

Beste raadsleden,

Graag stuur ik u hierbij mijn ingesproken bijdrage van gisteravond. Daarnaast wil ik graag nogmaals de nadruk leggen op de urgentie van het terugdringen van het gebruik van fossiele brandstoffen en het verminderen van onze consumptie van vlees en vis, mede vanwege de directe gezondheidsrisico's die hiermee samenhangen. Reclame verbieden zal hier een eerste stap in kunnen zijn. In de bijgevoegde toelichting treft u een aanvullende uiteenzetting.

Hieronder een samenvatting voor de drukke agenda's van de raad:

"Het document beschrijft hoe klimaatmaatregelen zoals schonere lucht, meer actieve mobiliteit en een voornamelijk plantaardig voedingspatroon niet alleen bijdragen aan het terugdringen van broeikasgasuitstoot, maar ook aanzienlijke gezondheidswinst opleveren. Het benadrukt dat luchtvervuiling, veroorzaakt door onder meer fossiele brandstoffen, verantwoordelijk is voor miljoenen verloren gezonde levensjaren en talrijke chronische aandoeningen. Ook wordt duidelijk dat plantaardige voeding het risico op hart- en vaatziekten, diabetes, kanker en vroegtijdige sterfte substantieel kan verlagen. Verder toont het rapport aan dat meer bewegen—zoals wandelen en fietsen—grote gezondheidsvoordelen biedt en hoge zorgkosten kan besparen. De auteurs pleiten voor een geïntegreerde benadering waarbij gezondheidswinst en klimaatbeleid gezamenlijk worden benaderd, omdat wat goed is voor de planeet, ook goed is voor de mens."

Ik ontvang graag bericht over de uitkomst van de beraadslagingen en de besluiten die de raad hierover heeft genomen. Nogmaals dank voor de geboden gelegenheid om in te spreken.

Met vriendelijke groet,

Rosanne Silvis-Ottevanger

Community manager | Groene Zorg Alliantie

Het is warm, erg warm. Het is 13 juni, half één 's middags — de zomer is nog niet begonnen - en het is wederom de **droogste en heetste lente** ooit gemeten. Ik ben net bevallen van mijn zoon met 32 graden en later deze week wordt het nog 36 graden in Arnhem. En **ik** maak me zorgen.

Goedenavond, mijn naam is **Rosanne Ottevanger**. Ik ben werkzaam als **change-agent** in het **verduurzamen** van de **zorg** bij de Groene Zorg Alliantie. Ik spreek hier vanuit mijn rol als zorgprofessional, Arnhemmer én als moeder.

Klimaatverandering is geen toekomstscenario. Het vindt **nú** plaats. En ons **gedrag** heeft hierin **een grote impact**. Denk aan onze reisbewegingen: fossiele verbranding zorgt immers voor luchtvervuiling. Onze voedselkeuzes leiden tot ontbossing en schade aan ecosystemen op land en in zee. En ook het kopen van fast fashion producten veroorzaakt grote hoeveelheden vervuiling.

Al deze effecten samen warmen onze aarde op. Per jaar overlijden nu al zo'n 250 mensen in Nederland aan de gevolgen van hittestress. Tegelijk worden er **meer mensen** getroffen door welvaartsziekten dan **ooit** tevoren. Met andere woorden: gedrag beïnvloedt gezondheid - en het zorgsysteem raakt verder overbelast.

Gezonde mensen hebben een **gezonde planeet nodig** - en vice versa. Zorgdragen voor de inwoners van Arnhem is de meest effectieve vorm van preventie en klimaatbescherming.

Daarom spreek ik vanavond over iets wat misschien klein lijkt, maar een **enorme invloed** heeft: reclame uitingen in de openbare ruimte. Reclame vraagt bewust en onbewust onze aandacht. Reclame voor fossiele brandstoffen, vlees & vis en fast fashion zet aan tot **meer** consumenten, **minder** bewegen en daarmee **ongezondere** inwoners! Vorig jaar zei onze denker des vaderlands:

*"Aandacht, is het belangrijkste middel waarmee je je **leven** kunt sturen. Dus hoe lang staan we nog toe dat bedrijven ons bombarderen met afleiding waar we niet om hebben **gevraagd**?"*

Arnhem heeft de ambitie om een **schone en gezonde stad** te zijn. Daar hoort geen straatbeeld bij wat het tegenovergestelde stimuleert. Met dit **reclameverbod** vervuilen we onze publieke ruimte niet langer met ongezonde afleiding.

Mijn zoontje groeit hier op, in deze stad. Ik hoop dat hij later kan zeggen: "Arnhem koos voor gezondheid." Laten we dit vanaf vandaag samen waar maken.

Dank u wel voor uw tijd en aandacht.

Healthy People, Healthy Planet

The co-benefits of clean air, plant-based diets, and physical activity to human health and climate change.

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Executive Summary

In 2019, the UK committed to reduce emissions of carbon dioxide (CO₂) and other greenhouse gases (GHGs) to 'Net Zero' by 2050 (1), in order to minimise the life-threatening impacts of the global heating which they cause. However, the pace and scale of action has fallen far short of what is required. At the international negotiations in Paris in 2012, countries agreed to reduce GHG emissions by 48% by 2030, and to try to limit the rise in global mean surface temperature to 1.5°C above preindustrial. However, given the continuing rise in annual GHG emissions (now nearly 58 billion tonnes CO₂e/year) and their atmospheric concentrations (2024 saw the greatest rise on record), its '1.5°C threshold' is now near certainly breached, with a likely 2°C rise by 2030 (2,3).

Whilst concern has grown, climate action is rarely considered the UK public's top priority: in September 2023, it ranked 5th, behind the economy, inflation, the National Health Service (NHS)/healthcare, and immigration (4). Such low ranking matters, both because it is reflected in limited individual/personal action, and because shifts in public sentiment and purchasing choices create a permissive environment into which both politicians and businesses can move.

Meanwhile, non-communicable diseases (NCDs) now account for 89% of deaths in the UK and 25,871 disability adjusted life years (DALYs) per 100,000 population in 2019 (5). Poor diet, high body mass index (BMI) and high fasting plasma glucose lie just behind tobacco as the top drivers of death and disability. Globally, air pollution, high BMI, and poor diet account for nearly half of the healthy years of life lost. Interventions to mitigate these diseases target the same causal pathways as those which mitigate climate change, providing important opportunities to generate co-benefits. In other words, low GHG lifestyles reduce the threat of climate change to human health and survival, but are themselves inherently good for health by mitigating NCDs. For example:

- Adherence to the World Health Organisation (WHO) recommendations on diet (including increased consumption of grains, fruit and vegetables and reduced consumption of red meat and dairy) would save almost 7 million life years in the UK over the next 20 years, with an increase in average life-expectancy of >8 months. Such action would also reduce GHG emissions by 17% (6).
- Increasing active travel in the UK would yield significant reductions in the incidence of diabetes, dementia, heart disease, cerebrovascular disease, and cancer. After adjustment for increased risk of road traffic injuries, increasing average adult daily cycling and walking distances to 3.4km and 1.6km (a 3km and 1km increase from 2010 levels respectively) in urban areas would save the NHS some £17 billion after 20 years, even without factoring in the benefits of cleaner air and GHG emission reductions (7).
- Changes in power generation from fossil fuel to renewable sources in line with the 80% reduction set by the UK 2008 Climate Change Act would result in a 40% reduction in small particulate matter (PM_{2.5}) concentrations by 2050. The resulting reduction in NO₂ concentration could save 4.89-7.18 million life years by 2154 (8,9).

Framing climate change and efforts to address it as health issues is one of the most effective ways to engage the public in action- action which improves health, reduces GHG emissions generally and those from healthcare (given the reduction in disease burden), creating the impetus and opportunity for politicians and businesses to act.

Many health charities seek to protect the public from NCDs, promoting increased active transport, clean air, and plant-based diets to achieve this. Examples include organisations working on asthma, cancer, dementia, diabetes, hypertension, mental health, obesity, stroke and more. We propose that such organisations unite with those 'environmental' groups who also advocate for low GHG emissions, to deliver one message: 'What is good for the planet is good for health', and its obverse- 'what is good for health is also good for the planet'. Here, we synthesise core data in support of such a message.

INTRODUCTION

Climate change now poses an immediate threat to our survival and to that of our children. Whilst the impacts of heat illness, vector-borne diseases and loss of shelter and food supplies are important, the gravest risk relates to that of societal (economic impacts, mass migration and conflict) and ecosystem collapse (10). In response, the UK has committed to reducing emissions of carbon dioxide (CO₂) and other greenhouse gases (GHGs), and to deliver carbon drawdown (by unspecified methods) to match those that remain, by 2050 ('Net Zero') (1). However, enacting the necessary transport and agriculture policies at the required rate and scale is impossible for politicians and businesses without popular support and engagement. Emerging evidence suggests that personal action in these areas can be stimulated by making clear their direct health benefits (8).

