. Ministry of Defence (2010). *Global strategic trends - out to 2040*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/33717/GST4\\_v9\\_Feb10.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/33717/GST4_v9_Feb10.pdf)
88. Office for National Statistics (2015). *National population projects: 2014-based statistical bulletin*. <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2015-10-29>
89. Office for National Statistics (2015). *Annual mid-year population estimates: 2014*. <http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2014/index.html>
90. Office for National Statistics (2015). *National population projects: 2014-based statistical bulletin*. <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2015-10-29>
91. Policy Exchange (2014). *A Portrait of Modern Britain*. <http://www.policyexchange.org.uk/publication/a-portrait-of-modern-britain/>
92. Pew Research Center (2015). *The future of world religions: population growth projections, 2010-2050*. <http://www.pewforum.org/2015/04/02/religious-projections-2010-2050/>

93. Office for National Statistics (2012). *Religion in England and Wales 2011*.  
<http://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/religion/articles/religioninenglandandwales2011/2012-12-11>
94. Organisation for Economic Co-operation and Development (2011). *The future of families to 2030*.  
<http://www.oecd.org/futures/49093502.pdf>
95. *Ibid.*
96. Stuckler D & Siegel K (2011). *Sick societies: responding to the global challenge of chronic disease*. Oxford University Press, Oxford.
97. World Health Organization (2004). *Macroeconomics and health: an update*.  
[http://www.who.int/macrohealth/action/mh\\_and\\_country\\_update.pdf](http://www.who.int/macrohealth/action/mh_and_country_update.pdf)
98. Greater London Authority (2002). *50 years on: the struggle for air quality in London since the great smog of December 1952*. <http://cleanair.london/wp-content/uploads/CAL-217-Great-Smog-by-GLA-20021.pdf>
99. Department for Transport & Hammond S (2013). *Thirty years of seatbelt safety*.  
<https://www.gov.uk/government/news/thirty-years-of-seatbelt-safety>
100. Department of Health (2011). *The impact of smokefree legislation in England: evidence review*.  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/216319/dh\\_124959.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/216319/dh_124959.pdf)
101. Office for National Statistics (2013). *Long-term profile of Gross Domestic Product (GDP) in the UK*.  
<http://www.ons.gov.uk/ons/rel/elmr/explaining-economic-statistics/long-term-profile-of-gdp-in-the-uk/sty-long-term-profile-of-gdp.html>
102. The Equality Trust (2014). *Income inequality in the UK*. <https://www.equalitytrust.org.uk/sites/default/files/Income%20Inequality%20UK.pdf>
103. Office for Budget Responsibility (2015). *Economic and fiscal outlook*. <http://cdn.budgetresponsibility.independent.gov.uk/July-2015-EFO-234224.pdf>
104. PricewaterhouseCoopers (2015). *The world in 2050. Will the shift in global economic power continue?*  
<https://www.pwc.com/gx/en/issues/the-economy/assets/world-in-2050-february-2015.pdf>
105. Ministry of Defence (2010). *Global strategic trends - out to 2040*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/33717/GST4\\_v9\\_Feb10.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/33717/GST4_v9_Feb10.pdf)
106. Institute for Fiscal Studies (2011). *Child and working-age poverty from 2010 to 2020*.  
<http://www.ifs.org.uk/comms/comm121.pdf>
107. Dredge S (2014). *30 things being 3D printed right now (and none of them are guns)*. The Guardian, January 29.
108. <http://uk.3dsystems.com/chefjet>
109. <http://www.totalkustom.com/3d-castle-completed.html>
110. Futurist Speaker (2012). *Printable houses and the massive wave of opportunity it will bring to our future*. <http://www.futuristspeaker.com/2012/04/printable-houses-and-the-massive-wave-of-opportunity-it-will-bring-to-our-future/>
111. Groopman J (2014). *Print thyself. How 3D printing is revolutionizing medicine*. The New Yorker, November 24.
112. <http://futureoflife.org/background/benefits-risks-of-artificial-intelligence/>
113. <http://futureoflife.org/ai-open-letter>
114. Perry P (2016). *How artificial intelligence will revolutionize healthcare*. Bigthink, May 10. <http://bigthink.com/philip-perry/how-artificial-intelligence-will-revolutionize-healthcare>
115. Hernandez D (2014). *Artificial intelligence is now telling doctors how to treat you*. Wired, June 2.
116. <http://cser.org/emerging-risks-from-technology/artificial-intelligence/>
117. <http://futureoflife.org/background/benefits-risks-of-artificial-intelligence/>

118. Ministry of Defence (2014). *Global strategic trends – out to 2045*. <https://www.gov.uk/government/publications/global-strategic-trends-out-to-2045>
119. RAND (2016). *Autonomous Vehicle Technology: A Guide for Policymakers*. [http://www.rand.org/content/dam/rand/pubs/research\\_reports/RR400/RR443-2/RAND\\_RR443-2.pdf](http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR443-2/RAND_RR443-2.pdf)
120. Ministry of Defence (2014). *Global strategic trends - out to 2045*. <https://www.gov.uk/government/publications/global-strategic-trends-out-to-2045>
121. McKinsey & Company (2015). *Ten ways autonomous driving could redefine the automotive world*. <http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world>
122. Ministry of Defence (2014). *Global strategic trends – out to 2045*. <https://www.gov.uk/government/publications/global-strategic-trends-out-to-2045>
123. KPMG (2015). *Connected and autonomous vehicles - the UK economic opportunity*. [https://www.kpmg.com/BR/en/Estudos\\_Analises/artigosepublicacoes/Documents/Industrias/Connected-Autonomous-Vehicles-Study.pdf](https://www.kpmg.com/BR/en/Estudos_Analises/artigosepublicacoes/Documents/Industrias/Connected-Autonomous-Vehicles-Study.pdf)
124. <https://www.soylent.com/>
125. <http://ambronite.com/>
126. <http://huel.com/>
127. Nesta (2015). *The sticky and sweet future of food hacking*. <http://www.nesta.org.uk/2016-predictions/sticky-sweet-future-food-hacking>
128. <https://www.23andme.com/>
129. German JB, et al. (2011). *Nutrigenomics and Personalized Diets: What Will They Mean for Food?* Annual review of food science and technology **2**, 97-123.
130. Monitor Deloitte (2015). *Digital Health in the UK: An industry study for the Office of Life Sciences*. [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/461479/BIS-15-544-digital-health-in-the-uk-an-industry-study-for-the-Office-of-Life-Sciences.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/461479/BIS-15-544-digital-health-in-the-uk-an-industry-study-for-the-Office-of-Life-Sciences.pdf)
131. The King's Fund (2016). *The digital revolution: eight technologies that will change health and care*. <http://www.kingsfund.org.uk/publications/articles/eight-technologies-will-change-health-and-care>
132. *Ibid.*
133. Nuffield Trust (2016). *Delivering the benefits of digital health care*. [http://www.nuffieldtrust.org.uk/sites/files/nuffield/nutj4099\\_healthtechreport\\_22.2.16\\_web.pdf](http://www.nuffieldtrust.org.uk/sites/files/nuffield/nutj4099_healthtechreport_22.2.16_web.pdf)
134. *Ibid.*
135. Ministry of Defence (2014). *Global strategic trends – out to 2045*. <https://www.gov.uk/government/publications/global-strategic-trends-out-to-2045>
136. Government Office for Science (2014). *The internet of things: making the most of the second digital revolution*. [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/409774/14-1230-internet-of-things-review.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/409774/14-1230-internet-of-things-review.pdf)
137. McKinsey Global Institute (2015). *Unlocking the potential of the internet of things*. <http://www.mckinsey.com/business-functions/business-technology/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world>
138. McNickle M (2012). *10 medical robots that could change healthcare*. InformationWeek, June 12. <http://www.informationweek.com/mobile/10-medical-robots-that-could-change-healthcare/d/d-id/1107696?>
139. <http://www.aethon.com/tug/tughealthcare/>
140. <http://www.swisslog.com/en/Products/HCS/Automated-Material-Transport/RoboCourier-Autonomous-Mobile-Robot>

141. <http://www.giraff.org/?lang=en>
142. <https://www.anybots.com>
143. Honigsbaum M (2013). *The future of robotics: in a transhuman world, the disabled will be the ones without prosthetic limbs...* The Guardian, June 16.
144. <http://www.anthrotronix.com/our-work/biomedical-assistive-devices/>
145. Kessler S (2011). *Robot invasion: Toyota unveils four healthcare "assistants"*. MashableUK, November 1. <http://mashable.com/2011/11/01/toyota-healthcare-robots/>
146. Martel S (2012). *Magnetic microbots to fight cancer*. IEEE Spectrum, September 25. <http://spectrum.ieee.org/robotics/medical-robots/magnetic-microbots-to-fight-cancer>
147. Ministry of Defence (2014). *Global strategic trends – out to 2045*. <https://www.gov.uk/Government/publications/global-strategic-trends-out-to-2045>
148. *Ibid.*
149. <http://storyofdigitalhealth.com/>
150. <http://www.fda.stfi.re/MedicalDevices/DigitalHealth>
151. <http://www.fda.gov/MedicalDevices/DigitalHealth/default.htm>
152. <https://deepmind.com/health>
153. <http://www.ibm.com/smarterplanet/us/en/ibmwatson/health/>
154. <http://www.merriam-webster.com/dictionary/crowdsourcing>
155. <https://www.patientslikeme.com/>
156. <https://www.23andme.com/en-gb/>
157. <http://genomera.com/>
158. <http://www.diygenomics.org/>
159. Feinstein L, et al. (2006). *What are the effects of education on health?* In OECD (2006). Measuring the effects of education on health and civic engagement: proceedings of the Copenhagen symposium. <https://www1.oecd.org/edu/innovation-education/37425753.pdf>
160. Devaux M, et al. (2011). *Exploring the relationship between education and obesity*. OECD Journal: Economic Studies **2011(1)**, 1-40.
161. The National Bureau of Economics (2006). *Education and health: evaluating theories and evidence*. <http://www.nber.org/papers/w12352>
162. Lager ACJ & Torssander J (2012). *Causal effect of education on mortality in a quasi-experiment on 1.2 million Swedes*. Proceedings of the National Academy of Sciences of the United States of America **109(22)**, 8461-8466.
163. World Health Organization Commission on Social Determinants of Health (2008). *Closing the gap in a generation: health equity through action on the social determinants of health*. [http://apps.who.int/iris/bitstream/10665/43943/1/9789241563703\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/43943/1/9789241563703_eng.pdf)
164. The Marmot Review (2010). *Fair society, healthy lives*. <http://www.instituteofhealthequity.org/Content/FileManager/pdf/fairsocietyhealthylives.pdf>
165. Department for Education (2014). *Influences on students' development at age 16*. <https://www.gov.uk/government/publications/influences-on-students-development-at-age-16>
166. Norton S, et al. (2014). *Potential for primary prevention of Alzheimer's disease: an analysis of population-based data*. The Lancet Neurology **13(8)**, 788-794.
167. Ofsted (2015). *Ofsted early years report 2015*. <https://www.gov.uk/government/publications/ofsted-early-years-report-2015>
168. Universities UK (2014). *Patterns and trends in UK higher education 2014*. <http://www.universitiesuk.ac.uk/policy-and-analysis/reports/Documents/2014/patterns-and-trends-in-uk-higher-education-2014.pdf>

169. Higher Education Funding Council for England (2013). *Trends in young participation in higher education.* [http://www.hefce.ac.uk/media/hefce/content/pubs/2013/201328/HEFCE\\_2013\\_28.pdf](http://www.hefce.ac.uk/media/hefce/content/pubs/2013/201328/HEFCE_2013_28.pdf)
170. University College London Institute of Health Equity (2010). *Employment and work task group report.* <http://www.instituteofhealthequity.org/projects/employment-and-work-task-group-report>
171. World Health Organization Commission on Social Determinants of Health (2007). *Employment conditions and health inequalities.* [http://www.who.int/social\\_determinants/resources/articles/emconet\\_who\\_report.pdf?ua=1](http://www.who.int/social_determinants/resources/articles/emconet_who_report.pdf?ua=1)
172. Scott-Marshall H & Tompa E (2011). *The health consequences of precarious employment experiences.* Work **38(4)**, 369-382.
173. Parliamentary Office of Science and Technology (2015). *POSTnote: towards 2020 and beyond.* <http://researchbriefings.files.parliament.uk/documents/POST-PN-0500/POST-PN-0500.pdf>
174. UK Commission for Employment and Skills (2014). *The future of work: jobs and skills in 2030.* [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/303335/the\\_future\\_of\\_work\\_key\\_findings\\_edit.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/303335/the_future_of_work_key_findings_edit.pdf)
175. McKinsey & Company (2015). *Four fundamentals of workplace automation.* [http://www.mckinsey.com/Insights/Business\\_Technology/Four\\_fundamentals\\_of\\_workplace\\_automation](http://www.mckinsey.com/Insights/Business_Technology/Four_fundamentals_of_workplace_automation)
176. The Economist (2014). *The future of jobs: the onrushing wave.* <http://www.economist.com/news/briefing/21594264-previous-technological-innovation-has-always-delivered-more-long-run-employment-not-less>
177. Waddell G & Burton AK (2006). *Is work good for your health and well-being?* TSO, London.
178. Standing G (2011). *The precariat: the new dangerous class.* Bloomsbury Academic, London.
179. Collins C, et al. (2014). *Informing investment to reduce health inequalities (III) in Scotland: a commentary.* Scottish Public Health Observatory (ScotPHO), Edinburgh.
180. Barr B, et al. (2016). 'First, do no harm': are disability assessments associated with adverse trends in mental health? A longitudinal ecological study. Journal of Epidemiology & Community Health **70(4)**, 339-345.
181. NHS England (2014). Five Year Forward View. <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
182. *Ibid.*
183. Kulhánová I, et al. (2014). Assessing the potential impact of increased participation in higher education on mortality: evidence from 21 European populations. Social Science & Medicine **117**, 142-149.
184. NHS England (2014). Five Year Forward View. <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
185. Salomon JA, et al. (2012). Healthy life expectancy for 187 countries, 1990–2010: a systematic analysis for the Global Burden Disease Study 2010. The Lancet **380(9859)**, 2144–2162.
186. Jagger C, et al. (2016). A comparison of health expectancies over two decades in England: results of the Cognitive Function and Ageing Study I and II. The Lancet **387(10020)**, 779-786.
187. The King's Fund (2015). *Making care fit for an older population.* <http://www.kingsfund.org.uk/projects/making-care-fit-older-population>
188. Annual report of the Chief Medical Officer 2013 (2014). *Public mental health priorities: investing in the evidence.* [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/413196/CMO\\_web\\_doc.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/413196/CMO_web_doc.pdf)
189. NHS Confederation Mental Health Network (2016). *Key facts and trends in mental health: 2016 update.* <http://www.nhsconfed.org/resources/2016/03/key-facts-and-trends-in-mental-health-2016-update>
190. NHS England (2014). Five Year Forward View. <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
191. The King's Fund (2013). *Spending on health and social care over the next 50 years.* <http://www.kingsfund.org.uk/time-to-think-differently/publications/spending-health-and-social-care-over-next-50-years>

192. Mackenbach JP (1996). *The contribution of medical care to mortality decline: McKeown revisited.* Journal of Clinical Epidemiology **49(11)**, 1207-1213.
193. Bunker JP, Frazier HS & Mosteller F (1994). *Improving health: measuring effects of medical care.* The Milbank Quarterly **72(2)**, 225-258.
194. The King's Fund (2013). *Spending on health and social care over the next 50 years. Why think long term?* [http://www.kingsfund.org.uk/sites/files/kf/field/field\\_publication\\_file/Spending%20on%20health%20...%2050%20years%20low%20res%20for%20web.pdf](http://www.kingsfund.org.uk/sites/files/kf/field/field_publication_file/Spending%20on%20health%20...%2050%20years%20low%20res%20for%20web.pdf)
195. *Ibid.*
196. Benach J, et al. (2013). *A new typology of policies to tackle health inequalities and scenarios of impact based on Rose's population approach.* Journal of Epidemiology and Community Health **67(3)**, 286-291.
197. Medical Research Council Social & Public Health Sciences Unit (2007). *Inequalities in health in Scotland: what are they and what can we do about them?* <http://www.sphsu.mrc.ac.uk/reports/OP017.pdf>
198. Bodenheimer T (2005). *High and rising health care costs. Part 2: technologic innovation.* Annals of Internal Medicine **142(11)**, 932-937.
199. Lorenc T, et al. (2012). *What types of interventions generate inequalities? Evidence from systematic reviews.* Journal of Epidemiology and Community Health **67(2)**, 190-193.
200. Tudor Hart J (1971). *The Inverse Care Law.* The Lancet **297(7696)**, 405-412.
201. Forrest LF, et al. (2013). *Socioeconomic inequalities in lung cancer treatment: systematic review and meta-analysis.* PLoS Medicine **10(2)**, e1001376.
202. Sustainable Development Unit (2016). *Sustainable development in health and care report: health check 2016.* <http://www.sduhealth.org.uk/policy-strategy/reporting/sustainable-development-in-health-and-care-report-2016.aspx>
203. World Health Organization (2011). *Global status report on noncommunicable diseases 2010.* [http://www.who.int/nmh/publications/ncd\\_report\\_full\\_en.pdf](http://www.who.int/nmh/publications/ncd_report_full_en.pdf)
204. Basu S, et al. (2013). *Relationship of soft drink consumption to global overweight, obesity, and diabetes: a cross-national analysis of 75 countries.* American Journal of Public Health **103(11)**, 2071-2077.
205. Wang X, et al. (2014). *Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies.* BMJ **349**, g4490.
206. Elwood P, et al. (2013). *Healthy lifestyles reduce the incidence of chronic diseases and dementia: evidence from the Caerphilly cohort study.* PLoS One **8(12)**, e81877.
207. Chetty R, et al. (2016). *The association between income and life expectancy in the United States, 2001-2014.* JAMA **315(16)**, 1750-1766.
208. NCD Risk Factor Collaboration (NCD-RisC) (2016). *Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants.* The Lancet **387(10026)**, 1377-1396.
209. Wang YC, et al. (2011). *Health and economic burden of the projected obesity trends in the USA and the UK.* The Lancet **378(9793)**, 815-825.
210. Public Health England (2014). *Everybody active, every day: an evidence-based approach to physical activity.* [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/353384/Everybody\\_Active\\_Every\\_Day\\_evidence\\_based\\_approach\\_CONSULTATION\\_VERSION.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/353384/Everybody_Active_Every_Day_evidence_based_approach_CONSULTATION_VERSION.pdf)
211. NHS Health England (2014). *Five Year Forward View.* <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>

212. Office for National Statistics (2016). *Alcohol related deaths in the United Kingdom: registered in 2014.* <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/bulletins/alcoholrelateddeathsintheunitedkingdom/registeredin2014>
213. *Ibid.*
214. Office for National Statistics (2015). *Deaths related to drug poisoning in England and Wales: 2014 registrations.* <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsrelatedtodrugpoisoningenglandandwales/2015-09-03/previous/v1>
215. Cancer Research UK (2015). *Can cancer be prevented?* <http://www.cancerresearchuk.org/about-cancer/causes-of-cancer/can-cancer-be-prevented>
216. Public Health England (2015). *HIV in the UK – situation report 2015: incidence, prevalence and prevention.* [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/477702/HIV\\_in\\_the\\_UK\\_2015\\_report.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477702/HIV_in_the_UK_2015_report.pdf)
217. House of Lords Science and Technology Select Committee (2011). *Behaviour change.* <https://www.publications.parliament.uk/pa/l201012/lselect/lscotech/179/179.pdf>
218. Thayer ZM & Kuzawa CW (2011). *Biological memories of past environments: epigenetic pathways to health disparities.* Epigenetics **6(7)**, 798-803.
219. Shonkoff JP, Boyce WT & McEwen BS (2009). *Neuroscience, molecular biology, and the childhood roots of health disparities.* JAMA **301(21)**, 2252-2259.
220. Lindblom R, et al. (2015). *The early life origin theory in the development of cardiovascular disease and type 2 diabetes.* Molecular Biology Reports **42(4)**, 791-797.
221. The Marmot Review (2010). *Fair society, healthy lives.* <http://www.instituteofhealthequity.org/Content/FileManager/pdf/fairsocietyhealthylives.pdf>
222. Health and Social Care Information Centre (2014). *Health survey for England – 2013 trend tables.* <http://www.hscic.gov.uk/catalogue/PUB16077/HSE2013-Trend-commentary.pdf>
223. He FJ, Brinsden HC & MacGregor GA (2014). *Salt reduction in the United Kingdom: a successful experiment in public health.* Journal of Human Hypertension **28**, 345-352.
224. University of California San Francisco (2016). *White House, Gates Foundation summit explores applying precision medicine to public health.* <https://www.ucsf.edu/news/2016/06/403221/white-house-gates-foundation-summit-explores-applying-precision-medicine-public>
225. <http://journal.frontiersin.org/researchtopic/4526/precision-public-health>
226. PHG foundation (2015). *Beyond public health genomics: a framework for future personalised healthcare.* <http://www.phgfoundation.org/file/16999/>
227. Medical Research Council (2014). *Maximising the value of UK population cohorts: MRC strategic review of the largest UK population cohort studies.* <https://www.mrc.ac.uk/publications/browse/maximising-the-value-of-uk-population-cohorts/>
228. <http://www.ukbiobank.ac.uk/about-biobank-uk/>
229. Office for National Statistics (2015). *Inequality in healthy life expectancy at birth by national deciles of area deprivation: England.* <http://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/datasets/inequalityinhealthylifeexpectancyatbirthbynationaldecilesofareadepreventionengland>
230. NHS Health Scotland (2015). *Health inequalities: what are they? How do we reduce them?* <http://www.healthscotland.com/uploads/documents/25780-Health%20inequalities%20-%20what%20are%20they%20and%20how%20do%20we%20reduce%20them.pdf>
231. Office for National Statistics (2014). *Life expectancy at birth and at age 65 by local areas in the United Kingdom: 2006-08 to 2010-12.* [www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/bulletins/lifeexpectancyatbirthandatage65bylocalareasintheunitedkingdom/2014-04-16](http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/bulletins/lifeexpectancyatbirthandatage65bylocalareasintheunitedkingdom/2014-04-16)

