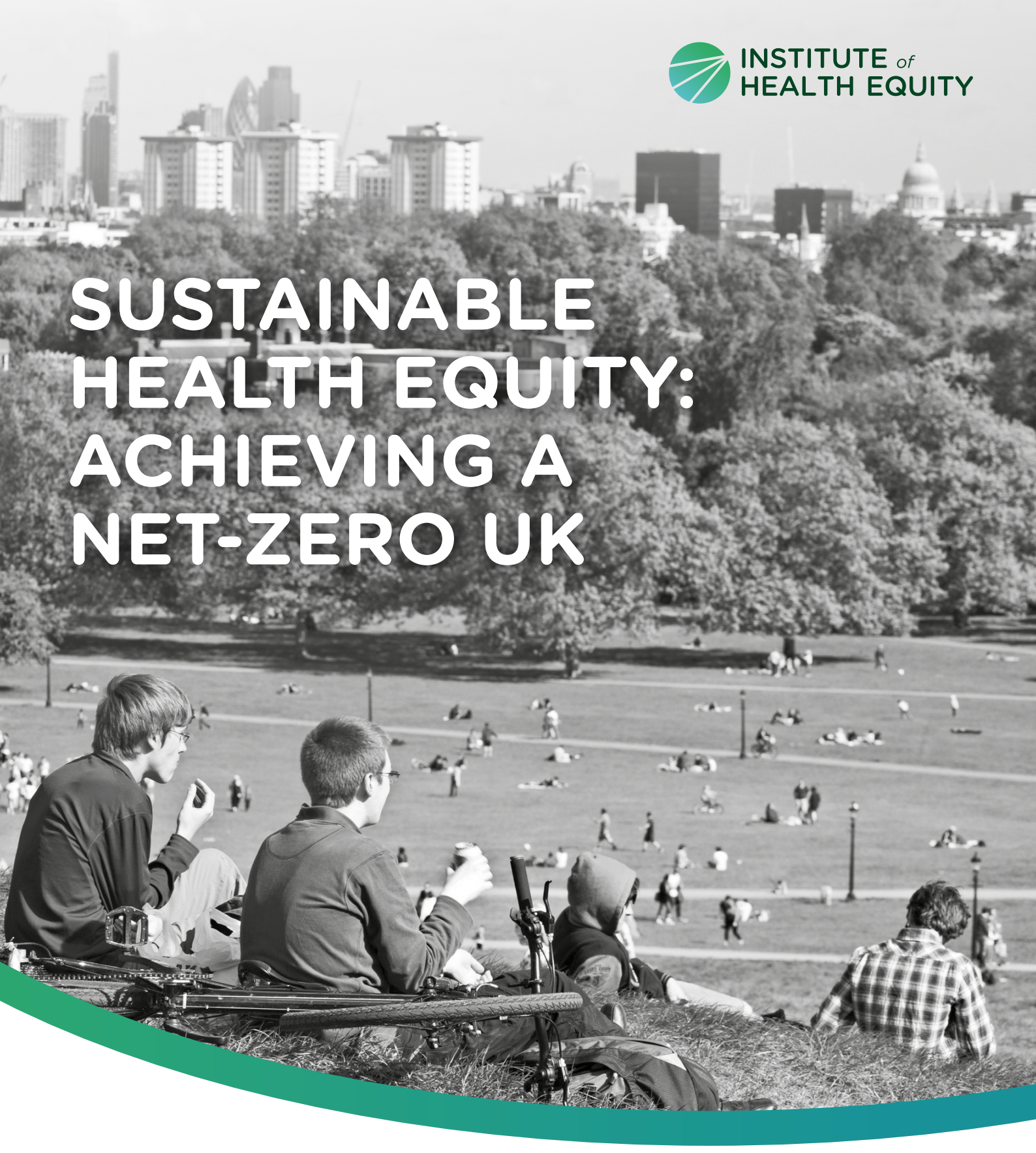
INSTITUTE of HEALTH EQUITY



SUSTAINABLE HEALTH EQUITY: ACHIEVING A NET-ZERO UK

Advisory Group Report for the UK Committee on Climate Change

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Executive Summary

Climate change is already damaging the health of populations in the UK and globally, and has the potential to increase health inequalities. Actions to combat climate change, done in the right way, could improve health and health equity. Conversely, actions to improve health and health equity have the potential to reduce greenhouse gas (GHG) emissions.

The UK Health Expert Advisory Group was formed by the Committee on Climate Change (CCC) in 2020 to advise on developing an approach to assessing the health impacts of setting the sixth carbon budget covering 2033-2037, which will set a new path towards the target date of net-zero carbon emissions by 2050. Although first convened prior to the COVID-19 pandemic, the group largely met during the pandemic, a period which has shown in stark terms how an external shock can amplify health inequalities. The evidence shows climate change will lead to more such systemic shocks, which will become increasingly unpredictable and which will impact population health, well-being and inequalities - both directly and indirectly. Communities that are already disadvantaged are among the most vulnerable to the effects of systemic shocks and extreme events and climate change has the potential to widen existing health inequalities within the UK. Moreover, some hazards are unavoidable due to climate change that is already 'locked-in' by existing concentrations of greenhouse gases in the atmosphere, and therefore adaptation and resilience must be considered in tandem with the mitigation of climate change.

Direct impacts on health of climate change are created by changing exposure to heat and cold, increased exposure to UV radiation, air pollution, pollen, emerging infections, flooding and associated water-borne diseases, and the impacts of extreme weather events such as storms and floods, notably on mental health. Indirect impacts will also occur as a result of climate change's impacts on the livelihoods of individuals, on prices for food, water and domestic energy; on utilities and supply chains that are at risk from extreme weather events, on global security - and on the increasingly complex interactions between these factors.

Aside from helping to avoid the worst of the above impacts, the near-term benefits to health of mitigating climate change are manifold. The group identified four key areas in which action would bring benefits to public health and reduction of health inequalities whilst contributing to the mitigation of, and adaptation to, climate change: transport, buildings, diets, and sustainable economic and employment models that better support health and well-being. A further theme that ran through all of these was air pollution. Achieving the UK's target of reaching net-zero greenhouse gas emissions by 2050 will necessitate transformational changes that have potential to generate significant health benefits in the near term, including via improved air quality, better diets, increased levels of physical activity, improved building standards and better work-life balance.

A central message of this report is that strategies and actions to achieve net-zero emissions should have health equity – the fair distribution of health – as an explicit policy goal. Action to improve health equity can be consistent with measures to reduce GHG emissions, but as is evident from some current and historical schemes, this requires careful consideration of who benefits and who pays for different policy measures: the costs should not be unfairly borne by people on low incomes, who bear least responsibility for the emissions that cause climate change.

Factoring the health equity effects into policies requires a more nuanced approach to mitigation and adaptation: for example, home energy efficiency measures must also benefit indoor air quality and temperature, and reach those most exposed to temperature extremes and indoor air pollution; reducing meat and dairy consumption needs to involve substitution with healthy, lower carbon alternatives that are affordable and accessible; and decarbonisation of transport must involve low pollution and safe forms of transport that are preferably active and, at the very least, accessible to all.

The government's support for a green recovery presents a window of opportunity to implement actions that will improve health and wellbeing, reduce health inequalities and mitigate climate change. The sense of urgency arising from COVID-19 needs now to be applied to the climate emergency. To deliver the health equity policy objective we

recommend an overarching health-equity-in-all-policies approach, recognising that decisions made in all government departments have implications for health, health equity and climate change. These policies must ensure the costs of measures to mitigate climate change are distributed progressively and that the benefits reach those who have the most potential to benefit. In addition, and consistent with the CCC's own view, adaptation to climate change cannot be siloed from mitigation given that both require systematic cross-departmental working across the same areas of government, including housing, transport, health and fiscal policies among others.

Key policy levers for health and climate change are described in the report and listed in full alongside the associated health benefits in the final table of recommendations; in summary these are:

SUPPORT A JUST ENERGY TRANSITION THAT MINIMISES AIR POLLUTION FROM ALL SOURCES

Continue to reduce dependence on fossil fuels and accelerate the transition to clean energy sources with decarbonisation of power generation and industrial, commercial and domestic energy. Some renewable fuels are nevertheless harmful to health due to pollutants they produce. To maximise the health benefits of decarbonised power home installations of new wood burning and gas stoves in urban areas should be eliminated and existing stoves phased out; in the meantime enforcing existing smokeless fuel standards. As renewable capacity increases, domestic gas heating systems should be upgraded to electric and/or additional support for heat pump and other renewable technology. Meanwhile, areas affected by closure of fossil fuel industry sites (power plants and extraction) should receive targeted investment in re-training and efforts to diversify affected economies.

DESIGN AND RETROFIT HOMES TO BE ENERGY EFFICIENT, CLIMATE RESILIENT AND HEALTHY

The dual need to reduce domestic CO_2 emissions whilst building and retrofitting healthy and climate resilient homes requires a fine balance of interventions that will depend on the age, design and location of homes. New building standards should be revised to become near-zero or zero-carbon with flexibility to adapt to local environmental needs (e.g. to manage exposure to damp, mould, cold, heat, and indoor and outdoor air pollution). Retrofits and the standards that guide them need to be carefully tailored to the home, installed, operated and maintained. Given increasing exposure to heat in urban areas, passive cooling measures should be included as standard in retrofits / new builds that are at risk of high indoor temperatures. Active cooling technology (i.e. conventional air-conditioning units) may still be needed to reduce exposure to extreme heat in some buildings, but refrigerants with high global warming potential should be phased out.

BUILD A SUSTAINABLE, RESILIENT AND HEALTHY FOOD SYSTEM

Enable a wider range of national and local powers to shape food systems, and combine these with the resources and statutory duties to support the transition to healthier and more sustainable diets. Policy-making should be led by an objective to reduce rates of diet-related disease via substitution of unhealthy and carbon intensive food products with fruit, vegetable and wholegrains. To achieve this requires a shift towards food production and retail models that consider triple-bottom-line effects, including benefits to society and the environment, as well as shareholders. Policy options will include a combination of fiscal and behavioural interventions to alter food consumption patterns, e.g. eco-labelling, restrictions on marketing and promotion; VAT and business rate reliefs or incentives; and food waste reduction duties on industry and relevant authorities. The draft text of trade deals must also be available for scrutiny for impacts on health and the environment.

DEVELOP A TRANSPORT SYSTEM THAT PROMOTES ACTIVE TRAVEL AND ROAD SAFETY, AND WHICH MINIMISES POLLUTION

Electrification of transport will play a necessary role in reducing transport related CO_2 emissions. However, continued private vehicle dependence does not constitute behaviour change towards more active and inclusive forms of travel, and will continue to be a significant source of harmful particulate matter. Whilst electrification will bring immediate benefits to some roadside emissions, a transport system that is accessible to all and which maximises the physical and mental health benefits of active and decarbonised transport will require a range of policy interventions including: urban planning models that encourage localised amenities; limits on road network capacity; greater availability of affordable and reliable public transport within and around urban areas; ride-share and car-pool schemes that incentivise the transition away from private vehicle ownership; new walking and cycling infrastructure that reaches areas with the lowest rates of physical activity; road space reallocation and holistic behaviour change programmes; and flexible traffic control measures that are monitored and enforced. Finally, given the effects of lockdown on home deliveries: optimisation of delivery services to reduce vehicle miles travelled and support for the transition to electric or other low emission small vans.

DEVELOP HEALTHY AND SUSTAINABLE MODELS OF WORK

Prioritise the health and wellbeing of citizens and environmental sustainability in economic recovery/growth policies. Shift from measuring economic success in terms of GDP to prioritising a wellbeing approach. Support more inclusive local economic growth and shift towards circular economy principles.

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1
INTRODUCTION

The UK has committed in law to achieve net-zero carbon emissions by 2050, a contribution to global emissions reductions considered compatible with achieving the Paris Climate Agreement ambition to keep the increase in global average temperature to well below 2°C above pre-industrial levels; and to pursue efforts to limit the increase to 1.5°C. The UK's Committee on Climate Change (CCC) is currently developing the sixth carbon budget for the UK, to cover the years 2033–2037. This will be the first carbon budget to be set in law following the new legal commitment to achieving net-zero by 2050.

Climate change has been described as "the greatest threat to health this century" [1]. However, it is also recognised that reducing carbon emissions presents an opportunity to address many of our greatest health challenges, such as the growing prevalence of non-communicable diseases [2]. The UK Health Expert Advisory Group was formed by the CCC in 2020 to advise on developing an approach to assessing the health impacts of setting the sixth and future carbon budgets. The group was asked to advise on the policies they would recommend based on evidence of benefits to public health, which would also contribute to the mitigation of climate change. The group also considered how these 'co-benefits' could contribute to reducing health inequalities. Finally, the group was asked to comment on the degree of confidence in the available evidence.

This report presents the recommendations of the Advisory Group and the evidence to support them. The central recommendation is that climate change mitigation policies will be more acceptable and effective in achieving a carbon-neutral economy, which is essential to present and future population health, if they factor health equity impacts and adaptation to climate change into policy design.

PROJECTED IMPACTS OF CLIMATE CHANGE ON HEALTH IN THE UK

The 2020 and 2010 Marmot Reviews into health inequalities in England labelled climate change a fundamental threat to health [3] [4]. It is therefore encouraging that since the first UK report into the co-benefits to health of setting emissions reduction targets through carbon budgets was published in 2013 [5], the relationship between health and climate change has received much more policy and academic attention [6]. The annually updated Lancet Countdown on Health and Climate Change has also played a major role in increasing global recognition of the emerging challenges [8].

The effects on health are cumulative and include both direct and indirect impacts. **Direct impacts** on health are created by changing exposure to heat and cold, increased exposure to UV radiation, air pollution, pollen, food safety risks, emerging infections, flooding and associated water-borne diseases [9] There will be increasing incidence of extreme weather events such as storms, heatwaves and flooding, the frequency and intensity of which can be linked to climate change.

For example, in the UK, in the absence of adaptation, heat-related deaths are projected to increase to an annual average of between 3,000 and 13,000 in the 2050s (mid estimate of 7,000) [10]. Meanwhile, flood risk is increasing in the UK, and approximately 1.8 million people, 3% of the population, currently live in homes in areas of significant river, surface water or coastal flooding risk. Housing continues to be built on land at risk of flooding [11]. By the 2050s the number of people living in homes at risk from flooding is projected to rise to between 2.6 million (in a 2°C temperature rise scenario) and 3.3 million (4°C scenario), assuming low population growth and a continuation of current levels of adaptation [12]. In a recent example of flooding impact, in February 2020 Storm Dennis flooded 1,650 homes in England and Wales; this was the wettest February since records began in 1766 [13]. Over 1,000 homes and businesses were flooded in Rhondda Cynon Taff, Wales, where more than one-third of children live in poverty [14]. The impacts on health and essential services when there is a flood event causes indirect health impacts too.