Non-communicable diseases (NCDs) now cause 89% of deaths in the UK and an estimated 25,871 disability adjusted life years (DALYs) per 100,000 population in 2019, and account for nine of the top ten causes of death (lower respiratory tract infections, ranking fifth, may of course be predisposed to by NCDs themselves) (5). Their incidence and prevalence is, in many cases, rising (e.g. for obesity, diabetes, asthma, chronic obstructive lung disease (COPD), Alzheimer's disease, and many cancers). Globally, risk factors including air pollution, high body mass index (BMI), and poor diets account for nearly half of the healthy years of life lost.

Many UK health charities seek to protect the public from NCDs, and promote low GHG lifestyles (increased active transport, clean air, and plant-based diets) to achieve this. Examples include organisations working to prevent asthma, cancers, dementia, diabetes, hypertension, mental health, obesity, stroke and more. We propose that such organisations unite with those 'environmental' groups who also advocate for low GHG living, to deliver one message: 'What is good for the planet is good for health', and its obverse- 'what is good for health is also good for the planet'. We here synthesise core data in support of such a message, summarising the impact which action to reduce airborne pollutants, increase physical activity and improve diet could have on both improving health outcomes and mitigating climate change. To this end, we provide a narrative review of studies that have examined the impact of either air pollution, diet, or physical activity on one or multiple NCDs, categorised by system (respiratory disease, cardiovascular disease, cancer, endocrine disease and mental ill-health).

METHODS

Searches were run separately for each exposure and disease category. Details of the search strategy are laid out in Table 1. We searched PubMed and Scopus for English language review articles (due to the overwhelming literature volume available) published between Jan 1st 2010 and December 31st 2023. This search was performed using the easyPubMed package in R 4.3.3. The population of interest was adults and children from high-income countries (World Bank Definition (11)) to ensure relevance to UK policy. Outcome measures included disease incidence, mortality, disability-adjusted life years (DALYs), years of life lost (YLL), and hospital admissions. Excluded were animal and *in vitro* studies; publications reporting intermediary outcome measures (such as biomarkers) or disease risk factors, or that did not measure a health outcome; and those set in low- or middle-income countries. Title and abstract screening was carried out by one reviewer per disease system.

Table 1

<i>Search Concept</i>	<i>Exposure Search Terms</i>		<i>Outcome Search Terms</i>
Air pollution and NCDs	[Pollution or pollutant* or air quality or particulate matter or road pollution]	AND	[resp* or asthma or COPD or cardio* or hypertension or blood pressure or isch?mic heart disease or heart disease or stroke or CVA or coronary* or diabet* or hyperglyc?m* or non-communicable disease or obesity or BMI or body mass index or mental health or cancer]
Physical Activity and NCDs	[Physical activity or sport or active travel or active commuting or walking or cycling]	AND	
Diet and NCDs	[plant-based or vegetarian* or vegan* or vegetable* or fruit* or plant* or health* or sustainab* AND diet*]	AND	

Searches were limited to title only, with abstracts. A snowball search method was then used to obtain relevant articles. Grey literature was examined from published governmental websites, intergovernmental organisations, and independent public bodies. Given the wealth of literature, diversity of primary research methods and metrics (see Box 1a), a narrative review was performed. Key evidence is summarised in Table 2. Detailed results for each disease system are presented in Appendix 1.

RESULTS

Reducing Air Pollution

Health Benefits

Air pollution (caused by particulate matter (PM- with a suffix indicating diameter in microns)), nitrogen and sulphur oxides (e.g. nitrous Oxide, NO₂), carbon monoxide (CO), and ozone (O₃)) caused the loss of 213 million DALYs in 2019 and has thus been declared a global health emergency by the World Health Organisation (WHO) (5). Impacts may persist across the life-course (12), and relate not only to respiratory diseases, but to diabetes, cancer, cardiovascular, cerebrovascular, metabolic, mental and neurological disease (13). Air pollution causes 1 in 5 global deaths (14), and fossil fuel use for 82% of these (>5.13 million excess deaths) (13).

The main sources of UK air pollution relate to the combustion of fossil fuels for industrial processing, manufacturing and construction; domestic heating and cooking; and road transport (15). Motorised road transport also contributes via generation of brake, tyre and road surface wear. The World Health Organisation (WHO) recommend keeping annual average concentrations of particulates with a diameter ≤ 2.5 microns ([PM_{2.5}]) below 5µg/m³: in 2019, London's outdoor annual *mean* [PM_{2.5}] was between 8 and 15µg/m³, with peaks far higher (16).

Air Pollution and Pregnancy

Air pollution reduces male fertility (sperm count and motility), and also causes low birthweight, low gestational age (in London, PM_{2.5} exposures >13.8 µg/m³ in pregnancy account for 3% of infants with low birthweight), pre-term birth and miscarriage (17–20).

Air Pollution and Children

Indoor (home, school) and outdoor (e.g. from school commutes) air pollution causes hypertension and atherosclerosis, even in adolescents (21–23). It also impacts childhood lung growth: in inner city London (2008-13), mean annual ambient concentrations of NO₂ and PM₁₀ were inversely related to forced vital capacity (FVC - the total amount of air which can be voluntarily exhaled in one breath), with average NO₂ exposure associated with an estimated 5% loss of lung volume after controlling for age, sex, height, BMI, ethnicity, socioeconomic status, and exposure to environmental tobacco smoke (24). Elsewhere, the proportion of children with smaller than expected lung volume declines when air quality improves (25). Air pollution is also associated with an increased incidence of asthma diagnosis and exacerbations (26). Between 2017 and 2019, air pollution in London accounted for an estimated 7% (700) of all child asthma hospital admissions (27). It impairs brain development: brain size is inversely related to PM_{2.5} exposure (28). Lastly, children exposed to higher levels of pollution aged 12 are more likely to be diagnosed with major depressive or conduct disorder diagnoses at age 18, after controlling for confounding variables (smoking, sex, ethnicity, neighbourhood and family socioeconomic status, family psychiatric history, exposure to severe childhood victimisation, relevant age-12 mental health problems (i.e. anxiety, depression, conduct disorder, or ADHD)) (29).

Air Pollution and Adults

In adult life, UK air pollution increases the risk of early death, and of cancer; cardiovascular, cerebrovascular and respiratory disease; dementia; impaired mental health; and multiple other chronic illnesses (12). Data from the UK Biobank reveals an association between air pollution and neurological, respiratory, and cardiovascular morbidity after adjusting for socioeconomic status (30). In London between 2008 and 2013, in those exposed to the highest versus lowest PM_{2.5} concentrations, the risk of common mental disorders and psychotic experiences were increased by 18-39% and 33% respectively (31). The Committee on the Medical Effects of Air Pollutants (COMEAP) 2022 review (32)

concluded that a causal association between air pollution exposure and dementia and cognitive decline likely exists (32).

In the UK Biobank Cohort, the risk of cardiovascular disease (atrial fibrillation, coronary heart disease, heart failure) was raised by 21% in those exposed to the highest vs lowest quartiles of $[PM_{2.5}]$, and of stroke by 25% for NO_2 (30). Additionally, stroke hospitalisation or mortality may increase by 1.20% (CI: 0.22-2.18) per $10\mu g/m^3$ increase in $PM_{2.5}$, and by 2.24% per 10 parts per billion (ppb) increase in NO_2 (33).

A 9% increased risk of T2DM, hypertension, and migraine in the highest vs lowest quartile of $[PM_{2.5}]$, and a 10% increased risk for NO_2 was also identified (30).

Respiratory impacts continue into old-age. The elderly face an increased risk of hospitalisation, home visits and emergency department attendance for COPD, asthma and pneumonia with increased short-term exposure to PM_{10} , and increased incidence of respiratory symptoms, reduced lung function, and COPD with increased long-term PM_{10} exposure (34). In London, pollution-attributable respiratory and cardiovascular admissions and mortality cost between £1.4 and £3.7 billion in 2010 (35) and, between 2017 and 2019, caused >1700 adult hospital admissions for asthma and other respiratory disease (27).

Airborne particulate matter is a type 1 carcinogen, and the relationship between air pollution exposure and lung cancer has been summarised in the UK COMEAP report 2009 (36).

Individuals in areas of high pollution commonly live with more than one chronic disease. Risk of multimorbidity is 20% higher among those living with $PM_{2.5}$ pollution $>10\mu g/m^3$ (30). With an ageing multimorbid population and a strained health service, improving air quality in the UK can have a significant impact on population health.

Climate Benefits

Moving power generation from fossil fuel to renewable sources in line with the 80% reduction set by the UK 2008 Climate Change Act would result in a 40% reduction in $PM_{2.5}$ concentrations by 2050 (8). Related reductions in NO_2 concentration would save an estimated 4.89-7.18 million life years in the UK by 2154 (9). Cleaner vehicles and active travel (discussed in detail below) would contribute to reducing emissions and air pollution whilst simultaneously reducing the incidence of NCDs. Substituting electrical power (from 100% renewable sources) for gas boilers and cooking stoves would likewise improve health by reducing indoor pollutant exposure (37).