232. The Poverty Site (2010). *Scotland: low birthweight babies*. <http://www.poverty.org.uk/s20/index.shtml>
233. Office for National Statistics (2015). *Childhood, infant and perinatal mortality in England and Wales: 2013. 9. Socio-economic status*. <http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/childhoodinfantandperinatalmortalityinenglandandwales/2015-03-10#socio-economic-status>
234. Audit Scotland (2012). *Health inequalities in Scotland*. [http://www.audit-scotland.gov.uk/docs/health/2012/nr\\_121213\\_health\\_inequalities.pdf](http://www.audit-scotland.gov.uk/docs/health/2012/nr_121213_health_inequalities.pdf)
235. Office for National Statistics (2015). *Trend in life expectancy at birth and at age 65 by socio-economic position based on the National Statistics Socio-economic Classification, England and Wales: 1982-1986 to 2007-2011. 1. Main findings*. <http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/bulletins/trendinlifeexpectancyatbirthandage65bysocioeconomicpositionbasedonthenationalstatisticssocioeconomicclassificationenglandandwales/2015-10-21#main-findings>
236. The Marmot Review (2010). *Fair society, healthy lives*. <http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review>
237. The Scottish Government (2008). *Equally well: report of the ministerial task force on health inequalities – volume 2: briefing paper on health inequalities*. <http://www.gov.scot/Publications/2008/06/09160103/2>
238. *Ibid.*
239. *Ibid.*
240. The National Institute for Health and Care Excellence (2007). *Evidence for the effect of inequalities in health of interventions designed to change behaviour*. <https://www.nice.org.uk/guidance/ph6/documents/evidence-for-the-effect-on-inequalities-designed-to-change-behaviour2>
241. House of Commons Health Committee (2009). *Health inequalities*. <http://www.publications.parliament.uk/pa/cm200809/cmselect/cmhealth/286/286.pdf>
242. Medical Research Council (2012). *Using natural experiments to evaluate population health interventions: guidance for producers and users of evidence*. <https://www.mrc.ac.uk/documents/pdf/natural-experiments-guidance/>
243. Medical Research Council (2008). *Developing and evaluating complex interventions: new guidance*. <https://www.mrc.ac.uk/documents/pdf/complex-interventions-guidance>
244. Department of Health (2011). *Health is global: an outcomes framework for global health 2011-2015*. [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/67578/health-is-global.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/67578/health-is-global.pdf)
245. All-Party Parliamentary Group on Global Health (2015). *The UK's contribution to health globally: benefiting the country and the world*. [http://www.appg-globalhealth.org.uk/download/i/mark\\_dl/u/4009611296/4622063799/The%20UK's%20contribution%20to%20health%20globally\\_FULL.pdf](http://www.appg-globalhealth.org.uk/download/i/mark_dl/u/4009611296/4622063799/The%20UK's%20contribution%20to%20health%20globally_FULL.pdf)
246. World Health Organization (2011). *Global status report on noncommunicable diseases 2010*. [http://apps.who.int/iris/bitstream/10665/44579/1/9789240686458\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/44579/1/9789240686458_eng.pdf)
247. Hughes BB, et al. (2011). *Projections of global health outcomes from 2005 to 2060 using the International Futures integrated forecasting model*. Bulletin World Health Organization **89(7)**, 478–486.
248. World Health Organization (2007). *World health report 2007*. [http://www.who.int/whr/2007/07\\_overview\\_en.pdf](http://www.who.int/whr/2007/07_overview_en.pdf)
249. Cabinet Office (2015). *National risk register of civil emergencies*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/419549/20150331\\_2015-NRR-WA\\_Final.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/419549/20150331_2015-NRR-WA_Final.pdf)
250. World Health Organization (2007). *World health report 2007*. [http://www.who.int/whr/2007/07\\_overview\\_en.pdf](http://www.who.int/whr/2007/07_overview_en.pdf)

251. Ministry of Defence (2014). *Global strategic trends - out to 2045*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/348164/20140821\\_DCDC\\_GST\\_5\\_Web\\_Secured.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/348164/20140821_DCDC_GST_5_Web_Secured.pdf)
252. Review on Antimicrobial Resistance (2016). *Tackling drug-resistant infections globally: final report and recommendations*. <http://amr-review.org/>
253. <http://www.gacd.org/>
254. Wellcome Trust (2015). *Fleming Fund launched to tackle global problem of drug-resistant infection*. <https://wellcome.ac.uk/press-release/fleming-fund-launched-tackle-global-problem-drug-resistant-infection>
255. <https://www.mrc.ac.uk/research/initiatives/antimicrobial-resistance/antimicrobial-resistance-funders-forum/>
256. Review on Antimicrobial Resistance (2016). *Tackling drug-resistant infections globally: final report and recommendations*. <http://amr-review.org/>
257. House of Commons Science and Technology Committee (2016). *Science in emergencies: UK lessons from Ebola*. <http://www.publications.parliament.uk/pa/cm201516/cmselect/cmstech/469/469.pdf>
258. <http://www.nihr.ac.uk/funding-opportunities/uk-rapid-response-team-competition-2015/3100>
259. <https://www.gov.uk/guidance/field-epidemiology-training-programme-fetp>
260. Legatum Institute (2014). *Wellbeing and policy*. <http://li.com/docs/default-source/commission-on-wellbeing-and-policy/commission-on-wellbeing-and-policy-report---march-2014-pdf.pdf>
261. Happy Planet Index (2012). *The Happy Planet Index: 2012 report*. [http://b.3cdn.net/nefoundation/d8879619b64bae461f\\_opm6ixqee.pdf](http://b.3cdn.net/nefoundation/d8879619b64bae461f_opm6ixqee.pdf)



### 3. Optimising research to improve the health of the public

---

To seize the opportunities and meet the challenges of the future, it is crucial that health of the public research is transdisciplinary, conducted at scale and strategically coordinated, with a far greater focus on research to promote health and prevent the onset of disease and behaviour-related conditions, and to effect and evaluate change across the population.



## Introduction

In the UK, research concerning population-level health outcomes has traditionally been carried out by individuals specialising in public health. This research made extensive contributions to improving human health in the past, and provided key evidence underpinning many health policies in the UK and globally (see Chapter 1). Looking to the future, generating the evidence required to achieve our aspiration described in Chapter 2 will require a step-change in the scale and ambition of research, supported by large-scale funding.

This chapter considers how the current research landscape might be enhanced – through improved coordination and rebalancing of priorities – to initiate a paradigm shift from public health to health of the public research.

### 3.1 The balance of UK research

Addressing the gaps in our current knowledge will require a more strategic approach to health of the public research conducted by transdisciplinary teams. It should draw on the skills and expertise of a wide range of disciplines outside the traditional sphere of public health research, from environmental sciences to law to ethics to engineering. Maximising the value of investments in health of the public research, and ensuring that outputs are converted into improved health outcomes, will require a rebalancing of research in five crucial areas outlined below:

#### ***Investment in prevention research***

Prevention is cost effective. A recent analysis of over 200 studies on preventive interventions showed that almost half cost less than £6,400 per quality-adjusted life year, and almost 80% cost less than the £30,000 ‘cost-effectiveness threshold’ often used by the National Institute for Health and Care Excellence (NICE).<sup>262</sup> The King’s Fund has stated: *‘primary prevention is an excellent use of resources compared with many treatments’*, leading the think tank to highlight it as number 2 in its 10 priorities for commissioners in 2015.<sup>263</sup> The importance of prevention is prominent in NHS England’s ‘Five Year Forward View’, which states that the future health of millions of children, the sustainability of the NHS, and the economic prosperity of Britain all now depend on a radical upgrade in prevention and public health.<sup>264</sup>

Funding for prevention research has increased but not sufficiently. In the 10 years from 2004/05 to 2014, public spending on prevention research increased threefold, from £29.6 million (in real terms) in 2004/05 to £102 million in 2014 (see Chapter 1). The largest increase in spend has been for primary prevention interventions to modify behaviours and promote wellbeing, and interventions to alter environmental risks. Prevention research, however, continues to account for only a small proportion of total investment in health research at 5.4%. The independent scientific panel responsible for reviewing the NPRI noted a relative paucity of behavioural and prevention research.<sup>265</sup>

#### ***Understanding the wider determinants of health***

Health of the public research has often been focused on a small number of disciplines and determinants. For instance, both NPRI and UKCRC have prioritised behavioural risk factors for disease and largely focused on interventions aimed at changing the behaviour of individuals including tobacco use, alcohol consumption, physical inactivity, diet and nutrition and drug use.<sup>266,267</sup>

Evidence submitted to us has reinforced the wide range of interrelated drivers that influence the health of the public, which include social and cultural factors, the built and natural environment, technological change, fiscal and legislative policies, and education and the workplace as outlined in Chapter 2. Working towards our desired future requires an increased focus on research into these wider determinants of health by transdisciplinary teams, as well as research that takes a systems approach to understanding the drivers of health.

#### ***From observational to interventional research***

We agree with the NPRI independent review panel that future investment in prevention research should involve a balance between observational, developmental, and intervention studies, with increased emphasis on solving problems rather than simply describing them.<sup>268</sup> This point was made numerous times during our project, reflecting a view held by many in the research and wider community.<sup>269</sup>

The argument for more interventional research was made most frequently in the context of social determinants of health, with more work required to narrow health inequalities,<sup>270,271</sup> and to tackle the anticipated increase in multiple morbidities. For any given intervention, evidence is required so that its efficacy, cost-effectiveness and impact on the whole population and subgroups of the population can be better understood and communicated to stakeholders. There is also a need to understand the complexities inherent in these interventions. For example, interventions that address single determinants of health in isolation may have unforeseen effects on other aspects of physical and mental health.

#### **From individual- to population-level interventions**

Evidence we received points to the need for more research on how to intervene at the organisational, system, population and environmental level in addition to interventions to modify individual behaviours.<sup>272,273</sup> This echoes the finding of the NPRI independent review panel which called for a '*greater focus on developing interventions that may act at a level other than the individual (e.g. at group, community or population level), or at more than one level*'.<sup>274</sup> Importantly, many population-level interventions may prevent multiple diseases simultaneously, as exemplified by the findings of the effects of smoke-free legislation on rates of hospital admission for asthma and acute myocardial infarctions.<sup>275,276,277</sup>

#### **Investment in evaluative research**

High-quality evaluation of interventions can provide evidence about attribution and causality, determining whether they deliver their intended outcomes and measuring the balance of intended and unintended costs and benefits.<sup>278</sup> However, evaluation is not consistently taking place, and evaluations based on natural experiments are substantially under-realised in relation to the potential they offer.<sup>279,280,281,282</sup> We need to better review and monitor interventions as they are implemented (including gathering good baseline data) to ensure they are effective and to inform future decision-making. The quality of evaluations that are conducted is also variable, with some unable to assess effectiveness or cost effectiveness.<sup>283,284</sup> Results of poor-quality evaluations may mislead decision-makers. Evaluation is discussed further in Chapter 6.

## **3.2 The need for enhanced coordination**

For many years successive reviews have highlighted the need for improved coordination of public health research in the UK. Despite recent positive trends in the funding landscape, these have been relatively small-scale and fragmented (see Chapter 1).

To have impact and answer population-level questions, health of the public research needs to be conducted at scale. Previous efforts have been largely limited to funders of health research supporting a relatively narrow field of public health research with restricted budgets. There remains a need to improve scale and coordination of activities and resources. Mechanisms are needed to allow funders to jointly fund research that they would not be able to do in isolation, to benefit from economies of scale and achieve impact that will arise from bringing together existing funding. The combined efforts of multiple research funders can assist in answering large-scale, systemic questions relevant to health, health inequalities and beyond.

These mechanisms will need to draw on the expertise and funding from multiple disciplines, beyond the stakeholders involved in existing UK research coordinating bodies such as the OSCHR, and must extend beyond the domain of health services.

### **Recommendation 1**

We recommend the establishment of the UK Strategic Coordinating Body for Health of the Public Research (SCHOPR) to help meet our aspiration of substantially, continually and sustainably improving health and health equity by identifying research needs and coordinating research activities.



We recommend that SCHOPR:

- Be formed by key public and charitable research funders (such as Research Councils, the National Institute for Health Research and its devolved equivalents, the British Heart Foundation, Cancer Research UK and Wellcome) and other stakeholders (such as Public Health England, Health Protection Scotland, Public Health Wales, Public Health Agency for Northern Ireland, NHS England, Scotland, Wales and Northern Ireland, and other relevant Government departments). The organisations involved must come from the full spectrum of sectors and disciplines relevant to the health of the public, extending far beyond biomedicine.
- Develop a strategy for UK health of the public research, including the UK's contribution to global health research.
- Identify priority areas for UK health of the public research.
- Review existing investment, and the impact of previous investment, in health of the public research and consider the scale of investment required and how funding can be effectively channelled and coordinated.
- Consider the best mechanisms to conduct health of the public research in the future, including how to bring together the wide range of skill sets and disciplines required, encourage collaboration and minimise duplication.
- Explore mechanisms for mobilising the research community to rapidly respond to challenges and opportunities as they arise, and to most effectively draw upon existing knowledge.
- Consider how to capitalise on and improve coordination of existing structures in health of the public research to enable them to work as an efficient UK-wide network.
- Catalyse connections between researchers, policymakers and practitioners, and provide leadership to generate the necessary evidence to improve the health of the public.

To fulfil these objectives, we believe that SCHOPR would require:

- A high-level Executive Board, led by an independent Chair, comprised of senior individuals from multiple disciplines and with strong links to other key bodies. It would have to be small enough to function efficiently and effectively and with the agility to quickly seize opportunities as they arise.
- A small permanent secretariat, responsible for supporting core functions, with long-term funding by partner organisations for operational stability.

While SCHOPR will bring together all the relevant funders, it is not intended as a funding agency. Rather, it would be a mechanism for funders, along with practitioners and policymakers, to identify and prioritise initiatives that are needed to address current and future health challenges, and to determine which they are individually prepared to contribute to, as well as to establish how other resources and partnerships could be mobilised. Initiatives could then be led and administered by one organisation with inputs and funds from all participating funders. Examples of this type of model – which shares the risks, costs and benefits stemming from the need to invest large sums to answer big questions or shared infrastructure – include the NPRI and the National Cancer Research Institute.

SCHOPR would therefore build on these existing structures and initiatives, but where these examples have operated on an ad-hoc basis, SCHOPR would instead be formalised and permanent, with long-term mechanisms to develop strategic initiatives and respond to emerging fields.

It is important that the identification of research priorities by SCHOPR is informed by horizon scanning to capture emerging trends and new drivers. SCHOPR should undertake regular and themed horizon scanning exercises, supported by the expertise of specialist horizon scanning organisations such as the Government Office for Science and the Cabinet Office Horizon Scanning Centre.

Accurate data on the level of activity and investment into health of the public research will be essential for SCHOPR to develop a strategy, identify priority areas and gaps and coordinate funding. Data currently available on the UK research landscape, however, does not provide this. SCHOPR should create a publicly available database with information on the overall level of activity and how investment is spread across the various areas of health of the public research.

Our proposal for SCHOPR is consistent with the recommendations of the ‘Nurse Review of Research Councils’,<sup>285</sup> which calls for strengthening and evolution of the seven Research Councils into a formal organisation to improve strategic thinking, cross-cutting activities and cost-effectiveness; a recommendation taken forward with the Government’s proposal of a single research and innovation funding body: UK Research and Innovation.<sup>286</sup>

### 3.3 Key elements for successful health of the public research

#### **Research strategy**

Generating the evidence necessary to support the emergence of a sustainably healthier, fairer future for the public is a ‘grand challenge’. Any strategy seeking to optimise health of the public research and tackle this grand challenge will need to have several qualities if it is to be successful. In developing the strategy, SCHOPR should:

- Bring together experts from a wide range of disciplines, beyond biomedical research, to work together in a transdisciplinary way to tackle a common set of research challenges. This is discussed further in Chapter 5.
- Embed mechanisms for involving policymakers, practitioners, the commercial sector and the public in identifying priority areas for research and pathways to implementation of interventions. This is discussed further in Chapter 6.
- Maintain long-term, sustainable and well-coordinated research capability.
- Connect UK health research to global health research, including considerations of sustainability and security.

#### **Balance of research**

SCHOPR should consider the following to improve the balance of UK health of the public research, as discussed in section 3.1:

- An increased focus on prevention – that is, research focused on promoting health, preventing disease and managing long-term conditions and multiple morbidities.
- Adopting a systems approach to understanding and influencing health outcomes, with greater emphasis on the full range of drivers shaping current and future health, and the complex interactions that exist between them.
- A change in focus from studies that primarily aim to understand health outcomes to ones that aim to improve health outcomes.
- Increased emphasis on interventions that can be applied at organisational, system, population and environmental levels in the UK and globally.
- Greater focus on research to evaluate interventions, including research into the methods and approaches for evaluation, to drive evidence-based investment and disinvestment to promote optimum use of resources.

#### **Research priorities**

Drawing on the evidence gaps detailed in Chapter 2, we believe that SCHOPR should consider the following when identifying areas of research priorities:

- Reducing health inequalities and addressing social gradients. Research conducted at all levels, from individual to global, that aims to improve our understanding of how to create and deliver conditions conducive to improved health equity.
- Delivering progress sustainably. Research that explores how to deliver health improvements in ways that are environmentally, economically and socially sustainable.
- Harnessing digital and technological developments. Research that enables us to maximise the benefits of technology and data for good health and improved and sustainable health systems delivery within appropriate ethical and regulatory frameworks.
- Improving health outcomes from the early years. Research that helps us to understand how best to promote lifelong health through investment in the early years.
- Creating societies in which older people experience the best possible health for as long as possible. Research that equips us to support an ageing population and maximises health-related quality of life across the lifecourse, including appropriate approaches to care towards the end of life.

- Supporting positive behaviours and maintaining good health. Research that helps us to develop and design enabling environments, policies and methods of communication that support maintenance of good health and make healthier behaviours easy to adopt.
- Improving global security. Research that enables us to develop resilience to potential health crises at the international level, particularly those related to infectious diseases and environmental change, and the establishment of a rapid response research capacity to address global health emergencies.

### 3.4 Conclusions

Public health research has made significant contributions to improve our health. Yet there is still much we do not know about the myriad factors that influence health, and, importantly, the steps that should be taken to meet our primary aspiration of substantial and ongoing improvements in health and health equity.

Addressing this challenge will require a shift in the balance of research from therapeutic interventions towards integrated approaches that take whole population perspectives with a particular emphasis on prevention; from focusing on a narrow range of determinants to a much wider range of drivers of health and health equity; from studies that primarily aim to understand health outcomes to ones that aim to improve health outcomes; from individual- to population-level interventions; and toward regular evaluation of interventions that are implemented.

It will also require a more coordinated approach to research, bringing together public and charitable funders and other stakeholders from across the range of the health-affecting disciplines and sectors, to provide strategic direction and ensure that crucial questions are addressed through large-scale and sustained funding, to improve and maintain the health of the public. The UK SCHOPR that we have proposed will support this endeavour.