There may be some near to medium term reductions in winter mortality rates and increases in some domestic food production in the UK. However, the latter could be offset by the effects of climate change on crop yields in the countries from which the UK imports almost half of food consumed[15], and also by adverse impacts on some aspects of the UK's own food production (see below).

The **indirect impacts** occur as a result of impacts on the livelihoods of individuals and the land on which people live and survive [16]. Indirect impacts on health result from: higher prices for food, water, domestic energy and motorised transport; overheating in homes; reduced mobility (especially among low-income groups); reduced consumption of some goods; and increased anxiety, poverty and unemployment [17]. Indirect impacts on health will also result from increases in winter precipitation in the UK, which could lead to more damp and cold homes and to changes in food production, potentially worsening food security [8].

The impacts of extreme weather on disease surveillance systems and the capacity of response systems to meet the needs of those exposed to risk of harm have also been noted, such as the effect of flooding evacuation orders on lockdown and quarantine measures taken in response to COVID-19 [18].

Over time these impacts will become more severe and more unpredictable, as direct impacts on health and indirect impacts on utilities, supply chains and livelihoods increasingly interact with each other. Notably, many of the drivers and levers for these effects occur outside of the UK. The likely impacts of climate change globally, including on food supply, water security and the global economy, are unprecedented in human history and will potentially have impacts on the UK that will be difficult to anticipate and adapt to.

Importantly, the direct and indirect health effects of climate change will not be felt equally across society. As the COVID-19 pandemic has demonstrated, communities that are already disadvantaged are among the most vulnerable to the effects of systemic shocks and extreme events, and climate change has the potential to widen existing health inequalities within the UK [19]. Older people are at most risk of extremes of heat and cold; while people living in deprived areas have less access to green space, are more likely to experience the urban heat island effect, and tenants are less able than owner-occupiers to modify their homes to adapt to climate change [20].

People's capacity to adapt to climate change will depend on individuals' level of exposure to potential hazards, such as heat or flooding; sensitivity to those exposures, for example older people or those with pre-existing conditions may be more vulnerable to the effects of heat and air pollution; and factors that make it more or less difficult to reduce exposure, including income, disability and social disadvantage [21].

Many of the actions required to mitigate climate change can and must contribute to adaptation and to reducing these variations – including in exposure to hazards, prevalence of chronic health conditions, and the adaptive capacity of individuals and communities [21].

THE CO-EFFECTS ON HEALTH OF CLIMATE MITIGATION POLICIES

In 2014 the Intergovernmental Panel on Climate Change (IPCC) recommended that climate change mitigation policies be carefully designed to maximise benefits and avoid unintended harmful consequences (39). There are many opportunities to reduce greenhouse gas (GHG) emissions and improve health and well-being and reduce health inequalities. The importance of these co-benefits is twofold: first, they are large and offset a significant part of the costs of changing to a carbon-neutral economy before the benefits of climate mitigation are accounted for. Second, awareness of these ancillary effects – including the reduction of inequalities – enables them to be factored into policy-making and maximised, creating the potential to increase the efficiency of policies, and avoiding or minimising trade-offs.

In this report we outline how policies to reduce emissions and adapt to climate change can improve current and future health and reduce health inequalities, both directly and indirectly. The positive effects will be maximised by ensuring interventions reach people with the most potential to benefit – for example, by improving energy efficiency in privately rented homes, and ensuring access to healthy and sustainable diets to people on low incomes.

Some but not all policies to reduce GHG emissions will automatically benefit health in the near term – where they contribute to improved air quality or more physical activity – and these health benefits will be maximised and adverse effects minimised with careful consideration of policy design [22]. Some of the households most affected by climate change will be those that bear the least responsibility for its cause: low-income households generally have much smaller GHG emissions than higher-income households [17]. In the UK the highest 5% income households consume, on average, over three times as many tonnes of oil equivalent (toe) annually, compared with those consumed by the lowest 5% income households [23]. Poorly designed policies could undermine health equity objectives by increasing the cost of food, heating and essential items. These costs and other structural barriers will limit the ability of households on low incomes to change their patterns of consumption and undermine climate change mitigation policies. If these adverse effects are avoided in the design and implementation of policies, there is potential for climate change mitigation to create a 'triple-win': in terms of benefits to environmental sustainability, health and health equity [24].

IN THE CONTEXT OF COVID-19

The CCC asked the Advisory Group to consider a range of sectors affected by the UK's net-zero policy that can affect health through various pathways: these span energy, the built environment, food systems, transport and employment. The group members were therefore chosen to represent a range of expertise across these domains.

Mortality rates from COVID-19 have shown a similar social gradient to those from all causes – the more deprived the area, the higher the mortality rate. Between March and the end of June 2020 the age-standardised mortality rate for all deaths was 92% higher in the most deprived than the least deprived areas of England [25]. COVID-19 follows a similar pattern of health inequalities that are well understood in England, where the difference in healthy life expectancy at birth was 18.9 years for males and 19.4 years for females between the most and least deprived areas in 2016–18 [1]. In part due to structural disadvantage, COVID-19 has had a disproportionate impact on black, Asian and minority ethnic (BAME) groups, and death rates from COVID-19 in Black and Asian ethnic groups have been the opposite of patterns in all-cause mortality seen in previous years – being higher than rates seen in people of White ethnicity, when historically all-cause mortality rates have been lower [26].

Systematic inequalities in health that are avoidable by reasonable means, but which are not avoided, are considered to be inequitable – and these avoidable inequities were one theme of the Advisory Group's discussions. The stark health inequities in the UK are not simply explained by personal choice and behaviours: this would imply that all people are faced with the same choices in where they live and work, what they eat and how they travel, as well as their wider social, cultural, economic and commercial environment. These ***social determinants of health*** are pertinent when considering the mitigation of climate change, as climate change mitigation policies are uniquely wide-ranging and systemic in their impacts: they have the potential to impact on many of the determinants of health, and will bring substantially greater health benefits at a population level if designed to explicitly address inequalities in these determinants. The steep social gradient in life expectancy and healthy life expectancy in the UK means that any examination of the co-effects of climate action on health should consider the effects on the determinants of health and health inequalities.

The experience of lockdown and the easing of lockdown restrictions have led to calls for a return to 'normality'. Yet what we know about health inequalities, and what has been confirmed by COVID-19, is that 'normal' is not desirable: life expectancies have been falling for women in the most deprived areas outside London, and the years some groups spent living in poor health have been increasing [3]. Climate science demonstrates that normal is not environmentally sustainable either. COVID-19 has delivered a moment in which to assess what we want from the ***new normal***, and when considered through both a health equity and a climate change lens, it calls for systemic changes in how we live, work, produce, consume and travel.

CLIMATE CHANGE AND HEALTH EQUITY

Today's GHG emissions and actions on climate change will be felt by current and future generations; inaction now will damage those generations' prospects for health and well-being immensely [1]. The immediate co-benefits to health of mitigation strategies, if pursued equitably in ways that benefit the whole of society, have the capacity to increase public engagement and the political acceptability of action on climate change.

There are three significant dimensions to considerations of health, health equity and climate change, globally:

1. The impacts of climate change on health and health equity, including who benefits from climate change adaptation measures.
2. The four mechanisms for cutting emissions: reducing demand, increasing efficiency (although this can lead to rebound emissions if demand rises as costs fall), switching to low-carbon alternatives, and action on non-energy emissions such as deforestation. The co-effects on health of climate mitigation policies relate to both demand-side interventions (such as those to decarbonise transport, buildings and reduce GHGs from food systems), and supply-side interventions to reduce emissions from fossil fuels and agriculture and their supply chains.
3. The effects of carbon sequestration in pursuit of net-zero, in particular the effects of reforestation and land use change on zoonotic disease risk and the livelihoods of affected communities.

STRUCTURE OF THE REPORT

The remainder of the report covers the major sources of emissions and how these can be reduced whilst maximising benefits to health and well-being. Where relevant the report considers adaptation to climate change impacts as well as mitigation. The report concludes with headline recommendations for policy objectives spanning the sectors covered, and specific policy suggestions aligned with these. Due to the complexity of the policy objectives and interventions the Group decided against providing quantitative health or carbon targets, but do recommend that health equity impact assessments be carried out on a sector by sector basis for future carbon budgets – an exercise which was beyond the scope of this report.

2

OUTDOOR AIR POLLUTION

A cross-cutting theme throughout the following sections is local air pollution and its relationship to greenhouse gas (GHG) emissions and health. For context, this section briefly summarises the main pollutants, their sources and major health effects.

Most attention in the UK and Europe is now focused on three pollutants: fine particles ($PM_{2.5}$), which can penetrate deep into the lungs, nitrogen dioxide (NO_2), and ozone. Other important pollutants are sulphur dioxide (SO_2), volatile organic compounds (VOCs) and Ammonia (NH_3), which together with nitrogen oxides (NOx) react chemically to produce secondary inorganic aerosols which travel over distances up to the European scale.

Climate change measures can support air quality improvement objectives. Many of the pollutants named above have common sources with GHGs: SO_2 and NOx and a large part of primary $PM_{2.5}$ are products of combustion; NH3 comes mainly from agriculture, overlapping with sources of methane (CH_4), and VOCs largely come from solvents used in industry and domestically.

The UK has immediate commitments to reduce its total emissions this year (2020), and for 2030 under the new National Emission Ceilings Regulations (NECR) – see Table 1 below. The UK has complied with European Commission legislation with respect to the health impacts of air pollution. The Government is developing its Clean Air Strategy, including targets for reducing exposure to $PM_{2.5}$ further, with a commitment to halve the number of people exposed to more than the World Health Organization (WHO) annual exposure guideline of $10ug.m^{-3}$ by 2025. It has become increasingly apparent that air pollution levels that flout the WHO guideline are also associated with adverse effects on health and therefore policies should aim to minimise exposure as far as possible [27].

Table 1 presents a summary of emissions in 2018 and the main source contributions, together with ceilings to be attained by 2030.

[1]Although various suggestions have been made that some particles, such as those in diesel exhausts, could be more harmful than others, the particles present at any location are a combined mixture from multiple sources and relative toxicities have not been established. The total mass of $PM_{2.5}$ is therefore used to indicate exposure and health effects, including both primary and secondary components.

TABLE 1. EMISSIONS OF AIR POLLUTANTS IN 2018 IN THE UK, AND THEIR SOURCES

Pollutant	UK annual emissions 2018 and trend	Dominant sources and current UK emission ceiling targets
SO_2	160kt Decreased by 96% relative to 1990	SO_2 from fuel combustion has greatly reduced due to decreased use of coal and other fossil fuels, and stricter limits on sulphur content. The main source in 2018 was energy production and transformation (31%), followed by domestic combustion (25%) and manufacturing industries (24%). The UK is committed to reducing SO_2 by 88% relative to 2005 by 2030, that is to ~92kt, under the National Emission Ceilings Regulations (NECR).
NOx	823kt Decreased by 73% relative to 1990	In 2018 31% of NOx emissions were from road transport, 20% from power stations and energy producers, and 17% from manufacturing. Currently there are many roadside locations in the UK that are not compliant with the limit value on NO_2 annual mean concentration. The UK has nevertheless committed to reducing NO_2 by 73% relative to 2005 by 2030, that is to ~460kt under the NECR.
$PM_{2.5}$	107kt Decreased by 71% relative to 1990	$PM_{2.5}$ emissions have reduced substantially since 1990 due to decreased coal burning and improved standards for industry and transport exhaust emissions. Transport emissions are increasingly dominated by non-exhaust emissions (tyres, brakes and road-wear). Recent decreases in some sectors have, however, largely been offset by increases in domestic wood burning and use of biomass. Currently the major sources of primary $PM_{2.5}$ are domestic combustion (44%, mostly domestic combustion of wood), industry (29%) and road transport (11%). Local sources of primary $PM_{2.5}$ are superimposed on background contributions and long-range secondary $PM_{2.5}$, including imported contributions from other countries and international shipping. The UK is committed to reducing $PM_{2.5}$ by 46% from a 2005 baseline by 2030, that is to ~67kt under the NECR.
NH_3	276kt ~15% lower than 1990	Agricultural sources dominate, generating around 87% of emissions in 2018, with cattle a major component and also a source of methane. A reduction of 16% from 2005 emissions is required to meet the UK emission ceiling for 2030, that is to ~234kt.
VOCs (non-methane)	804kt 72% lower than 1990	VOCs come from a wide range of sources, many of which have reduced their emissions considerably. Currently, domestic solvents and fugitive emissions each account for about 18.5% of emissions; food and beverages for around 14%; other industrial processes and solvent use, and coating applications each around 10%. Under the NECR, excluding agricultural emissions of around 100kt, a reduction of 32% in non-methane VOCs is required relative to 2005 emissions by 2030, that is to ~827kt, which had already been achieved in 2018.

Source: National Atmospheric Emissions Inventory data [28]

Poor air quality causes significant harm to health, it is associated with heart disease and stroke, as well as exacerbating respiratory conditions such as asthma, chronic obstructive pulmonary disease, lower respiratory tract infections and carcinomas of the respiratory tract [29]. Particulates are estimated to cause around 29,000 deaths in the UK each year and up to 40,000 deaths when nitrogen dioxide exposure is also included [30]. While there is significant certainty over the health effects of $PM_{2.5}$, the contributions from nitrogen dioxide (NO_2) and ozone are subject to greater uncertainty due to difficulties measuring their independent effects [31].

Climate change mitigation strategies need to be consistent with targets to reduce levels of $PM_{2.5}$, especially where these affect roadside concentrations and more deprived communities. While improvements in absolute exposure are expected, some sources of $PM_{2.5}$ may rise under some scenarios, including domestic wood burning and non-exhaust emissions from electric vehicles (i.e. tyre, brakes and road-wear) [32]. If roadside non-exhaust emissions of $PM_{2.5}$ increase while other sources decline, inequalities in exposure between the least and most deprived fifth of wards are expected to widen [32].

The picture is more positive for NO_2. With some localised exceptions, electrification of road transport will reduce absolute exposure to NO_2 substantially and also inequalities in exposure to NO2: as concentrations decrease, so does the ratio between mean concentrations in most deprived wards compared with the least deprived fifth of wards in 2011 across Great Britain [32]. This will benefit morbidity rates as well as mortality. For example, the phase-out of internal combustion engine vehicles will contribute to reduced rates of childhood asthma [33]. It will also contribute to reducing inequalities in exposure to NO_2 between different subpopulations, including the higher average exposure experienced by ethnically diverse communities (those that are more than 20% non-White) in England, than would be predicted by deprivation alone [34].

Power stations provide the energy consumed directly by households and businesses for end-use energy services such as lighting, heating, cooking and appliances, and indirectly via consumer goods, services and infrastructure. In 2019 the power sector accounted for 12% of carbon dioxide (CO_2) emissions in the UK, with net total CO_2 emissions from energy generation falling, being 3.9% lower in 2019 than in 2018. This fall has largely been driven by a 13.2% decrease in emissions from power stations as coal is phased out, enforced by European legislation. As well as benefiting climate change mitigation, the transition away from coal-fired power generation has been positive for health, with the reduction in PM2.5 concentrations calculated to have prevented 80,000 premature deaths annually across the European Union (95% confidence interval 37,000–116,000) [35]. However, in some locations coal has been replaced with biomass, which has led to a small increase in $PM_{2.5}$.