Active Travel

Health Benefits

One in six deaths in the UK may be caused by physical inactivity, costing approximately £7.4 billion annually. Current trends suggest that the 2035 population will be 35% less active than in the 1960s (38). Increasing physical activity can reduce the risk of all-cause mortality by 30%, cardiovascular disease by <35%, T2DM by <40%, dementia by <30%, colon cancer by 30%, breast cancer by 20%, and depression by <30% (38).

Physical activity via commuter cycling or walking can help address this: increasing active travel to European best practice levels could reduce disease burden of IHD by 7.6%, T2DM by 7.2%, stroke by 7.0%, and dementia by 5.3% (39). Only 2.5 hours per week of moderate physical activity from active transport could yield relative risk reductions of 0.23 for IHD, 0.11 for dementia, 0.08 cerebrovascular disease, 0.13 for breast cancer, 0.08 for colorectal cancer, 0.07 for depression, and 0.19 for T2DM (40). Doubling the distance walked in London, and increasing the distance cycled eight-fold, would have greater impact, reducing cases of IHD (10–19%), cerebrovascular disease (10–18%), dementia (7–8%), depression (4–6%), and breast cancer (12–13%). In keeping, in prospective UK cohort studies, cyclist commuters have a reduced risk of cardiovascular disease (HR 0.79 95% CI 0.69-0.90), cancer diagnosis (0.89, 95% CI 0.84 to 0.94), and all-cause mortality (0.88, 95% CI 0.78 to 1.00) when compared with other commuters (41).

Evidence from eight randomised controlled trials (RCTs) suggest a positive impact of walking for the prevention and treatment of clinical depression, with four studies showing a positive impact for prevention and treatment of anxiety (42). Spanish bicycle commuters have a significantly lower risk of being stressed (RR 0.73) compared to non-bicycle commuters using the Perceived Stress Scale (PSS-4) (43).

Physical activity protects against fracture risk across the life course, increasing bone mineral density in childhood and adolescence (44), and slowing progression of osteoporosis & reducing osteoporotic fractures in adults (45,46).

Traffic collisions and pollution could partially mitigate the health benefits of increasing active commuting. Increases in traffic collisions, injuries, and hospital admissions were observed or modelled in several studies (7,41): in London, doubling walking distance and increasing the distance cycled eight-fold, was predicted to cause a 39% increase in road traffic injury (but with absolute numbers remaining very low) (40). However, the health gains from physical activity outweigh the increase in trauma cases (47), and a 91% increase in London cycling since 2000 has been associated with a *reduction* in cycling deaths and serious injuries of 33% (7). The benefits of physical activity, particularly for active commuters, far outweigh the negative impact of pollution (48,49), but there remain benefits to addressing both air pollution and active travel simultaneously.

Increasing active travel in the UK would deliver significant reductions in cases of T2DM, dementia, heart disease, cerebrovascular disease, and cancer. After adjustment for increased risk of road traffic injuries, £17 billion in NHS savings would accrue from increased walking and cycling in urban areas, within 20 years (7). This highlights the importance of urban planning to create an environment that promotes active travel. Whilst electric vehicles are likely to improve local air quality, overall benefit to climate change can only be achieved if these vehicles are powered from low carbon sources. Shifting to alternatively powered vehicles does not address the non-exhaust emissions related to road surface wear and road dust (50). A move away from private motorised vehicles to active transport addresses both air quality and physical activity, and is likely to be more impactful for both climate change and public health.

Climate Benefits

The mechanised vehicles in which we travel all require power for manufacture and use, and much still derives from fossil fuel use. The transport sector alone accounted for 8 billion tonnes CO₂e emissions in 2022, or 14% of all emissions worldwide and 24% of the UK's total emissions in 2020 (406 MtCO₂e) (51,52). UK passenger cars emitted 59.6 million tonnes of carbon dioxide equivalent (MtCO₂e) in 2022, accounting for >50% of UK transportation emissions that year (53).

Plant-Based Diets

Health Benefits

Sub-optimal diet is an important and remediable risk factor for many NCDs. In the Health Survey for England in 2021, only a minority of the adult population were of healthy weight: a quarter were obese and a further 37.9% overweight. There was a 14% difference in obesity prevalence between affluent (20%) and deprived (34%) areas (54).

Global Burden of Disease (GBD) studies, which estimate the proportion of disease burden attributable to risk factors including diet, suggest that low intake of whole grains and fruits, and high intake of sodium, together account for more than 50% of deaths and 66% of DALYs lost globally (55). Low intake of nuts, seeds and vegetables account for more than 2% of global deaths. Modelling by the UK Office of Health Economics suggests that a 100% adoption of a vegan diet would save £6.7 billion per year and 172,735 additional Quality Adjusted Life Years (QALYs) in England, mostly through a reduced incidence of T2DM (56).

Achieving the 5-a-day target for fruit and vegetables could increase average UK life expectancy from birth by 7-8 months- 13% of the NHS target to increase average life expectancy by five years by 2035 (57). A systematic review and meta-analysis of 95 cohort studies showed that an increase of 200g/day fruit and vegetables was associated with a reduction in mortality from coronary heart disease (RR 0.92), stroke (RR 0.84), and total cancer (RR 0.97) (58). Studies examining the impact of diet on cardiovascular disease have been extensively reviewed (59). The Adventist Mortality study reported a reduction in mortality from IHD of 26%, and of 35% for cerebrovascular disease in those following a vegetarian or vegan diet. Vegetarian diets were associated with a 22% reduction in UK IHD risk, sustained over 18 years of follow-up (60).

There is increasing research into plant-based diets (that emphasise foods derived from plants, but which may include a small proportion of animal foods) rather than strict vegetarian or vegan diets (61). A recent meta-analysis suggested a plant-based diet to be associated with lower cardiovascular and cancer mortality (RR 0.79 and 0.82

respectively), and reduced incidence of T2DM (18% lower in those with a higher adherence to a plant-based diet), cardiovascular disease, and cancer (relative risk of prostate, pancreas, digestive system and breast cancer being 0.87, 0.68, 0.82 and 0.91 respectively) (62).

Specific food types are associated with altered risk of disease. Meta-analysis suggests an 18% reduction in cardiovascular mortality and a 12% lower risk of cancer mortality and 26% lower diabetes incidence for those with the highest consumption of wholegrains compared to those with the lowest (63). A systematic review and meta-analysis of 16 studies (RCT, prospective and retrospective studies) predominantly from North America or Europe, found regular consumption of nuts to be associated with a 24% and 22% lower risk of fatal and non-fatal IHD respectively, and a 13% reduction in risk of incident T2DM, while a four times a week consumption of legumes is associated with a 14% lower risk of IHD (64). A meta-analysis of prospective studies examined fruit and vegetable subtypes and coronary heart disease. Inverse associations were noted between high consumption of several subtypes (apples, citrus fruits, fruit juices, green leafy vegetables, beta carotene and vitamin-rich fruits and vegetables) and coronary heart disease mortality (58). In comparison, cardiovascular disease mortality rises with every serving/day of total red meat (HR 1.16 (95% CI 1.12-1.20)), unprocessed red meat (HR 1.18 (95% CI 1.13-1.23)), and processed red meat (HR 1.21 (95% CI 1.13-1.31)) (65). Cancer mortality is greater with a one serving per day increase in total (HR 1.10 (95% CI 1.07-1.13)), unprocessed (HR 1.10 (95% CI 1.06-1.14)) and processed (HR 1.16 (95% CI 1.09-1.23)) red meat consumption. An increase in red meat intake greater than half a serving per day is associated with a 48% elevated risk of T2DM (66).

Increasing consumption of predominantly plant-based diets clearly has significant benefits to health. While individuals changing from animal to plant-based foods may consume lower quantities of protein, this impact is not great at a population level: the EPIC-Oxford study noted inadequate consumption of protein in 5% of meat-eaters and in only 8-16% of vegans (60). After adjustment for BMI, and when compared with meat-eaters, the risk of hip fracture was greater in vegetarians (HR 1.25 (95% CI 1.04-1.5)) and vegans (HR 2.31 (95% CI 1.66-3.22)), a finding not fully explained by lower calcium intake. Fifty-two percent of vegans had a vitamin B12 concentration below 118 pmol/l compared with <1% of meat eaters. Such data suggest that, in the absence of supplement use, a plant-based diet (in which reduced quantities of meat and/or dairy products are consumed) may be optimal.

Climate Benefits

Overall, the food supply chain accounts for 70-80% of tropical and subtropical deforestation (67), reducing GHG draw-down. It also contributes 38% of global GHG emissions. Agriculture alone contributes 10-12% of GHG emissions (mostly due to the production of foods from animal sources) (68). Ruminant sources (beef, lamb, mutton, milk) have higher emissions than monogastric sources (pork, chicken, eggs) which in turn are higher than plant sources due to the requirement for cereals and soy for livestock feed (77% of crops are grown to feed livestock globally) (69). In the UK, the food system contributes a fifth of all its emissions. The overall area of land used for UK diets is estimated at 24-38 million hectares (approximately 50% of this is overseas), with 85% of this land being used for animal and dairy farming despite this only providing 32% of the calories we eat (69). Meanwhile 15% of farmland grows crops for direct human consumption, providing 68% of our calories. Several strategies related to food production, consumption, and transportation have been proposed to reduce GHG emissions in line with UK targets whilst accruing health benefits.