## References

262. van Gils PF, et al. (2010). *Cost-effectiveness research on preventive interventions: a survey of the publications in 2008*. European Journal of Public Health **21(2)**, 260-264.
263. The King's Fund (2015). *Transforming our health care system: ten priorities for commissioners*. [http://www.kingsfund.org.uk/sites/files/kf/field/field\\_publication\\_file/10PrioritiesFinal2.pdf](http://www.kingsfund.org.uk/sites/files/kf/field/field_publication_file/10PrioritiesFinal2.pdf)
264. NHS England (2014). *Five Year Forward View*. <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
265. National Prevention Research Initiative (2015). *Initiative outcomes and future approaches*. <http://www.mrc.ac.uk/publications/browse/national-prevention-research-initiative-npri-report-2015/>
266. *Ibid*.
267. UK Clinical Research Collaboration (2008). *Strengthening public health research in the UK*. [http://www.ukcrc.org/wp-content/uploads/2014/03/Public\\_Health\\_Report\\_July\\_08.pdf](http://www.ukcrc.org/wp-content/uploads/2014/03/Public_Health_Report_July_08.pdf)
268. National Prevention Research Initiative (2015). *Initiative outcomes and future approaches*. <http://www.mrc.ac.uk/publications/browse/national-prevention-research-initiative-npri-report-2015/>
269. House of Lords Science & Technology Select Committee (2011). *Behaviour change*. <http://www.publications.parliament.uk/pa/ld201012/ldselect/ldsctech/179/179.pdf>
270. Wanless D (2004). *Securing good health for the whole population: 5. Public health evidence*. [http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/prod\\_consum\\_dh/groups/dh\\_digitalassets/@dh/en/documents/digitalasset/dh\\_4076139.pdf](http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/en/documents/digitalasset/dh_4076139.pdf)
271. National Prevention Research Initiative (2015). *Initiative outcome and future approaches*. <http://www.mrc.ac.uk/publications/browse/national-prevention-research-initiative-npri-report-2015/>
272. *Ibid*.
273. House of Lords Science & Technology Select Committee (2011). *Behaviour changes*. <http://www.publications.parliament.uk/pa/ld201012/ldselect/ldsctech/179/179.pdf>
274. National Prevention Research Initiative (2015). *Initiative outcome and future approaches*. <http://www.mrc.ac.uk/publications/browse/national-prevention-research-initiative-npri-report-2015/>
275. Pell JP, et al. (2008). *Smoke-free legislation and hospitalizations for acute coronary syndrome*. New England Journal of Medicine **359(5)**, 482-491.
276. Mackay DF, et al. (2012). *Impact of Scotland's smoke-free legislation on pregnancy complications: retrospective cohort study*. PLoS Medicine **9(3)**, e1001175.
277. Mackay D, et al. (2010). *Smoke-free legislation and hospitalizations for childhood asthma*. New England Journal of Medicine **363(12)**, 1139-1145.
278. National Audit Office (2013). *Evaluation in Government*. [https://www.nao.org.uk/wp-content/uploads/2013/12/10331-001-Evaluation-in-government\\_NEW.pdf](https://www.nao.org.uk/wp-content/uploads/2013/12/10331-001-Evaluation-in-government_NEW.pdf)
279. Medical Research Council (2012). *Using natural experiments to evaluate population health interventions: guidance for producers and users of evidence*. <https://www.mrc.ac.uk/documents/pdf/natural-experiments-guidance/>
280. Craig P, et al. (2012). *Using natural experiments to evaluate population health interventions: new Medical Research Council guidance*. Journal of Epidemiology & Community Health **66**, 1182-1186.
281. Katikireddi SV, et al. (2014). *The NHS reforms in England: four challenges to evaluating success and failure*. Journal of the Royal Society of Medicine **107(10)**, 387-392.
282. Macintyre S & Petticrew M (2000). *Good intentions and received wisdom are not enough*. Journal of Epidemiology & Community Health **54**, 802-803.
283. Katikireddi S, et al. (2011). *How evidence based is English public health policy?* BMJ **343**, d7310.
284. House of Commons Health Committee (2009). *Health inequalities*. <http://www.publications.parliament.uk/pa/cm200809/cmselect/cmhealth/286/286.pdf>

285. Department for Business, Innovation & Skills (2014). *Nurse review of research councils*. <https://www.gov.uk/government/collections/nurse-review-of-research-councils>
286. Department for Business, Innovation & Skills (2016). *Success as a knowledge economy: teaching excellence, social mobility and student choice*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/523396/bis-16-265-success-as-a-knowledge-economy.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/523396/bis-16-265-success-as-a-knowledge-economy.pdf)



## 4. Harnessing the digital revolution

The opportunities presented by the digital revolution are profound. They offer a chance to understand the full spectrum of the determinants of health, to more effectively evaluate the health impacts of interventions, to engage the public in research in new ways, and to deliver health and social care in entirely novel ways. But embracing these opportunities requires us to collectively address issues of data access and management; ethics, regulation and governance; community engagement and trust; benefit and harm; and capacity and skills.



## Introduction

Advances in digital technology have changed our lives over the past 25 years. They are continually opening up ever greater volumes of quantitative and qualitative data from a range of health and non-health sources. The nature of data is itself changing. Commonly envisaged as figures in columns and rows, data are increasingly seen as text, image, video and sound, with many new forms inevitably on the horizon. Changes to data access and ownership are also taking place, with the volume of data held by commercial organisations, for example, dwarfing that held by public bodies, a difference that is set to increase.

These changes present profound opportunities across all reaches of society as well as significant challenges.<sup>287,288</sup> The ability for researchers in health of the public to utilise the rapidly increasing volumes of data is a vital component of any strategy to help meet our vision of significant and ongoing improvements to the health and health equity of the public. Enabling this will require a shift in our approach, as a society, to the use and sharing of data for research, as well as a transdisciplinary workforce to link and analyse these data, and to interpret and communicate the findings. While this chapter deals with the use of data for health of the public research, we also recognise the potential of digital and other technologies – including artificial intelligence, sensors and wearable devices – to transform the delivery of health and social care, a topic explored in Chapter 2.

### 4.1 The potential of big data

Historically, population data have been the foundation upon which some of the great achievements in health of the public research have been built, as outlined in Chapter 1 and Annex VI. Large, representative datasets including those held by the NHS, Government departments, non-Governmental organisations, researchers and the private sector, as well as data generated by individuals, provide extraordinary power to understand the full spectrum and complex interactions of the broad range of factors that drive population and individual health.<sup>289,290,291</sup> Combined with increasing computing capability, this will offer unprecedented opportunities to:

- Understand the distribution and determinants of health and disease in populations.
- Explore competing risks and the relative contributions of environmental, behavioural, biological and genetic factors on health and interventions to improve health.
- Develop population-level interventions and personalised care and prevention, and evaluate their effectiveness, potentially in real time and at relatively low cost.
- Model future scenarios for non-communicable and infectious disease outcomes.
- Develop early warning and real-time systems for emerging health risks.

Capitalising on this opportunity will require the development of integrated systems linking together the full range of datasets that can be used across a range of time and space. To avoid vulnerability, such systems must be adaptable to the constantly changing data landscape and to the players within it. It must also operate within a careful ethical and governance framework based on public interest. This section explores some of the specific issues across different sectors that therefore need to be addressed.

#### **Government and public services**

##### *Electronic health records*

At present, patients in the UK tend to have various paper and electronic health records (EHRs) stored in different places: EHRs are not yet consistently implemented across primary, secondary and social care.<sup>292</sup> NHS England has committed to '*fully interoperable electronic health records so that patients' records are largely paperless*' by 2020.<sup>293</sup> Considerable progress towards enabling the sharing of EHRs has been made in Scotland, Wales and Northern Ireland.<sup>294</sup> Rapid developments in the field of population informatics mean that well-maintained, secure and trusted system of EHRs could have significant impact on the health of the public. The datasets are critical to monitoring quality of care, improving integration of care, supporting clinical decision-making, monitoring disease and risk burden factors, and integrating behavioural and biological risk factors. The free exchange of this data within a trusted regulatory framework would allow for quicker evaluation and implementation of interventions. The potential result is a learning healthcare system that is able to quickly adopt recommendations drawn from population-level datasets.<sup>295</sup>

In time, full genome sequences seem likely to become part of routine EHRs, enabling the full range of competing risks between environmental, behavioural, biological and genetic variables to guide ambitions for personalised treatment and prevention (see Section 2.8). The clinical recording of data will remain an essential component of the picture of the health of the public. However, integrating other key data sources – from Government departments, the research community, the private sector and from the public themselves – will allow us to better understand and influence the entire spectrum of drivers of health over the long term, and will be a crucial challenge in the years to come.

While recognising the challenges associated with community engagement and trust, we heard through our public dialogue activities a broader public desire for these profound benefits; a desire for the aggregation of data and the use of innovative technologies to uncover and address the root cause of health problems.

#### *Administrative data*

Administrative data – which are routinely gathered, usually during the delivery of a service, for administrative rather than research purposes – are a crucial source of information about many drivers of the health of the public, whether socioeconomic, environmental, demographic or geographic.<sup>296</sup> They are also an important source of information for evaluating the health impacts of interventions. The Government and public services are the main producers of large administrative datasets in the UK, which include educational, welfare and tax records.<sup>297</sup> They are public resources which, within appropriate regulatory and ethical frameworks, should be made available to those who will use them to contribute to the public good.

Progress has been made towards facilitating access to and linkage of these data for research in recent years, including by the Administrative Data Research Network,<sup>298</sup> the Farr Institute of Health Informatics Research,<sup>299</sup> and an open policymaking process on data sharing by Involve and the Cabinet Office<sup>300</sup> (see Box 4.1). However, further work will be required to simplify these mechanisms for data sharing, to make them cost-effective and to reduce delays in accessing data for research. Suitable standards and methods of assurance must also continue to be developed, and environments created in which access to and linkage of data is facilitated while upholding the duty of confidentiality and protecting the data subject's right to privacy.<sup>301</sup> Mechanisms will also be required to ensure the quality and appropriateness of analyses conducted with the data.

## Box 4.1 Initiatives for access to administrative data

**Administrative Data Research Network (ADRN)**, a partnership between Government departments and agencies, researchers, universities, national statistics authorities, the third sector and funders, helps accredited researchers use administrative data for social and economic research, much of which is apposite to the health of the public.<sup>302</sup> ADRN consists of: an overarching coordinating Administrative Data Service; the ADRN Board, chaired by the UK Statistics Authority, which reports directly to Parliament; four Administrative Data Research Centres, one in each country in the UK; Government departments and agencies (the data custodians); and the ESRC (the funders). All research projects go through an independent ADRN Approvals Panel which assesses them for ethics, feasibility, privacy, public benefit and scientific merit, before researchers can access de-identified data.

**The Farr Institute of Health Informatics Research**, consisting of four nodes distributed across the UK, aims to deliver high-quality, cutting-edge research linking electronic health data with other forms of research and routinely collected data.<sup>303</sup> The Institute is a UK-wide research collaboration involving 21 academic institutions and health partners in England, Scotland and Wales. It is publicly funded by a consortium of 10 organisations led by the MRC. It does not own or control data but analyses data to better understand the health of patients and populations. The Institute also runs education and training programmes to nurture a new community of ‘health data scientists’ with an understanding of both big data and healthcare.

**Involve and the Cabinet Office open policymaking process on data sharing** was undertaken between 2014 and 2015 to explore the risks, benefits, limitations and governance for sharing personal data within Government. Its aim was to enhance the availability of high-quality research and statistics from administrative data; prevent fraud and help citizens manage the debt they have with Government; and ensure the right services are offered to the right person at the right time.<sup>304</sup> The initiative concluded that representatives within and outside Government saw the need for public bodies to be able to link data for research purposes, provided this linking was carried out securely using a trusted third party. All relevant parties would need to be accredited under a system established by legislation, and any research that intended to make use of this system under the legislation would have to be ‘*in the public interest*’.<sup>305</sup>

To continue developing frameworks for the sharing of administrative data for health of the public research, it is important that all Government departments are involved in future initiatives to develop mechanisms for data sharing and linkage across Government.

### ***The non-Governmental, research and private sector***

Very large and increasing volumes of data are also held by the non-Governmental and private sectors. Social media companies, for instance, have a wealth of such data: every day 400 million Tweets are shared on Twitter, 350 million photos are added to Facebook, and 4 billion videos viewed on YouTube.<sup>306</sup> Supermarkets similarly hold substantial quantities of data on consumer habits with health of the public research potential.<sup>307</sup> In all, estimates suggest that big data was worth £25 billion to UK businesses in 2011,<sup>308</sup> while predictions suggest that big data analytics and the internet of things combined will be worth £322 billion to the UK economy between 2015 and 2020.<sup>309</sup> But there are no regulatory or ethical frameworks to facilitate access to these data for research.

Academia is a rich source of data of relevance to health of the public research. Despite the benefits it offers, including establishing reproducibility of results and the use of old data for new research questions, data sharing is relatively uncommon among researchers.<sup>310,311</sup> Several initiatives have worked to tackle this issue,<sup>312</sup> and most research funders have policies on data sharing and open access.<sup>313,314,315,316</sup>

It is in the interest of the health of the public that steps are taken to improve access to these valuable data where appropriate; steps that strike a balance between the safe and secure use of personal data in research, the rights and interests of individuals, and the commercial or other interests of the organisations holding the data. There are examples of bodies helping to strike such a balance, such as the Consumer Data Research Centre, established by ESRC, which works with consumer-related organisations to help make their data available to trusted economic and social researchers.<sup>317</sup>

Regarding private sector organisations, such endeavours, while important, do not necessarily address the underlying tension between the interests of health of the public research and the need for companies to protect their commercial interests. Indeed, there are times when these tensions are irreconcilable, such as the inherent conflict between the interests of the tobacco industry and those of public health policy.<sup>318</sup> How to address this is considered further in Chapter 6.

### ***Data collected and held by individuals***

By 2040 people will be generating quantities of data far exceeding those produced today. As discussed in Chapter 2, it is likely that there will be 20,000 times more digital information in 2045 than there is today.<sup>319</sup> At present, social media, internet searches, mobile devices, health apps and wearable technologies represent increasingly important sources of information with the potential to enhance our understanding of the health of the public. The use of such data for health of the public research is in its infancy, but they can offer insights into people's health-related behaviours and provide data on people's step count, calorie intake, heart rate, body temperature, sleep patterns and weight.<sup>320</sup> One notable example is data gathered through the emerging concept of the 'quantified self' or 'auto-analytics'—that is, people voluntarily collecting and analysing data about themselves to inform their decisions and behaviours.<sup>321</sup>

Several new terms have been coined to articulate the opportunities presented by these data: 'digital epidemiology' describes the move towards assessing the health of the public in real time by analysing its digital traces,<sup>322,323,324</sup> and 'digital phenotype' describes how new technologies and digital platforms can be used to capture data about individuals outside current healthcare settings.<sup>325</sup>

To access, link and analyse these data, they need to be made available by those who own them; in many cases, by the individuals generating the data. A new approach to data sharing is therefore required. Some posit that a move towards a paradigm of 'data donation', analogous to blood donation, may be one way to help facilitate access to these data for health of the public research.<sup>326,327</sup> But we are conscious of such a concept's very real limitations for population-level research, as those donating their data are likely to represent only a subset of the population. Furthermore, such an approach may even threaten the viability of population-based linkage studies that are currently permitted without obtaining individual consent. Any proposals to harness these data must therefore carefully consider the risks and benefits of the mechanisms in question.

As the digital environment is rapidly evolving, and our response to the digital revolution is far from clear, we also need further evidence on how to utilise new data being generated.

## Recommendation 2



We recommend that key public and charitable research funders (such as Research Councils, the National Institute for Health Research and its devolved equivalents, the British Heart Foundation, Cancer Research UK and Wellcome) continue to work with relevant stakeholders (such as the Administrative Data Research Network, the Cabinet Office, NHS Digital, Involve, and the commercial sector) to maximise the potential of data generated within and outside the health system, within appropriate ethical and regulatory frameworks, for health of the public research. This should be linked to existing major health informatics investments such as the Farr Institute of Health Informatics Research.

In particular, we recommend that key research funders support a programme of research to better understand how society can best balance maximising social and health utility from data generated by new digital technologies with safeguarding citizen and commercial privacy.

### 4.2 Cross-cutting challenges

There are several cross-cutting issues that need to be addressed in order to benefit from the opportunities offered by the wealth of existing and future data:<sup>328,329,330,331</sup>

- Data access and management (including data linkage, quality, standards and storage).
- Ethics, regulation and governance (including data ownership).
- Community engagement and trust.
- Benefit and harm.
- Capacity and skills.

Many of these issues are not specific to health of the public research and a significant number of initiatives to tackle them are underway both in the UK and internationally.<sup>332,333</sup> We do, however, consider that there are capacity and skills issues that are specific to health of the public research. This is discussed further in the section below.

#### ***Transdisciplinary capacity and skills***

It is likely that by 2040 more conventional approaches to inference at the population level may no longer be sufficient, given the variable size, specificity and quality of various datasets. Challenges associated with the increasing multidimensionality of data can potentially be met by machine learning, the strengths and limitations of which should be understood, and then utilised within the core field of epidemiology.

The management and analysis of large datasets and the subsequent communication of findings require a range of specialist skills, from mathematics to computer science, communication skills and topic-specific expertise. Working with big data must therefore be transdisciplinary, involving a mixture of qualitative and quantitative methods.<sup>334</sup> It will be necessary, for example, to link data scientists with those dual-trained in data science and other relevant disciplines – such as epidemiology, mathematical modelling or behavioural science – as well as those who specialise in drawing insights from data drawn across the health service.

The analytical capacity of data scientists must go well beyond the usual approaches, to be able to use shared data to generate meaningful results. New and existing disciplines must work together in innovative ways to collect, link, analyse, visualise and interpret these data for different audiences. Such contextualisation brings in social sciences and humanities.

It is widely agreed that there is a significant skills gap in these areas, with 57% of those recruiting big data staff having struggled to find people with the requisite skills and experience, and demand for big data specialists in the UK expected to increase by 160% between 2013 and 2020.<sup>335</sup> This shortage is therefore limiting our ability to conduct academic research on large and complex datasets.

Training in quantitative and qualitative skills should therefore be incorporated at an early stage for current and future researchers, and health and social care practitioners. Many university departments now provide data science and health informatics courses. Funders are also providing programs, including cross-disciplinary Centres for Doctoral Training, to recruit and train more researchers in these fields (see Box 4.2). Investment in postdoctoral funding is also required, so that the research sector retains highly trained staff after they complete their PhDs.

## Box 4.2 Capacity building for data science

### The Farr Institute's Centre for Improvement in Population Health through

**E-records** works to build capacity and capability in health informatics research, by increasing the number of trained individuals in the research community (including the NHS and industry) and by developing a different breed of health data scientist across the relevant methodological and applied disciplines. To achieve this, a number of technical, practical and skills-based short courses at undergraduate level are currently being developed. Masters level modules are also being planned, and opportunities for PhD studies will be developed.<sup>336</sup>

**The Alan Turing Institute** is the UK's national institute for data science. Bringing together leaders in advanced mathematics and computing science, its aim includes conducting cutting-edge data science research, facilitating collaboration between researchers from industry and academia, and drawing in leaders from around the world to engage with the UK in data science and its applications.<sup>337</sup>

**Engineering and Physical Sciences Research Council Centre for Doctoral Training (CDT) in Data Science**, based at the University of Edinburgh, provides 50 PhDs over five intake years. It aims to train a new generation of data scientists with the technical skills and interdisciplinary awareness necessary to become R&D leaders in this emerging area.<sup>338</sup> The Government is investing over £40 million in CDTs<sup>a</sup> in different areas of data science.<sup>339</sup>

**Medical Research Council Skills Development Fellowships** are early postdoctoral training fellowships that support capacity building in MRC priority areas. The scheme currently focuses on:

- Quantitative expertise: covering mathematics, statistics, computation and informatics applicable to any biomedical or health-related data sources, from molecular to population level.
- Expertise at the social science interface: with a focus on areas of health economics and/or mixed methods research.<sup>340</sup>

**The Q-Step programme**, funded by the Nuffield Foundation, ESRC and the Higher Education Funding Council for England, is designed to promote quantitative social science training in the UK. For example, the UCL Q-Step Centre offers training in quantitative methods on interdisciplinary undergraduate degree programmes including a BSc in Population Health and BSc in Social Sciences with Quantitative Methods.<sup>341</sup>

<sup>a</sup> CDTs stimulate collaborations at the interdisciplinary interface and allow students from different disciplines to derive benefits from 'growing up together' as a cohort.

While these measures will help close the growing skills gap of data scientists, training data scientists within disciplines will not address the fundamental needs that have been identified in this report. Evidence we heard suggests that achieving better integration of health, social care and public health services, and meeting major challenges posed by demographic shifts and financial constraints, will require substantial investment in training public health professionals to identify and act on opportunities for using health informatics to improve the health of the public.

## Recommendation 3



We recommend that higher education institutions and key research funders (such as Research Councils and Wellcome) further enhance training pathways in informatics for health that are open to a wide range of disciplines. The aim should be to help build a critical mass of expertise in the UK to process and analyse the full range of available data now and in the future to understand and improve the health of the public.

Such training should include study of informatics systems, methodological research for the analysis of large health-related datasets, synthesis of diverse and multidimensional data sources, analytical approaches (such as machine learning), and linkage of quantitative and qualitative data across organisational, sectoral and international boundaries. It will necessarily be transdisciplinary, and will help foster coordination between health of the public research and service delivery.

### 4.3 Conclusions

The potential societal and health benefits offered by the digital revolution are substantial. This chapter focuses on how to maximise the opportunities provided by qualitative and quantitative data from various health and non-health sources. These data, properly linked and analysed, have the potential to provide deep, real-time insights into the full range of drivers of health of the public and in turn guide individual- and population-level care and prevention. They will enable us to develop more effective and tailored interventions and to assess their health impacts through improved evaluation.

But accessing, linking and analysing these data present a unique set of challenges. Addressing them will require different sectors of society to work together in new ways, fostering a culture of trust and trustworthiness. We call for funders to continue to work with relevant stakeholders to maximise the potential of data within appropriate ethical and regulatory frameworks. We also recommend the development of training pathways to ensure that the UK has sufficient transdisciplinary informatics expertise to maximise the benefits offered by these data.