The maximisation of co-benefits to health from reduced air pollution will depend on the future renewable component in the energy mix. Low GHG scenarios that rely on increased use of domestic biofuels and biomass to replace fossil fuels will bring lesser health gains than if these fuels play a smaller role. Burning wood on open fires is highly inefficient for energy production and is detrimental for air quality, with $PM^{2.5}$ emissions of around 2,950 g/MWh. $PM_{2.5}$ emissions range from around 2,660 g/MWh for conventional stoves to 335 g/MWh for a Defra-exempt Eco-design Stove [36]. Reducing these domestic emissions to avoid the health impacts is essential. It is also worth noting that even though PM2.5 emissions are lower when biomass is used for electricity generation rather than fossil fuels, the role of biomass in achieving net-zero is highly contested given first the time lag (from decades to hundreds of years) between CO_2 from biomass combustion being emitted and the sequestration of those emissions via new tree growth, and second the fact that emissions from imported biomass are not accounted for in the UK [37].

RECOMMENDATIONS

Below are headline policy objectives and suggested interventions to ensure that reducing carbon emissions is achieved in tandem with reducing exposure to indoor and outdoor air pollutants from power. See also Housing (section 3) and Transport (section 5) for further air quality recommendations.

REGULATORY INTERVENTIONS

- Transition to clean energy sources – decarbonising both power generation and industrial, commercial and domestic energy.
- Set a target date to eliminate home installations of wood burning and gas stoves, prioritising elimination in urban areas.
- Set a further target date to eliminate/remove all existing wood burning stoves in urban areas.
- Enforce existing and new fuel standards.

FISCAL INTERVENTIONS

- Invest in re-training and efforts to diversify affected local economies with a just transition for workers, prior to closure of fossil fuel industry sites (power plants and extraction).
- As renewable capacity increases upgrade domestic heating systems, including gas, to renewable heating systems, including electric, and air or ground source heat pumps.
- Target subsidies towards low-income households and private or socially rented accommodation.

3

HOUSING AND BUILDINGS

In 2019 the residential and public sectors emitted 19% of the UK's direct CO_2 emissions, (18% of CO_2-equivalent emissions), largely resulting from the combustion of natural gas for heating, hot water and cooking [38]. In addition, about two-thirds of electricity consumption in the UK is within buildings, emissions from which are covered by the previous section of this report. The UK has adopted a target to reduce energy use in homes by at least 24% by 2030, based on 1990 levels. The Committee on Climate Change's 2020 Progress Report to Parliament finds a number of shortfalls in progress on this target, leading it to conclude that government actions related to buildings and heating policies "lag behind what is needed"; and in 2019 the CCC concluded that government actions fell "short of what is needed" to meet net-zero emissions [39].

With regard to adaptation, the CCC has recommended, more than once, new standards to prevent overheating, and recommends improving ventilation, passive and active cooling and heating, and policies to encourage adaptation by occupants [40]. Such measures would contribute to reducing exposure to high summer temperatures and the excess mortality associated with heatwaves.

There are significant co-benefits to health from improving the quality and energy efficiency of homes and buildings to mitigate and adapt to climate change. Poor housing quality exacerbates health inequalities and these may widen under conditions of climate change, therefore improvements could help reduce these [22] [12].

HEALTH IMPACTS OF HOUSING AND BUILDINGS

Living in a cold home that is difficult or expensive to heat, or both, increases the risk of exposure to cold and is associated with a variety of health impacts. Excess winter deaths are those that occur between December to March that are in excess of the average daily mortality in the non-winter period. Respiratory infections are the leading cause of excess winter mortality in England, followed by circulatory diseases [41]. Analysis of indoor temperatures and mortality in England has found that for each degree Celsius fall in outdoor temperature, the percentage rise in mortality was greater in those living in cold than warm homes [42]. There are also well evidenced negative effects on mental health in adults, including worry about debt and affordability and consequences of cold and damp for health [43]. Fuel poverty (see following sub-section) has also been associated with poorer respiratory health and depressive symptoms [42]. Conversely, warm homes have been found to contribute to reductions in the incidence of cardiovascular disease, cardiopulmonary disease, lung cancer and childhood asthmas and improved mental health and well-being [44] [45].

It is estimated that close to one-third of excess winter deaths, of which there were 23,200 in England and Wales in winter 2018/19 [41], are attributable to living in a cold home [46]. Cold-related deaths are more likely in older properties and homes with the poorest thermal efficiency ratings, and among older occupants. Overall, cold homes follow the social gradient: the lower a person's socioeconomic status, the more likely that they will live in a cold home [47].

It is estimated that milder winters will reduce excess winter mortality and morbidity by 9% by the 2020s and 26% by the 2050s, despite population growth and demographic change increasing the size of the susceptible population [48].

Actively reducing exposure to cold homes through improving their thermal and energy efficiency has also been found to contribute to wider social and health benefits, including:

- Delaying and reducing the need for primary care and social care
- Preventing hospital admissions
- Increased school attendance
- Increased engagement with (community and social) services
- Reduced incidence of risky health-related behaviours
- Enabling timely discharge from hospital, and preventing re-admissions
- Enabling rapid recovery from periods of ill health or planned admissions. [49] [50]

However, while improved thermal efficiency will reduce people's exposure to cold homes, interventions to warm homes by reducing air leakage need to include adequate ventilation, otherwise they can worsen indoor air quality by concentrating pollutants generated indoors. This is an unintended consequence of high performance retrofits, along with overheating [51] [52], which can have negative impacts on respiratory conditions (including lung cancer), cardiovascular disease and allergic symptoms (e.g. atopic dermatitis, rhinitis, conjunctivitis and hay fever) [53]–[57]. These effects have major implications for building standards with respect to health. Improved home energy efficiency alone could lead to 2,200 quality adjusted life years (QALYs) gained per 10,000 people aged over 50 per year [58]. However, without adequate ventilation it is estimated that more than 700 QALYs could be lost per 10,000 people aged over 50 because of increases in indoor generated pollutants [58].

If ventilation systems are added alongside all fabric and heating retrofits, a 30% reduction in annual heating energy demand and improved indoor temperatures could be achieved from the insulation. The added ventilation would reduce exposure to indoor sources of pollutants, although slightly increasing indoor exposure to outdoor-generated $PM_{2.5}$. Modelling suggests the combined effects would lead to reductions in net mortality and morbidity of 2,241 QALYs gained per 10,000 people over 50 years in the UK [45].

There are further trade-offs between adaptation and mitigation to be considered when considering higher average summer temperatures, heatwaves and health. In the absence of adaptation measures, heat-related deaths are estimated to increase to up to 13,000 per year from a current annual baseline of around 2,000 deaths, while cold-related mortality could decline by an estimated 2% from a baseline of around 41,000 deaths [10]. Household air conditioning will be a necessary adaptation measure to extreme heat in some settings and protective against heatwave-related mortality. However, the majority of air conditioning units also contribute to hydrofluorocarbon emissions (a potent GHG) [59]. Passive cooling measures with no or low emissions, such as increasing shade, generating air movement, and reflecting radiation, will be adequate to reduce temperatures in many settings, although adapting all the existing housing stock to incorporate passive cooling will be challenging. Passive cooling measures should nevertheless be factored into retrofit and building standards to help mitigate against future uptake of air conditioning units and restrict their usage to all but the hottest days. To maximise the benefits to health these measures should be prioritised in inner city neighbourhoods in which more people are exposed to the urban heat island effect.

FUEL POVERTY AND HEALTH

A household is in fuel poverty if paying home energy costs would leave them below the poverty line. The three main drivers of fuel poverty in the UK are the thermal efficiency of homes, household incomes and energy prices [60]. In 2014 the most deprived fifth of households spent 11% of their disposable income on household energy and the richest fifth spent 2% [61]. Fuel poverty and poor housing elevate the risk of cold-related deaths [18]; older people often suffer from both and thus can be more exposed than other groups to dangerously low indoor temperatures.

Some of the largest health gains from improving home energy efficiency will therefore be mediated by reducing fuel poverty. For example, energy efficiency measures (e.g. insulation) in homes have been shown to reduce daily gas use by up to 37%, reducing heating bills and increasing affordability [62].

Single parents and couples with children are the most likely households to be living in fuel poverty, and households with an ethnic minority head of household have a higher likelihood than White households [63] [64]. People living in private rented accommodation are more likely than owner occupiers to be in fuel poverty and in damp homes, with those in social rented accommodation slightly less likely [65]. However, homes that are more likely to be cold and thermally inefficient – even if not categorised as fuel-poor – are not necessarily those located in the most deprived areas: homes that are older, detached, single occupancy or located in the North of England have a higher than average likelihood of being cold – they experience the lowest share of hours at at least 18°C, considered the minimum temperature for comfort [47].

Mitigation measures to improve energy efficiency and ventilation may widen inequalities, however, depending on who the beneficiaries are. Currently, home energy efficiency improvements are addressed through schemes that are sometimes regressive and do not actively address fuel poverty. Several decarbonisation policy interventions are funded through a levy on household and business energy bills, averaging 13% of energy costs (£6.5 billion in 2016). Most of the revenue generated funded renewable energy investments in 2916, while 22% was allocated to the Affordable Warmth scheme and the Energy Company Obligation (ECO) to fund boiler replacements and improve home energy efficiency [23]. Due to the structure of the levy as a flat rate on home energy bills, low-income households spent a larger proportion of their income on the levy than high-income households: the 5% of UK households on the lowest income paid an estimated average of 1.10% of their total income towards low-carbon policy costs compared with 0.18% paid by those in the highest income group [23]. In paying this, low-income households are more than self-funding the schemes which exist to mitigate fuel poverty in low-income households; for example, the lowest income 5% of households are estimated to have paid £51 million more towards low-carbon policy costs in 2016 than they received in benefits from energy efficiency schemes. This impacts on income availability to pay for energy and other essential living costs, and is regressive in its current design.

The UK government introduced the Renewable Heat Incentive (RHI) in 2014, which supported the cost of using domestically generated renewable energy for home heating. The high upfront costs and complex subsidy structure were a noted concern and four years after its launch, the National Audit Office's review stated that only 22% of expected installations were achieved. It also concluded that high-income households were more likely to be able to pay initial costs [66]. The new Green Homes Grant addresses some of this in making support available to low-income households in receipt of benefits with the full cost of energy efficiency measures up to a value of £10,000. However, both the grant and the current ECO scheme, which requires energy suppliers to deliver energy efficiency in homes, are limited to benefit claimant recipients and are only directly available to homeowners and landlords [67]. There are limited incentives for landlords in the private rented sector when compared to homeowners, given that subsequent energy savings primarily accrue to the tenant.

Improving the affordability of keeping warm and addressing the regressive nature of some low-carbon energy subsidies will reduce exposure to fuel poverty [68]. Meanwhile, increasing the energy efficiency of the homes of residents aged over 60 will mitigate the need for the Winter Fuel Payment (which is currently £200–300 depending on the age of the resident).

Domestic energy levies place additional costs on meeting the basic needs of warmth and lighting of all households, despite knowledge that the variation in total carbon footprint of a household varies considerably more between income groups than the energy consumed for heating and lighting alone. If energy efficiency and low-carbon policy interventions continue to be funded through general taxation rather than energy levies, as with the Green Homes Grant, it will better align energy consumption with subsidies for policy costs. One analysis showed that subsidising energy efficiency measures via general taxation would reduce costs for 65% of UK households: in particular, based on energy usage patterns, women of retirement age who live alone, single parent families, and households who have never worked or are long-term unemployed could see reductions in bills [23]. Carbon pricing policies and low-carbon/decarbonisation policies should be reviewed with a health equity impact assessment to avoid exacerbating existing inequalities or creating new inequalities.

POLICY OPTIONS

The majority of the homes that will exist in 2050 have already been built, and much of the UK's housing stock is difficult or costly to heat, thus retrofitting policies should dominate approaches to reaching net-zero emissions. Adapting the existing housing stock to increased exposure to heat, damp and flooding, dependent on location, is essential to future health, while improvements to home energy efficiency will reduce fuel poverty and benefit health if ventilation and insulation are implemented in tandem. However, these measures will only make a significant contribution to reducing health inequalities if they are designed in such a way that they do not disproportionately advantage those with the ability to pay. Policies must balance support for the retrofitting of social housing (primarily owned by housing associations) and private rental sector housing with support for owner-occupied housing.

RECOMMENDATIONS

Below are summary of recommendations to improve housing standards whilst reducing domestic GHG emissions in ways that maximise co-benefits and allow for adaptation to climate change.

REGULATORY INTERVENTIONS

- Establish an ambitious target for the number of existing homes to be upgraded each year with energy efficiency and ventilation improvements.
- Establish ambitious targets for reducing the percentage of non-decent homes (those that are not in a reasonable state of repair, have inadequate facilities and services, or ineffective insulation or heating).
- Revise building standards to become near-zero or zero-carbon with flexibility to adapt to regional needs: for example, whether priority is to reduce exposure to indoor air pollutants and increase ventilation, or to reduce exposure to outdoor air pollutants (e.g. in major cities).
- Passive cooling measures should be mandated as standard in new builds and supported (e.g. to fit external shutters) in homes at risk of high indoor temperatures, especially in urban areas.
- Active cooling technology may still be needed to reduce exposure to extreme heat in some buildings, but refrigerants with high global warming potential should be phased out.

4

SUSTAINABLE DIETS

There is a growing evidence base to inform the general principles for a healthy and environmentally sustainable diet. However, in many respects, food systems globally are increasingly unhealthy and unsustainable. The adverse health consequences are especially clear in the rising prevalence of obesity and the increasingly unequal distribution of obesity: a consequence of food systems geared towards cheap, energy-dense foods, which are readily available and intensively marketed. Excess consumption is placing additional strain on the climate and environmental resources as well as health. Rising demand for meat, dairy products and palm oil are specifically associated with environmental damage, including, but not limited to, greenhouse gas emissions.

There are three principal greenhouse gases (GHGs) originating from agriculture within the UK, which together accounted for 10.4% of the UK's carbon dioxide-equivalent (CO2-e) emissions in 2017: methane, nitrous oxide and carbon dioxide [69]. Agriculture is also one of the most important sources of outdoor air pollution, including from methane, a precursor of tropospheric ozone. Food production further contributes to water stress and is the single largest stress to biodiversity given the habitat destruction and nutrient pollution that arise from farming [70].