Springmann et al. (70) modelled different sustainable dietary strategies to quantify their impact. Following public health objectives of low-meat diets in line with guidance on adequate nutrients led to large reductions in premature mortality (reduction of 19% [95% CI 18–20] for the flexitarian diet to 22% (19–25) for the vegan diet). It also resulted in 54-87% reductions in GHG emissions. A systematic review (71) found that adherence to well-known (sustainable) diets including the Mediterranean diet, vegetarian diet, and the Dietary Approaches to Stop Hypertension (DASH) diet promoted better health outcomes and reduced GHG emissions and land, energy and water usage mainly through reductions in meat consumption. Adherence to a 5-a-day target in the UK could reduce GHG emissions by 6-12Mt CO₂e per year (72). The greatest reduction is achieved by prioritising vegetable consumption over fruit, and for blue water footprints, local varieties were key to minimising impact. Adherence in the UK to the WHO recommendations on diet could save 7 million life years over the next two decades, with an increase in average life-expectancy of over eight months. Incidental impact on the environment would result in a 17% reduction in GHG emissions (6). Alternatively, adherence to at least five out of the nine Eatwell Guide recommendations (73) was

associated with a reduced risk of mortality (RR 0.93; 99%CI 0.90 to 0.97) and 30% lower dietary GHG emissions. Adhering to the recommendation on fruit and vegetable consumption was associated with a 10% reduction in mortality (RR: 0.90; 99%CI 0.88 to 0.93).

A modelling study analysed the co-benefits of dietary change until 2050 (74). Compared to the Food and Agriculture Organisation projections on dietary trends, three alternative scenarios were modelled: adherence to a healthy diet according to global dietary guidelines, and two scenarios that also assumed healthy intake based on either vegetarian or vegan diets. All three scenarios reduced avoidable deaths from coronary heart disease by 45-47%, stroke by 26%, cancer by 16-18%, and T2DM by 10-12%. The principal driving factors in order of importance were decreased meat consumption, increased fruit and vegetable consumption, and weight loss. These alternative healthy diets reduced food-related GHG emissions by 29–70% compared with a reference scenario in 2050.

Food security is an increasing concern with climate change. Changes in diets have the potential to reduce GHG emissions whilst improving health. In the UK almost 2 billion meals a year are served in public sector settings (75). The government spends and estimated £2.4 billion (5.5% of UK food service sector turnover) on food to schools (29%), further and higher education (29%), hospitals and care homes (25%), armed forces (11%), and prisons (5%) (75). Providing access to and encouraging consumption of sustainable healthy meals in these settings can contribute substantially to reducing GHG emissions, optimising nutrition, improving health, reducing healthcare costs, and reducing inequality.

Table 2: Evidence demonstrating how key factors in climate change mitigation impact on health outcomes

Exposure	Outcomes					
	Respiratory	Cardiovascular	Cancer	Type II Diabetes and Obesity	Mental health	Others / All-cause
Air Pollution						
Global Burden of Disease in 2015 Cohen et al. 2017 (76)	24.7% of lower respiratory infection Mortality (0.7 million deaths globally)	17.1% of IHD and 14.2% of cerebrovascular disease mortality	16.5% of lung cancer			
<i>% Mortality attributable to air pollution</i>	27.1% of COPD mortality (0.9 million deaths globally)					
Cohort Study Ronaldson UK Biobank 2022 (30)	24-26% higher risk of developing respiratory disease (asthma and COPD)	21% higher risk of cardiovascular disease (Atrial fibrillation, CHD, heart failure)	4% higher risk of cancer	9% higher risk of diabetes, hypertension, migraine	73% higher risk of alcohol or substance dependency:	20% higher chance of multimorbidity living in areas where pollution is worse than the 2040 England target of 10 µg/m ³
<i>Risk of disease groups in highest pollution quartile compared to lowest</i>	PM _{2.5} : OR = 1.24 (95% CI = 1.16, 1.33)	OR 1.21 (1.13 to 1.30) <0.001	PM _{2.5} OR 1.04 (1.02 to 1.07) 0.001	OR 1.09 (1.06 to 1.13) <0.001;	NO ₂ OR = 1.73, 95% CI = 1.35–2.20	
		25% higher risk of stroke:	NO ₂ OR 1.04 (1.01 to 1.08) 0.010	NO ₂ OR 1.10 (1.05 to 1.15) <0.001	12% higher risk of depression, anxiety	
	NO ₂ : OR = 1.26 (95% CI = 1.15, 1.38)	OR = 1.25, 95% CI = 1.02–1.52			PM _{2.5} OR 1.12 (1.09 to 1.15) <0.001; NO ₂ OR 1.15 (1.11 to 1.18) <0.001	
Single outcome studies	2-5% higher risk of asthma exacerbation in children	Increases in NO ₂ and PM _{2.5} associated with a 1.2-2.4% increase in stroke hospitalizations or mortality per 10µg/m ³ increase in pollutant.	Each 10 µg/m ³ increase in PM _{2.5} associated with 8% increase risk of lung cancer mortality		Growing evidence that dementia and cognitive decline are associated pollution exposure	
Respiratory (26,77)						
Cardiovascular (33,78)	NO ₂ (OR: 1.040; 95% CI: 1.001,1.081), SO ₂ (OR: 1.047; 95% CI: 1.009,1.086), and PM _{2.5} (OR: 1.022; 95% CI: 1.000,1.045)	Exposure to PM _{2.5} associated with hypertension	6-17% increase in risk of all-cancer mortality associated with long-term exposure to pollutants.		Air pollutants are associated with 18–39% increased odds of common mental disorders; 19–30% increased odds of poor physical symptoms; 33% increased odds of psychotic experiences	
Cancer (79-81)		(OR 1.05; 95% CI 1.01-1.09).	PM _{2.5} (RR: 1.17; 95% CI: 1.11–1.24; I2: 97.4%), PM10 (RR: 1.09; 95% CI: 1.04–1.14; I2: 45.7%) (Figure 2), and NO ₂ (RR: 1.06; 95% CI: 1.02–1.10; I2: 95.5%)			
Mental Health (31,32)	10µg/m ³ increase in PM _{2.5} associated with increased incidence of COPD (HR 1.18 95% CI 1.13-1.23)		This was significant for kidney (35%), bladder (32%), liver (29%) and colorectal cancer (8%)			
			Mortality from liver cancer 1.29 (1.06-1.58), colorectal cancer 1.08 (1.00-1.17), bladder cancer 1.32 (1.07-1.60), kidney cancer 1.35 (1.07-1.72) mortality			
Development, Childhood and Adolescent studies	Asthma exacerbations due to air pollution resulted in an estimated 700 paediatric	London adolescents: 1 µg/m ³ increase in PM2.5 associated with 1.34 mmHg (95% CI 0.85 to 1.82)			Higher levels of air pollution at age 12 had	

Respiratory (27) Cardiovascular (23) Mental Health (29)	asthma exacerbation admissions are due to air pollution (London, 2017–19) – 7% of all paediatric asthma admissions 3.2-3.9% increased risk of asthma hospitalization in children for every 10µg/m³ increase in pollution	increase in systolic BP for girls and 0.57 mmHg (95% CI 0.04 to 1.03) increase in systolic BP for boys	greater odds of depression at age 18 PM _{2.5} OR 1.63 CI1.08–2.46 0.021p and NO ₂ OR 1.57 CI1.05–2.35 p=0.029 Adolescents living in the most polluted areas had 3-4 times the odds of depression at age 18 (compared to areas of lowest pollution (PM _{2.5} : OR = 3.69, 95% CI 1.11–12.25, p = 0.033; NO ₂ : OR = 4.08, 95% CI 0.90–18.60, p = 0.069)	
Pre- and neonatal outcomes (17–19)	5-10 % of total PTBs were associated with ambient PM _{2.5} > 4.3 µg/m³ 22 grams (95% UI: 12, 32, p<0.001) lower birth weight, 11% greater risk of LBW (1.11, 95% UI: 1.07, 1.16, p<0.001), and 12% greater risk of PTB (1.12, 95% UI: 1.06, 1.19 p<0.001), per 10 µg/m³ increment in ambient PM _{2.5} . A reduction in gestational age of between 3-5 days is thought to be attributable to PM _{2.5} In London estimates that PM _{2.5} exposures greater than 13.8 µg/m³ in pregnancy accounted for three percent of London-born infants with low birthweight Male fertility: a meta-analysis demonstrating significant decreases in semen volume, motility, and sperm concentration associated with higher air pollution			
Plant-based Diets (PBD)				
Systematic Review and Meta-analysis. (62) 2023 <i>Higher adherence to a PBD pattern associated with lower risk of:</i>	CVD mortality (0.79 95% CI: 0.72–0.87) and incidence (0.90 [0.85–0.94]) CHD risk (0.86 :95% CI: 0.81–0.91), but not with risks of stroke (0.92: 95% CI:0.85–1.00) and heart failure (0.89: 95% CI:0.75–1.06)	Cancer mortality (0.82: 95% CI: 0.71–0.93) Cancer incidence (0.88: 0.84–0.92) Breast cancer (0.91: 95% CI: 0.86–0.95) Digestive system cancer (0.82: 95% CI: 0.72–0.94) Pancreatic cancer (0.68: 95% CI: 0.55–0.84) Prostate cancer (0.87: 95% CI: 0.77–0.99)	T2DM incidence (RR 0.82 95% CI: 0.77–0.86)	All-cause mortality (0.84 0.78–0.92)
Systematic Analysis of the GBD (82) 2017	For a 100g increase in fruit – IHD: RR 0.86 (0.79-0.95); ischaemic stroke RR 0.65 (0.55-0.79); 100g increase in vegetables – IHD: 0.86 (0.78-0.94) 50g increase in Legumes: RR IHD 0.76 (0.65-0.89) ischaemic stroke RR0.87 (0.79-0.97)	100g increase in fruit – tracheal/bronchus/lung Ca RR 0.93 (0.89-0.97); oesophageal cancer RR 0.87 (0.78-0.97). 100g decrease red meat: colorectal ca RR 0.86 (0.76-0.97).	100g increase in fruit associated with a reduction in diabetes RR 0.91 (0.84-0.98) 100g decrease in red meat RR 0.8 (0.68-0.97) 50 g decrease in processed meat RR 0.58 (0.47-0.76)	