## References

287. UN Secretary-General's Independent Expert Advisory Group on the Data Revolution for Sustainable Development (2014). *A world that counts: mobilising the data revolution for sustainable development*. <http://www.undatarevolution.org/wp-content/uploads/2014/12/A-World-That-Counts2.pdf>
288. House of Commons Science & Technology Committee (2016). *The big data dilemma*. <http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/468/468.pdf>
289. Parliamentary Office of Science and Technology (2016). *POSTnote: electronic health records*. <http://researchbriefings.files.parliament.uk/documents/POST-PN-0519/POST-PN-0519.pdf>
290. <https://wellcome.ac.uk/what-we-do/our-work/our-policy-work-using-patient-data-research>
291. National Institute for Health Research and UK Clinical Research Collaboration (2011). *Your health records save lives. What? How? Why?* <http://www.nihr.ac.uk/documents/about-NIHR/NIHR-Publications/NIHR-Patient-Health-Records-leaflet.pdf>
292. Parliamentary Office of Science and Technology (2016). *POSTnote: electronic health records*. <http://researchbriefings.files.parliament.uk/documents/POST-PN-0519/POST-PN-0519.pdf>
293. NHS England (2014). *Five Year Forward View*. <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
294. Parliamentary Office of Science and Technology (2016). *POSTnote: electronic health records*. <http://researchbriefings.files.parliament.uk/documents/POST-PN-0519/POST-PN-0519.pdf>
295. Friedman C, Wong A & Blumenthal D (2010). *Achieving a nationwide learning health system*. Science and Translational Medicine **2(57)**, 57cm29
296. Parliamentary Office of Science and Technology (2014). *POSTnote: big data and public health*. <http://www.parliament.uk/briefing-papers/POST-PN-474.pdf>
297. Administrative Data Liaison Service (2016). *Administrative data introduction*. <http://www.adls.ac.uk/adls-resources/guidance/introduction/>
298. <http://adrn.ac.uk/about>
299. <http://www.farrinstitute.org/>
300. Data Sharing (2016). *Updates from civil society engagement with the UK Government on data sharing*. <http://datasharing.org.uk/>
301. The Academy of Medical Sciences (2014). *Data in safe havens: workshop report*. <http://www.acmedsci.ac.uk/viewFile/53c7d8a7567db.pdf>
302. <http://adrn.ac.uk/about>
303. <http://www.farrinstitute.org/about>
304. Data Sharing (2016). *Updates from civil society engagement with the UK Government on data sharing*. <http://datasharing.org.uk/>
305. Data Sharing (2015). *Conclusions of civil society and public sector policy discussions on data use in Government*. [http://datasharing.org.uk/wp-content/uploads/sites/2/2015/03/20150327\\_Conclusions\\_OPM\\_paper\\_Data\\_final.pdf](http://datasharing.org.uk/wp-content/uploads/sites/2/2015/03/20150327_Conclusions_OPM_paper_Data_final.pdf)
306. Parliamentary Office of Science & Technology (2014). *POSTnote: social media and big data*. <http://researchbriefings.files.parliament.uk/documents/POST-PN-460/POST-PN-460.pdf>
307. Parliamentary Office of Science & Technology (2014). *POSTnote: big data and public health*. <http://www.parliament.uk/briefing-papers/POST-PN-474.pdf>
308. Parliamentary Office of Science & Technology (2014). *POSTnote: big data in business*. <http://researchbriefings.files.parliament.uk/documents/POST-PN-469/POST-PN-469.pdf>
309. SAS (2016). *The value of big data and the internet of things to the UK economy*. [http://www.sas.com/en\\_gb/offers/16q1/cebr-big-data-internet-of-things.html](http://www.sas.com/en_gb/offers/16q1/cebr-big-data-internet-of-things.html)

310. Fecher B, Friesike S & Hebing M (2015). *What drives academic data sharing?* PLoS One **10(2)**, e0118053.
311. Doshi P (2016). *Data too important to share: do those who control the data control the message?* BMJ **352**, i1027.
312. Expert Advisory Group on Data Access (2015). *Governance of data access.* <https://wellcome.ac.uk/sites/default/files/governance-of-data-access-eagda-jun15.pdf>
313. Digital Curation Centre. *Overview of funders' data policies.* <http://www.dcc.ac.uk/resources/policy-and-legal/overview-funders-data-policies>
314. Research Councils UK (2015). *RCUK common principles on data policy.* <http://www.rcuk.ac.uk/research/datapolicy/>
315. <http://www.wellcome.ac.uk/About-us/Policy/Spotlight-issues/Data-sharing/>
316. Cancer Research UK. *Data sharing guidelines.* <http://www.cancerresearchuk.org/funding-for-researchers/applying-for-funding/policies-that-affect-your-grant/submission-of-a-data-sharing-and-preservation-strategy/data-sharing-guidelines>
317. <https://www.cdrc.ac.uk/about-cdrc/>
318. World Health Organization (2008). *Guidelines for implementation of article 5.3 of the WHO framework convention on tobacco control.* [http://www.who.int/fctc/guidelines/article\\_5\\_3.pdf](http://www.who.int/fctc/guidelines/article_5_3.pdf)
319. Ministry of Defence (2014). *Global strategic trends – out to 2045.* [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/348164/20140821\\_DCDC\\_GST\\_5\\_Web\\_Secured.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/348164/20140821_DCDC_GST_5_Web_Secured.pdf)
320. Expert Advisory Group on Data Access (2015). *Governance of data access.* <https://wellcome.ac.uk/sites/default/files/governance-of-data-access-eagda-jun15.pdf>
321. Wilson HJ (2012). *You, by the numbers.* Harvard Business Review, September.
322. Brownstein JS, Freifeld CC & Madoff LC (2009). *Digital disease detection – harnessing the web for public health surveillance.* New England Journal of Medicine **360**, 2153-2157.
323. Salathé M, et al. (2012). *Digital epidemiology.* PLoS Computational Biology **8(7)**, e1002616.
324. Salathé M, et al. (2013). *Influenza A (H7N9) and the importance of digital epidemiology.* New England Journal of Medicine **369**, 401-404.
325. Wellcome Trust (2015). *Frontiers: Digital phenotypes. Health research in the digital age.* <https://wellcome.ac.uk/sites/default/files/wtp060238.pdf>
326. Nature Biotechnology (2015). *Incentivizing data donation.* Nature Biotechnology **33**, 885.
327. Skatova A, Ng E & Goulding J (2014). *Data donation: sharing personal data for public good?* Fifth Digital Economy Conference. <http://www.cs.nott.ac.uk/~psxjog/papers/DataDonation.pdf>
328. Parliamentary Office of Science and Technology (2014). *POSTnote: big data an overview.* <http://researchbriefings.files.parliament.uk/documents/POST-PN-468/POST-PN-468.pdf>
329. Sciencewise Expert Resource Centre (2014). *Big data.* <http://www.sciencewise-erc.org.uk/cms/assets/Uploads/SocialIntelligenceBigData.pdf>
330. Parliamentary Office of Science and Technology (2014). *POSTnote: big data and public health.* <http://researchbriefings.files.parliament.uk/documents/POST-PN-474/POST-PN-474.pdf>
331. Royal Statistical Society (2015). *The opportunities and ethics of big data.* <http://www.rss.org.uk/Images/PDF/influencing-change/2016/rss-report-opps-and-ethics-of-big-data-feb-2016.pdf>
332. <http://www.rcuk.ac.uk/research/infrastructure/big-data/>
333. National Data Guardian (2016). *Review of Data Security, Consent and Opt-outs* [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/535024/data-security-review.PDF](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/535024/data-security-review.PDF)
334. Parliamentary Office of Science & Technology (2014). *POSTnote: big data an overview.* <http://researchbriefings.files.parliament.uk/documents/POST-PN-468/POST-PN-468.pdf>

335. SAS & Tech Partnership (2014). *Big data analytics: assessment of demand for labour and skills 2013-2020.* [https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata\\_report\\_nov14.pdf](https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata_report_nov14.pdf)
336. <http://www.farrinstitute.org/>
337. <https://turing.ac.uk/>
338. <http://datascience.inf.ed.ac.uk/>
339. House of Commons Science & Technology Committee (2016). *The big data dilemma: Government response to the committee's fourth report of session 2015-2016.* <http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/992/992.pdf>
340. <http://www.mrc.ac.uk/skills-careers/fellowships/skills-development-fellowships/>
341. <https://www.ucl.ac.uk/q-step/study-with-us>





## 5. Developing the next generation of researchers and practitioners

---

Generating the necessary evidence to meet our aspiration will require subject experts from all disciplines relevant to the health of the public, as well as those with broader expertise who are able to work across and link these disciplines. We need an ambitious plan to build transdisciplinary research capability, which harnesses the changing drivers of health and capitalises on emerging technologies.



## Introduction

A recent report by the Royal Society for Public Health identified approximately 20 million people in England as working in areas relevant to public health.<sup>342</sup> Public Health England's workforce review recognises that '*a strong relationship between the core and wider workforce is key in realising the potential of the latter to have an impact on public health outcomes*'.<sup>343</sup>

Similarly, health of the public research needs experts from a wide range of disciplines and backgrounds to work together, as outlined in Chapter 3. This requires a strategy for training researchers from relevant academic disciplines outside of the traditional public health sphere including architecture, computer science, demography, design, economics, education, engineering, environmental sciences, ethics, geography, informatics, law, mathematics, statistics, political science and other social and life sciences. A highly skilled, research-aware health of the public workforce will also be essential to ensure that the UK health and social care systems function in a way that supports the health of the public.

Another area of critical importance for health of the public research is a strong workforce with appropriate quantitative skills to collect, link, analyse, visualise and interpret the wealth of emerging data, and for the design and interpretation of large-scale experimentation and evaluation. This is explored in Chapter 4. Development of research capacity in global health research, particularly for responding to infectious disease outbreak, is another important area that is highlighted in Chapter 2.

This chapter considers the education, training and continuing professional development of researchers and practitioners from university onwards. We recognise, however, that understanding the many factors that impact our health starts in the early years and continues throughout life. Furthermore, while acknowledging the importance of all health and social care practitioners having a health of the public perspective, we focus our recommendations on the training of clinicians that may be used as a template for other relevant professions.

### 5.1 Capacity building, education and training

The UK must invest in training and education to equip current and future researchers with the understanding and skills required to achieve our vision for the health of the public in 2040. We need to find ways to embed transdisciplinarity and leadership through relevant disciplinary content and skills training into established undergraduate and postgraduate curricula. Examples include: incorporating environmental science, political economy and behavioural change science into public health courses; modules within law degrees on health of the public law; and modules in architecture degrees on design for healthy cities and buildings. Undergraduate students in relevant disciplines should also be given opportunities for health of the public research through internships and placements. We also need to develop educators who can reach out to other disciplines within and across institutions, as well as to external bodies relevant to the health of the public.

Approaches to support early career researchers to work in transdisciplinary environments should also be explored. In addition to strong discipline-specific training, they should be given opportunities to learn and interact with researchers outside their core fields. The creation of more CDTs (see Box 4.2) based on topics relevant to health of the public, rather than on single disciplines, may be one approach. Calls by funders to support health of the public research that is conditional on bringing together researchers, including early career researchers, from different disciplines to develop new partnerships could act as a catalyst for increased training in the field. More fellowship schemes should also be created, specifically linked to some of the areas highlighted in the report such as informatics, economics, law and environmental sciences. The Academy's Springboard Award for medical humanities and social sciences is an example that could be expanded to encourage working across disciplines.<sup>344</sup>

## Recommendation 4



We recommend that higher education institutions:

1. Incorporate opportunities for learning about health in a wide range of disciplines relevant to the health of the public.
2. Incorporate these broader disciplines into public and population health courses.
3. Consider mechanisms for building joint modules between public and population health and these other disciplines to foster transdisciplinary approaches to learning and research.

## 5.2 Enhancing transdisciplinary research

Public health research has traditionally been collaborative, but a number of barriers will need to be overcome to facilitate joint working in health of the public research. A recurring theme in this project has been the need to move beyond professional silos and address health needs holistically. For instance, certain disciplines – such as social care and environmental and occupational health – are underrepresented in health of the public research. Experts from some disciplines such as informatics are sometimes being seen as a service provider and not as a co-creator of research outputs. There are silos between medically-trained public health practitioners, the rest of the medical community and those coming from disciplines outside of medicine. It is important to build research around ‘question-focused’ groupings with shared goals rather than the traditional disciplinary-based groupings. Greater flexibility for individuals to move between disciplines related to health of the public is also required.

### ***Team science***

As many of the research fields recognise the importance of transdisciplinarity, increasing attention is being paid to the importance of ‘team science’ – output-focused research involving multiple research groups. The Academy’s report ‘Improving recognition of team science contributions in biomedical research careers’ highlights the steps needed to ensure appropriate reward and recognition for researchers participating in large, collaborative projects.<sup>345</sup>

The report found that:

- Many biomedical researchers were worried about the impact of participating in team science on their career due to the likely lack of recognition for individuals’ contributions.
- It is difficult to find sources of funding that are sufficient to fully support the needs of team science. This includes the longer timescales of projects, and budgets to cover services of support and administrative staff.
- Despite the growth in team science, researchers (at all levels) often lack the skills required to contribute effectively to this way of working. These include leadership skills, communication skills, networking, forming successful collaborations and project management.
- There is inadequate support from employers and funders for those staff critical to excellent team science, but who are not on a career track to being principal investigators.
- Different culture and ‘language’ of communication exists between disciplines and there is a lack of senior peer recognition of individuals when they career hop into other fields.

Addressing these issues requires the cooperation of multiple stakeholders, including research funders, publishers, research institutions, and individual researchers. Health of the public research, where transdisciplinarity is hugely important, is an area where the recommendations from this report would be highly relevant (see Box 5.1).

## Box 5.1 Improving recognition of team science contributions in biomedical research careers

Key relevant recommendations from the Academy of Medical Sciences' report:

- All research outputs and grants should include open, transparent, standardised and structured contribution information.
- Team science funding should provide the length, breadth and magnitude of support required by recognising the longer timescales often needed to achieve outputs and the additional costs associated with effective team working.
- Team science grant proposals need to be appraised holistically, as well as from the perspective of the relevant disciplines.
- Focused and appropriate training in team skills should be provided.
- Clear career paths and development opportunities should be provided for researchers outside of the 'principal investigator track' who play key roles in (and provide key competencies to) team science, such as skills specialists.

### ***Co-location of researchers***

One way to overcome systemic silos is by developing infrastructure to support connectedness between researchers across different disciplines. The physical co-location of disciplines required for health of the public research in a 'cluster' could be a solution. Clusters in which different disciplines train together in the same physical space can be a strong catalyst for collaboration. In addition to bricks and mortar, virtual infrastructure – including virtual research cells – will also promote cross-disciplinary communication, overcoming differences in physical locations. Such approaches allow enduring relationships to form even in the face of repeated reorganisations of formal structures. See Box 5.2 for examples. Co-location of researchers with practitioners is also important and this is discussed further in Chapter 6.

## Box 5.2 Examples of clusters with co-location of expertise

**The Cambridge Institute of Public Health** is a multidisciplinary partnership of academics and public health professionals, aimed at facilitating collaboration between population health scientists and the health service and other sectors influencing health. Its health service partners include public health teams in local authorities, local hospitals, and foundation trusts.<sup>346</sup>

**The University of Glasgow Institute of Health and Wellbeing** comprises five Research Groups – public health; general practice and primary care; health economics and health technology assessment; social sciences; and mental health and wellbeing – as well as the Robertson Centre for Biostatistics, Clinical Trials Unit and the MRC/Chief Scientist Office Social and Public Health Sciences Unit. They address three specific research themes: determinants of health and health inequalities; complex intervention studies and randomised trials; and data science.<sup>347</sup>

**The Helix (Healthcare Innovation Exchange) Centre** is a cluster whose aim is to 'transform healthcare using design'. The Centre, co-founded by Imperial College London and the Royal College of Art, has a group of designers sharing a work space in a hospital with clinicians and researchers. The Centre brings together clinicians, academics, technologists and venture capitalist expertise with NHS staff to develop innovations with global application.<sup>348</sup>

## 5.3 Reframing and revitalising public health for the health and social care community

Through our project, we heard of concerns about a lack of understanding about the broader determinants of health of the public among those training to be health and social care practitioners. In the case of clinicians, this may be because students are trained in individual disciplines and therefore do not develop a wider perspective. The medical curriculum also focuses on teaching doctors how to treat individual patients rather than considering the wider determinants of population health, prevention and upstream drivers of health.

Achieving our vision for the health of the public will require a sustainable and integrated model of health and social care that places far greater focus on prevention and the potential impacts of key external interventions (such as fiscal, environmental, and educational) on health and the interplay between the two. Skills and training of health and social care practitioners will need to evolve in line with this. They will need a systems-based mindset with a holistic understanding of the determinants of health, and an ability to practice in a way that incorporates a health of the public perspective and consider how scarce resources can most efficiently be linked to improve health.

Health and social care practitioners also need to be able to contribute to research, use the evidence from research, have an understanding of translation and application of research into practice, and understand the need for evaluation of interventions. Professional bodies, such as the Faculty of Public Health which is responsible for the accreditation of public health practitioners, need to support and develop a culture of research in the workforce (including the majority who will not go into academia). Similarly, organisations such as PHE and local authorities need to support a research culture, alongside other professional groups such as the Association of Directors of Public Health and the Royal Society for Public Health. Career pathways and opportunities for research placements need to be developed and well-communicated to encourage the emergence of a strong research-informed workforce.

### Recommendation 5



We recommend that, through education and training, health and social care practitioners are:

1. Better equipped with an understanding of the drivers and interventions that affect the health of the public and the relevance to their practice.
2. Able to engage with research, and evaluate and use evidence.

This should be taken forward by the relevant training and regulatory bodies for each of the professions, such as the Faculty of Public Health for public health professionals.

As an example, we make recommendations for strengthening undergraduate and postgraduate curricula for clinicians. We stress the need to extend such an approach beyond medically qualified clinicians to all disciplines, and then to relevant vocational training.

### **Strengthening undergraduate medical curricula**

Current public health teaching in medical schools largely focuses on specific technical skills.<sup>349</sup> The General Medical Council (GMC) emphasises the importance of '*applying to medical practice the principles, method and knowledge of population health*'.<sup>350</sup> However, the interpretation and implementation of public health learning outcomes are variable within UK medical schools.<sup>351</sup>

The GMC Council has approved a plan to develop a unified assessment for doctors seeking to practise in the UK, tentatively termed the United Kingdom Medical Licensing Assessment.<sup>352</sup> As the development of structure and content of UKMLA is underway, there is an opportunity for the GMC to assess how population science, preventative medicine and informatics are taught in UK medical schools, and to bring about an update to the curriculum.

The new curricula should encompass the many drivers of health of the public and their relevance to clinical practice, and should emphasise quantitation, evaluation of evidence and preventative interventions.

To embed health of the public into the core competencies for clinical practice, GMC's 'Tomorrow's Doctors' should be amended to include a proper understanding of health of the public as a fundamental competency that students could expect to be examined on.

### **Recommendation 5.1**



We recommend that the Medical Schools Council, in collaboration with the General Medical Council and other relevant stakeholders, should undertake a review of competencies within the existing undergraduate medical curricula to identify opportunities to embed, strengthen and develop health of the public training and its broader application in clinical practice.

We note that Health Education England (HEE) is a key contributor in delivering the NHS England's 'Five Year Forward View', given its remit for educating and training all components of the healthcare and public health workforce. We are aware that HEE North West has recently completed a pilot of a Quality Assurance toolkit to benchmark undergraduate healthcare curricula for public health education content. We support this initiative and HEE's plans for wider roll-out of the toolkit by March 2017.

Intercalated BSc, Masters and MB-PhD degrees offer medical students the opportunity to become familiar with aspects of health of the public research, including project work and research methods. Involvement with health of the public should be encouraged within graduate entry medicine, not least because some trainees within this group of students may have particularly relevant skills and backgrounds.

### **Recommendation 5.2**



We recommend that higher education institutions and their medical schools should develop and maintain intercalated BSc, Masters and MB-PhD degrees in health of the public to encourage further study and develop further capacity in this area.

### **Strengthening postgraduate training**

Following graduation from medical school, all junior doctors complete two years of foundation training before moving to speciality training. Not many postgraduate trainees gain health of the public experience during this period. The 2013 UK Foundation Programme Annual Report reveals that only 0.1% of Foundation Year one doctors and approximately 1.7% of Foundation Year two doctors rotated through a placement in public health medicine.<sup>353</sup> We acknowledge that currently there is increasing emphasis on rotations that involve a community component, for example in primary care and community psychiatry. Some of these may be more relevant to health of the public than current public health rotations.

We recognise that future planning regarding postgraduate training in health of the public must consider the Shape of Training Review, which advocates for a broader medical education through division of training into an early generalist (core) phase followed by broad-based speciality experience.<sup>354</sup> It must also consider the Shape of Caring Review into nurse and care assistant education and training in England.<sup>355</sup>

#### *Training in research*

Integrated academic training pathways provide a route for aspiring clinical academics to progress into the clinical academic workforce. Opportunities for clinical trainees, who are not interested in this pathway, to be involved in research exist but these are taken ‘out-of-programme’. There are a number of disincentives to this route, such as having to obtain approval, securing grant funding, and provision for research activity in job plans.