The term 'food system' refers to both the production and consumption of food, including the people, inputs, processes, infrastructure and institutions that are involved in the production, promotion, distribution, sale and disposal of food. The complexity of this system means that it is difficult to precisely estimate the climate impact of the average diet and of making changes to it: some GHG emissions are not intrinsic to the food product itself but are associated with how it is produced, for example, differing depending on how it is farmed, processed and transported. In one study of 15 major food groups differences in production methods meant there was a 10-fold difference in estimates of the GHG emissions associated with the same food product from different manufacturers [71].

As has been noted recently by the House of Lord's Select Committee on Food, Poverty, Health and the Environment, the UK has a highly unequal food system, with significant inequalities in both the consumption and production of food [72]. These manifest in diet-related health inequalities. In a 2018 survey, 10% of households in England, Wales and Northern Ireland were 'food insecure', meaning they regularly reduced the quality, variety and desirability and for many also the quantity of food consumed, due to lack of resources; whilst the same proportion again experience 'marginal' food security and are vulnerable to insecurity [73].

Globally, nine of the top 15 risk factors for morbidity, including high body mass index (BMI), high blood pressure and malnutrition, are associated with poor diet [74]. Estimates from the Global Burden of Disease study suggest that in the UK dietary risk factors outweigh risks to health from air pollution, the indoor environment and low levels of physical activity [75]. While obesity and diet-related diseases affect all socioeconomic groups, there are higher rates in more deprived areas. The health impacts of obesity in children include type-2 diabetes, asthma and mental health problems, but the greatest risk is that of excess weight stretching into adult life [76]. The gap in rates of childhood obesity has widened between the most and least deprived deciles over the last decade, largely explained by increasing rates in the most deprived areas (13). Among adults the health impacts are greater than among children, significantly increasing the risk of type 2 diabetes, cardiovascular disease, and some cancers, leading to reduced life expectancy, as well as significant additional morbidity attributable to musculoskeletal conditions and impaired quality of life.

The disparities seen in obesity are in part attributable to differences in diet. There is also a social gradient in fruit and vegetable consumption, with adults and children in the lowest income decile on average eating 42% less fruit and vegetables than recommended, while the least deprived decile eat 13% less [78]. By some analyses, the NHS Eatwell guide recommends a diet that exceeds the food budget of some of the lowest income households. The increased vulnerability of these households to food insecurity was apparent during April 2020, the first month of the COVID-19 lockdown, when 14% of households with a child reported cutting meal size or skipping meals, twice the rate of those without children [79]. Interventions to promote lower carbon and healthy diets therefore need to be designed so that any costs are offset by support to access sustainably produced and healthy foods.

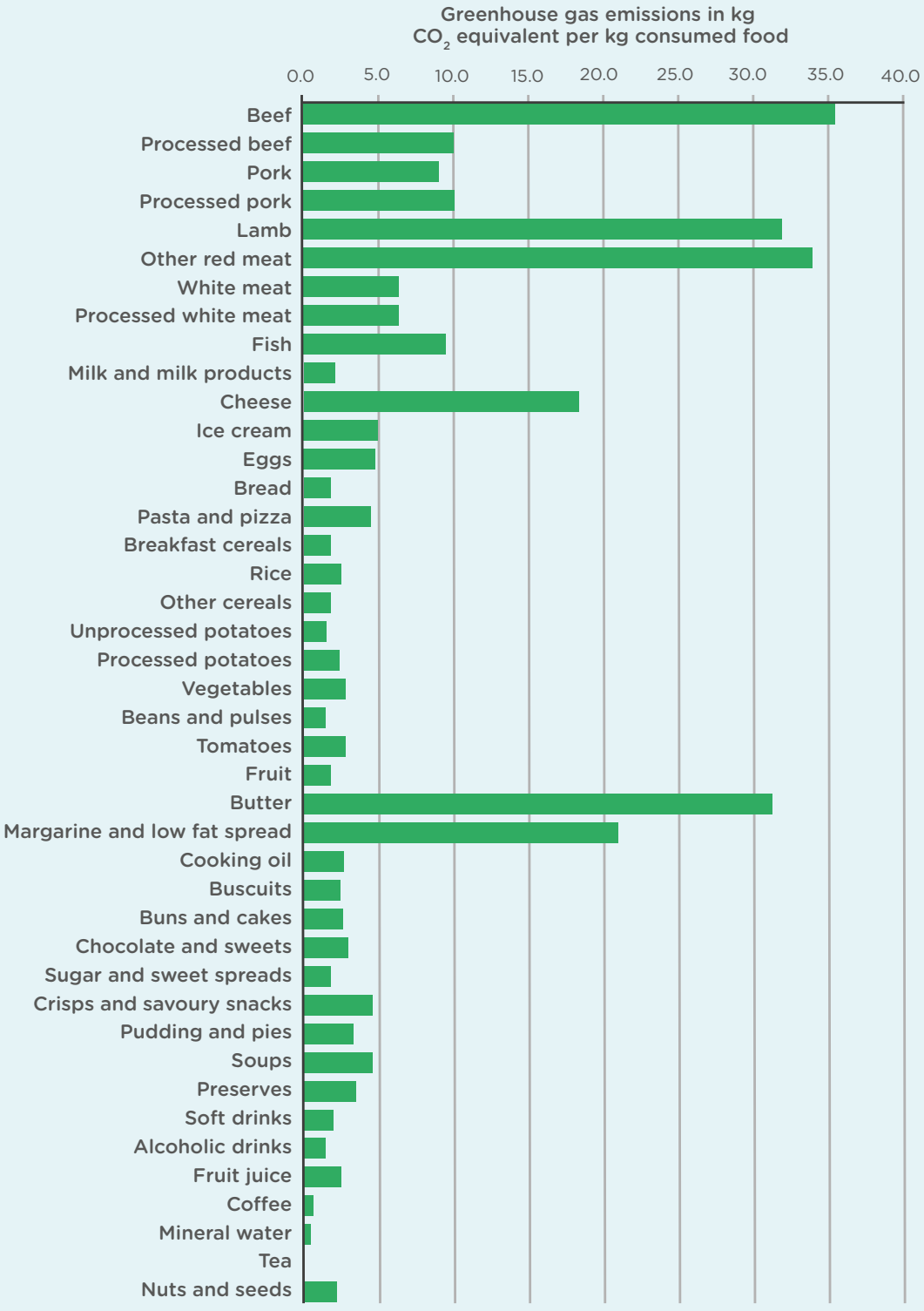
The environmental impact of food systems, unequal and poor UK diets, the obesity epidemic and food waste are all interlinked issues that require joined-up government action. For the average diet to change will require a coordinated effort between farmers, manufacturers, health organisations and civil society, and for government to have the political and social licence to intervene where the market is not moving in the right direction or at sufficient pace [80]. Currently, this is not happening, as responsibilities are split across different departments that tend to represent different interests. There is a need for a cross-governmental body with ministerial representation to take on these linked issues.

To reform the entire food system to achieve healthy and more sustainable average diets is a complex subject that will be more thoroughly addressed in the forthcoming National Food Strategy. Here we focus on primary objectives to reduce diet-related GHG emissions from the production and consumption of food while promoting equitable availability of healthy diets.

UK DIETS

The National Diet and Nutrition Survey is a rolling survey of 1,000 people per year across the UK that monitors consumption and nutrient intake. Figure 1 presents a complete Life Cycle Analysis of the 42 most commonly consumed food products identified by the survey, with their associated GHG emissions, specific to the UK where possible, including emissions from food production, processing, packaging, transport, storage and waste (most studies do not include all of these elements) [81].

FIGURE 1. ESTIMATES OF GREENHOUSE GAS EMISSIONS ASSOCIATED WITH 42 FOOD GROUPS IN THE UK NATIONAL DIET AND NUTRITION SURVEY



Source: Green, R et al. "The potential to reduce greenhouse gas emissions in the UK through health and realistic dietary change". [81]

Meat from ruminants and dairy products produce some of the highest CO2 emissions per kilo of consumed food, with over 30 kgCO_2e produced per kilo of beef, lamb, other red meat and dairy products. Meats produce more emissions per unit of energy available for dietary consumption compared with plant-based foods because energy is lost at each stage of the food chain, or trophic level. In particular, although meat from ruminants can support small volumes of carbon to be sequestered in grassland soils, this is significantly outweighed by the direct CO_2e (methane) emissions from ruminants themselves. There is also the opportunity cost of using land for grazing, or growing feed, in favour of growing crops for direct consumption or afforestation schemes that would sequester carbon [80].

The CCC currently makes a conservative assumption of a 20% reduction in the consumption of lamb, beef and dairy by 2050, which implies continuing the current trajectory of average meat consumption, which fell by 10% between 2007 and 2018 [82]. Reducing consumption of animal products further, in particular from ruminants, is widely acknowledged to be a 'win-win' for both health and the climate.

In the UK the average diet contains 25% more saturated fat than recommended by the WHO (10), which includes fat found in animal food products as well as meat itself. According to modelling studies of the effect of dietary changes replacing meat and dairy sources of protein with non-meat sources, such as nuts and plant proteins, could reduce both overall and cardiovascular mortality - outcomes that are mediated by anticipated reductions in cholesterol, body fat, blood pressure and rates of type-2 diabetes and cardiovascular disease [88–90].

The indirect benefits to health of reduced meat consumption include from air quality. Globally, air pollution related to food production is responsible for around 20% of all deaths from air pollution [71]. In the UK, the largest sources of ammonia, a precursor to particulate matter, are dairy and beef cattle and fertiliser application [86].

Low consumption of wholegrains, fruit, vegetables, nuts and seeds are all disease risk factors that are independent of meat consumption. In the UK, the fruit and vegetable content of the average diet is 30% lower than recommended by the WHO and saturated fat intake is 25% higher. If the average UK diet met WHO nutritional guidelines, GHG emissions from diets could be reduced by 17%. Over 30 years this could avert almost 7 million years of life lost and increase average life expectancy by over 8 months [81]. The same study that produced these figures found that a diet involving a 20% reduction in emissions remains very similar to the basic nutritionally optimised diet. Further, GHG emission reductions of around 40% could be achieved by making realistic modifications to diets so that they contain fewer animal products and processed snacks and more fruit, vegetables and cereals. However, such a diet may also potentially lead to increased consumption of sugary snacks – while these have low emissions, they are energy-dense and harmful to health. Dietary GHG emission reductions greater than 40% are likely to require diets that are too limited to be acceptable to the general population and would potentially reduce the nutritional quality of diets. This is clearly important when modelling net-zero scenarios as it is unlikely to be nutritionally advisable or practically feasible to reduce dietary emissions by more than 40%, although this may change with targeted work to reduce emissions at the production stage.

Finally, while it cannot be assumed that reducing meat and dairy intake will lead to substitution with healthier foods, if half of UK meat and dairy consumption were replaced with fruits, vegetables and cereals, diet-related GHG emissions could be reduced by 19% and roughly 37,000 premature deaths from cardiovascular disease and cancer averted each year [87].

FOOD CONSUMPTION, HEALTH AND CLIMATE CHANGE: INTERVENTIONS TO CHANGE EATING BEHAVIOURS

There is an extensive literature on interventions that affect choice. These interventions include ones that influence conscious, rational decision-making, for example via labelling and certification processes, levies on unhealthy foods and subsidies for lower carbon healthy alternatives; and non-conscious, automatic processes to alter the formulation of products and the presentation and layout of the food environment, including in shops, cafes and restaurants [80]. These cognitive and non-cognitive 'nudge' interventions that make it easier for people to consciously make healthier and more sustainable food choices, or unconsciously alter their eating patterns, will play a role in changing dietary behaviours. Below we outline some of the policy levers and interventions available to the UK government to influence food consumption patterns and production methods in the UK.

DIETARY GUIDELINES

The Eatwell Guide, published by the NHS, does not currently consider sustainability in its recommendations [88]. In spite of this, compared with 'very low' adherence to the Eatwell recommendations, 'intermediate-to high adherence' is associated with an estimated 30% lower average dietary GHG emissions (1.6 kgCO2e per day) and a significantly reduced risk of mortality. Of the individual Eatwell guidelines, adherence to the recommendation on fruit and vegetable consumption is associated with the largest reduction in total mortality risk; whereas increased adherence to the recommendation on red and processed meat consumption is associated with the largest decrease in environmental footprints, of −1.48 kg kgCO2e per day [89]. Other food system interventions outlined below could be strengthened if future iterations of the Eatwell guide factor sustainability into their recommendations.

FISCAL INTERVENTIONS

The UK's VAT system does not align with healthy eating advice. Numerous anomalies have been highlighted in the categorisation of zero-rated foods such as cakes and takeaways that do not align with healthy eating advice, or with reducing environmental impacts [76]. The Soft Drinks Industry Levy introduced in 2018 indicates the potential impact of fiscal interventions: it has led to the reformulation of soft drink products to reduce their sugar content, as well as to reduced sales as a result of higher retail prices, leading to an overall reduction of sugars sold in soft drinks of 30% [90].

The price of meat does not currently reflect its environmental impact. Interventions that target specific food groups by raising their price may lead to substitution with other foods, and this is a greater concern for those facing a more limited range of healthy alternatives. Fiscal interventions will therefore play a role, but need to be carefully structured to ensure that any increased cost for one food group is balanced by reducing the cost of the recommended alternative.

Strategies to increase fruit and vegetable consumption must factor in affordability and accessibility, including engaging with the challenge of maintaining supplies in a changing climate. These will need to implemented with increasing ambition because predicted environmental changes will reduce global yields of fruits, nuts and seeds – which will affect imports to the UK, although potentially less so domestic production, in the near-term [94].

LABELLING AND PROMOTIONS

It is now accepted by the Government that restricting the advertising of high-fat, -sugar and -salt content foods will reduce demand for these products. We endorse the Government's action on promotions and recommend extending the approach to foods with high carbon footprints.

Currently, most food product labelling reveals little about the sustainability of food products. The effect of labelling on some parameters, although not sustainability focused, suggests it can decrease total energy (calorie) and fat intake by as much as 6.6% and 10.6% respectively, and increase vegetable consumption by 13.5%. It can also change industry behaviours, having significantly decreased sodium and trans fats in food products where labelling was required. Existing evidence points to the likelihood that people are willing to pay more, on average, for more eco-friendly and healthy foods where that is clearly labelled on the product [92].

BEHAVIOURAL NUDGES

Interventions such as reducing the portion size of meat products in restaurants have been shown to decrease meat consumption with no detrimental impact on customers' perception of their restaurant experience [93]. Better marketing strategies that emphasise what is in the food rather than what is missing (e.g. 'meat-free' labels emphasise missing ingredients over the actual content) have been found to increase the take-up of vegetarian and vegan menu options [94].

Little is known about the impact of dietary change on people who are induced to switch to low-meat diets compared with those who have chosen a low- or no-meat diet, although research into this is underway [95]. Currently, while 14% of people in Britain identify as 'flexitarian' or semi-vegetarian, only 4% of the population are vegan or vegetarian [96]. There is a need to engage with emerging evidence to understand responses to interventions that induce people to switch to plant-based and low-meat diets, to see whether the effects on diet and health are the intended ones.