	50g decrease in processed meat: IHD RR 0.56 (0.39-0.97)	50g decrease Processed meat colorectal cancer RR 0.85 (0.79-0.91)		
Systematic review and meta-analysis Aune et al 2017 (58) <i>Per 200 g/day increment in intake of fruit and vegetables:</i>	8–16% reduction in the RR of coronary heart disease, 13–18% reduction in the RR of stroke; 8–13% reduction in the RR of cardiovascular disease	3–4% reduction in the RR of total cancer		10–15% reduction in the RR of all-cause mortality
Systematic Review and Meta-analysis Afshin et al, 2014 (64) <i>4 weekly 28.4-g servings of nuts were associated with:</i>	24% lower risk of fatal IHD (RR: 0.76; 95% CI: 0.69, 0.84) 22% lower risk of nonfatal IHD (RR: 0.78; 95% CI: 0.67, 0.92). 4 weekly 100-g servings of legumes was associated with 14% lower risk of total IHD (RR: 0.86; 95% CI: 0.78, 0.94)		13% lower risk of developing diabetes (RR: 0.87; 95% CI: 0.81, 0.94) legume consumption was inversely associated with diabetes (RR: 0.79; 95% CI: 0.71, 0.87)	
Systematic Review and Meta-analysis Zong 2016 (63) <i>comparing the highest to the lowest groups of Wholegrain intake:</i>	CVD mortality: Pooled RR 0.82 (0.79, 0.85; P<0.001) PAF 11.6% for CVD mortality	Cancer mortality: RR 0.88 (0.83, 0.94; P<0.001) PAF 10.2% for Cancer mortality	For diabetes risk, pooled RR (95% Cis) 0.74 (0.69, 0.80) Each 2–3 servings/day increment associated with 21–32% lower risk	Total mortality was RR 0.84 (0.80, 0.88; P<0.001), Estimated PAF were 10.4% for total mortality
UK Cohort Study Key et al. 2022 (60) <i>Vegetarians compared with meat eaters:</i>	IHD HR 0.77 (0.69-0.86) after 18 years follow up Combined vegetarian and vegan risk was 22% lower than meat eaters, adjusted for BMI this reduced to 17%	Lower HR of all cancers 0.90 (0.844-0.97), stomach 0.38 (0.2-0.71), haematological 0.64 (0.48-0.84)	Lower risk of diabetes: HR 0.65 (0.55-0.76) although after adjustment for BMI crosses 1 – 0.89 (0.75 -1.05) mean BMIs of vegetarians and vegans in EPIC-Oxford were approximately 1 and 2 kg/m2 lower than those of meat-eaters	Diverticular disease vegetarians compared with meat eaters: HR 0.73 (0.58-0.92), kidney stones 0.69 (0.48-0.98)

<i>Vegans compared with meat eaters:</i>	18% lower IHD in vegans but small numbers wide	vegans compared with meat eaters: all cancers HR 0.82 (0.86-1.00)	vegans compared with meat eaters: diabetes HR 0.53 (0.36-0.79) note this effect appears to be entirely mediated through BMI – adj HR 0.99 (0.66-1.48)	vegans compared with meat eaters: diverticular disease 0.28 HR (0.1-0.74)	
Physical Activity					
Burden of Disease Study 2012 (83)	CHD incidence and leisure activity, RR 1.16 (1.04–1.30)	Breast cancer: Adjusted for BMI, RR 1.33 (1.26, 1.42)	T2DM incidence: RR 1.20 (1.10–1.33) adjusted for BMI Burden of disease was 7% (ranging from 3.9% to 9.6%) due to T2DM	All-cause mortality: RR 1.28 (1.21–1.36), crude RR was 1.47 (1.38–1.57)	
Pooled RR associated with inactivity compared with current recommendations	6% of the burden of disease worldwide due to CHD can be eliminated, if all inactive persons become active	The burden of Breast Ca that could be eliminated if all inactive persons become active: 10% (5.6–14.1%) Colon cancer: RR 1.32 (1.23–1.39) The burden of Colon cancer that could be eliminated if all inactive persons become active: 10% (5.7–13.8%)		Population Attributable Fraction was 9%. >5.3 million deaths/year may be averted if all inactive persons become active	
Systematic Review and Meta-analysis Kelly et al. 2014 (84)				For a standardised dose of 11.25 MET.hours per week (or 675 MET. Minutes per week), the reduction in risk for ACM was 11% (95% CI = 4 to 17%) for walking and 10% (95% CI = 6 to 13%) for cycling	
London Modelling study Woodcock et al 2009 (40)	Relative Risk reduction in CVD incidence of 23%	Breast cancer incidence Relative Risk reduction 13%	Relative Risk reduction of 19% in T2DM incidence	Relative Risk reduction in Depression of 7%	Although walking and cycling became safer per km travelled the large increase in the total distance walked and cycled led to the road traffic injury disease burden rising by 39%
<i>2.5hr per week of moderate intensity physical activity is associated with:</i>	Relative Risk reduction of 23% in Cerebrovascular disease	Relative Risk reduction in Colorectal cancer incidence: of 8%		Relative Risk reduction of 11% in Dementia incidence	
Pooled prospective UK cohort study 2016 (85)04/12/2025 19:58:00	Swimming associated with reduced risk of CVD mortality of 41% (HR=0.59, 95% CI 0.46 to 0.75) Racquet sports was associated with reduced risk of CVD mortality of 56% (HR=0.44, 95% CI 0.24 to 0.83)				All-cause mortality Cycling: 15% lower risk (HR=0.85, 95% CI 0.76 to 0.95) Swimming 28% lower risk (HR=0.72, 95% CI 0.65 to 0.80) Racquet sports 47% (HR=0.53, 95% CI 0.40 to 0.69)

		Aerobics associated with reduced risk of CVD mortality of 36% (HR=0.64, 95% CI 0.45 to 0.92).			Aerobics 27% (HR=0.73, 95% CI 0.63 to 0.85).
Danish Cohort Study 2015 (86)	<i>Respiratory mortality</i> Participation in sports: HRs 0.60 (95% CI: 0.47, 0.77) Walking: (HR=0.71; 95% CI: 0.51, 0.97) Cycling HR 0.62 (95% CI:0.50, 0.77) and Gardening HR 0.63 (95% CI: 0.50, 0.79)	<i>CVD mortality</i> Participation in sports: HRs 0.78 (95% CI:0.69, 0.88) Cycling HR 0.78 (95% CI:0.69, 0.88) and Gardening HR 0.82 (95% CI: 0.72, 0.93)	<i>Cancer mortality</i> Participation in sports: HRs 0.82 (95% CI: 0.76, 0.89)	<i>Diabetes mortality</i> Participation in sports: HRs 0.34 (95% CI: 0.21, 0.55). For cycling HR 0.61 (95% CI:0.42, 0.89) and gardening HR 0.42 (95% CI: 0.28, 0.62)	In general, exposure to high levels of traffic-related air pollution did not modify associations
UK Biobank Cohort Study. Welsh et al 2020 (41)		Reduced risk of cardiovascular disease (HR 0.79, 95% confidence interval 0.69 to 0.90)	Reduced risk of cancer diagnosis (HR 0.89, 0.84 to 0.94)		Reduced risk of all-cause mortality (HR 0.88, 0.78 to 1.00) Higher risk of injury (HR 1.45, 95% CI 1.30 to 1.61). 3.42-fold (3.00- 3.90) and 2.62-fold (2.37- 2.91) higher risk of hospital admission due to transport incidents

Table1: Studies demonstrating the effect of polluted air, plant-based diets, and physical activity on outcomes grouped by system (respiratory; cardiovascular; cancers; diabetes and obesity; mental health; and overall measures. IHD Ischaemic heart disease, CVD Cardiovascular Disease, CHD Coronary Heart Disease, T2DM Type 2 Diabetes Mellitus, PBD plant based diet, BMI body mass index.