## **Recommendation 5.3**



We recommend that, as proposed in the Royal College of Physicians’ ‘Research for All’, all doctors have appropriate grounding in research and in particular the core principles and methods of quantitative research that underpin health of the public research. All doctors should have opportunities for long-term research throughout the course of their training, preferably linked to an academic department and further opportunities in the course of other continuing professional development.

### **Credentialing**

Credentialing<sup>b</sup> could be a viable option to stimulate interest in the health of the public from across medicine, and to upskill clinicians in health of the public research. The focus of such a credential would include areas such as health informatics and bioinformatics, clinical epidemiology and prevention, health economics, qualitative methodology, behaviour change, and intervention methodology including the development and evaluation of complex interventions, and the wider determinants of health. The skills gained should be relevant to public health and the clinical practice of personalised medicine and prevention.

The credential would be approved by the GMC.

Credentialing in health of the public must be accessible for all trainees (including those who will not go into clinical academia) to allow them to acquire particular skills in health of the public research. To have the broadest impact, credentialing should be available to post-Certificate of Completion of Training (CCT) trainees, and senior clinicians who develop an interest in health of the public research later on in their careers. Opportunities for accreditation of competencies in health of the public should also be offered to pre-CCT trainees. The opportunity to gain a credential would benefit both academic training and service delivery, so the approach is likely to prove attractive to clinicians across the board. The Royal College of Physicians Training Board is already developing guidelines on what credentialing would look like.

<sup>b</sup> The GMC defines credentialing as ‘a process which provides formal accreditation of competencies (which include knowledge, skills and performance) in a defined area of practice, at a level that provides confidence that the individual is fit to practise in that area...’. The GMC has recently consulted on the broad principles and processes for their credentialing model.

[http://www.gmc-uk.org/education/continuing\\_professional\\_development/27258.asp](http://www.gmc-uk.org/education/continuing_professional_development/27258.asp)

## Recommendation 5.4



We recommend that the Medical Royal Colleges, led by the Royal College of Physicians and the Faculty of Public Health, should establish a special interest group to develop a credential in health of the public research. This credential should encompass qualitative and quantitative research methods including health informatics and bioinformatics, clinical epidemiology and prevention, health economics, qualitative methodology, behaviour change, intervention methodology including the development and evaluation of complex interventions, and the wider determinants of health. Opportunities for credentialing should be provided for all trainees and not just those who wish to pursue a career in public health.

Credentialing is in its infancy but we would like to see it delivered by universities. The possibility of funding through Research Capability Funding, which is allocated to research-active NHS organisations, should be explored. If such an approach is taken up, a strong and sustainable cadre of health of the public researchers who understand the settings in which public health is practised will be essential as the demands for curriculum development, delivery and assessment will be substantial.

PHE's recent review of the public health workforce recommended that credentialing schemes for the public health workforce should be explored as a means of nurturing sub-specialisation, building on core competencies.<sup>356</sup>

### 5.4 Conclusions

Health of the public research must draw on individuals from a wide range of disciplines and skill sets, with a solid understanding of the full range of drivers of health. We need researchers with intimate knowledge of their specialist fields as well as those with the breadth of knowledge to bridge different disciplines and areas, and facilitate communication between them. There is also a need to facilitate a 'team science' approach to support transdisciplinary endeavours.

To increase capacity in health of the public research, undergraduate and postgraduate courses in the UK must place more emphasis on the relationship between disciplines outside the traditional public health and health sphere. We recommend the development of joint modules so that opportunities to learn about health of the public are offered in training of disciplines relevant to the population's health – such as architecture, computer science, demography, design, economics, education, engineering, environmental sciences, ethics, geography, informatics, law, mathematics, statistics, political science and other social and life sciences – and vice versa.

We make recommendations to strengthen undergraduate and postgraduate medical curricula so that clinicians across all specialities are equipped to understand the fundamental principles of health of the public and the continuum of interventions from population to individual. Although we focus on medical education here, we emphasise that all health and social care practitioners should be trained to have a holistic understanding of the determinants of health, and to practice in a way that incorporates a health of the public perspective. Trainees (including the majority who will not go into academia) should gain better understanding of health of the public research to create a workforce that is increasingly able to engage with research and use its findings. Career pathways and opportunities for research placements need to be developed and well-communicated to encourage the emergence of a strong research-informed workforce.



## References

342. Royal Society for Public Health (2015). *Rethinking the public health workforce*. <https://www.rspph.org.uk/asset/B84C8AA9-7526-425E-B6F738B1C7053BA0/>
343. Public Health England (2016). *Fit for the future – public health people: a review of the public health workforce*. [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/524599/Fit\\_for\\_the\\_Future\\_Report.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/524599/Fit_for_the_Future_Report.pdf)
344. <http://www.acmedsci.ac.uk/mhss>
345. <http://www.acmedsci.ac.uk/policy/policy-projects/team-science/>
346. <http://www.iph.cam.ac.uk/about-us/>
347. <http://www.gla.ac.uk/researchinstitutes/healthwellbeing/>
348. <http://www.helixcentre.com/>
349. Frenk J, et al. (2010). *Health professionals for a new century: transforming education to strengthen health systems in an interdependent world*. *The Lancet* **376**(9756), 1923-1958.
350. General Medical Council (2009). *Tomorrow's doctors: outcomes and standards for undergraduate medical education*. [http://www.gmc-uk.org/Tomorrow\\_s\\_Doctors\\_1214.pdf\\_48905759.pdf](http://www.gmc-uk.org/Tomorrow_s_Doctors_1214.pdf_48905759.pdf)
351. Gillam S, Rodrigues V & Myles P (2015). *Public health education in UK medical schools – towards consensus*. *Journal of Public Health* pii: fdv069.
352. General Medical Council (2015). *GMC council approves development of UK medical licensing assessment*. <http://www.gmc-uk.org/news/26549.asp>
353. The Foundation Programme (2013). *Foundation programme annual report 2013 UK summary*. [http://www.foundationprogramme.nhs.uk/download.asp?file=UK\\_Foundation\\_Programme\\_Annual\\_Report\\_2013\\_FINAL.pdf](http://www.foundationprogramme.nhs.uk/download.asp?file=UK_Foundation_Programme_Annual_Report_2013_FINAL.pdf)
354. Shape of Training (2013). *Securing the future of excellent patient care*. [http://www.shapeoftraining.co.uk/static/documents/content/Shape\\_of\\_training\\_FINAL\\_Report.pdf\\_53977887.pdf](http://www.shapeoftraining.co.uk/static/documents/content/Shape_of_training_FINAL_Report.pdf_53977887.pdf)
355. <https://hee.nhs.uk/hee-your-area/south-london/our-work/attracting-developing-our-workforce/multi-professional-workforce/team-0>
356. Public Health England (2016). *Fit for the future – public health people: a review of the public health workforce*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/524599/Fit\\_for\\_the\\_Future\\_Report.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/524599/Fit_for_the_Future_Report.pdf)





## 6. Working together to improve health and health equity

Achieving substantial and ongoing improvements in health and health equity will require people from all sectors of society to work together. We need a convergence of clinical and health of the public approaches to build the agenda for prevention in our health and social care system. We need re-engagement between researchers and practitioners, health and health equity in all relevant policies, and empowerment of people through co-production of individual and societal health.



## Introduction

Creating a health-promoting society in which people enjoy longer, healthier lives will require health and health equity to be considered in the development and implementation of interventions – and the delivery of health and social care – at all levels. To support this, researchers, practitioners, policymakers and the public will need to work together through meaningful and iterative engagement, reflecting on the constantly changing health and social care and wider environments. Depending on the issue being addressed, each stakeholder is likely to be involved at different phases of the research, translation and implementation process. Maintaining impartiality and building trust, given the often widely divergent interests of stakeholders, will remain a challenge. Nevertheless, where interests can be appropriately aligned, it will be essential that we work together.

In the following sections, we consider specific actions to enhance researchers' engagement with different stakeholder groups: practitioners, policymakers, the commercial sector, and the public.

### 6.1 Engaging with practitioners

#### ***Improving mutual understanding and building long-term relationships***

There have been significant efforts in recent years to better align clinical research and practice in the UK, promoting a culture of clinical research in the health service. Such efforts include Academic Health Science Networks (AHSNs), Academic Health Science Centres (AHSCs) and funding provided by the NIHR. While other mechanisms, including the CLAHRCs and the NIHR SPHR, represent the extension of such initiatives to include public health, evidence submitted to us indicates that a similar culture of research and evidence is less prevalent in public health practice. This is an issue compounded by limited funding for public health research, as discussed in Chapter 1, and by the cultural differences that exist between researchers and practitioners, such as the timelines over which they expect to see results.<sup>357</sup> Public health practitioners in England are now located in local authorities, which provide key opportunities for investment in interventions outside health and social care. Disinvestment in public health, however, reduces time and resources available to maintain links with external bodies including AHSNs.<sup>358</sup>

To produce relevant and accessible evidence concerning the health of the public for practitioners – that is, the full range of the health and social care workforce from public health practitioners to clinicians to allied health professionals – the research community needs to improve its awareness of their priorities and concerns. In turn, practitioners need to be more research aware and enhance their understanding of research methods and objectives and the interpretation and use of evidence. We make a recommendation to achieve this in Chapter 5 (see recommendation 5.3), in line with the proposals of the Royal College of Physician's 'Research for All'.<sup>359</sup>

To improve mutual understanding and build long-term relationships, we see the need for regional hubs of engagement between researchers and practitioners from across the spectrum of health and social care. This will assist in the identification of research priorities that are relevant to practitioners, and will support the joint delivery of research and evaluation. Engagement at a regional level, rather than local authority level, is needed to ensure access to a large enough unit of population for producing generalisable evidence. These hubs could provide opportunities for the transdisciplinary training that we called for in Chapter 5, as well as career posts for those completing such training. To facilitate this, it will be important that HEE, NHS Education Scotland, Wales Deanery and Northern Ireland Medical and Dental Training Agency are involved in their development. The hubs could also provide input into horizon scanning and identification of research priorities by the SCHOPR proposed in Chapter 3 (see recommendation 6).

The regional hubs of engagement could be established by building on existing structures. For example, PHE has regional structures and local centres that could link into their local academic assets as well as HPRUs. Another option may be to build on the 44 Sustainability and Transformation Plan (STP) 'footprints'. STPs are a key element of the NHS Shared Planning Guidance and the local implementation of the NHS 'Five Year Forward View'. The geographic 'footprints' are local health and care systems that have come together to develop and deliver STPs based on local needs.<sup>360</sup> The formation of new devolved structures for joint commissioning of health and social care services, for example in Manchester, may also provide opportunities for the formation of such hubs. The Government's health and social care information project,

'Connected Health Cities', may be yet another model to build on as information from across the civic system will be a crucial element of these hubs.<sup>361,362</sup> The academic assets will vary from place to place, and from time to time, but might include geographical clusters of universities, AHSNs, AHSCs, CLAHRCs, the NIHR SPHR, NHS Health Scotland and the Scottish Collaboration for Public Health Research and Policy, as well as equivalents in Wales and Northern Ireland. The regional hubs should establish links with major infrastructure developments including the recent investment of £350 million in public health labs in Harlow, which will see part of PHE moving from its existing facilities.<sup>363</sup> They should also take account of the move towards health and social care devolution in England.

While this section is focused on engagement between researchers and the health and social care workforce, key links also need to be established with the wider community as many of the interventions to improve health lie outside of the remit of health and social care. As noted in Chapter 5, in a recent review of the public health workforce, PHE highlighted the importance of engaging and developing the wider workforce.<sup>364</sup> Practitioners need to work with, for instance, town planners, teachers and regulators, and put forward evidence of health benefits arising from a range of interventions in these broader areas.

#### ***Provision of advice on improving the health of the public***

There is a need for a convergence of thinking between population-level and clinical approaches to improving the health of the public, to facilitate a shift in emphasis from treating ill health to preventing disease and maintaining good health. Furthermore, improvement in individual care – through personalised medicine – will depend on understanding not only the biology of disease but the entire range of external, competing influences on health. In Chapter 5, we proposed revisions to the training of practitioners so that they have a systems-based mindset with a holistic understanding of the determinants of health, and practice in a way that incorporates a health of the public, and particularly preventive, perspective. This will need to be supported by access to the most up-to-date information on improving health. Research evidence is part of the mosaic of information that practitioners pull together, and a number of resources currently exist for the provision of this evidence (see Box 6.1).

## **Box 6.1 Sources of evidence**

**The National Institute for Health Research** launched a new Dissemination Centre in 2015 aimed at helping NHS clinicians, commissioners and patients make informed decisions about which treatments and practices are most effective in healthcare, social care and public health.<sup>365</sup>

**Public Health England** (PHE) has a role to deliver advice and information. This is facilitated by the Healthcare Protection Research Units which were established in 2013 as research partnerships between universities and PHE and that act as centres of excellence in multidisciplinary health protection research in England.<sup>366</sup>

**NHS Health Scotland** is a national health board that works with public, private and third sectors to improve health and reduce health inequalities.<sup>367</sup> Its strategy includes compiling evidence to better understand health inequalities in Scotland and how to address them, as well as helping policymakers design and evaluate interventions to improve health and reduce health inequalities.

**The National Institute for Health and Care Excellence** public health guidelines make evidence-based recommendations regarding local interventions that can help prevent disease or improve health, focusing on particular topics (such as smoking), particular populations (such as schoolchildren) or a particular setting (such as the workplace).<sup>368</sup>

However, stronger mechanisms to synthesise current knowledge in an independent and authoritative way will further assist practitioners to implement evidence into practice and evaluate the outcomes. In view of inevitable gaps of evidence in many areas, such evidence synthesis must allow practitioners a means to identify the most suitable interventions based on limited information. To ensure credibility, the evidence provided will have to address the need for quality assurance by experts and be transparent about the interests of those contributing the advice.

There is also a need for mechanisms to disseminate experiential evidence regarding health systems and health of the public practice. These are often outcomes resulting from trying to implement evidence or to critically appraise evidence in light of practical experience. There are several barriers to the publication and dissemination of these findings, including a paucity of channels for publication, which deters practitioners from formally reporting their findings.

## Recommendation 6



We recommend that Public Health England, Health Education England and their equivalents in Scotland, Wales and Northern Ireland work with the research community to:

1. Develop regional hubs of engagement between practitioners and researchers to integrate health of the public research and health and social care delivery, building on existing national and regional public health structures, which together can form a UK-wide network.
2. Strengthen the mechanisms for obtaining and providing independent evidence on improving the health of the public, directed at all health and social care practitioners, and for reviewing the uptake of evidence-based practice guidance.

## 6.2 Engaging with policymakers

Decisions regarding our many environments should be guided by a robust understanding of how to most effectively support and improve the health of the public and allow healthy behaviours to flourish. They should also be based on a better understanding of how to create and deliver conditions conducive to addressing health inequalities, which lies largely outside of the health and social care system. In short, all policy – from local to global – should consider its positive and negative impact on the health of the public and on health inequalities. Cross-council/authority and cross-Government engagement is necessary to develop interventions that positively affect the health of the public and to achieve a '*health and health equity in all policies*' approach.<sup>369</sup> New structures for joint working between local Government and health and social care may provide new opportunities for such an approach.

### **Policy development**

In recent years, the Government has made a commitment to evidence-informed policy, with the majority of Government departments now having a Chief Scientific Adviser (CSA) to help ensure that good evidence is at the heart of Government decision-making.<sup>370</sup> The Government also appoints a Chief Medical Officer, who acts as its principal medical adviser and the professional head of all directors of public health in local Government. Additionally, in 2013, a network of seven independent What Works Centres<sup>c</sup> was launched to ensure that robust evidence is incorporated in policymaking at all levels of Government.

In 2015, the University of Essex and Essex County Council appointed the first CSA to a county council in the UK. A large part of the Essex County Council CSA's work will be to coordinate evaluations and use of big data analytics to increase efficiency and effectiveness of all kinds of commissioning.<sup>371</sup>

<sup>c</sup> The What Works Centres systematically synthesise evidence on what works within their field, develop widely accessible evidence summaries, and support commissioners and practitioners to act on this evidence. They include those that provide information relevant to the health of the public (e.g. the What Works Centre for Wellbeing and the Centre for Ageing Better).

<https://www.gov.uk/guidance/what-works-network>

We applaud these initiatives but recognise that some are works in progress. Evidence submitted to us indicates that much policy and practice that will impact the health of the public is poorly supported by evidence about these impacts.

## Recommendation 7



We recommend that each Government department reviews how it obtains evidence and advice on health and health equity, in order to ensure that impact on health and health equity is incorporated in the development of all relevant policies within departments and across Government. These reviews could be led by the departmental Chief Scientific Advisers and supported by the Health of the Public Policy Fellowships we propose in recommendation 9. Working with departmental policymakers, the Fellows would identify evidence requirements and the mechanisms needed for the research community to provide this evidence and advice.

### Evaluation

Mechanisms to evaluate policy impacts are recognised by the Government as crucial for effective internal decision-making.<sup>372</sup> As discussed in Chapter 3, high-quality evaluations can provide evidence about attribution and causality, determining whether interventions deliver their intended outcomes and measuring the balance of intended and unintended costs and benefits.<sup>373</sup> Evaluation needs to be embedded in the policymaking process, and health outcomes systematically considered, while recognising that better evaluation alone will not be sufficient to stimulate changes in policy.

Many opportunities for evaluation exist because of the large number of ‘natural experiments’ taking place in local, regional and national policy such as the devolution of health and social care to regions,<sup>374</sup> minimum unit pricing for alcohol,<sup>375</sup> new guidelines on alcohol consumption,<sup>376</sup> a sugar tax,<sup>377</sup> welfare reform,<sup>378</sup> and the impact on patients of public health reform.<sup>379</sup>

We acknowledge the funding constraints in sectors where most of the programmes to address health and health equity are commissioned. Without appropriate evaluation, however, we will not be able to disinvest in uneconomic interventions: evaluation is crucial for optimising the use of resources.

## Recommendation 8



We recommend that all major policies and programmes that address health and health equity, as well as those that affect the key drivers of health and health equity, should have independent effectiveness and economic evaluation of their short-, medium- and long-term impacts built in from the start. This will support decisions on wider investment or disinvestment, as appropriate, to promote optimum resource allocation.

### ***Enhancing utility and accessibility of research findings***

Researchers will need to provide accurate, credible, relevant and accessible evidence to facilitate the incorporation of health in all relevant Government policies.

#### *Relevant evidence*

Due to the fast-paced process of policymaking, it is vital that evidence is provided in a timely fashion. It is also important that researchers do not ignore the wider policymaking context and that broader factors influencing policymaking – values, language, discourse – are taken into account.<sup>380,381</sup> We need a better understanding of the drivers of political decision-making, and how political beliefs and ideologies interface with research evidence to shape policymaking.

Since many interventions to improve the health of the public require behaviour change, quantitative and qualitative social science research that can provide the context to make evidence translatable into policy would also assist decision-makers. Evidence that challenges or modifies assumptions, or provides an unpredicted insight into the impacts of policy decisions, is also valued.<sup>382</sup> Empirical literature suggests that the greatest impact is often achieved through ‘enlightenment’ — changing thinking around a specific problem in an unanticipated way.<sup>383,384</sup> Other research outputs valued by policymakers include those that indicate outcomes in real-world scenarios (such as effectiveness or pragmatic trials) and rigorous and unbiased synthesis of existing information, preferably from multiple disciplines.<sup>385</sup>

Producing relevant evidence, however, does not always mean that it meets the immediate needs of users: it may instead aid decision-making by future Governments and policymakers. Similarly, we must not forget the importance of curiosity-driven, blue skies research, which will remain vital.

#### *Accessible evidence*

To make it accessible, research evidence must be made easily available and understandable to policymakers. The framing of evidence also affects how it is accessed and engaged with. In Scotland, for example, the passing of legislation for minimum unit pricing of alcohol was in part a result of the framing of the issue as being broad, multi-sectoral and requiring a whole-population approach.<sup>386</sup>

Researchers in population health already engage successfully and reciprocally with the policy community in a variety of ways, such as through advisory boards, committees, consultation and research partnerships.<sup>387</sup> However, there is no systematic process for communicating high-quality research findings to the policy community in a timely way.

Academic journals are still the primary mode of communicating research evidence, with ‘lay summaries’ not routinely produced. Many academic publications sit behind paywalls, meaning they are not readily accessible to those outside the higher education community, and evidence we received suggests that academic journals are good for quality assurance, but not as good for creating widespread change, given the vast amount of information they disseminate. Mandatory lay summaries might help bridge the gap between scientific and non-scientific communities, but novel methods of communicating research findings must be sought and harnessed for the future, especially unbiased syntheses of current knowledge, which are of particular value to decision-makers.<sup>388,389,390</sup>

### ***Improving mutual understanding and building long-term relationships***

One way of enhancing the utility and accessibility of research outputs is by building long-term relationships between researchers and policymakers at all levels of Government: international, national, regional and local. We heard that relationships between researchers and policymakers are particularly lacking at the local level and that there are limited models for effectively translating evidence into local policy. We also hear the challenge of researchers and policymakers maintaining connections, particularly when faced with frequent personnel and system changes.