VOLUNTARY AGREEMENTS

Voluntary agreements with industry to reduce the salt content of food have been successful with some, but not all, food products: for example, breakfast cereals are now 40% less salty than a decade ago [97]. However, others, such as meat products, have failed to meet targets and four in ten contain salt levels above the maximum targets set by the Department of Health and Social Care, partially owing to the essential function of salt in certain food products as a preservative. Given meat and dairy are major food groups and not added ingredients, voluntary agreements are unlikely to play a significant role in reducing their consumption in the absence of other legislation to drive change in production methods and in demand for these products.

FOOD PRODUCTION, HEALTH AND CLIMATE CHANGE

Currently, 46% of food consumed in the UK is imported [15]. Much of this food comes from countries that are vulnerable to climate change impacts and from countries where there are unsustainable farming practices. At a time when the UK is seeking new trade deals, there is a risk that the country will increase imports of less sustainably produced food. Simultaneously, the UK is seeking to improve domestic farming practices to improve sustainability, which may add costs and make UK producers less competitive.

UK food production and the land footprint associated with it is currently dominated by meat and dairy production and crops for animal consumption, over fruit and vegetable production for direct human consumption. Both the Agriculture and Trade Bills will therefore be important vehicles to consider the policy levers required to support UK farmers to implement climate mitigation measures through afforestation and other carbon sequestration schemes, transitioning to horticulture where possible, making improvements in the efficiency of fertiliser and water use, and enhancing biodiversity within agricultural systems [98].

Consistent with the recommendations of the recent National Food Strategy, verification programmes applied to trading partners are needed to ensure that UK producers remain competitive in the face of competition from markets with lower environmental standards. Under World Trade Organisation rules there are limits to the degree of protectionism that the UK can use to support local food production beyond food safety measures [80]. Trade negotiations must consider climate change mitigation and the effect of trade deals on domestic production if environmental and welfare standards are lower (and therefore production costs are cheaper) in trading partner countries. The draft text of trade deals must be subject to assessment for impacts on health and the environment among other potential impacts.

FOOD SYSTEM RESILIENCE

As indicated above, the UK relies heavily on imports for both food security and variety. Trade in food products is important to incomes and food security in all countries, but the vulnerability of those supply chains is likely to increase, raising food prices and affecting affordability. Any consideration of food production and climate change must therefore consider the vulnerability of supply chains to climate change, and competition for imports, and this is especially critical in view of current diet-related health inequalities. Adaptation strategies that include food system planning will be essential to resilience in the context of future environmental changes. These need to strike a balance between purchasing sustainably sourced food internationally to maintain food security, and promoting locally produced food with lower emissions, i.e. shifting the balance from meat and dairy towards fruit and vegetable production, to reduce our dependence on climate-vulnerable countries [91]. With regard to increasing local food production, this is challenging in an intensively competitive food system and may or may not achieve health or environmental benefits unless associated with a shift towards food production and retail models that consider 'triple-bottom-line' effects, accounting for the total benefits to society and the environment, as well as to shareholders [88].

MEAT PRODUCTION

There is an ongoing debate about solutions to the climate/environmental impacts of meat and the health implications of these. One solution to red meat emissions has been to encourage uptake of meat substitutes. Recent innovations in plant-based meat substitutes are likely to bring significant environmental benefits in terms of less water usage and GHG emissions relative to red meat from ruminants, although less so relative to poultry [99]. Nutritionally, while higher in fibre, some of the plant-based meat alternatives have higher sugar and sodium content than the meat they substitute, although the amount of salt added to meat during cooking is highly variable [100]. The health effects of replacing meat with highly processed meat substitutes are therefore currently unknown.

FOOD WASTE

Finally, side from food intake, food not consumed also contributes to climate change. It is estimated to contribute about 8% of all greenhouse gas emissions globally and around 20 million tonnes of CO2e in the UK (about 4% of annual emissions) [101]. There is further wastage on the farm, but no data available to estimate the emissions. Food wastage becomes more carbon-intensive the later in the food chain it occurs, with food wastage at the point of consumption, which is responsible for the largest proportion of food waste in the UK, contributing the largest share, 37%, of waste-associated emissions [101] [102].

Lack of regard for waste also encourages over-purchasing and excess food availability, promoting over-consumption, both through larger portions and increased frequency of consumption. There is frequently a financial incentive to consume too much food that is nutritionally low-quality, for example with special offers and supersized portions that are much cheaper per calorie than smaller servings. If sustained reductions in exposure to larger-sized food portions, packages and tableware could be achieved across the whole diet, this could reduce waste and the average daily energy consumed from food by between 144 and 228 kcal (8.5% to 13.5% from a baseline of 1,689 kcal) among children and adults in the UK [103].

Indirect benefits to the determinants of health may arise from the money saved on buying unnecessary food (estimated to cost the average family £700 per year in 2015), and from increased opportunities for the redistribution of surplus food [101]. Reduced food waste at the consumption phase could involve simply making better use of domestic freezers, and planning portion sizes more effectively [101].

RECOMMENDATIONS

There is no one single approach to both reducing the GHG emissions from food systems and improving health by improving diets. A combination of approaches is required, including: adapting livestock practices, educational interventions and enacting behavioural change to reduce meat consumption and food waste, increasing the nutritional value of food, increasing the consumption of minimally processed plant-based proteins, and solutions addressing fair distribution of food resources [99].

Overarching objectives that will bring both health and climate/environmental benefits include to:

REGULATORY INTERVENTIONS

- Shift towards food production and retail models that consider triple-bottom-line effects, including benefits to society and the climate/environment as well as shareholders.
- Restrict marketing and promotion of foods which have both large carbon footprints and negative health impacts, for example, products containing red meat, high fat dairy and palm oil.
- Restrict retailers from offering financial incentives to over-consume, such as multi-buy offers, as these contribute to both obesity and food waste.
- Reduce food waste via investments in alternative methods of food waste processing as well as duties on all actors in the food system to reduce waste.

LEGISLATIVE / POLICY INTERVENTIONS

- Enable a wider range of local and national powers to shape food systems and combine these with the resources and statutory duties to support the transition to healthier and more sustainable diets.
- Make the draft text of trade deals available to assessment for impacts on health and the climate and environment.
- Support interventions to reduce rates of obesity via substitution of unhealthy foodstuffs with fruit, vegetables and wholegrains.
- Develop a labelling system to inform consumers about the health and climate/environmental impacts of their purchases.
- Incorporate sustainability criteria into future iterations of UK dietary guidelines.

FISCAL INTERVENTIONS

- Subsidise production and sale of fruit, vegetables, nuts, seeds and wholegrain products to support increased uptake of plant-based diets.
- Change VAT structures to reflect the health and climate/environmental impacts of food.
- Support a transition away from meat- and dairy-dominated agriculture in the UK. Subsidise farmers to undertake environmental stewardship and carbon sequestration activities.

5

TRANSPORT

Transport is the largest source of carbon dioxide emissions in the UK, surface transport accounting for 24 per cent and aviation and shipping a further 10 per cent of emissions in 2019 [38]. The COVID-19 pandemic has had an unprecedented impact on transport patterns in the UK and globally, both in terms of the modes of transport we use and how frequently and far we travel. It has also revealed stark inequalities in how different groups are more or less exposed to COVID-19 due to their occupation; bus drivers, for example, have had almost double the mortality rate during the pandemic than would have been expected in this group based on rates over the last five years [104].

The pandemic also led to unprecedented increases in the numbers of journeys made via walking and cycling, and temporarily reduced car journey numbers due to lockdown measures[105]. At this stage, the long-term implications of these impacts on how we travel are hard to predict, but it has created an opportunity to radically overhaul a twentieth century transport system that does not meet 21st century climate, environmental or health priorities.

The two primary approaches to reducing the transport sector's GHG emissions include increasing the uptake of electric vehicles (EVs) and creating a modal shift away from private car ownership and towards more active forms of travel, including walking and cycling as well as public transport. Legal duties to reduce emissions from vehicles will go some way to reducing air pollution from transport, but more ambitious policies are required to drive a modal shift towards behavioural changes and increased use of walking, cycling and public transport. The Advisory Group therefore welcomed the ambition presented in the Department for Transport's new Cycling and Walking Plan for England, published in July 2020, which draws on the evidence base for the approach required to increase uptake of walking and cycling – and which relies on strong and continued political will and public support for delivery [106].

The GHG reduction benefits of replacing standard internal combustion engine vehicles with EVs would be considerable and there would also be modest benefits to air pollution via reduced NOx emissions, although increased non-tailpipe emissions (break and tyre-wear). The benefits to public health would however entail minimal or no benefits to physical activity or road safety, unless part of an integrated approach to healthy and sustainable transport systems.

Some degree of modal shift to active travel will play an essential role in achieving net-zero in the transport sector. This calls for an urgent reversal of the policy approach of the last 60 years – to 'predict and provide' road space, which drives up both road use and the cost of public transport over time - by encouraging driving and reducing public transport passenger numbers.

While large-scale rollout of EVs will bring substantial GHG reductions if powered by renewable electricity, a focus on public transport and active travel as solutions to transport emissions has much greater potential to improve health and reduce health inequalities. To maximise these health gains, the focus must be on ensuring that investment reaches those with the most potential to benefit. Throughout this report we highlight the opportunities that climate mitigation policies present to reduce health inequalities, and for transport in England this means weighting new investment towards areas least served by public transport and active travel infrastructure: currently the wealthiest 10% of the population receive almost four times as much public spending on their transport needs as the poorest 10% [107], while between 2010 and 2017 funding for bus travel reduced by 45% [108].

HEALTH IMPACTS OF ACTIVE TRAVEL

Low levels of physical activity are associated with a range of poor health outcomes across the life course, including cardiovascular disease, diabetes, musculoskeletal health, cancer, and poor mental health and well-being [109]. Encouraging active travel may also play a role in a wider approach to reducing obesity – based on country-level evidence that obesity rates are increasing in countries where active travel is declining [110].

A challenge in synthesising and using this evidence is that 'active travel' is not defined consistently across studies, and the definition is dependent on what is considered normal in a particular setting. Thus, differences between active and sedentary populations may be masked by the methods by which active travel is defined and reported.

In the most recent Active Lives Survey, 63.3% of adults in England achieved 150 minutes of moderate intensity physical activity a week. There is again a social gradient in physical activity, with those in routine/semi-routine jobs and those who are long-term unemployed or have never worked the least likely to be active (54%) and most likely to be inactive (33%) [111]. Given baseline levels of physical activity are lower in the UK than in many of the countries in which active travel studies have been conducted, adding 30 minutes of activity per day in some areas may produce much larger benefits to health of more sedentary populations than have been observed elsewhere.

Empirical evidence to support the health case for active travel includes a study that used data from the UK Biobank (a major national and international health resource) about regular commuters. The study found that more active patterns of travel for commuting were associated with estimated reductions of 11% in incident cases and 30% in fatal cases of cardiovascular disease. For commuters who regularly used active travel for their commute and also for leisure, their risk was even lower [112]. Another study using UK Biobank data found that after five years, bicycle commuters had a 41% and 52% reduced risk of all-cause mortality and cardiovascular disease respectively [113]. Similar effects have been found using other longitudinal cohort study designs [114] [115].

Such evidence has informed modelling to project the impacts of increased active travel [116] [117]. One such study estimated the benefits of increasing walking and cycling in urban England and Wales to the levels in Copenhagen, and identified that about £17 billion of costs to the NHS could be averted over a 20 year period from reducing the burden of seven diseases that are associated with physical inactivity: type-2 diabetes, dementia, cerebrovascular disease, breast cancer, colorectal cancer, depression and ischaemic heart disease. These benefits would increase further over time due to the lag period between increasing physical activity and reducing health risks, and take into account exposure to risk of injury on the road [118].

The greatest benefits to children may be found from increased cycling rather than walking. This may be because vigorous intensity physical activity, such as cycling, has a greater effect on body weight than moderate intensity exercise, such as walking [119]. Studies in Scandinavian countries where baseline levels of walking and cycling are higher than in the UK show a significant health benefit (as measured by weight or biomarkers such as cholesterol or blood glucose) to children who cycle regularly and over the long term, compared with those who do not cycle or those who take breaks from regular cycling [120] [121].

Electric bikes (e-bikes) will play an essential role in making it easier for older and more sedentary people to take up and continue cycling. There is some evidence of improved cognitive function and well-being in cyclists compared with those who do not cycle [122].

HEALTH IMPACTS OF PUBLIC TRANSPORT USE

There will be many groups and many journeys that for reasons of health, disability, cargo or distance cannot reasonably be replaced by walking or cycling. For these, the health effects of public transport in comparison with car use are less well understood. The physical activity benefits of using public transport use usually derive from walking between connections and to/from public transport stops or stations [114]. COVID-19 has also presented an unprecedented challenge to make public transport a low-risk environment for transmission, for which face coverings and encouraging staggered journey times to reduce rush hour demand will form an essential but not sufficient part of the solution.

Future innovations that may enable more efficient use of vehicles and balance the need for public transport with ongoing demand for private car ownership include ride share autonomous vehicles (AVs), which will be necessary if there is not capacity for renewable electricity to power all cars. These have the potential to significantly alter travel behaviours, to contribute to reduced road traffic accidents and to free up road space from parked cars to make space for cyclists [123]. However, there is also a risk that they will drive up sedentarism if they encourage more journeys to be taken by car (for example, if they are cheaper as a ride share vehicle and parking is no longer a consideration). These will therefore only be a part of the solution if well-regulated and combined with strong incentives to travel by other modes.

HEALTH INEQUALITIES AND TRANSPORT

In England and Wales, commute mode is patterned by socioeconomic groups, as shown by 2011 Census data, with walking and the use of public transport more common among more deprived populations and car use more frequent among less deprived populations [124]. In terms of health outcomes, few studies of active commuting and health outcomes adequately consider the socioeconomic status of participants, making it difficult to draw conclusions about differential benefits to the health of people in different income groups of active travel [115]. Looking at behaviours however, a study of responses to improvements in local walking and cycling routes in three English towns found that over time there was a levelling up in physical activity: any differences in take-up between socioeconomic groups disappeared and people with lower educational level and income were equally likely to use walking and cycling infrastructure at two-year follow-up [125]. The social and environmental benefits of walking are further intertwined to the extent that the more people who walk in an area, the safer people feel in public, and the more likely they are to walk, particularly in more deprived areas [126].

INCREASING ACTIVE TRAVEL

Significantly increased rates of walking and cycling will bring major co-benefits to health but may only bring modest benefits to greenhouse gas emissions unless combined with measures to reduce emissions from other transport sources.