Climate Policy and the Co-Benefits

The 2018 Intergovernmental Panel on Climate Change (IPCC) clearly describes the magnitude of the effort required to prevent climate catastrophe (87). In 2022, they warned that lack of concerted global action meant missing “a brief and rapidly closing window to secure a liveable future” (88). The 2024 State of the Climate report warns that “we are on the brink of an irreversible climate disaster”, that, “much of the very fabric of life on Earth is imperiled” and that we face, “a global emergency beyond any doubt” (89).

However, the pace & scale of action falls far short of that required. A 1.5°C rise above pre-industrial temperatures is now inevitable. Without rapid reductions to GHG emissions, we will likely breach a 2°C temperature rise by 2030 (10,90). 2024 was the hottest year on record, and the first in which every day exceeded 1°C above pre-industrial levels for that time of year (2), with temperatures consistently >1.64°C above pre-industrial (91). Due to positive feedback loops, the pace of heat gain is rapidly increasing, with extreme weather events more severe and more frequent: climate-related events increased by 83% between 1980-1999 and 2000-2019 (10). One in three species are threatened by extinction with rising GHG emissions (10). In approximately 45 years, one in three of the global population will be exposed to mean annual temperatures of >29°C (currently only found in 0.8% of land surface area) (92). Heat-related mortality has increased by 85% since the 1990s (93). Climate change has caused USD\$1.3 trillion global losses over the last decade, and is estimated to cost USD\$5 trillion in losses over the next five years (94). Alongside global food insecurity, this can incite migration and conflict. Therefore, climate change “threatens our economies and employment, social fabric and security” (10).

Consequently, governments face a particularly difficult challenge to mitigate climate change whilst attending to other public services including health. A Grantham Institute briefing paper summarises the key areas for action on climate change and how these are linked to health (95). Effectively addressing climate change demands urgent cross-sectoral coordination. Consequently, efforts to address climate change through governmental policy, communities and individual actions should be explicit about the expected effects on health.

Public Opinion

Economic growth and reducing GHG emissions are often falsely pitted against one another as trade-offs (96). Whilst concern has grown, climate action is rarely considered the UK public’s top priority: in September 2023, it ranked 5th behind the economy, inflation, the National Health Service (NHS)/healthcare, and immigration (4). Such low ranking matters, both because it is reflected in limited individual and personal action, and because shifts in public sentiment and purchasing choices create a permissive environment into which both politicians and businesses can move. Public opinion matters because of its influence on government prioritisation. Communicating the urgency of climate action will be far more effective and comprehensive if framed around the positive benefits for health, rather than focussing solely on environmental damage. Government departments risk addressing each of these issues in isolation which ignores the significant co-benefits described here (projected scenarios presented in Table 3). Whilst beyond the scope of this report, evidence supports the co-benefits of climate action across other policy areas including employment, economic growth and housing, as well as health (95).

Table 3: Projection scenarios demonstrating the dual impact of clean air, active travel, and plant-based diets

Co-benefits	Climate Benefits	Health Benefits
Cleaner Air (8,9) <i>Changes in power generation from fossil fuels to renewable sources</i>	Targeted 80% reduction in GHG emissions by 2050 compared to 1990 levels (UK Climate Change Act, 2008). This would result in 40% reduction in PM _{2.5} concentrations by 2050.	NO ₂ concentration reduction can save 4.89-7.18 million life years between 2011-2154.
Active Travel (40) <i>If London replaced a proportion of car travel with active travel</i>	38% reduction in transport CO ₂ emissions from 1990 levels. Per person CO ₂ emissions are 0.69 tonnes.	7332 DALYs saved and 530 premature deaths avoided per million population.
Plant-based Diets (6) <i>If the average UK dietary intake were optimised to comply with the WHO recommendations</i>	Estimated incidental reduction of 17% in GHG emissions.	Almost 7m years of life lost prematurely in the UK would be saved over the next 30 years, with average life expectancy increasing by >8 months.

Inequality

The difference in mortality between rich and poor in the UK first received significant attention following the Sir Douglas Black report in the 1980s. Since then, numerous reports, commissions and plans for action have attempted to reduce inequalities with limited success. Fair Society Healthy Lives 2010 set out the action required to reduce inequality and, following a re-review in 2020, the need to pursue environmental sustainability and health equity together was added (97).

Inequalities persist in exposure to air pollution and mode of transport. A Scottish study identified higher levels of active travel in more deprived areas (98). Deprived areas tend to have higher levels of pollution, mostly caused by congestion of private vehicles. The adverse impact of air pollution amongst the poor is further compounded by increased use of public and active transport in deprived groups. Evidence shows that those from areas of higher deprivation rely heavily on public transport and receive higher exposures to pollution whilst generating less emissions per person (99). These inequalities would be addressed through decarbonisation of transport and increases in active travel.

Climate change will have significant impacts on food security. Direct effects include changes in temperature and rainfall distribution for agriculture, with extreme weather events causing disruption to food systems. Indirect effects include the reduction in pollinators and increase in pests and disease vectors. These changes are likely to drive up the price of food. A UK survey found that almost 20% of parents reported that they regularly had to go without food to ensure that their children had sufficient food (100). The poorest 20% of households spend a higher proportion of income on food and are therefore more vulnerable to changes in food prices (74). Twenty-five percent of households in the most deprived areas report eating reduced quantities of fruit and vegetables due to cost (101).

A public health approach needs to address the widening of inequity between the wealthy and poorest in society. Climate change has its greatest effects on those who have contributed the least, and without intervention will worsen the gap through its adverse effects on the social determinants of health (102). Climate change mitigation therefore has the potential to reduce inequity through the development of effective policies.

Conclusions

If decision-makers adequately account for the co-benefits of climate change mitigation, faster, more effective reductions in GHG emissions may be achieved with considerable cost-savings. The disconnect between public perception on issues that matter most, and the potential role environmental policy can play in addressing these issues, represents an important point of action to establishing a health sustainable future. The competing priorities of different issues and different government departments undervalues the power of a collaborative approach to climate change.

Focus on the key areas of cleaner neighbourhoods, increasing active travel, and consumption of plant-based diets provide clear examples where individuals, communities, corporations, and government can make decisions that benefit both human and planetary health.

But we must remember: our lives, and those of our children are under immediate threat if climate change is not averted. The time to do so is very limited indeed: the IPCC warn that we risk 'missing a brief and rapidly closing window to **secure a livable future**' (88). We all have a responsibility to act, rather than to be complacent or to continue 'business as usual'. Health charities can unite in a public message, that 'what is good for health is good for our planet'. They have a moral responsibility to do so.

Key Messages

- Reducing GHG emissions to mitigate climate change represents a significant challenge for governments facing competing issues such as health, economic growth, immigration, and inequality.
- Delayed, inconsistent action in response to the climate emergency threatens our lives and livelihoods.
- A health-centred response can deliver transformational health benefits globally.
- The health sector is critical to climate change: it is the first line of defence, and it has direct control over a portion of GHG emissions and >10% of the world's GDP.
- Focusing on a single risk factor undervalues potential impact on health due to synergistic effects (Increased air quality and physical activity with active travel).
- Addressing climate change in isolation ignores key wider benefits of mitigation.
- Public discourse should be informed by the co-benefits of reducing air pollution, reducing animal-source foods, and increasing active travel on both personal and planetary health.
- Joined-up awareness campaigns would reinforce the benefits of moving to a cleaner, healthier society and increase public support.

Appendix 1: Health System Evidence

Respiratory Diseases

Air pollution

Morbidity and mortality from respiratory disease is one of the most direct health effects of air pollution. Numerous observational studies causally link impaired lung function, asthma, chronic obstructive pulmonary disease (COPD), respiratory infection, interstitial lung disease (ILD), pulmonary embolism, and obstructive sleep apnoea (OSA) with exposure to air pollutants, with emerging evidence focusing on the causative mechanisms. Disorders of the upper respiratory tract (e.g. allergic rhinitis (AR) and rhinosinusitis) have not been considered.