A number of fellowships and internships exist to provide a means through which connections can be made at the national level (see Box 6.2 for examples). We consider, however, that a specific mechanism to promote links between health of the public researchers and policymakers is required.

## Box 6.2 Linking researchers and policymakers

### **Department of Health/Ministry of Justice/Department for Education**

**policy fellowships:** In 2015, the Departments of Health, Education and Justice began recruiting experts from outside Government to open up policymaking to a wider range of expertise. As part of this scheme the NIHR recruited a number of public health registrars to the Department of Health.<sup>391,392,393</sup>

### **Cambridge University Centre for Science and Policy (CSaP) Fellowship Programme:**

The CSaP Fellowship programme introduces senior figures from the public, private and third sector to academic experts. Fellows are encouraged to go on to use this network when formulating policy. The programme aims to inform policymaking in the long term by making scientific research more accessible to policymakers.<sup>394</sup>

### **Scottish Graduate Schools of Social Science (SGSSS)-Scottish Government**

**Internship scheme:** The SGSSS runs an internship scheme where PhD students are invited to work in a Scottish Government department and complete a research project that will act as evidence in the formulation of policy. The aim of the scheme is to encourage researchers to become involved in Government research and allow the Scottish Government to utilise their skills.<sup>395</sup>

### **Canadian Institutes of Health Research: Institute of Health Services and**

**Policy Research:** The Institute of Health Services and Policy Research is one of 13 national health research institutes. It funds research with an aim of improving healthcare services in Canada. It is Government funded but independent and reports directly to the Canadian parliament.<sup>396</sup>

**Robert Wood Johnson Foundation Health Policy Fellows:** This US-based fellowship programme assigns successful researchers to high-profile policymakers, usually Senators or Senate committees, to inform policymaking and give high-profile researchers an understanding of health policy.<sup>397</sup>

## Recommendation 9



We recommend the development of 'Health of the Public Policy Fellowships' to build reciprocal relationships, mutual understanding and long-term networks between researchers and policymakers. These Fellows should be based in the most relevant parts of Government departments.

This competitive scheme could target researchers identified as being tomorrow's leaders in health of the public research. It would be open to researchers whose core disciplines are in both traditional public health and non-traditional health of the public disciplines. We would anticipate these fellows being based in the offices of the Chief Scientists (or equivalent) across all relevant departments of Government and the devolved administrations. Fellowships could be full - or part-time for up to 12 months full-time equivalent. If this fellowship proves successful, similar models with local Government could be considered in the future.

### 6.3 Engaging with the commercial sector

The commercial sector, as a provider of goods and services and as an employer, plays a major role in shaping health outcomes in both positive and negative ways. Working with the commercial sector could yield important benefits to the health of the public, both as a result of product innovation and improvements to social and other wider determinants of health. However, working with the commercial sector offers significant challenges: history has shown that collaboration with the commercial sector may actually be disadvantageous to the health of the public, resulting in less effective policy.<sup>398,399,400,401</sup> While it is acknowledged that there is diversity within the sector – including producers of products both beneficial and harmful for the health of the public – competing interests often hamper the development of productive relationships, particularly with those industries producing products that harm health, such as tobacco, alcohol and energy-dense/nutrition-poor foods.<sup>402,403</sup>

In relation to health of the public research, the commercial sector plays an important role and will continue to do so out to 2040. The sector is a major funder of research: a study commissioned by the Department for Business, Innovation & Skills found that, in 2012, 70% of all UK investment in science, research and innovation was funded by the private sector.<sup>404</sup> The sector can also create products that are health-enhancing. For example, the development of safer and fuel efficient cars gives manufacturers a competitive advantage, as it is something consumers value, while contributing to reductions in road fatalities and green house gas emissions. Technological innovation within the commercial sector – through remote diagnostics, wearable technologies and machine learning, for example – has the potential to reshape health-related behaviours and, if properly harnessed and evaluated, to transform the delivery of health and social care, as discussed in Chapter 2. Additionally, the sector increasingly curates and analyses data that, if available to researchers, could bring about a step-change in monitoring and understanding the health of the public. For example, analysis of Nielsen market data has been invaluable in understanding alcohol-related harms in Scotland and evaluating its alcohol strategy.<sup>405,406</sup> The use of non-health data for health of the public research is discussed further in Chapter 4.

However, there is also evidence of the commercial sector undermining health of the public research, leading to mistrust among the research community. Commercial sector funding can alter research priorities by shaping the research agenda through funding provision or by lobbying decision-makers or funders – for example, by privileging intervention approaches that are less likely to be effective.<sup>407,408</sup> The sector's involvement in the design or conduct of research has sometimes been found to result in more biased research.<sup>409,410</sup> The dissemination process could also be affected, with greater risks of non-publication and misrepresentation of research findings.<sup>411,412</sup> Furthermore, some commercial sector research has been used as an extension of political lobbying, with the role of specific industries in the production and dissemination process not made explicit.<sup>413,414,415</sup>

Cultural differences to be overcome for successful industry-academia collaboration include the tension between academia's slower, long-term pace and industry's time-sensitive product development cycles; and the tension between the interests of academia in publishable research and the need for companies to protect their commercial interests.<sup>416</sup> There is also concern among some researchers that they will be viewed negatively by colleagues if they collaborate with industry.<sup>417,418,419</sup>

Some research questions, however, can only be answered, or would be better answered, with collaboration between researchers and the commercial sector. Such collaboration is common between health researchers and the pharmaceutical industry. The Academy has been exploring how sources of funding (or other potential conflicts of interest) might impact on the generation or interpretation of medical evidence, and how conflicts can be effectively managed.<sup>420</sup> In some areas, for example in tobacco control research, collaboration between health of the public researchers and the commercial sector may always be inappropriate,<sup>421</sup> unless the industry turns to beneficial diversification. In others, it has potential to advance knowledge. To enable successful joint working in these circumstances we see a need for processes to address competing interests and for more guidance to the research community on how such collaborations can be undertaken ethically and effectively.

## Recommendation 10



We recommend that research funders (such as the Medical Research Council, Wellcome, the National Institute for Health Research and its devolved equivalents) consider mechanisms to explore joint working between health of the public researchers and the commercial sector.

### 6.4 Engaging with the public

#### *Co-production of research*

The UK public is very supportive of scientific research: 81% of people in the UK agree that science will make people's lives easier, and only 16% do not believe that the benefits of science outweigh the harms. In addition, people are interested in learning more about science, with 84% believing we should all take an interest, and 91% of people agreeing that future prosperity is dependent on young people's interest in science.<sup>422</sup> The public is also increasingly involved in producing data for research, as noted in Chapter 4.

Although approaches to assessing or describing impact are inconsistent, there is evidence that meaningful public involvement in research yields a range of benefits: for instance, opening up new areas of research, influencing funding decisions, identifying ethical concerns, and affecting change.<sup>423</sup> Advocates of co-production (see Box 6.3) also argue that it can enhance the effectiveness of research by making it better informed by communities' preferences and needs, with communities then contributing to improved outcomes and achievable solutions.<sup>424,425</sup> There is also a move towards drawing on the resources, skills and assets in groups and places so that a better partnership is built with the public around issues of interest to them, termed asset based community development.<sup>426</sup> With increasing contributions from patient groups and the rise in citizen science (research conducted by non-professional scientists who crowdsource their contributions, such as Cell Slider, a project which saw millions of images of cancer cells analysed by volunteers)<sup>427</sup> more research may be conducted outside of the academic sphere in the future.<sup>428</sup>

### Box 6.3 Co-production

'Co-production' broadly describes the need for relationships to be reciprocal in order for change to occur. It is about more than consultation and participation; it is about encouraging people to use their skills and experience so that public services are no longer solely in the domain of professionals, but are a shared responsibility.<sup>429</sup> There are other terminologies around these and similar concepts, such as, 'co-delivering', 'knowledge exchange' and 'asset-based community development'.

However, despite some positive steps, such as the establishment of public and patient involvement in NIHR-funded research,<sup>430</sup> much research, including interventional research, is designed without meaningful and iterative public engagement,<sup>431</sup> despite the efforts of organisations such as the National Coordinating Centre for Public Engagement and INVOLVE,<sup>432</sup> which support universities and researchers to engage with the public.

Public engagement more often happens at the policy-development stage, but this is not always meaningful. The Government places a strong focus on consultation as a means of ascertaining public opinion, although its effectiveness, compared to alternatives such as deliberative dialogue, is not conclusive.

More needs to be done to ensure that meaningful and iterative public involvement takes place from early in the process of designing research to produce the evidence base for influencing the health of the public. This is particularly the case when investigating potential interventions.

#### **Communication of public health messages**

Evidence we received during this project, in particular from our public dialogue activities, highlighted the importance of public health messaging and its potential to act as both a driver of positive health outcomes and a source of health inequalities.

Health information should be communicated in a way that empowers people to make informed decisions about their health, recognising that messages which emphasise gain rather than loss are more likely to encourage prevention behaviours.<sup>433</sup> Evidence submitted to us also suggests that messages need to be framed in terms of what people's health will allow them to achieve rather than in terms of health benefits per se, as health often only becomes important to people when it goes wrong. The power of narrative in communicating messages and engaging the public should not be underestimated.<sup>434,435</sup>

The internet is revolutionising public and professional access to detailed and up-to-date health, diagnostic and clinical management information. This so-called 'democratisation of knowledge' has the potential to fundamentally alter clinician-patient relationships in terms of information exchange and joint decision-making about effective personalised prevention and care.<sup>436,437,438</sup> This in turn requires systematic study to optimise future clinical practice, patient engagement and communication in a model which is predictive, pre-emptive, personalised and participatory.<sup>439</sup>

We need more information on how to improve health literacy (that is, how such messages are received) while increasing the focus on health communication (that is, how such messages are sent) with a particular focus on the opportunities and challenges presented by new methods of communication, including e-learning and social media. Health communications research that draws on insight from the communication, education and behavioural sciences should be promoted. There should also be more exploration on the impact of personalised health recommendations.

## **Recommendation 11**



We recommend that key public and charitable research funders (such as Research Councils, the National Institute for Health Research and its devolved equivalents, the British Heart Foundation, Cancer Research UK and Wellcome) support research into:

1. Strengthening and developing methods of engagement between researchers and the public.
2. Strengthening and developing methods of communicating health messages that are appropriate to the values, culture and norms of different sectors of society.

In both cases, particular focus should be given to those groups that do not traditionally engage in research and those most at risk of poor health.

## 6.5 Conclusions

Better engagement between all sectors of society regarding health of the public will be essential if we are to meet our aspiration of substantial and ongoing improvements to health and health equity.

To help facilitate cross-Government thinking on health of the public, we call for a review of how Government departments obtain evidence and advice on health and health equity; for the creation of 'Health of the Public Policy Fellowships' to be based across Government departments and the devolved administrations; and for independent evaluation of the short- to long-term effects on health and health equity to be built into all relevant policies and programmes.

The regional hubs of engagement between researchers and practitioners that we recommend will increase the relevance and accessibility of research outputs. They will also help support practitioners to deliver effective interventions based on evidence, and to provide evidence to work with people from across a range of sectors – such as transport, built environment, food and finance – and take forward health-improving interventions across all relevant areas.

Given the often challenging relationship between the commercial sector and health of the public research community, appropriate guidance on collaboration is needed where there is the potential to improve the health of the public through joint work and data sharing. We ask research funders to consider appropriate frameworks to explore this issue.

New models for meaningful and iterative engagement between researchers and the public are needed to create a health-promoting society where good health and health equity is valued by all. We also need to know more about better ways of communicating to empower people to actively contribute to their own and other people's health. To achieve this, we call on research funders to support work into developing and strengthening methods of engaging and communicating effectively with the public, particularly those groups that do not traditionally engage in research and those most at risk of poor health.

## References

357. The Academy of Medical Sciences (2013). *Public health research: reflections from the CDC*. <http://www.acmedsci.ac.uk/viewFile/517e9fc870cd7.pdf>
358. <http://www.nuffieldtrust.org.uk/publications/focus-public-health-and-prevention>
359. Royal College of Physicians (2016). *Research for all*. <https://www.rcplondon.ac.uk/projects/outputs/research-all>
360. NHS England. *Five Year Forward View: NHS shared planning guidance: sustainability and transformation plans*. <https://www.england.nhs.uk/ourwork/futurenhs/deliver-forward-view/stp/>
361. <http://www.connectedhealthcities.com/>
362. Northern Health Science Alliance (2015). *Health north: powering UK health and wealth transformation*. <http://www.ahsn-nenc.org.uk/wp-content/uploads/2015/04/Health-North-Connected-Health-Cities-submitted.pdf>
363. HM Treasury, Public Health England & The Rt Hon George Osborne MP (2015). *Government invests £350 million to create world-class public health labs in Harlow*. <https://www.gov.uk/government/news/Government-invests-350-million-to-create-world-class-public-health-labs-in-harlow>
364. Public Health England (2016). *Fit for the future – public health people: a review of the public health workforce*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/524599/Fit\\_for\\_the\\_Future\\_Report.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/524599/Fit_for_the_Future_Report.pdf)
365. <http://www.dc.nihr.ac.uk/>
366. <http://www.nihr.ac.uk/funding/health-protection-research-units.htm>
367. <http://www.healthscotland.com/>
368. <https://www.nice.org.uk/about/what-we-do/our-programmes/nice-guidance/nice-guidelines/types-of-guideline>
369. All Party Parliamentary Health Group and Health Foundation (2016). *A Healthier Life for All: The Case for Cross-Government Action*. <http://www.health.org.uk/publication/healthier-life-all>
370. Government Office for Science (2015). *Chief scientific advisors and their officials: an introduction*. [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/426307/15-2-chief-scientific-advisers-and-officials-introduction.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/426307/15-2-chief-scientific-advisers-and-officials-introduction.pdf)
371. University of Essex (2015). *Chief scientific advisor appointed to bring data-driven approaches to public services in Essex*. [http://www.essex.ac.uk/news/event.aspx?e\\_id=9294](http://www.essex.ac.uk/news/event.aspx?e_id=9294)
372. HM Treasury (2013). *Managing public money*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/454191/Managing\\_Public\\_Money\\_AA\\_v2\\_-jan15.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/454191/Managing_Public_Money_AA_v2_-jan15.pdf)
373. National Audit Office (2013). *Evaluation in Government*. [https://www.nao.org.uk/wp-content/uploads/2013/12/10331-001-Evaluation-in-government\\_NEW.pdf](https://www.nao.org.uk/wp-content/uploads/2013/12/10331-001-Evaluation-in-government_NEW.pdf)
374. <http://www.gmhsc.org.uk/>
375. <http://www.gov.scot/Topics/Health/Services/Alcohol/minimum-pricing>
376. Department of Health (2016). *UK Chief Medical Officers' Alcohol Guidelines Review: Summary of the proposed new guidelines*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/489795/summary.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/489795/summary.pdf)
377. Public Health England (2015). *Sugar reduction: the evidence for action*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/470179/Sugar\\_reduction\\_The\\_evidence\\_for\\_action.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470179/Sugar_reduction_The_evidence_for_action.pdf)
378. <https://www.gov.uk/government/policies/welfare-reform>
379. Department of Health (2015). *Public health in local Government: local Government's new public health functions*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/216710/dh\\_131905.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/216710/dh_131905.pdf)

380. Russell J, et al. (2008). *Recognizing rhetoric in health care policy analysis*. Journal of Health Services Research & Policy **13(1)**, 40-46.
381. Contandriopoulos D, et al. (2010). *Knowledge exchange processes in organizations and policy arenas: a narrative systematic review of the literature*. The Milbank Quarterly **88(4)**, 444-483.
382. Whitty CJM (2015). *What makes an academic paper useful for health policy?* BMC Medicine **13**, 301.
383. Liverani M, Hawkins B & Parkhurst JO (2013). *Political and institutional influences on the use of evidence in public health policy. A systematic review*. PLoS ONE **8(10)**, e77404.
384. Weiss CH (1979). *The many meanings of research utilization*. Public Administration Review **39(5)**, 426-431.
385. Whitty CJM (2015). *What makes an academic paper useful for health policy?* BMC Medicine **13**, 301.
386. Katikireddi SV, Bond L & Hilton S (2014). *Changing policy framing as a deliberate strategy for public health advocacy: a qualitative policy case study of minimum unit pricing of alcohol*. The Milbank Quarterly **92(2)**, 250-283.
387. Haynes AS, et al. (2011). *Galvanisers, guides, champions and shields: the many ways that policymakers use public health researchers*. The Milbank Quarterly **89(4)**, 564-598.
388. Woolston C (2015). *Petition calls for lay summaries in ecology journals*. Nature **520**, 135.
389. Ogilvie D, et al. (2009). *A translational framework for public health research*. BMC Public Health **9**, 116.
390. Whitty CJM (2015). *What makes an academic paper useful for health policy?* BMC Medicine **13**, 301.
391. Department of Health (2012). *Chief Medical Officer's annual report 2011: postscript public health research NIHR*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/141777/CMO\\_Annual\\_Report\\_2011\\_Chapter\\_6.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/141777/CMO_Annual_Report_2011_Chapter_6.pdf)
392. Department for Education (2015). *DfE policy fellowship*. <https://www.gov.uk/government/news/dfe-policy-fellowship>
393. Ministry of Justice (2015). *Ministry of Justice policy fellowships*. <https://www.gov.uk/government/news/ministry-of-justice-policy-fellowships>
394. <http://www.csap.cam.ac.uk/policy-fellowships/>
395. [http://www.socsciscotland.ac.uk/skills\\_and\\_training/internships](http://www.socsciscotland.ac.uk/skills_and_training/internships)
396. <http://www.cihr-irsc.gc.ca/e/13733.html>
397. <http://www.healthpolicyfellows.org/about/>
398. Gilmore AB, Savell E, & Collin J (2011). *Public health, corporations and the New Responsibility Deal: promoting partnerships with vectors of disease?* Journal of Public Health **33(1)**, 2-4.
399. McCambridge J, Hawkins B & Holden C (2013). *Industry use of evidence to influence alcohol policy: a case of submissions to the 2008 Scottish Government consultation*. PLoS Medicine **10(4)**, e1001431.
400. Moodie R, et al. (2013). *Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries*. The Lancet **381(9867)**, 670-679.
401. Stuckler D & Nestle M (2012). *Big food, food systems, and global health*. PLoS Medicine **9(6)**, e1001242.
402. World Health Organization (2008). *Guidelines for implementation of article 5.3 of the WHO framework convention on tobacco control*. [http://www.who.int/fctc/guidelines/article\\_5\\_3.pdf](http://www.who.int/fctc/guidelines/article_5_3.pdf)
403. Gilmore AB, Savell E, & Collin J (2011). *Public health, corporations and the New Responsibility Deal: promoting partnerships with vectors of disease?* Journal of Public Health **33(1)**, 2-4.
404. Economic Insight (2015). *What is the relationship between public and private investment in science, research and innovation? A report commissioned by the Department for Business, Innovation and Skills*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/438763/bis-15-340-relationship-between-public-and-private-investment-in-R-D.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/438763/bis-15-340-relationship-between-public-and-private-investment-in-R-D.pdf)

405. Robinson M, et al. (2012). *A review of the validity and reliability of alcohol retail sales data for monitoring population levels of alcohol consumption: a Scottish perspective*. Alcohol and Alcoholism **48(2)**, 231-240.
406. Robinson M, et al. (2014). *Evaluating the impact of the alcohol act on off-trade alcohol sales: a natural experiment in Scotland*. Addiction **109(12)**, 2035-2043.
407. McGarity TO & Wagner WE (2008). *Bending science: how special interests corrupt public health research*. Harvard University Press, Cambridge USA.
408. Miller PG, et al. (2011). *Vested interests in addiction research and policy. Alcohol industry use of social aspect public relations organizations against preventative health measures*. Addiction **106(9)**, 1560-1567.
409. Kjaergard L & Als-Nielsen B (2002). *Association between competing interests and authors' conclusions: epidemiological study of randomised clinical trials published in the BMJ*. BMJ **325(7358)**, 249.
410. Bes-Rastrollo M, et al. (2013). *Financial conflicts of interest and reporting bias regarding the association between sugar-sweetened beverages and weight gain: a systematic review of systematic reviews*. PLoS Medicine **10(12)**, e1001578.
411. Oreskes N & Conway EM (2011). *Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. Bloomsbury Publishing, New York, USA.
412. McKee M & Diethelm P (2010). *How the growth of denialism undermines public health*. BMJ **341**, c6950.
413. Petticrew MP & Lee K (2011). *The "father of stress" meets "big tobacco": Hans Selye and the tobacco industry*. American Journal of Public Health **101(3)**, 411-418.
414. McCambridge J & Hartwell G (2014). *Has industry funding biased studies of the protective effects of alcohol on cardiovascular disease? A preliminary investigation of prospective cohort studies*. Drug and Alcohol Review **34(1)**, 58-66.
415. Smith KE, Kay L & Torres J (2013). *Think tanks as research mediators? Case studies from public health*. Evidence & Policy: A Journal of Research, Debate and Practice **9(3)**, 371-390.
416. Perkmann M & Salter A (2012). *How to create productive partnerships with universities*. MIT Sloan Management Review, June 18. <http://sloanreview.mit.edu/article/how-to-create-productive-partnerships-with-universities/>
417. BMJ (2015). *BMJ investigation reveals extensive network of links between public health scientists and sugar industry*. <http://www.bmj.com/company/wp-content/uploads/2015/02/sugar-invest.pdf>
418. Savill J (2015). *Re: Sugar: spinning a web of influence*. BMJ **350**, h231.
419. MRC Epidemiology Unit & Centre for Diet and Activity Research (2015). *Dietary public health research and the food industry: towards a consensus*. <http://www.cedar.ipb.cam.ac.uk/wp-content/uploads/2015/07/Dietary-public-health-food-industry-event-report-FINAL-210416.docx>
420. <http://www.acmedsci.ac.uk/policy/policy-projects/conflicts-of-interest-workshop/>
421. World Health Organization (2008). *Guidelines for implementation of article 5.3 of the WHO framework convention on tobacco control*. [http://www.who.int/fctc/guidelines/article\\_5\\_3.pdf](http://www.who.int/fctc/guidelines/article_5_3.pdf)
422. Ipsos MORI Social Research Institute (2014). *Public attitudes to science 2014*. <https://www.ipsos-mori.com/Assets/Docs/Polls/pas-2014-main-report.pdf>
423. National Institute for Health Research (2009). *Exploring impact: public involvement in NHS, public health and social care research*. <http://www.invo.org.uk/wp-content/uploads/2012/01/INVOLVEExploringImpactSummary2009.pdf>
424. Ostrom E (1996). *Crossing the great divide: co-production, synergy and development*. World Development **24(6)**, 1073-1087.
425. Connected Communities (2011). *Towards co-production in research with communities*. [https://www.dur.ac.uk/resources/geography/reframing\\_state/CCDiscussionPaperDurose2etal.pdf](https://www.dur.ac.uk/resources/geography/reframing_state/CCDiscussionPaperDurose2etal.pdf)