Cycling: In England and Wales, only 17% of adults live within easy walking distance (2km) of work, and only 35% live within easy cycling distance (5km), according to the 2011 Census – although these percentages may well have changed with new working patterns following COVID. If people in England were as likely to cycle as those in the Netherlands (allowing for distance and hilliness), about 18% would cycle to work and 41% cycle to school [127]. Translated into environmental benefits, if the proportion of the English population who cycle regularly, but still use cars for longer journeys, increased from the pre-lockdown rate of 4.8% to 25%, there would be a 2.2% reduction in passenger-related CO_2 emissions, and a 2.1% reduction in life years lost due to premature mortality [128]. This would previously have seemed highly ambitious, but is now a not unreasonable target given the sustained increase in cycling levels since lockdown, with the number of weekend cycling trips having remained at up to 100% above pre-lockdown levels into September 2020 [105].

Walking and cycling schemes typically have a cost-benefit ratio considerably greater than £4 return for every £1 invested, considered to be very good value for money [129]. Meanwhile, a review of UK road schemes found that evidence of benefit was weak, absent or even negative. Of 25 road schemes promoted as beneficial to the economy, only six actually did show economic benefit, and even then there was no evidence to say that this was not displaced economic activity from elsewhere [130].

Walking: A large cross-sectional study spanning 14 cities across ten countries assessed the frequency of transport-related walking and cycling over the previous seven days among adults and compared these with measures of the built environment. It found the key variables associated with more walking and cycling were living in more densely populated areas, having a well-connected street network, more diverse land uses and more parks [131]. However, while there is strong associational evidence between urban form and active travel, the causal evidence base is much weaker. For example, it is difficult to adjust for neighbourhood self-selection: that people who want to walk more are likely to choose to live in more walkable neighbourhoods [132]. In a longitudinal study of changes in walking habits over time during a period of significant regeneration in Glasgow, there was found to be little relationship between changes in the 'walkability' of a neighbourhood (features that encourage walking, e.g. new street layouts, environmental improvements, new amenities) and people's walking habits. In particular, the authors found that in deprived areas there was little change in aggregate neighbourhood walking frequency in the four years following area regeneration that sought to increase walkability [132]. The authors conclude that although connectivity and density are associated with walking internationally, that does not mean that changes in walkability will lead to changing in walking in all contexts.

These studies of targeted interventions point towards the need for whole-systems approaches. This extends beyond transport to the location of destinations of journeys, for example making retail, leisure and social destinations more accessible [132]. In one systematic review, all included studies that combined changes to green space in the built environment and physical activity promotion interventions were reported as being effective in increasing activity when deployed together, while only half of the studies that featured only a built environment intervention showed a positive impact on activity [133]. Another systematic review of interventions to promote walking found that combined mass media, community initiatives and environmental change approaches in combination increased walking the most, with increases ranging from nine to 75 minutes per week [134]. Similar patterns of combining communications with changes to the built environment were seen in three UK towns where 18% of people who knew about the project reported they used cycling as a transport mode, compared with 7% of the full sample at two-year follow up [125].

There is a shortage of evidence regarding behaviour change affecting essential travel, i.e. journeys to work, school or other essential destinations, rather than for leisure, but policies focusing on cleaner vehicles and shorter travel distances are likely to contribute the most to changing behaviours whilst reducing emissions and air pollution (except non-exhaust emissions) [58].

Recommendations

The following recommendations guide how benefits to health, health equity and carbon emissions can be maximised from delivery of the Cycling and Walking Plan for England as well as action to reduce air pollution from transport sources.

REGULATORY INTERVENTIONS

- Reduce car dependency and move away from models of private car ownership towards shared ownership and public transport: increase availability of affordable and reliable public transport within and around urban areas, and ride-share options that incentivise the transition away from private vehicle ownership, as well as connectivity with walking and cycling routes.
- Stop increasing the road network capacity increase; strengthen and enforce traffic regulations; reduce travel distances by, for example, reducing the need to travel by car or air (e.g. encourage continued remote working and virtual conferencing); implement speed restrictions (e.g. 20 MPH limits in residential areas) and traffic control measures that are locally appropriate and may change with time of day dependent on average road use; ringfence and increase funding to support holistic behaviour change programmes that combine interventions such as cycle training, segregated cycle networks, travel planning support to schools and businesses and large-scale social marketing campaigns.
- Prioritise supporting the replacement of the oldest, most polluting vehicles with electric vehicles, including incentives to replace vehicles with e-bikes where feasible; develop promotional campaigns to raise awareness of GHG benefits of electric vehicles.
- Regulatory: Reduce delivery vehicle emissions: support transition to electric or other alternative (low-GHG) fuelled small vans; optimise delivery services to reduce vehicle miles travelled by small vans and heavy goods vehicles.
- Legislate for urban planning models that reduce journey distances by encouraging localised amenities to reduce routine journey distances.

FISCAL INTERVENTIONS

- Ensure new investment into walking and cycling infrastructure reaches those who would experience the highest returns to health – in more deprived areas where healthy life expectancies are lower than average, air quality worse, rates of car ownership lower, and cycling infrastructure poor or non-existent.
- Replace the predict and provide model of national road investment with a process that incentivises investment in walking and cycling routes. As part of the requirement for transformational change there is the need for traffic restraint. Build on the Department for Transport's Decarbonising Transport report of March 2020, which outlined what needs to be done on the supply side to move away from predict and provide road planning [135].

6

A SUSTAINABLE AND HEALTHY ECONOMIC MODEL

The UK's current economic approach, like many other Western economies, will not lead to a net-zero future within the timescale required to achieve the aims of the Paris Agreement. While UK emissions have declined steadily while GDP has risen [136], economic growth nonetheless has depended on non-renewable energy, which has harmed our climate and natural resources as well as our health and well-being. The current economic approach has also led to substantial income inequalities as well as an unhealthy dependence on greenhouse gas-emitting activity. The UN states "inequitable development can never be sustainable human development" and similarly, inequitable economic growth can never be sustainable economic development [137].

In the last decade in the UK, the rich have become richer and as a result, the rich have also become healthier [3]. Wealth inequality in the UK increased faster between 2010 and 2016 than in all other OECD nations except the USA: the richest 1% of the population owned 20% of the wealth in the UK in 2016, up from 16% in 2010 [138]. In 2018 the average CEO in the UK was paid 117 times more than the average wage in the UK (and about 200 times more than those on minimum wage), whereas in 1978 the average CEO was paid 18 times the average salary [139]. Around the world, as well as in the UK, during the COVID-19 pandemic many of the rich have become much richer, despite economies closing down [140] [141].

Over the course of the COVID-19 pandemic many businesses and companies with large carbon emissions have received sizeable UK government support. Airlines and the car industry have been given huge loans: EasyJet and Ryanair each received £600 million, car-makers Honda, Nissan and Toyota received £1 billion between them, and two oilfield services, Baker Hughes and Schlumberger, received £600 million and £150 million respectively [142]. The UK's 'Project Birch' bailout plan is aimed to "save strategically important companies" but it is unclear how 'strategic' is defined. In order for the UK to be on track to meet its 2050 net-zero obligation as well as to provide healthy and fair workplaces, it is strategically important companies should be required to address climate change and the well-being of their employees in order to receive bailout funding. After EasyJet received its loan in April, less than a month later it reduced its workforce by 30%, cutting 4,500 jobs.

The transition to a net-zero carbon economy and society will require new ways of working and a shift in our understanding of work/life balance, including redefining the definition of 'quality work'. In 2017 the Taylor Review of Modern Working Practices (for the UK Government) concluded well-being was central to quality work and that there are six indicators of good quality work: satisfaction with pay; employment quality, including job security and reduction in long hours; education and training support and lifelong learning opportunities; supportive working conditions and the ability to shape one's own work; healthy work-life balance and opportunities for flexible work and, lastly, consultative participation & collective representation and the ability to actively engage with decisions affecting people's working lives [143].

The long-term packages aimed at stimulating the UK's economy could have been an opportunity to shift priorities and work towards meeting the net-zero target whilst maximising health benefits. Many have called for a 'green recovery' and to 'build back better'. In the UK and globally, business leaders have also called on governments to 'build back better' and align economic recovery plans with climate change targets [144]. In the UK over 200 businesses called on the Government to "(d)rive investment in low carbon innovation, infrastructure and industries, as well as improved resilience to future environmental risks" [145]. In May 2020 the World Health Organization published a 'Manifesto for a health recovery from COVID-19' and called for six actions for a healthy, green recovery: investing in essential services; transitioning to renewable energy sources and healthy sustainable food systems; adapting cities to become healthier places and reforming financial structures to reduce dependence on fossil fuel subsidies [146]. In June 2020 the Committee on Climate Change, in its annual report published called on the Government to 'act courageously' and to 'embed fairness as a core principle'. Their short-term and long-term recommendation place fairness and sustainability at the centre of recovery packages: "action by Government must protect workers and businesses, restore confidence, stimulate spending and rebuild a greener economy, particularly for the most affected regions and sectors...Public money should not support industries

or infrastructure in a way that is not consistent with the future net-zero economy or that increase exposure to climate risks' [39]. Inclusive and sustainable growth has not been the focus of the UK's COVID-19 recovery. Yet there is potential to guide the huge injection of public resources into the economy required for the recovery, to achieve employment, health, environmental and socioeconomic benefits through an integrated approach [147].

To reach net-zero and to reduce the effects of the social determinants of health – such as cold, damp housing and poor working conditions – the drivers of health inequalities, the drive for continual economic growth must be replaced by sustainable economic policies and a fair distribution of economic resources, to lead to a 'greener' and more equitable economy. A net-zero economy should have equity at its core, with a 'minimum income standard': this is a standard developed by the Joseph Rowntree Foundation and Loughborough University and is a useful measure of the income needed to live a healthy life [148].

The 2008 financial crisis led to a number of 'green' government policies, such as retrofitting homes, creating zero-carbon infrastructure, renewable energy and in the UK, these interventions created more jobs than traditional stimulus projects such as road building [149]. In 2020 we are now in a better position to create green jobs: around the world environmental and social considerations are more important for investors and regulators and the issue is higher up the political agenda as politicians recognise their citizens calling for change [149].

Alongside transitioning to a more sustainable economy there is an opportunity to shift our current work patterns. Shortening the working week could deliver a number of co-benefits: in addition to improving health, well-being and quality of life, a better work-life balance could be accompanied by lower unemployment and reduced GHG emissions.

When jobs are replaced by automation and artificial intelligence, income inequalities increase. It is estimated that 30% of existing jobs in the UK could be impacted by automation by the early 2030s [150]. Jobs with higher rates of female employment are at highest risk of automation [184]. This can partly be explained by the higher risk of automation to part-time workers, of whom women make up a greater number than men [160]. Educational status also influences a person's chance of their job being at risk from automation. For the jobs at low risk, 87% are held by employees with a degree, whereas the three occupations at the highest risk of automation are low skilled or routine occupations (waiting staff, shelf-fillers and elementary sales occupations), which are typically held by people with lower level or fewer qualifications [151]. Artificial intelligence and automation should not to be rejected outright as they can have a positive impact on GHG emissions, acting as an impetus to structure work differently: if work can be done in four days rather than five or done remotely it will benefit climate, health and well-being; but crucially it is important that incomes do not decline as a result for those on lower incomes.

In 2019 approximately 5% of the UK workforce worked from home [152]. In a demonstration of how quickly economies adapted to the lockdown, during the first full month of lockdown, April 2020, 47% of the UK's workforce did some work from home [153]. Those able to work from home were in higher paid positions. Over two-thirds (70%) of those in professional occupations, managers, directors and senior officials, associate professionals, technical and administrative occupations worked from home during this period. In contrast, fewer than one in five of those in skilled trade jobs, caring, leisure and other service occupations, sales and customer service occupations, and process plant and machine operatives were able to work from home [153]. An analysis of the sectors heavily affected by the lockdown (e.g. retail (excluding food), hotels and restaurants, cleaning, arts and entertainment, personal services such as hairdressing) found employees' weekly pay to be £320, compared to an average of £455 for the economy as a whole [154].

Working from home reduced GHG emissions from commercial areas (populated by shops and offices) and increased emissions from homes, but a net decrease in most emissions has been estimated. There was no detectable surge in residential gas use; overall, gas distribution fell by 11% between 16 March (the first day of lockdown) until 30 April [155].

By the first week of July, more than three months after the lockdown began, many were still working from home. In Leeds, for example, it was estimated that only 15% of workers had returned to the city centre [156]. The decline in city and town centres started before the pandemic, with the shift of shopping online being one major factor. Between 2014 and 2018, there was a 78% decline in shopping centre investment in towns and cities in the UK and 12% of shops were already vacant in March 2020; close to half of the UK high street was owned by real estate companies, overseas investors and other investment funds [157].

WORK-LIFE BALANCE

In 2019 the average number of weekly hours worked was 37.2, a decrease from 1992 – an average of 38.1 hours per week – but an increase from 2009, when weekly hours were at their lowest since 199, at 36.8 [158]. Since 2010 men's weekly working hours have fluctuated between 35.9 and 36.8 whereas women's weekly paid working hours have gradually increased, from 26.3 hours in 2010 to 27.4 hours in 2019 [159]. These added hours increase the workload for many mothers who work outside the home. Women are still the main providers of childcare and unpaid household work. Research during the COVID-19 pandemic showed women were more likely to provide childcare and housework and more women than men stopped working [160] [161].

HEALTH IMPACTS OF WORK

Current working hours (see box on work-life balance) and practices are not sustainable for either our health and well-being or the planet. Research from around the world shows people's relationship with work, their employment status and their employment arrangements and the nature and conditions of their work all influence their health and well-being to a very significant extent [162]. There are four ways in which the nature of work can adversely affect health: adverse physical conditions at work; adverse psychosocial conditions at work; poor pay or insufficient hours and temporary work, insecurity, and the risk of redundancy or job loss.

Working long hours, defined as 48 hours or more per week, uses more resources and requires more outputs and consumption, while increasing the risk of fatigue and accidents. There is some evidence that it can lead to stress, depression or mental ill health. In the UK approximately one in eight workers works more than 48 hours per week, rising to one in six in London [163]. One in four of all sick days taken in the UK is directly attributed to workload problems [164]. Long hours and poor work-life balance are serious concerns for NHS staff in particular. And it seems to be a growing problem, with two-and-a-half times as many NHS staff citing 'work-life balance' as a reason for leaving a job in 2018/19 as in 2011/12 [165].

Having to undertake stressful work can be more detrimental to health than being unemployed [166]. Chronic stress at work is related to coronary heart disease and metabolic syndrome [167] [168] [169]. In 2018/2019 there were 602,000 workers in the UK who reported as suffering from work-related stress, depression or anxiety (1,800 per 100,000 workers) and a total loss of 12.8 million working days as a result (an average of 21.2 days lost per case) [170]. More people suffer from poor mental health in the workplace than from work-related musculoskeletal disorders [171].

HEALTH INEQUALITIES AND WORK

The health and well-being effects of work are not experienced equally across the population. The Whitehall Studies of British civil servants found that people lower in the social hierarchy at work have worse health than those above them and better health than those below them: this is the social gradient in health [172]. The Whitehall Studies showed an inverse social gradient in mortality and worse coronary heart disease, diabetes, metabolic syndrome, mental disorder and sickness absence in those in lower socioeconomic positions [172]. Psychosocial conditions at work (such as lack of control, anxiety, low self-esteem, social isolation, depression) play a role in generating this social gradient in health [173].