Lung Function

Pulmonary function tests (PFTs) provide a standardised measure of different breathing and respiratory parameters to aid identification of health and disease, and are subject to international guidance (e.g. (103)). Lung function in childhood is a predictor of peak lung function in adulthood and later decline; hence, focusing on this group is of lifelong importance (104). A global meta-analysis pooled 25 studies investigating PM_{2.5} exposure and lung function in children. A statistically significant decrease in lung function values – forced vital capacity (FVC), forced expiratory volume in the first second (FEV1) and peak expiratory flow (PEF) – was identified for every 10 µg/m³ increase in PM_{2.5} concentration, with a greater lung function reduction in long term compared with short term exposure (105). Despite data heterogeneity and small study sizes, this finding appears consistent in adults, where short-term PM_{2.5} exposure is associated with a fall in FEV1 and FVC (106). Cohort studies have consistently shown that increases in ozone (O₃) concentration result in short-term reduction in lung function parameters in children with and without asthma. However, the long-term effects of O₃ exposure on lung function are inconclusive (107). Most studies show a negative impact of traffic-related air pollution on lung function, with the effect larger for FEV1 than FVC (104). The Southern California Children's Health Study demonstrated deficits in FEV1 correlating with higher levels of NO₂, PM_{2.5}, elemental carbon and acid vapour; FVC deficits associated with NO₂ and acid vapour; and significant reductions in FEV1 and FVC if living within 500m of a freeway (108).

Asthma

Illness from airborne pollution can be caused by exposure prenatally and during the early years. A systematic review of birth cohort studies examined ten cohorts exposed to PM and NO₂ in pregnancy and identified a consistent association with asthma incidence (109). Referenced cohort studies in the Netherlands and the USA found that exposure to PM_{2.5} and NO₂ at home addresses at birth and during the first three years of life, respectively, are associated with increased childhood asthma incidence (110,111). This adds to a substantial body of evidence linking prenatal and early-year air pollution to the development of asthma in childhood and later life (109,112–114). A recent meta-analysis reviewed respiratory health effects of prenatal exposure to airborne pollutants. Included studies from the USA and Poland and considered heterogeneous exposures, outcomes and time courses. It identified a significant association of exposure to ultra-fine particulates with asthma, and of exposure to polycyclic aromatic hydrocarbons (PAH) PM_{2.5} with wheezing in children (115). In the initial cohorts of the Southern California Children's Health Study, children with homes within 75m of a main road had an increased risk of lifetime asthma and a 50% increased risk of asthma after adjusting for confounders (108). A recent systematic review of observational studies including children and adults examined specific pollutant exposure and visits to the emergency department or hospital admissions in the following days. The strongest association was with PM_{2.5}: an increase in concentration of 10 µg/m³ led to a statistically significant increase in asthma-related emergency department visits on the same day or up to three days afterwards. Non-significant associations were observed with NO₂, O₃, sulphur dioxide (SO₂), PM₁₀ and carbon monoxide (CO). Increased exposure to all pollutants also led to increased hospital admissions, although the data did not reach significance across all time lags (116). A further meta-analysis linked short-term exposure to PM_{2.5},

PM₁₀, and SO₂ to respiratory morbidity, with PM_{10-2.5} associated with an increased risk of asthma morbidity in the following hours (117). A scoping review looked at individual pollutants, finding that PM, O₃, CO, SO₂, and NO₂ can all precipitate asthma exacerbations, leading to emergency department attendance and hospital admissions, with PM_{2.5}, NO₂ and O₃ associated with higher mortality in asthmatics (118). Amongst children in Southern California with asthma, symptoms (bronchitis, phlegm and wheeze), medication use, emergency department visits or hospitalisations, and school absences were negatively impacted by air pollution exposure (108). Whilst not yet a major issue in the UK, the Thoracic Society of Australia and New Zealand have highlighted the impacts of wildfire (landscape fire smoke) on asthma exacerbations. International data consistently demonstrate an increased risk of asthma exacerbations during wildfire periods, with the greatest risk in older adults (>65 years) and children (119). Epidemiological evidence supports a positive association between wildfire smoke and emergency department attendances due to asthma, and with increased asthma reliever inhaler use and oral steroid prescription. (120).

COPD

The European Respiratory Society (ERS) reviewed several systematic reviews and meta-analyses on air pollution and COPD in 2023, proposing mechanistic pathways and producing recommendations for healthcare professionals. An increase in PM_{2.5} concentration of 10 µg/m³ was associated with an 18% increase in COPD incidence (121). Population-based data and cohort studies identify a supra-linear relationship of incident COPD with ambient concentrations of PM_{2.5}, NO₂ and O₃ (122,123). In a Taiwanese cohort of 285,000 patients, lung function trajectories and PM_{2.5} concentrations were examined at their home addresses over two years. A higher PM_{2.5} concentration was associated with lower FEV₁, FVC and FEV₁/FVC ratio, with the risk of COPD over time increasing by approximately 40% for people living in the most polluted areas compared with the least (by quartiles) (124). The review highlights that data are more robust in supporting the relationship between fine and ultra-fine (PM_{2.5} and smaller) particulate matter and poor COPD outcomes, compared to other components such as NO₂, SO₂ and CO.

A ERS report further notes that patients with COPD experience more symptoms (such as wheezing, cough and breathlessness), and an acute decline in both FEV₁ and FVC, when exposed to air pollution such as that in London's Oxford Street or a commercial road, when compared to Hyde Park (an urban park) (125). A 2016 meta-analysis concluded that worse air quality is associated with COPD exacerbations, with the relationship strongest for particulate matter three days after exposure and for gaseous pollutants on the first day of exposure (126). Medicare data of 11.5 million patients in the USA demonstrated that a short-term increase of 10 µg/m³ in ambient PM_{2.5} concentration was associated with a 2.6-fold increased risk of COPD-related hospitalisation (127). Mortality data relating to COPD and air pollution are less well established, especially in the UK. One meta-analysis assessing air pollution and respiratory disease mortality demonstrated that a 10 µg/m³ increase in NO₂ was associated with a relative risk of 1.03 for COPD mortality, with mixed results for O₃ exposure (128). In 2016, the WHO estimated that approximately 25% of COPD deaths were attributable to air pollution (129).

Respiratory Infection

The link between air pollution and respiratory infection has been most extensively studied in relation to COVID-19. A systematic review suggested that for an increase in PM_{2.5} concentration of 10 µg/m³, there was a 66% increase in infection, 127% increase in severity and 40% increase in mortality (130). Other studies corroborate the association between air pollution and respiratory infection, such as viral infection (131) and pneumonia (132) in children. In this global meta-analysis of paediatric populations, the excess risk of pneumonia was greatest with SO₂, with a 2.9% increase per 10 parts per billion (ppb) gaseous concentration rise, but the findings were also significant with PM_{2.5}, O₃, PM₁₀ and NO₂. In adults, a 10 µg/m³ increase in PM_{2.5} concentration led to a 1% increase in hospital admission or emergency department visits for pneumonia, while increases of 10 ppb in NO₂ and SO₂ led to a significant 3.2% and 2.4% increase in hospital presentation or admission with pneumonia

respectively (133). The previously discussed meta-analysis of air pollution and respiratory disease mortality identified that a 10 $\mu\text{g}/\text{m}^3$ increase in NO_2 was associated with a relative risk of 1.06 for acute lower respiratory tract infection mortality, with mixed results for O_3 exposure (128).

Interstitial Lung Disease (ILD)

ILD is an umbrella term for inflammation and often irreversible fibrosis of the lung tissue, with idiopathic pulmonary fibrosis (IPF) being the most common form. Air pollution has been postulated to have a causal role in initial IPF development, severity, and prognosis (134). A review of IPF initiation and outcomes (134) highlights a retrospective study of over 2000 patients with IPF in Northern Italy, concluding that there was an approximate 7% increase in IPF incidence per 10 $\mu\text{g}/\text{m}^3$ in NO_2 concentration, although with a non-significant confidence interval once confounders were accounted for (135). An additional narrative review has reported on the impact of air pollution on interstitial lung diseases (136). Of the referenced studies, results from an Indian cohort diagnosed with hypersensitivity pneumonitis (an inflammatory ILD) had a 7% greater chance of developing the condition for every 10 $\mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$ concentration (137). In a French cohort of 192 patients with IPF followed for five years, an increase in the mean O_3 concentration was associated with an increased risk of exacerbations, with mortality risk rising with cumulative $\text{PM}_{2.5}$ and PM_{10} exposure (138). O_3 and NO_2 exposure have previously been shown to increase exacerbation risk in South Korea (139). Further research is required to determine the impact of pollutants on the natural history of ILDs; a single cohort study previously demonstrated a decline in FVC with increasing PM_{10} exposure but inconsistent results with $\text{PM}_{2.5}$ and on six-minute walk tests (140).

Pulmonary Embolism

A single meta-analysis has examined air pollution and pulmonary embolism risk (141). The nine studies included were mainly from developed countries and examined a range of pollutants. Increased NO_2 exposure (and, to a lesser extent O_3) were associated with an increased risk of pulmonary embolism.

Obstructive sleep apnoea

A systematic review reported six studies which examined the relationship between airborne pollution exposure and sleep-disordered breathing (142). Two identified an association of $\text{PM}_{2.5}$ and NO_2 exposure and sleep-disordered breathing measured via polysomnography (143,144). Two more demonstrated an association with PM_{10} (one with a worsening respiratory disturbance index (RDI) and sleep time spent in hypoxia (oxygen saturation <90%) (130), the other with worsening severity of obstructive sleep apnoea (OSA) (145)). One other reported a positive association between the severity of OSA and CO exposure (146).