426. <http://www.abcdinstitute.org/index.html>
427. <http://www.nesta.org.uk/digital-social-innovation/citizen-science>
428. European Commission DG Environment (2013). *Science for environment policy in-depth report: environmental citizen science.* [http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR9\\_en.pdf](http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR9_en.pdf)
429. New Economics Foundation (2008). *Co-production: a manifesto for growing the core economy.* [http://b.3cdn.net/nefoundation/5abec531b2a775dc8d\\_qjm6bzpt.pdf](http://b.3cdn.net/nefoundation/5abec531b2a775dc8d_qjm6bzpt.pdf)
430. <http://www.nihr.ac.uk/funding/pgfar-patient-and-public-involvement.htm>
431. <http://www.publicengagement.ac.uk/>
432. <http://www.invo.org.uk/>
433. Gallagher KM & Updegraff JA (2012). *Health message framing effects on attitudes, intentions, and behaviour: a meta-analytic review.* Annals of Behavioral Medicine **43(1)**, 101-116.
434. Frank LB, et al. (2014). *Telling stories, saving lives: creating narrative health messages.* Health Communication **30**, 154-163.
435. Hinyard LJ (2007). *Using narrative communication as a tool for health behavior change: a conceptual, theoretical, and empirical overview.* Health Education & Behavior **34(5)**, 777-792.
436. European Group on Ethics in Science and New Technologies (2015). *Opinion on the ethical implications of new health technologies and citizen participation.* [https://ec.europa.eu/research/ege/pdf/opinion-29\\_ege\\_executive-summary-recommendations.pdf](https://ec.europa.eu/research/ege/pdf/opinion-29_ege_executive-summary-recommendations.pdf)
437. NHS Scotland (2016). *Chief Medical Officer's Annual Report 2014-15.* <http://www.gov.scot/Resource/0049/00492507.pdf>
438. <http://www.pwc.com/us/en/health-industries/publications/health-care-social-media.html>
439. The Academy of Medical Sciences (2015). *Stratified, personalised or P4 medicine: a new direction for placing the patient at the centre of healthcare and health education.* <https://www.acmedsci.ac.uk/viewFile/564091e072d41.pdf>

# Annex I. Membership of working group, review group and secretariat

## Working group

Job titles and affiliations were correct at the time of publication. Members participated in a personal capacity and not on behalf of their affiliated organisations.

### **Professor Dame Anne Johnson DBE FMedSci [Chair]**

Chair of the Population and Lifelong Health Domain, and Vice-Dean for External and International Relations, Faculty of Population Health Sciences, UCL

### **Professor Carol Brayne FMedSci**

Director of the Cambridge Institute of Public Health, University of Cambridge

### **Professor Rachel Cooper OBE**

Professor of Design Management, University of Lancaster

### **Professor Yvonne Doyle**

Regional Director for London, Public Health England

### **Professor David Ford**

Professor of Health Informatics, Swansea University

### **Professor Sarah Harper**

Director of the Institute of Population Ageing, University of Oxford

### **Dr Srinivasa Vittal Katikireddi**

Senior Clinical Research Fellow in Public Health, MRC/CSO Social and Public Health Sciences Unit, University of Glasgow

### **Professor Catherine Law CBE FMedSci**

Professor of Public Health and Epidemiology, UCL Institute of Child Health

### **Professor Paul Little FMedSci**

Professor of Primary Care Research, University of Southampton

### **Professor Dame Sally Macintyre DBE FMedSci**

Honorary Senior Research Fellow and Professor Emeritus, University of Glasgow

### **Professor Johan Mackenbach**

Chair of the Department of Public Health at Erasmus MC, University Medical Centre, Rotterdam

### **Professor Theresa Marteau FMedSci**

Director of the Behaviour and Health Research Unit, University of Cambridge

### **Councillor Jonathan McShane**

Cabinet Member for Health, Social Care and Culture, London Borough of Hackney

### **Dr Geoff Mulgan CBE**

Chief Executive of the National Endowment for Science Technology and the Arts (Nesta)

### **Baron Peter Piot CMG FMedSci**

Director of the London School of Hygiene & Tropical Medicine

### **Professor Jules Pretty OBE**

Deputy Vice-Chancellor and Professor of Environment & Society, University of Essex

### **Professor David Stuckler**

Professor of Political Economy and Sociology, University of Oxford

## Review group

This report was reviewed by an external panel appointed by the Council of the Academy of Medical Sciences. Reviewers were asked to consider whether the report met the terms of reference, and whether the evidence and arguments presented in the report were sound and supported the conclusions. Reviewers were not asked to endorse the report or its findings. Reviewers participated in a personal capacity and not on behalf of their affiliated organisations. Job titles and affiliations were correct at the time of publication.

### **Professor Anne Dell CBE FRS FMedSci [Chair]**

Professor of Carbohydrate Biochemistry, Department of Life Sciences, Imperial College London

### **Professor Brian S Collins FREng**

Professor of Engineering Policy, Director, International Centre for Infrastructure Futures (ICIF), UCL

### **Dr Alexis Gilbert**

Speciality Registrar in Public Health, North Yorkshire and the Humber Health Protection Team, Public Health England

### **Professor George Griffin FMedSci**

Emeritus Professor of Infectious Diseases and Medicine, St George's University of London

### **Professor Graham Hart FMedSci**

Dean, UCL Faculty of Population Health Sciences, UCL

### **Professor Andrew Morris FRSE FMedSci**

Professor of Medicine, Director of the Usher Institute of Population Health Sciences and Informatics, and Vice-Principal Data Science, University of Edinburgh

### **Professor Jonathan Shepherd CBE FMedSci FLSW**

Associate Dean of Innovation, Professor of Oral and Maxillofacial Surgery, Director of Violence and Society Research Group, University of Cardiff

### **Dr Helen Walters**

Head of Health, Greater London Authority

## Secretariat

### **Dr Naho Yamazaki [Lead Secretariat]**

Head of Policy

### **David Bennett**

Policy Officer (Medical Science)

### **Victoria Charlton**

Interim Head of Policy [February – November 2015]

### **Dr Mehwaesh Islam**

Policy Officer (Careers and Medical Science)

### **Dr Rachel Quinn**

Director of Medical Science Policy

### **Holly Rogers**

Communications and Engagement Officer

## Annex II. Sources of input and contributors to the project

### Visioning and drivers analysis workshop: November 2014

In conjunction with the launch of the project, the Academy hosted a visioning and drivers analysis workshop on 24 November 2014. The workshop brought together a diverse, interdisciplinary group of key stakeholders to explore visions for the desired state of the nation's health in 2040 and the drivers of change which are likely to affect the health of the public over the course of the next 25 years. A report of the event and list of attendees can be found on the Academy's website.<sup>440</sup>

### Written input submissions

A call for written input was launched in early March 2015 to build on the findings of the initial workshop and other research conducted by the working group. The call closed in May, with over 50 submissions received from a wide range of organisations and individuals. These are listed on the Academy's website.<sup>441</sup>

### Roundtable discussions

We hosted seven roundtable discussions to supplement the written input and explore particular topics of interest, allowing us to better understand the drivers of health and how they might be influenced through research.

Attendees at the following roundtables are listed on the website:<sup>442</sup>

- The built and natural environment [Friday 29 May 2015]
- Education and working life [Friday 29 May 2015]
- Technological change [Monday 15 June 2015]
- Demographic change [Monday 15 June 2015]
- Economic and political systems [Wednesday 15 July 2015]
- Health-related behaviours [Wednesday 15 July 2015]
- Health systems and health protection [Wednesday 15 July 2015]

### Stakeholder workshop: July 2015

A second one-day workshop was held on 29 July 2015, providing an opportunity for stakeholders to support the development of recommendations. A list of attendees can be found on the Academy's website.<sup>443</sup>

### Public dialogue workstream: 'Health, lies and videotape'

Throughout the project, the working group's activities were complemented by a programme of public dialogue. This workstream, entitled 'Health, lies and videotape,' involved a combination of film screenings and public discussion workshops. The screening events presented old public health films provided by the Wellcome Library to promote discussion about the past, present and future of health research, while the workshops facilitated more in-depth discussion to test the working group's vision for the health of the public in 2040. This programme of events and workshops was structured to allow iterative discussion between the working group and members of the public. See Figure 3 for a visual summary of these discussions.

Participants generally expressed enthusiasm for the project and support for the working group's vision, prioritising ambitions which relate to child health, national resilience and equal access to health outcomes and health information. A recurring theme across discussions was an enthusiasm for sharing health data, with participants noting that the linking of this data should be a priority for the future. However, there was some divergence of opinion between groups. Younger, more digitally engaged participants, for example, expressed an expectation that digital technologies will be central to future health treatments and interventions, while older participants with faith values were more focused on face-to-face engagement with health professionals.

A more detailed summary of the findings of our public dialogue activities can be found on the Academy's website.<sup>444</sup>

**Figure 3. Public dialogue: visual note-taking**



## The Lancet's call for mini-essays

The Lancet, in support of the project, published a call for mini-essays early in 2015, asking its readership to describe the three biggest issues for the health of the UK population in 2040.<sup>445</sup> 23 responses were received, discussing topics ranging from climate change and antimicrobial resistance to health-related behaviours and loneliness. The submissions broadly described futures categorised by disruptive events and extreme outcomes of various drivers of health.

## Landscape mapping: public health research and practice

To inform the report, the Academy commissioned Dr Norman Freshney to produce an independent review of the UK landscape for public health research and practice. It can be found on the Academy's website.<sup>446</sup>

## Individual meetings with key decision-makers

Over the course of the project, the Chair met with many key decision-makers across Government departments and agencies, professional bodies, and the wider research funding community. In its early stages, these meetings were crucial for shaping the direction of the project. As the project drew to a close, they focused on discussing and honing the report's recommendations.

## Annex III. Some recent UK initiatives in public health research

### **Department of Health (DH) Policy Research Programme (PRP)**

The PRP is a national research funding programme within the DH's Research and Development Directorate. It commissions research by inviting applications for specific areas, according to the requirements of ministers and national policymakers in the DH and its health and social care system partners. The PRP works alongside other national programmes within the National Institute for Health Research (NIHR). Funded researchers are members of the NIHR Faculty.<sup>447,448</sup>

### **Global Health Trials scheme**

Designed to provide funding to generate knowledge about interventions that will contribute to the improvement of health in low- and middle-income countries, the Global Health Trials scheme is a joint initiative between Wellcome, the Department for International Development, the Medical Research Council, and, most recently, the National Institute for Health Research. The seventh and most recent funding call, launched in July 2016, pools £20 million to provide funding to proposals that are likely to address the major causes of mortality or morbidity in low- and middle-income countries.<sup>449</sup>

### **Medical Research Council (MRC) units**

MRC units provide focused investments to meet specific needs, whether tackling important research questions that cannot be easily addressed through grant funding or providing scientific leadership in crucial research areas.<sup>450</sup> There is no set limit on their lifespan, and many of them are focused on areas relevant to public health, such as the Clinical Trials Unit at UCL, the Epidemiology Unit at the University of Cambridge, the Lifecourse Epidemiology Unit at the University of Southampton, the Population Health Research Unit at the University of Oxford, and the Unit for Lifelong Health and Ageing at UCL.<sup>451</sup>

### **NIHR Collaborations for Leadership in Applied Health Research and Care (CLAHRCs)**

The NIHR CLAHRCs are collaborations of local providers of NHS services and commissioners with universities, local organisations and the Academic Health Science Network (AHSN). Funding supports applied health research across the NHS and the translation of findings into improvements in patient outcomes. There are 13 collaborations, organised regionally, which mainly focus on research targeting chronic disease and public health interventions. They have received £124 million collectively for a five-year period, from January 2014.<sup>452</sup>

### **NIHR Healthcare Protection Research Units (HPRUs)**

The NIHR HPRUs are research partnerships between Public Health England (PHE) and universities. Their role is to support PHE in delivering its objectives for the protection of the public's health in a range of topic-based priority areas – from emergency preparedness and response to environmental change and health to immunisation – as well as two cross-cutting priority areas: evaluation of interventions and modelling methodology. They act as centres of excellence in multidisciplinary health protection research.<sup>453</sup>

### **NIHR Public Health Research (PHR) Programme**

The NIHR PHR Programme funds a broad range of research across multiple disciplines to evaluate the benefits, costs, acceptability and wider impacts of non-NHS interventions intended to improve the health of the public and reduce health inequalities. The research serves a variety of key stakeholders including policymakers, public services, national agencies, researchers, public health practitioners and the public.<sup>454</sup>

### **NIHR School for Public Health Research (SPHR)**

The NIHR SPHR was established in 2012 and is a partnership between eight leading academic centres with excellence in applied public health research in England. The SPHR's mission is to increase the evidence base for cost-effective public health practice: they research practical approaches to improve population health and reduce health inequalities which can better meet the needs of policymakers, practitioners and the public. The SPHR is funded by the NIHR and a further five years of funding, commencing in 2017 and in the region of £20 million, was agreed in 2015.<sup>455</sup>

### **The National Prevention Research Initiative (NPRI)**

The NPRI was a national initiative, managed by the Medical Research Council (MRC), consisting of Government departments, Research Councils and major medical charities, which aimed to encourage and support research into chronic disease prevention. Specifically, the initiative aimed to develop and implement successful, cost-effective interventions that reduce people's risk of developing major diseases by influencing their health behaviours. £34 million of funding was committed by the NPRI partners and a review report of the initiative, including the outputs and advice on future opportunities in prevention research, was published in 2015.<sup>456</sup>

### **NHS Academic Health Science Networks (AHSNs)**

The AHSNs were established in 2013/14 by NHS England as a result of the Government's Innovation, Health and Wealth strategy. They connect academics, the NHS, researchers and industry with the aim of accelerating the process of innovation and facilitating the adoption and spread of innovative ideas and technologies across large populations. There are 15 AHSNs in England, each with a five-year licence commitment and organised geographically; the priorities of each reflect the diversity and challenges of improving health in each region while sharing a number of core focus points.<sup>457</sup> NHS England commissioned a survey in 2015, independently conducted by YouGov, to collect feedback from a range of stakeholders in order to inform the future work of AHSNs; over 70% of respondents recommended working with the AHSNs.<sup>458</sup>

### **Our planet, our health**

Recognising the relationship between the global population and the planet, and the extent to which threats to the planet are also threats to human health, Wellcome's 'Our planet, our health' initiative aims to '*gain deeper insights into the issues to inform the global response through transdisciplinary research, and develop policies that will help mitigate the risks to human health*'.<sup>459</sup> It calls for ambitious, transdisciplinary programmes that research the ways complex changes in our environment affect our health and that develop potential solutions to enhance resilience.

### **UK Biobank**

Having recruited half a million people from across the country between 2006 and 2010, UK Biobank aims to improve '*the prevention, diagnosis and treatment of a wide range of serious and life-threatening illnesses*'.<sup>460</sup> Collecting detailed health information over the years, from genetic to biochemical to behavioural, UK Biobank will provide a rich resource for researchers across the globe to help determine why people develop particular diseases. With initial funding of around £63 million, it was established by Wellcome, the MRC, the Department of Health, the Scottish Government and the Northwest Regional Development Agency. It has also received funding from the Welsh Assembly Government, British Heart Foundation and Diabetes UK.<sup>461</sup> See Annex VI for more information.

### **The UK Clinical Research Collaboration (UKCRC) Public Health Research Centres**

The UKCRC Public Health Research Centres were established in 2008 following a report by the UKCRC Public Health Research Strategic Planning Group in 2006, which aimed to develop a coordinated approach to improving the UK public health research environment. In 2008 a commitment of over £20 million was made by a consortium of eight funding partners, to create five UKCRC Public Health Research Centres of Excellence. The initiative aims to integrate public health research, policy and practice by providing effective collaboration in building a UK-wide infrastructure for public health research, attracting academics from different disciplines and generating innovative ways of engagement with policymakers to give clear evidence of impact at local and national levels. The progress of these centres was assessed in 2013 by an international scientific panel and all were recommended for further funding; a second five-year term is being supported at a cost of £16 million, managed by the Medical Research Council. A more general review of the UKCRC Public Health Research Centres initiative also reported success in capacity building and engaging with policy and practice across the UK.<sup>462</sup>

## Annex IV. Previous reviews of UK public health research

### **Department of Health, 'A Research and Development Strategy for Public Health' (2001)<sup>463</sup>**

Concluded that a 'lack of coordination across funding agencies leads to lost potential for complete understanding of particular public health issues, for identifying and addressing gaps in the evidence base, for promoting multidisciplinary research, and for encouraging widespread dissemination and use of research results', and recommended the creation of 'a public health R&D funders group', to 'support funders in their public health R&D role, take stock of research activity and the evidence base, identify gaps, and ensure that cross-cutting issues are addressed'.

### **Wellcome, 'Public Health Sciences: Challenges and Opportunities' (2004)<sup>464</sup>**

Highlighted the 'limited strategic interest' that is taken in the infrastructure and conduct of public health sciences and stated that 'an overarching national strategy needs to be developed to secure the future of the public health sciences'. Recommended the creation of 'a national academic public health strategy group, involving all the major relevant Governmental and non-Governmental funding agencies'.

### **Sir Derek Wanless, 'Securing Good Health for the Whole Population' (2004)<sup>465</sup>**

Highlighted the multitude of organisations involved in UK public health research and stated that 'it is not clear how their efforts are coordinated' towards building the necessary evidence base. Recommended that their various roles and priorities 'be defined as part of an overall public health research strategy'.

### **Sir David Cooksey, 'A review of UK health research funding' (2006)<sup>466</sup>**

Drew attention to the absence of an 'overarching UK health research strategy' and recommended that an Office for Strategic Coordination of Health Research be established 'to achieve better coordination of health research and more coherent funding arrangements to support translation'.

### **UKCRC, 'Strengthening Public Health Research in the UK' (2008)<sup>467</sup>**

Identified the need for improved 'multidisciplinary and collaborative working, both within the public health research community and between academics, practitioners and policymakers' as a common theme emerging from consultation and other recent reviews. The UKCRC Public Health Research Strategic Planning Group was established to help overcome this.

### **McCarthy et al, 'Public health research in the UK: a report with a European Perspective' (2013)<sup>468</sup>**

Concluded that 'the UK public health research system is complex, with numerous funding, performing and collaborative organisations', and that while there is 'active communication and coordination' between the major funders and devolved nations, 'within this a focus on public health research and its contribution to national health was less clear'. Stated that 'strategic coordination between public health researchers and practitioners, and the UK Research Councils, ministries of health and medical charities would strengthen research for policy and practice'.

### **NPRI Scientific Review Group, 'Initiative outcomes and future approaches' (2015)<sup>469</sup>**

Concluded that while the NPRI had been largely successful in achieving what it set out to achieve, 'a successful programme of public health prevention research involving concerted, multi-partner collaboration is needed as much today as in 2005 when the NPRI started', and that 'scale and stability of funding, multidisciplinarity, and researcher-user cooperation remain essential'.