Unemployment reduces income and access to material resources for health and has profound psychosocial effects that can adversely affect health [162]. Unemployment, particularly long periods of unemployment, is harmful to physical health (e.g. increasing the risk of cardiovascular disease and musculoskeletal disorders) and mental health and is associated with higher mortality and morbidity, for all social classes. There is a significant longitudinal association between long periods of continual unemployment and worse mental health, including anxiety and psychological distress [174].

Insecure work, characterised by short-term, or no, contract, and a consequential high risk of losing a job and the associated anxiety are harmful to health [3]. Zero-hour contracts that do not guarantee a minimum number of paid hours are a highly insecure form of work. People in lower skilled and lower paid occupations and people from BAME groups are more likely to be on zero-hour contracts than in those in higher skilled occupations and people from White backgrounds [3].

POLICY OPTIONS

The number of job losses in the UK during the COVID-19 pandemic reflects what is happening around the world: hundreds of thousands of jobs have disappeared. In July 2020 the Department for Work and Pensions announced it would reopen many of the 100 job centres that they closed in 2018, in order to meet the growing demand to help people back into work [175].

A survey in May 2020 found most people thought that after the pandemic the UK should prioritise the health and well-being of its citizens (Table 2).

TABLE 2. UK PUBLIC OPINION ON WHAT THE HOME NATIONS' GOVERNMENTS SHOULD PRIORITISE IN THE FUTURE (MAY 2020, %)

	England	Wales	Scotland
The health and well-being of UK citizens	81	87	89
The economic growth of the UK	12	9	5
Don't know	7	4	6

Source: YouGov [176]

The economic recovery from COVID-19 is an opportunity to both plan for a net-zero future and create more contented and equitable working environments. While the COVID-19 pandemic has led to a temporary reduction in global GHG emissions [177] [178], these declines are not sustainable and are likely to be accompanied by significant mass unemployment [179]. Redistributing working hours, reducing the working week to four days, and encouraging everyone who wants to work to be able to work would reduce unemployment, reduce poor health and well-being resulting from unemployment, increase productivity and reduce GHG emissions [180].

For example, a study of time and consumption patterns in Swedish households estimated that a 1% reduction in working time could reduce energy use and GHG emissions by approximately 0.7%. The researchers estimate the effect of reducing a 40 hour week to 30 hours (not substituted by other workers) would significantly slow energy demand and reduce GHG emissions [181]. Analysis of data from 1970 to 2007 in 29 OECD countries found 10% less time working reduced CO2 emissions by 4%, largely due to less commuting, changes to diets and reduced intake of high-carbon convenience foods [182]. A UK study of 505 business owners and more than 2,000 individuals found a four-day working week would reduce the number of miles driven by employees travelling to work by 558 million miles each week, reducing car mileage as much as 9% [183]. Another study of UK firms that adopted a four-day working week found that over three quarters of staff were happier, 70% were less stressed and 62% took fewer days off due to sickness [184].

One of the main criticisms of a four-day week is the compromise in terms of productivity. However, research consistently shows that the most productive and wealthy countries are ones that work fewer hours: that the more productive a nation gets, the more time it frees up for its workers [185]. In France, the working week has been 35 hours since a cap on working hours was introduced in 2000, without repercussions for its productivity. While GDP is not an ideal metric to assess progress, it does provide comparable data between nations. Productivity as measured by GDP/hour worked in 2017 found France's productivity was £69.60/hr, while in the UK its was £61.10 [186].

The Committee on Climate Change has suggested that the UK prioritise and deliver both economic and climate goals in its recovery plans. It recommends a number of principles, which are likely to be good for work and jobs as well as for climate change mitigation:

- Use climate investments to support economic recovery and jobs (e.g. clean physical infrastructure investment, efficiency spending for renovations and retrofits including improved insulation, heating, and domestic energy storage systems).
- Shift towards positive, long-term behaviours that benefit well-being, improve productivity and reduce emissions.
- End economic short-termism and the maximisation of economic efficiency over the resilience of communities.
- Embed fairness and create a more resilient economy (e.g. through investment in education and training to address immediate unemployment from COVID-19 and structural shifts from decarbonisation).
- Ensure the post-COVID-19 recovery does not lock-in GHG emissions or increase the risk of increasing GHG emissions.
- Strengthen incentives to reduce emissions when considering tax changes. [187] [177] [188]

Situating well-being at the centre of climate change decision-making can help to increase the political and social support for more ambitious action on climate change mitigation and to overcome the barriers to change [189]. Reducing the average hours worked and rebalancing work and life outside work will help to reduce GHG emissions and health inequalities and also improve health and well-being. A 'well-being economy' shifts the goal of economic policy from ever higher GDP to collective well-being [190]. For example, Wales, with its Well-being of Future Generations Act, defines a healthier Wales as: "a society in which people's physical and mental well-being is maximised and in which choices and behaviours that benefit future health are understood" [191]. The Act of 2015 is a unique piece of legislation that requires all public bodies in Wales to consider the long-term impact of every decision, to work with Welsh people to prevent persistent problems such as poverty, health inequalities and climate change.

In a further example, New Zealand announced in 2019 the world's first 'well-being budget', which shifted the country's goal from increasing GDP to improving the welfare of all its citizens. The expectations for New Zealand's well-being economy are similar to those in Wales's Well-being Act. It requires all new government spending to work towards six priorities: taking mental health seriously, improving child well-being, supporting Maori and Pacific island people, building a productive nation, transforming the economy and investing in New Zealand [192].

In the UK a new economic model is needed post-Brexit and as a result of the COVID-19 pandemic: an economic model that does not emphasise the benefits of increasing GDP and infinite growth, but one that is more sustainable and equitable. In other countries the COVID-19 recovery has prompted discussions about creating more equitable and sustainable economies. Returning to New Zealand, the possibility of a four-day week was suggested by Prime Minister Jacinda Ardern to rebuild a fairer and greener economy, with Ardern arguing, "We have to be bold with our model. This is an opportunity for a massive reset" [193]. A report commissioned to set the direction of Scotland's recovery by the Scottish government recommended it "must ensure that reducing and seeking to eradicate inequalities and advancing equality, rights and non-discrimination, are at the heart of the policy response" [194].

There are other models that seek to embed equality and sustainability in economic strategies, including circular economies, which involve reducing resource and energy use and pollution through more efficient manufacturing and recycling and investing in 'weightless' goods such as software apps. Increasingly, there is recognition that decarbonisation cannot be achieved in the absence of a circular economy because of embodied emissions in consumer products [195]. Well-designed circular economy policies could generate large numbers of jobs. It is estimated that by 2030 in the UK a circular economy could create over 200,000 gross jobs, reduce unemployment by over 50,000 and offset approximately 7% of the expected decline in skilled employment (due to automation) to the year 2022 [196]. In the USA $1 million of spending in renewables creates 7.49 full-time equivalent (FTE) jobs, and $1 million spent in energy efficiency creates 7.72 jobs, whereas the fossil fuel industries create just 2.65 FTE jobs per $1 million spent [197]. A circular economy encourages the efficient use of environmental resources and seeks more equitable economic outcomes, similar to the aim of 'anchor institutions', a concept that encourages large, local organisations, such as health systems, to procure services and goods locally and employ local people in order to contribute to sustainable local economies [198] [199].

Well-being-Years (WELLBYs) or Well-being-adjusted-life-years (WALYs) could help to frame how to create a more sustainable and equitable economy. WELLBYs are a metric analogous to QALYs – Quality-Adjusted Life Years – and are used by the National Institute for Clinical Excellence (NICE). WELLBYs and WALYs use self-reported happiness and life-satisfaction scales to evaluate benefits of treatments, cures and interventions (e.g. lifelong learning programmes, reducing air pollution) [200]. They can be used as a common metric to enable policymakers, scientists and politicians to make decisions in a consistent, transparent manner. An analysis of when to end the UK COVID-19 lockdown using WELLBYs found the net benefits of releasing the UK lockdown were higher the longer the lockdown was in place. The net benefits include economic factors and are based on income, unemployment, mental health, confidence in governments, schools and the costs associated with COVID-19 deaths, road deaths, commuting, CO2 emissions and air quality [201].

THE UK'S HEALTHCARE SUPPLY CHAIN AND ESTATE

Health systems both provide an essential service and contribute a significant proportion of GHG emissions, representing a large and often carbon-intense part of the economy. Health and social care in the UK is responsible for 5.4% of the UK's total GHG emissions, with its supply chain accounting for a majority share of its emissions profile [202].

The largest single employer in Europe, the National Health Service (NHS) in England leads the world in understanding and delivering on emissions reductions from health and social care systems. In January 2020, the NHS committed to delivering a net-zero health service by 2050, forming an expert taskforce to chart a route forward. This is made possible by the work of the Greener NHS team (formerly the Sustainable Development Unit), which is responsible for working with local trusts to meet the health service's commitments under the Climate Change Act. Their work has achieved impressive success already: between 2007 and 2017 emissions from the NHS decreased by 18%, while clinical outcomes improved significantly and activity increased 27% [203]. This reduction in the carbon footprint applies across the NHS, from estates and facilities (from reductions in waste and energy and water usage) through to patient and staff travel [204].

Specific medical devices and certain pharmaceuticals are among the most carbon-intensive items used by the NHS. For example, inhalers (specifically, metered-dose inhalers/MDIs) used to treat asthma and chronic obstructive pulmonary disease represent 3.2% of all carbon emissions from health and social care [204]. Modelling data analysed the reductions in CO2 that would arise if MDIs were replaced with dry powder inhalers (DPIs). The researchers found 58 kilotons could be saved every year for every 10% of MDIs shifted to DPIs, and estimate one MDI changed to a DPI is "roughly equivalent to installing wall insulation at home, recycling or cutting out meat" [205].

In England the NHS's Long Term Plan is committed to using video technology to make up to 30 million outpatient appointments redundant, improving patient care, expanding healthcare access, and reducing trips to and from hospital. It is estimated that 6.7 billion road miles each year are from patients and their visitors travelling to NHS sites [202]. A number of studies show shifting health services out of hospitals, i.e. delivering services at home or in local health centres, can reduce GHG emissions [206] [207] [208].

The fact that the NHS has cut CO2 emissions at a time of increased activity is good evidence for other sectors that there are many possibilities to reduce GHG emissions without compromising on quality or the delivery of services. In October 2020 the NHS went further and committed to become the world's first health system to deliver a net zero health service. Clear pathways, targets and interventions, including commitments to Net Zero hospitals and ambulances.[209]

The Greener NHS team continue to evolve their analysis of net-zero pathways, with a range of tools available to assess the health effects of this transition. One example is the 'health outcomes of travel tool' (HOTT), which offers a model for quantifying the benefits of low-carbon travel and transport. Other sectors (e.g. large employers, universities and council offices) both within the UK and outside can draw on such expertise and learning, substantially multiplying the benefits of what we might otherwise think of as the NHS's remit. A collaborative approach that sees the NHS engaging across society and acting as an anchor institution for local communities will increase the benefits for health and the environment.

RECOMMENDATIONS

The transformation in workplaces that have resulted from the COVID-19 pandemic are an opportunity to shift to more sustainable and equitable forms of work.

REGULATORY INTERVENTIONS

- Shift towards a circular zero-carbon economy and invest in equitable work places.

LEGISLATIVE / POLICY INTERVENTIONS

- Consider actions to make four-day working weeks a realistic option for all. In order not to worsen health or income inequalities, shortening the working week should be voluntary, and incomes should meet the minimum income for healthy living, with implementation of the minimum income standard developed by the Joseph Rowntree Foundation and Loughborough University.

CONCLUSION

Human activity and actions have jeopardised both the Earth's natural systems and the health of future generations. Measures we take now to mitigate and adapt to climate change can improve the health of current and future generations in ways that are fair and equitable [210]. Achieving the UK's target of reaching net-zero greenhouse gas emissions by 2050 will necessitate transformational changes that have potential to generate significant health benefits in the near term, including via improved air quality, better diets, increased levels of physical activity and improved home standards and work-life balance. To maximise health benefits these measures must also, where relevant, build-in resilience to the effects of climate change and seek to reduce inequalities in the distribution of impacts. A strategy to achieve net-zero emissions should have health equity – the fair distribution of health – as an explicit policy goal.

As the effects of the COVID-19 pandemic have shown, socioeconomic status and structural inequalities influence exposure to adverse events. But as the pandemic has also shown, a rapid response to create social change is possible – within weeks, not months or years. The shift to cycling and walking in cities around the world [211] [212] [213], albeit temporary in some areas, and the explosion in the number of bicycle lanes in many cities present an opportunity to transform the way we travel in urban environments whilst reducing vehicle emissions and air pollution. Although increased active travel is likely to make only a modest contribution to reducing GHG emissions, the rapid changes that have occurred in some locations illustrate the potential for substantial behaviour change to happen when the situation demands. This should be borne in mind when anticipating the potential pace of future behavioural changes.

The sense of urgency arising from COVID-19 needs now to be applied to the climate emergency: returning to the status quo is not an option. For a few weeks in the spring of 2020 almost every government decision around the world put health and well-being at the forefront of policy development and implementation. The urgency with which governments shifted their agendas showed that actions and policies can be swift and decisive. The UK Government should develop and implement robust and transparent criteria to guide how private companies are supported in the recovery that should include not only firms' economic viability but also their impacts on the environment and health.

As an approach to climate change mitigation policy-making, and as shown by the wide range of studies cited in this report, health benefits can be maximised and impacts on health inequality mitigated by integrating a range of assessment methods of the health co-benefits derived from action on climate change. Health equity impact assessments can help to identify harmful and inequitable effects of new climate change mitigation and adaptation policies and actions, and reduce barriers to equitable delivery and uptake of new policies [214]. Assessments should consider the full range of effects on health and health equity, both direct and indirect, and how these interact, which will require cross-departmental working. Consistent with the recommendation for a whole-of-government approach to reducing emissions and adapting to climate change contained in the Committee on Climate Change's recent Progress Report to Parliament, we therefore recommend an overarching health-equity-in-all-policies approach, recognising that decisions made in all government departments have implications for the climate, health and health equity.

In addition, upon implementation, to ensure that intended health benefits are realised, there will be a need to check for anticipated interactions, feedback and adaptation to ensure there are no unintended consequences. To minimise unintended consequences, and to maximise acceptability and the ensuing health co-benefits, affected groups or communities should be involved in decision-making processes and project delivery [215].

Meanwhile, policy measures that widen inequalities should be mitigated via greater redistribution of benefits. As most of the policies cited in this report relate to demand-side interventions, (i.e. requiring a degree of public support and participation) minimising inequalities will require systemic changes to enable and support all of the UK population to benefit from uptake of active travel, sustainable diets and energy efficiency measures, among others. These actions and polices need to consider our relationship with systems and processes; for example,

to maximise the health gains of reducing red meat consumption requires action across the food system, from how we produce our food in the UK and purchase it from abroad, to how we promote healthy and unhealthy alternatives, how food is distributed, and what we do with our food waste.