## Annex V. Some recent UK initiatives for the strategic coordination of research

### **The Office for Strategic Coordination of Health Research (OSCHR)**

In March 2006, the Chancellor of the Exchequer and the Secretaries of State for Health and Trade and Industry invited Sir David Cooksey GBE FMedSci to undertake an independent review to advise on the best design and institutional arrangements for the public funding of health research in the UK.<sup>470</sup> The review found that while the UK health research system had '*many strengths*', the UK was '*at risk of failing to reap the full economic, health and social benefits*' that its investment in health research should generate, in part because of the absence of an '*overarching UK health research strategy to ensure UK health priorities are considered through all types of research*'.<sup>471</sup> The Cooksey Review therefore recommended the establishment of a new Office for Strategic Coordination of Health Research (OSCHR), which would report jointly to the Secretaries of State for Health and Trade and Industry, and would allow for strategic input from the health departments from the devolved administrations.<sup>472</sup>

Following publication of the Cooksey Review, the recommended OSCHR was set up in 2007 under the Chairmanship of Professor Sir John Bell FRS HonFREng FMedSci, Regius Professor of Medicine at Oxford University and then President of the Academy of Medical Sciences. Its role, as described to Parliament in 2009, is: '*a) to forge agreement between the OSCHR Partners [the research funders represented on the OSCHR Board] on the UK Health Research Vision and their integrated plan to deliver the Vision, and b) to monitor the coordination and implementation of the OSCHR Partners' delivery of the Vision*'.<sup>473</sup> OSCHR identified public health research as one of its five key areas of work. A Public Health Research Board (PHRB), chaired by Professor Ray Fitzpatrick FMedSci, was set up in December 2008 and produced a map of public health research funding available in the UK.<sup>474</sup>

### **The UK Clinical Research Collaboration (UKCRC)**

The UK Clinical Research Collaboration (UKCRC) was established in 2004 '*with the aim of re-engineering the clinical research environment in the UK*' by bringing together the major stakeholders influencing clinical research in the UK. Partners include the major UK health research funding bodies, academia (including the Academy), the NHS, regulatory bodies, the bioscience, healthcare and pharmaceutical industries, and patients.<sup>475</sup> Its activities have included clinical infrastructure development (including the registration of accredited clinical trial units), initiatives to streamline the UK regulatory and governance environment, and research coordination. The latter has consisted of both the development of an evidence base to inform strategic planning – summarised in the periodic UK Health Research Analysis reports published by UKCRC – and joint funding initiatives, including the creation in 2008 of five UKCRC Public Health Research Centres of Excellence, representing a total investment of £20 million, under the auspices of the UKCRC Public Health Research Strategic Planning Group. In 2013, following an independent assessment of progress and impact, support for all five Centres of Excellence was secured until 2018, at a total additional cost of £16 million.<sup>476</sup>

### **Organisational structures**

In addition to cross-sectoral structures, research coordination occurs at the organisational level through a variety of strategy boards and other executive committees. The MRC Strategy Board, for example, '*advises the Chief Executive and Council on areas requiring high level strategic input, including scientific strategies, prioritisation of funding and the distribution of budgets across the Research Boards and Panels. The Strategy Board is also responsible for the development, implementation and evaluation of MRC's Strategic Plan and for allocating funding from the Strategic Budget*'.<sup>477</sup>

Likewise, the NIHR Strategy Board '*advises on strategic issues relating to the management of the NIHR and the implementation of NIHR's strategic plans*', helping to ensure that '*the NIHR acts as one entity and communicates effectively both externally and internally*'.<sup>478</sup> Similar structures also exist across other major research funders, providing a vehicle through which priorities discussed at the cross-sector level can potentially be translated into organisational strategy.

## Annex VI. Examples of the impact of population data

Population data is the foundation on which population health research is built, and a variety of sources have been used for many years to generate a rich body of evidence about the psychosocial, biological and socioeconomic determinants of the health of the public. These include cohort studies, electronic health records, administrative data and, increasingly, data generated by individuals through digital technologies. Some examples are offered below.

Traditionally, large, long-term cohort studies have been an important source of data for population health researchers. For instance, the National Survey of Health and Development (NSHD), which began in 1946, is the longest running British birth cohort study. The study is said to have been at the forefront in showing the impact of early life experiences on health and ageing throughout life, and that research into lifelong health and ageing must take account of the physical, cognitive and emotional function of the entire population.

A more recent example can be seen in the Millennium Cohort Study (MCS), a multidisciplinary project studying the lives of around 19,000 children born in the UK in 2000/01, which, reflecting a diversity of background, aims to explore a wide range of topics: parenting, childcare, school choice, child behaviour and cognitive development, child and parental health, parents' employment and education, income and poverty, ethnicity, housing, neighbourhood and residential mobility.<sup>479</sup>

An ongoing initiative investigating the contributions of genetic and environmental factors to health is the UK Biobank, which recruited 500,000 people aged between 40–69 years in 2006–2010 who have provided samples and information for analysis and whose health will be followed long term.<sup>480</sup> UK Biobank was established by Wellcome, the MRC, the Department of Health, the Scottish Government and the Northwest Regional Development Agency, with additional funding from the Welsh Assembly Government, the British Heart Foundation and Diabetes UK and support from the University of Manchester and the NHS. It is an open-access resource, open to scientists in any health-related research in the UK and overseas;<sup>481</sup> costs are involved in accessing the data, which remains anonymous. The variety of data collected (genetic, proteomic, metabonomic, biochemical and haematologic) alongside lifestyle information hopes to provide a national database<sup>482</sup> which will expand over time providing a uniquely rich resource for investigating the reasons behind health outcomes of different individuals.<sup>483</sup> See Annex III for more information.

In addition to specific cohort studies, routine data such as NHS records has been used extensively to investigate the outcomes of natural experiments. For example, comparison of hospital records in Scotland and England demonstrated that the enactment of the smoking legislation in public places in Scotland contributed to a decrease in admissions for acute myocardial syndrome: a 17% reduction in Scotland compared to a 4% reduction in England over a 20-month period spanning the implementation of legislation.<sup>484</sup> Similarly, records of suicide rates were used to demonstrate a reduction in deaths from suicide in England, Scotland and Wales in the 1960s, following the replacement of North Sea gas with natural gas in the UK which corresponded to a fall in CO levels;<sup>485</sup> this data suggested a causal relationship.

Death certificates, which provide information on cause of death and occupational status, have been used to analyse inequalities in health around the time of each decennial census in the UK since 1961. This has provided a rich source of information and has highlighted trends in inequalities in health,<sup>495</sup> providing a resource for many reports on health inequalities: the Black Report in 1980, which described the inequality in mortality rates of different occupational classes;<sup>485,488</sup> the Government's independent inquiry into inequalities in health report, intended to address the widening health gap across the social scale;<sup>489</sup> and the Marmot Review from the UCL Institute of Health Equity, undertaken to propose the most effective evidence-based strategies for reducing health inequalities,<sup>490</sup> among others.<sup>491</sup>

# Glossary

## **Drivers of change**

Drivers of change are major factors which affect the future by causing change. They can be categorised as 'direct' or 'indirect'. A direct driver univocally influences an outcome in the system, while an indirect driver operates by altering one or more direct drivers.<sup>492</sup>

## **Health**

Throughout the report we consider 'health' to include mental health, physical health and health-related quality of life.

Defining health is inherently challenging. The Constitution of the World Health Organization (WHO) states that '*health is a state of complete physical, social and mental wellbeing, and not merely the absence of disease or infirmity*', and that enjoying the best possible health is a fundamental human right.<sup>493</sup> However, there is criticism that this definition, established in 1948, does not account for the situation today, with an ageing population and changing pattern of illnesses and that the term 'complete' implies that the majority of people are unhealthy most of the time.<sup>494</sup> A conference in the Netherlands to address the definition of health led to suggestions of health being an ability to adapt and self-manage, rather than a state.<sup>495</sup> The WHO describes mental health as being '*a state of wellbeing in which an individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community*'.<sup>496</sup>

## **Health inequalities**

In common with many authors, we use the term health inequalities to refer to:

*'Unfair and avoidable differences in people's health across social groups and between different population groups...unfair because these health inequalities do not occur randomly or by chance, but are socially determined by circumstances largely beyond an individual's control. These circumstances disadvantage some people and limit their chance to live a longer, healthier life. Health inequalities are avoidable because they are rooted in political and social decisions. There was a substantial narrowing of health inequalities in the UK and USA between the 1920s and 1970s, the period in which welfare states were constructed and income inequalities declined.'*<sup>497</sup>

## **Health of the public research**

Health of the public research is transdisciplinary: it works across traditional discipline boundaries, integrating aspects of natural, social and health sciences, as well as the arts and humanities, which directly or indirectly influence the health of the public. We favour the use of this term in the report, over public health and population health research, as it includes disciplines that would not usually be considered to be within the public health field but which ultimately shape population health.

## **Intervention**

We use the term intervention throughout the report to refer to any effort or strategy aimed at improving the health of the public and/or reducing health inequalities. Interventions may include any combination of policies, campaigns or changes to our environments.

## **Multidisciplinarity, interdisciplinarity and transdisciplinarity**<sup>498</sup>

These terms all refer to the involvement of multiple disciplines to varying degrees, but should not be used interchangeably:

- Multidisciplinarity: An 'additive' approach; uses knowledge from different disciplines but remains within their boundaries.
- Interdisciplinarity: An 'interactive' approach; analyses, synthesises and brings together links between disciplines into a coordinated whole.
- Transdisciplinarity: A 'holistic' approach; integrates the natural, social and health sciences in a humanities context, working across traditional discipline boundaries.

### **Population health**

Population health is defined as the health outcomes of a group of individuals, including the distribution of such outcomes within the group.<sup>499</sup> These groups are often geographic populations such as nations or communities, but can also be other groups such as employees, ethnic groups, disabled persons, prisoners, or any other defined group.<sup>500</sup>

### **Prevention (primary, secondary and tertiary)<sup>501</sup>**

In terms of health, prevention involves a range of interventions aimed at reducing risks or threats to health. Primary prevention aims to prevent disease or injury before it occurs, for example by immunisation, health education and preventing exposure to hazards. Secondary prevention aims to reduce the impact of a disease or injury which has already occurred, for example by detecting, diagnosing and treating as soon as possible as well as taking steps to prevent reoccurrence. Regular screening programs, such as mammograms for detecting breast cancer, are an example. Tertiary prevention aims to reduce the impact of a disease or illness which is ongoing and has long-term effects, by helping people to manage often complex health problems and injuries to maximise their quality of life and life expectancy. Rehabilitation programs and support programs are forms of tertiary prevention.

### **Public health**

The World Health Organization (WHO) describes public health as '*all organised measures (whether public or private) to prevent disease, promote health and prolong life among the population as a whole*'.<sup>502</sup> Public health therefore involves monitoring the health of populations to identify priorities and problems, formulating policy to solve such problems and ensuring that all populations have access to appropriate care. It can also be described as '*the science and art of promoting and protecting health and wellbeing, preventing ill-health and prolonging life through the organised efforts of society*'.<sup>503</sup>

### **Quality of life**

The WHO defines quality of life as '*an individual's perception of their position in life in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns*'.<sup>504</sup> It is a broad, multidimensional concept that generally includes subjective evaluations of both positive and negative aspects of life. The concept of health-related quality of life (HRQOL) encompasses those aspects of overall quality of life that can be clearly shown to affect health, either physical or mental.<sup>505</sup> On the individual level, this includes physical and mental health perceptions and their correlates, including health risks and conditions, functional status, social support, and socioeconomic status. On the community level, HRQOL includes resources, conditions, policies, and practices that influence a population's health perceptions and functional status.<sup>506</sup>

### **Wellbeing**

Wellbeing is a subjective measurement and there is no consensus around a single definition. However wellbeing is generally considered to include, at a minimum: the presence of positive emotions and moods, such as contentment and happiness; the absence of negative emotions, such as depression and anxiety; satisfaction with life; fulfilment; and positive functioning.<sup>507</sup> Therefore wellbeing can be described in simple terms as judging life positively and feeling good.

# References

## Annex II

440. The Academy of Medical Sciences (2014). *Workshop report: aspirations and drivers of change.* <http://www.acmedsci.ac.uk/download.php?f=file&i=30963>
441. <http://www.acmedsci.ac.uk/hotp2040contributors>
442. *Ibid.*
443. *Ibid.*
444. <http://www.acmedsci.ac.uk/hotp2040dialogue>
445. The Lancet (2015). *Health of the UK population in 2040.* <http://www.thelancet.com/health-challenges-2040>
446. Norman Freshney Consulting (2016). *UK research landscape for population health research and public health practice.* <http://www.acmedsci.ac.uk/phlandscapemapping>

## Annex III

447. <http://www.nihr.ac.uk/policy-and-standards/policy-research-programme.htm>
448. <http://www.prp-ccf.org.uk/>
449. <http://www.mrc.ac.uk/funding/browse/joint-global-health-trials-scheme-launch-of-seventh-call-for-proposals/>
450. <http://www.mrc.ac.uk/about/institutes-units-centres/what-are-institutes-units-and-centres/>
451. <http://www.mrc.ac.uk/about/institutes-units-centres/list-of-institutes-units-centres/>
452. <http://www.nihr.ac.uk/about/collaborations-for-leadership-in-applied-health-research-and-care.htm>
453. <http://www.nihr.ac.uk/funding/health-protection-research-units.htm>
454. <http://www.nets.nihr.ac.uk/programmes/phr>
455. <http://sphr.nihr.ac.uk/>
456. <http://www.mrc.ac.uk/research/initiatives/national-prevention-research-initiative-npri/>
457. <http://www.ahsnnetwork.com/about-academic-health-science-networks/>
458. <https://www.england.nhs.uk/ourwork/part-rel/ahsn/>
459. <http://www.wellcome.ac.uk/Funding/Strategic-funding/Our-planet-our-health/index.htm>
460. <http://www.ukbiobank.ac.uk/about-biobank-uk/>
461. *Ibid.*
462. <http://www.ukcrc.org/research-coordination/joint-funding-initiatives/public-health-research/>

## Annex IV

463. Department of Health (2001). *A research and development strategy for public health.* [http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/prod\\_consum\\_dh/groups/dh\\_digitalassets/@dh/@en/documents/digitalasset/dh\\_4020946.pdf](http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4020946.pdf)
464. Wellcome Trust (2004). *Public health sciences: challenges and opportunities.* [https://wellcome.ac.uk/sites/default/files/wtd003191\\_0.pdf](https://wellcome.ac.uk/sites/default/files/wtd003191_0.pdf)
465. Wanless D (2004). *Securing good health for the whole population: 5. Public health evidence.* [http://webarchive.nationalarchives.gov.uk/20130129110402/http://www.hm-treasury.gov.uk/d/Wanless04\\_ch5.pdf](http://webarchive.nationalarchives.gov.uk/20130129110402/http://www.hm-treasury.gov.uk/d/Wanless04_ch5.pdf)
466. Cooksey D (2006). *A review of UK health research funding.* [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/228984/0118404881.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228984/0118404881.pdf)
467. UK Clinical Research Collaboration (2008). *Strengthening public health research in the UK.* [http://www.ukcrc.org/wp-content/uploads/2014/03/Public\\_Health\\_Report\\_July\\_08.pdf](http://www.ukcrc.org/wp-content/uploads/2014/03/Public_Health_Report_July_08.pdf)

468. McCarthy M, Dyakova M & Clarke A (2014). *Public health research in the UK: a report with a European perspective*. Journal of Public Health **36(2)**, 325-335.
469. National Prevention Research Initiative (2015). *Initiative outcomes and future approaches*. <http://www.mrc.ac.uk/publications/browse/national-prevention-research-initiative-npri-report-2015>

**Annex V**

470. Cooksey D (2006). *A review of UK health research funding*. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/228984/0118404881.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228984/0118404881.pdf)
471. *Ibid.*, paragraph 6.
472. *Ibid.*, paragraph 9.
473. House of Lords Science and Technology Committee (2010). *Setting priorities for publicly funded research. Annex 2: OSCHR board membership and terms of reference*. <http://www.publications.parliament.uk/pa/ld200910/ldselect/ldsctech/104/10011204.htm>
474. House of Lords Science and Technology Committee (2010). *Setting priorities for publicly funded research. Memorandum by the Office for Strategic Coordination of Health Research (OSCHR)*. <http://www.publications.parliament.uk/pa/ld200910/ldselect/ldsctech/104/10011203.htm>
475. <http://www.ukcrc.org/about-the-ukcrc/what-is-the-ukcrc/>
476. <http://www.ukcrc.org/research-coordination/joint-funding-initiatives/public-health-research/>
477. <http://www.mrc.ac.uk/about/strategy-board-overview-groups/strategy-board/>
478. <http://www.nihr.ac.uk/about/setting-strategic-priorities-and-priorities.htm>

**Annex VI**

479. <http://www.cls.ioe.ac.uk/page.aspx?sitesectionid=851&sectiontitle>Welcome+to+the+Millennium+Cohort+Study>
480. <http://www.ukbiobank.ac.uk/about-biobank-uk/>
481. <http://www.ukbiobank.ac.uk/scientists-3/>
482. <http://www.ukbiobank.ac.uk/>
483. UK Biobank (2007). *UK Biobank: protocol for a large-scale prospective epidemiological resource*. <http://www.ukbiobank.ac.uk/wp-content/uploads/2011/11/UK-Biobank-Protocol.pdf>
484. Pell JP, et al. (2008). *Smoke-free legislation and hospitalizations for acute coronary syndrome*. New England Journal of Medicine **359**, 482-491.
485. Kreitman N (1976). *The coal gas story. United Kingdom suicide rates, 1960-71*. British Journal of Preventive Medicine **30(2)**, 86-93.
486. Office for National Statistics (1997). *Health inequalities: decennial supplement (series DS)*. Stationery Office Books, Norwich.
487. Whitehead M (1992). *Inequalities in health: the Black Report and the health divide*. Penguin Books, London.
488. Macintyre S (1997). *The Black Report and beyond: what are the issues?* Social Science & Medicine **44(6)**, 723-745.
489. Department of Health (1998). *Independent inquiry into inequalities in Health Report*. <https://www.gov.uk/government/publications/independent-inquiry-into-inequalities-in-health-report>
490. The Marmot Review (2010). *Fair society, healthy lives*. <http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review>
491. MRC Social and Public Health Sciences Unit (2007). *Inequalities in mortality in Scotland 1981-2001*. [http://www.sphsu.mrc.ac.uk/files/File/current\\_research/Inequalities/Inequalities\\_in\\_health.pdf](http://www.sphsu.mrc.ac.uk/files/File/current_research/Inequalities/Inequalities_in_health.pdf)

## Glossary

492. Forward Thinking Platform (2014). *A glossary of terms commonly used in Futures Studies.* <http://www.fao.org/docs/eims/upload/315951/Glossary%20of%20Terms.pdf>
493. World Health Organization (2006). *Constitution of the World Health Organization.* [http://www.who.int/governance/eb/who\\_constitution\\_en.pdf](http://www.who.int/governance/eb/who_constitution_en.pdf)
494. Huber MT, et al. (2011). *How should we define health?* BMJ **343**, d4163.
495. Health Council of the Netherlands (2010). *Is health a state or an ability? Towards a dynamic concept of health.* [https://www.gezondheidsraad.nl/sites/default/files/bijlage%20A1004\\_1.pdf](https://www.gezondheidsraad.nl/sites/default/files/bijlage%20A1004_1.pdf)
496. World Health Organization (2016). *Mental health: strengthening our response.* <http://www.who.int/mediacentre/factsheets/fs220/en/>
497. NHS Health Scotland (2015). *Health inequalities: what are they? How do we reduce them?* <http://www.healthscotland.com/uploads/documents/25780-Health%20inequalities%20-%20what%20are%20they%20and%20how%20do%20we%20reduce%20them.pdf>
498. Choi BC & Pak AW (2006). *Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness.* Clinical and Investigative Medicine **29(6)**, 351-364.
499. Kindig DA & Stoddart G (2003). *What is population health?* American Journal of Public Health **93(3)**, 380-383.
500. <http://www.improvingpopulationhealth.org/blog/what-is-population-health.html>
501. <http://www.iwh.on.ca/wrmb/primary-secondary-and-tertiary-prevention>
502. World Health Organization (2005). *Life science research: opportunities and risks for public health.* <http://www.who.int/ethics/Life%20Science%20Research.pdf>
503. [http://www.fph.org.uk/what\\_is\\_public\\_health](http://www.fph.org.uk/what_is_public_health)
504. World Health Organization (1997). *Measuring quality of life.* [http://www.who.int/mental\\_health/media/68.pdf](http://www.who.int/mental_health/media/68.pdf)
505. Centers for Disease Control and Prevention (2000). *Measuring healthy days: population assessment of health-related quality of life.* <https://www.cdc.gov/hrqol/pdfs/mhd.pdf>
506. <http://www.cdc.gov/hrqol/concept.htm>
507. <http://www.cdc.gov/hrqol/wellbeing.htm#three>



The Academy of Medical Sciences is the independent body in the UK representing the diversity of medical science. Our mission is to promote medical science and its translation into benefits for society. The Academy's elected Fellows are the United Kingdom's leading medical scientists from hospitals, academia, industry and the public service. We work with them to promote excellence, influence policy to improve health and wealth, nurture the next generation of medical researchers, link academia, industry and the NHS, seize international opportunities and encourage dialogue about the medical sciences.

[www.acmedsci.ac.uk](http://www.acmedsci.ac.uk)



Academy of Medical Sciences  
41 Portland Place  
London W1B 1QH

 [@acmedsci](https://twitter.com/acmedsci)

+44 (0)20 3141 3200  
[info@acmedsci.ac.uk](mailto:info@acmedsci.ac.uk)  
[www.acmedsci.ac.uk](http://www.acmedsci.ac.uk)

Registered Charity No. 1070618  
Registered Company No. 3520281