Our overarching recommendations therefore include:

- Health-equity-in-all-policies approach: The UK Government should avoid increasing health and economic inequalities by ensuring the costs of measures to mitigate climate change are distributed progressively and that the benefits reach those who have the potential to be most positively impacted. The aim should be to reduce health inequalities and to advance health equity, for example by applying a health equity impact assessment to legislation, including the next carbon budget.
- Adopting an appropriate metric: The UK government should consider adopting Well-being-Years (WELLBYs) or an equivalent metric to measure impacts on health and wellbeing and ensure that health considerations are incorporated into decision-making in a consistent and transparent manner.
- Many of the actions required to mitigate climate change can and should also factor in adaptation and resilience to unavoidable climate change. Reducing variations in vulnerability to the impacts of climate change requires action to reduce prevalence of chronic health conditions and build the adaptive capacity of individuals and communities.

Enaction of these recommendations should be guided by the following principles:

- Integration: Integrate the advocated approaches at the national, regional and local levels and between departments at all levels of government.
- Inclusion: Recognise a diverse range of interests and views regarding the systemic change called for to address climate change, addressing the differential impacts on different communities and on people with protected characteristics including race, age, gender and disability.
- Transparency and recognition of trade-offs: Ensure transparency of decision-making about wide-scale systemic changes that impact health and well-being. Acknowledge and seek to address how climate change adaptation measures that benefit health – e.g. adaptation to extreme heat or flooding – may impact mitigation targets and vice versa.
- Evidence-based: Take action based on data and evidence of what works, informed by a public health intelligence function that includes both qualitative and quantitative data, and ability to analyse, interpret and communicate this data and evidence.

The key areas for action that pose the most significant co-benefits for health are:

- Encourage sustainable food production and consumption. Ensure affordability of universal access to healthy diets that have low GHG emissions.
- Move towards a sustainable economic model that values health, well-being and nature.
- Provide employment opportunities that support health and sustainability.
- Accelerate the transition to electric vehicles while moving away from models of private car ownership towards shared ownership and public transport.
- Increase the modal share of journeys under 5km made by walking and under 10km by cycling (including by e-bicycles) and invest in public transport and connectivity with walking and cycling routes.
- Reduce demand for energy in homes by improving and enforcing energy efficiency and ventilation standards, reaching households in fuel poverty in particular.
- Reduce the use of fossil fuels and accelerate the transition to clean energy sources, decarbonising both power generation and industrial, commercial and domestic energy.

The objectives are summarised in the table below with example policy measures that could be used to achieve them. The proposed objectives do not include quantitative targets, as these are subject to wide-ranging uncertainties regarding health impacts depending on assumptions made about how policy is designed and implemented.

POWER GENERATION

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Reduce fossil fuel combustion	**Regulatory:** Transition to clean energy sources – decarbonising both power generation and industrial, commercial and domestic energy. **Fiscal:** Invest in re-training and efforts to diversify affected economies prior to closure of fossil fuel industry sites (power plants and extraction).	A reduction in PM2.5 from power generation will reduce short and long term effects of exposure to the pollutant, including respiratory and cardiovascular illness and mortality from these diseases and from lung cancer.	The energy transition will have major implications for the wider determinants of health (income and security) in some areas of the country. Addressing this directly via investment in skills and a just transition will mitigate against widening inequalities and increase public acceptability.
	Regulatory: Set a target date to eliminate home installations of new wood burning and gas stoves in urban areas. Set a further target date to eliminate/ remove all wood burning stoves from urban areas.	Removal and phase-out of wood burning stoves will reduce particulate generation and indoor air pollution in the primary home and neighbouring homes. This has direct health benefits, and is also supportive of insulation measures that increase exposure of households and their neighbours to particulates from domestic wood burning.	
	Fiscal: Target subsidies towards low-income households. **Fiscal/regulatory:** As renewable capacity increases, upgrade domestic heating systems, including gas, to electric, including support for air and ground source heat pumps.	Transitioning away from gas will reduce the risk of (indoor etc) indoor exposure to oxides of nitrogen formed by incomplete combustion of fossil fuels, and reduced risk of exposure to carbon monoxide due to faulty appliances or pipework.	Subsidies that cover 100% of upgrade costs for households on low incomes and/or in rented accommodation can contribute to reduced home energy costs, reducing fuel poverty and the associated effects on mental health and well-being.

BUILDINGS

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Support a just energy transition that minimises air pollution from all sources	Establish an ambitious target for the number of existing homes to be retrofitted each year. Establish targets for reducing the percentage of non-decent homes. Ensure that upgrade measures are carefully designed, installed, operated and maintained.	Upgrades will contribute to a reduction in excess winter deaths and to reduced morbidity related to homes that are difficult to heat, with benefits to children's respiratory health, and cardiovascular, respiratory and mental health in adults. Appropriate insulation and ventilation controls can help reduce exposure to cold homes while reducing exposure to air pollutants. However, trade-offs exist between improving warmth and increasing exposure to indoor air pollutants.	Targeting low-income households will benefit population groups that have shorter than average healthy life expectancy.
	Regulatory: Revise building standards to become near-zero or zero-carbon with flexibility to adapt to local environmental needs (e.g. to manage exposure to damp, mould, cold, heat and air pollution).	Different locations will have different priorities in terms of whether to reduce exposure to indoor air pollutants (e.g. radon or particulates) or outdoor pollutants (e.g. from traffic) and/or to increase passive cooling measures. The health benefits of interventions will be maximised if the balance between insulation, cooling and ventilation is flexible to context specific needs.	
	Regulatory: Support passive cooling measures (e.g. to fit external shutters) in homes at risk of high indoor temperatures. Active cooling technology may still be needed to reduce exposure to extreme heat in some buildings, but phase out refrigerants with high global warming potential.	Passive cooling measures may reduce or avert rising excess heat-related mortality.	People in inner cities are more likely to experience the urban heat island effect, and be on low incomes, thereby impacting their ability to mitigate heat exposure. Passive cooling systems, such as shutters and green roofs, should be promoted in these locations.

FOOD SYSTEMS

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Enable and encourage sustainable food production and consumption	**Legislative:** Enable a wider range of local and national powers to shape food systems and combine these with the resources and statutory duties to support the transition to healthier and more sustainable diets. **Regulatory:** Incorporate sustainability criteria into future iterations of UK dietary guidelines. Make the draft text of trade deals available to assessment for impacts on health and the climate and environment.	In the UK the food system is the sector with the greatest potential for health co-benefits from action on climate change. Healthier diets that contain more fruit, vegetables and wholegrains and less meat will contribute to reduced rates of diabetes, cardiovascular disease, some cancers and other diet-related diseases.	Local decision-making will enable involvement of those most affected by the currently unequal food system.
Reduce obesity	**Behavioural:** Support interventions to reduce rates of obesity via substitution of unhealthy foodstuffs with fruit, vegetable and wholegrains. **Behavioural:** Develop a labelling system to inform consumers about the health and environmental impacts of their purchases. Restrict marketing and promotion of foods with large environmental and health impacts.	Complex interventions to support access, affordability, awareness and skills with regard to fruit, vegetables and wholegrains will contribute to reduced incidence and prevalence of child and adult obesity and diabetes, as well as other diet-related diseases. A necessary measure to enable informed choice in food purchasing decisions. Labelling can have a modest effect on consumption of unhealthy food and will provide an incentive for the industry to move to more sustainable production systems.	Obesity and diabetes disproportionately affect people in more deprived areas, improving the average diet should particularly benefit low-income households, although this will depend on policy design.

Food systems continued...

FOOD SYSTEMS

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Reduce red meat consumption	**Fiscal:** Subsidise production and sale of fruit, vegetables, nuts, seeds and wholegrain products to support plant-based diets. Shift towards food production and retail models that consider triple-bottom-line effects, including benefits to society and the environment as well as shareholders.	Reducing red and processed meat and consumption and increasing consumption of fruits, vegetables and wholegrains is likely to reduce rates of cardiovascular disease and some cancers.	Reducing the cost of healthy and more sustainable foods could help to address inequalities, although such policies must consider and address the risk of substitution with less healthy foods.
		Increased fruit and vegetable production and consumption will align the UK average diet more closely to WHO recommended dietary intakes as well as to the NHS's Eatwell plate.	Not all land can support the transition away from meat production, which has potential impacts on small farms, whose farmers more likely to be are in financial hardship groups. Such impacts need to be addressed via measures that subsidise land use change towards biodiversity protection, forestry and stewardship.
Reduce food waste	**Legislative:** place food waste reduction duties on industry and any authorities assigned local or national powers to develop more sustainable food systems. **Technological:** Reduce food waste via investments in alternative methods of food waste processing. **Behavioural:** Create policy to reduce financial incentives – e.g. multi-buy offers – to purchase larger quantities of food than needed.	Reducing wastage of fresh food and over-consumption of processed foods will contribute to achieving more sustainable diets and reducing diet-related disease incidence, including cardiovascular disease, obesity, diabetes and some cancers.	Diet related diseases, including obesity, diabetes and cardiovascular disease, disproportionately affect people in more deprived areas, so improving the average diet should particularly benefit low-income households, although this will depend upon policy design.

TRANSPORT

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Support and enable transport systems that promote active travel and road safety, and which minimise pollution	Move away from models of private car ownership towards shared ownership and public transport. Facilitate electrification of transport, whilst recognising that it is only a partial solution to transport related emissions. **Fiscal:** Support replacement of oldest, most polluting vehicles with electric vehicles, including incentives to replace vehicles with e-bikes where feasible. **Regulatory:** Stop increasing the road network capacity. Support localised amenities including shops and services to reduce journey distances.	Older vehicles generally produce more air pollutants and greenhouse gases which are harmful to health (see above). Electric vehicles do not produce NO2 but do produce particulate matter from non-tailpipe emissions which are associated with respiratory and cardiovascular disease and which are the subject of ambitious government targets to reduce in line with WHO exposure guidelines.	Replacing oldest vehicles first will particularly benefit those on lower incomes who are more likely to own older vehicles. Supporting localised amenities can contribute to reduced inequalities in access to shops and services by reducing the need to travel long distances. It may also strengthen communities, increasing resilience to future systemic shocks.
Invest in public transport and connectivity with walking and cycling routes	**Fiscal (subsidies):** Increase the availability of affordable and reliable public transport within and around urban areas, and ride-share options that incentivise the transition away from private vehicle ownership. Ensure that new investment into walking and cycling infrastructure reaches those with the most potential to benefit – in more deprived areas where healthy life expectancies are lower than average, air quality worse, rates of car ownership lower, and cycling infrastructure poor or non-existent.	By minimising the demand for new EVs by reducing car dependancy, the particulates and road traffic accidents that result from those will be minimised too.	This may reduce health inequalities by changing the norm of car ownership over time and with it the issue of 'locked-in' sedentary behaviours, also releasing disposable income from 'forced car ownership' among those on lower incomes.

Transport continued...

TRANSPORT

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Increase modal share of journeys under 5km made by walking and cycling	**Fiscal:** Ringfence and increase funding to support road space reallocation and holistic behaviour change programmes with cycle training, segregated cycle networks, travel planning support to schools and businesses and large-scale social marketing campaigns. **Behavioural:** Set progressively ambitious targets to increase the share of journeys made by walking, cycling, e-bike and public transport. **Regulatory:** All new housing developments to be mandated to allocate or reallocate road space for pedestrians, cyclists, public transport users and electric vehicle owners. Developments to include links to the National Cycle Network where possible.	Increasing the share of journeys by active and public transport can contribute to increased physical activity as well as reduced road accidents, air pollution and noise, whilst it may also benefit social cohesion.	Rates of car ownership are strongly correlated with income. Public transport, walking and cycling are more affordable and inclusive modes of transport that if subsidised equitably can contribute to reducing inequalities in rates of physical activity, exposure to air pollution and access to services and opportunities.
Strengthen and enforce traffic regulations	Implement speed restrictions, e.g. 20 MPH limits in residential areas, and traffic control measures that are locally appropriate and may change with time of day, dependent on average road use. **Regulatory:** Increase monitoring and enforcement of traffic regulations of both moving and parked vehicles.	Lower speed limits represent a potential strategy to reduce road injuries. An emphasis on traffic smoothing will lead to less stop and start and as a result will reduce GHG and air pollutant emissions. Enforcement is essential for the benefits to be realised.	There is a social gradient in road traffic accident casualty rates; lower speeds, especially with enforcement, could help reduce injuries overall but especially among lower income groups. Enforcement is likely to benefit urban areas with high population density to a greater extent due to the higher risk of road traffic accidents there.
Reduce delivery vehicle emissions	**Technological:** Optimise delivery services to reduce vehicle miles travelled by small vans and heavy goods vehicles. **Fiscal/regulatory:** Support transition to electric or other alternative (low-GHG) fuelled small vans.	Small vans account and are often owned by private contractors or small / medium sized enterprises. They contribute an increasing proportion of air pollution and CO2 emissions and if the increasing demand for home delivery services continues a transition to electric and models of 'last mile' delivery that is completed by bicycle will be necessary to reduce pollution.	

SUSTAINABLE ECONOMIC MODEL

Climate change and/or health objective	Example policy measures to achieve this	Direct effects on health and health inequalities	Indirect effects on health and health inequalities via impacts on wider determinants of health
Move towards a sustainable economic model that values health and well-being	**Legislative:** Prioritise the health and wellbeing of citizens and environmental sustainability in economic recovery/growth policies. Shift from measuring economic success in terms of GDP to prioritising a wellbeing approach.	Measuring impact using a common concept such as wellbeing, and the contribution that different sectors make to societal wellbeing, enables an approach to allocating resources that will maximise benefits to health via a focus on the foundations of good health.	
	Legislative: Support more inclusive local economic growth, shift towards circular economy principles and local procurement and development practices.	Creating local job opportunities may contribute to better mental health outcomes, reducing levels of stress and anxiety.	A circular economy could yield substantial health benefits and would reduce exposure to hazards that are more likely to affect deprived populations (e.g. poor air quality in inner city areas).
	NHS to continue to work towards delivering a net-zero health service. All new hospitals delivered by the NHS should be built to be 'net-zero ready', in line with existing commitments. **Regulatory:** Use the NHS as a model for good practice for industry: develop procurement strategies that incentivise pharmaceutical and equipment companies to decarbonise their supply chains.	Examples of ways in which a net-zero NHS can contribute to direct health benefits include that telehealth/medicine can reduce travel associated air pollution, travel costs, and costs associated with time away from work and families. The NHS is committed to achieving net-zero by 2041 - further details of the benefits and approach that can be taken to achieving net-zero are anticipated in a forthcoming report from the NHS Net-Zero Expert Panel.	

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