Diet

The role of diet in the development of chronic respiratory disease is less established compared to air pollution. Hypothesised mechanisms predominantly focus on nutrition as an inflammatory mediator, identifying certain nutrients associated with the development and severity of allergic disease. Longitudinal cohort studies indicate that maternal and early childhood nutrition is crucial in the development of allergic disease (147). While allergic diseases are beyond the scope of this review, studies on asthma are discussed here.

Asthma

Diets high in calories, saturated fat, and protein, and low in fibre, are associated with an increased risk of asthma and allergic rhinitis. In comparison, a Mediterranean diet high in vegetables, fruit, fibre, olive oil, and fish is associated with reduced risk (147,148). Cohort studies indicate that higher fruit and vegetable intake is correlated with lower risk of developing asthma, higher FEV1, and

reduced wheeze in children, adolescents and adults (149). This is consistent with RCT evidence: after a two-week period of following either a high or low fruit and vegetable diet, asthmatic adults in the low intake group had more than double the risk of an asthma exacerbation and significantly lower spirometry values than the high intake group (150). Notably, the supplementation arm of the trial run in parallel found no difference in outcomes between lycopene supplementation and placebo, supporting a whole-food approach. However, the European Academy of Allergy and Clinical Immunology find insufficient evidence to recommend increasing fruit and vegetables solely to reduce asthma risk (151). That said, obesity is an established risk factor for asthma and dietary interventions for weight loss are effective at improving asthma control in children (152).

Observational evidence supports an inverse correlation between dairy intake and asthma incidence. An eight-week experimental study in asthmatic children eliminating milk and eggs demonstrated a 22% improvement in peak expiratory flow rate in the intervention group, significantly different from the slight decrease seen in the control group (153). Further research is needed given the small study size and short follow up period.

COPD

Epidemiological studies report an inverse association between consumption of the Mediterranean diet, and COPD incidence. Higher adherence to the Mediterranean diet is associated with a lower risk of developing COPD (case-control evidence reports a 27% lower risk in those with middle to high adherence scores compared with low scores after adjustment for education level) (154). The Mediterranean diet typically contains less processed meat. A systematic review and meta-analysis of five prospective cohort studies reported a dose-response relationship with an 8% increased risk of COPD per 50g/week increase in processed meat consumption (155).

Physical Activity

Research on the relationship between physical activity and respiratory disease focuses predominantly on pulmonary rehabilitation as a therapeutic intervention, particularly for COPD patients. The evidence discussed here considers first the effectiveness of supervised rehabilitation, then exercise and active travel.

Pulmonary Rehabilitation

Pulmonary rehabilitation (PR) is a multi-component intervention that includes exercise training, education, and behavioural change. Literature reviews have examined the impact of PR on acute exacerbations, quality of life, exercise tolerance, respiratory muscle strength and mortality in COPD patients (156–162). Exercise-based PR is associated with improvements in walking distance, exercise capacity, and health-related quality of life in COPD patients (including low-quality evidence supporting the use of PR in those with severe COPD (158,160,161). Two reviews of RCTs focused on early PR (within four weeks) after acute COPD exacerbations (159). Early PR was associated with a reduced length of hospital stay, reduced risk of hospital readmission, and lower mortality at the end of treatment (RR = 0.58; CI 0.35-0.98), although the long-term impact on mortality is unclear. PR has also been trialled in patients with fibrotic ILD, and is associated with an improvement in six-minute walking distance with mixed effects on dyspnoea, and a trend towards significance in improving quality of life (163,164).

Aerobic Exercise

Aside from controlled exercise programmes, COPD patients can also benefit from general increases in physical activity. Unsupervised physical activity, predominantly walking, is associated with improved walking distance as well as improved emotional function, health-related quality of life, muscle strength, reduced fatigue, and symptoms of anxiety and depression (165). A review examining

barriers to exercise in COPD patients included anxiety about breathlessness, recommending light physical activities such as walking as a more acceptable long-term approach (166). Aerobic exercise is beneficial for both asthma symptoms and fitness. A systematic review and meta-analysis of 11 RCTs showed that aerobic exercise improves asthma control and lung function (but not markers of airway inflammation) (167). A second systematic review and meta-analysis found walking distance to also be improved, as might be expected (168). Intensive inpatient exercise protocols have demonstrated significant improvements in walking distance in patients with pulmonary arterial hypertension (after medical optimisation), but are unlikely to be generalisable outside of clinical settings (169). The greatest benefit was seen with interventions combining aerobic exercise, strength training and respiratory muscle exercises. However, outpatient programmes that are feasible to follow long-term require further research.

Commuting

Concerns that air pollution may mitigate or reverse the health benefits of active commuting have been raised. A comprehensive systematic review found that higher levels of air pollution mildly reduced the short-term benefits of walking or cycling on lung function, with the strongest associations being with PM_{2.5} and ultrafine particle concentrations (170). However, evidence for modification of the long-term health benefits of exercise is not clear, with many studies suggesting that air pollution does not reduce these benefits, and no significant impact of NO₂ levels on chronic respiratory diseases (including lung cancer, asthma and COPD). It is also important for policymakers to consider that increasing numbers of active commuters can reduce air pollution and the associated negative health effects (171).

Electrically assisted, or e-, bikes provide powered assistance and can shift the choice of transport by providing a less exertional alternative to conventional cycling. E-bikes that require pedalling have been investigated to determine the health impact of these less intensive approaches. A review of experimental and observational studies conducted a meta-analysis demonstrating increased maximal oxygen consumption and power output compared to baseline (172). Two included studies, that used conventional cycling as a comparator, found no difference in improvements in VO₂max or maximal power, suggesting that e-bikes might provide equivalent health benefits.

Cardiovascular Diseases

Air pollution

Air pollution represents a complex mixture of particles and gases (such as CO, SO₂, and NO) that are either not part of natural air or are present in abnormally high concentrations (173). Air pollution is normally considered by location: ambient (outdoor) or indoor exposure. Ambient air pollution mainly stems from burning of fossil fuels. Indoor pollution in high income countries also relates to the burning of gas in boilers and cooking stoves, but also from aerosol and candle use.

Long-term (one to five year) exposure to increased PM_{2.5} concentrations causes a 16-31% increase in annual IHD mortality (174). Even short-term exposure (hours to days) can increase the risk of cardiovascular-related death by <1%. Air pollution also increases the risk of developing heart failure, and of atrial fibrillation and other cardiac arrhythmias (175). Short-term exposure to increased PM_{2.5} concentrations increases systolic blood pressure by up to 10mmHg (176), while long-term exposure is associated with increased atherosclerotic plaque formation, left ventricular hypertrophy, and carotid intima media thickness (177). The main physiological mechanism underlying the cardiovascular risk increases appears to be vascular inflammation and oxidative stress.

Diet

Plant-based diets reduce cardiovascular-associated mortality by up to 32% (178,179). Additionally, vegetarians (especially men) have lower BMI, blood pressure and circulating cholesterol concentrations.

Adherence to the Mediterranean diet reduces the risk of cardiovascular events (such as myocardial infarction, ischaemic stroke) or of peripheral vascular disease by more than one third (180). The physiological mechanism underlying these health benefits is not fully understood, but likely relates to reduced consumption of meat, saturated fat, refined sugar and refined starches, and possibly to increased substitution with omega three fatty acids (181,182). Increasing evidence suggests that plant-based diets confer benefit via impacts on the gut microbiome (182,183).

Physical Activity

The World Health Organization (WHO) defines physical activity (PA) as “any bodily movement produced by skeletal muscles that requires energy expenditure”. It reduces the risk of chronic diseases, including IHD and ischemic stroke (184). The WHO thus recommends a minimum exercise target of 600 metabolic equivalent minutes (METs) per week: approximately 150 minutes of total (brisk) walking time or 75 minutes of running per week. One MET is defined as the amount of oxygen consumed while a person is sitting quietly (approximately 3.5 mL O₂/kg body weight/minute).

Increases in daily step count lead to a non-linear reduction in cardiovascular death risk: an increase in 500 steps per day can reduce cardiovascular-related mortality risk by 7%, but the extent of risk reduction lessens with higher total step counts (185). Meta-analyses including other types of activity have come to similar conclusions (186). Increasing weekly METs from <600 to 4000-7999 can reduce the risk of ischaemic stroke by 19% and that of IHD by 23% (186). Conversely, higher daily sitting time is associated with an increased risk of cardiovascular disease and diabetes. This relationship remains when adjusted for physical activity, albeit somewhat weakened for cardiovascular disease (187).

Physical activity increases postprandial glucose and insulin responses, improves blood pressure (predominantly systolic) and lower limb vascular function. If maintained for a longer time period, it also leads to improvements in body weight, waist circumference, body fat percentage, fasting glucose, HbA1c and HDL concentrations (188). While such improvements may appear incremental, the synergistic effects lead to overall cardiovascular risk reduction (189).

Cancer

Pollution

Air pollution exposure increases cancer risk (including that related to liver and colorectal cancers (190), breast and brain cancer (191,192)). Even pre-natal exposure is a risk (193). The WHO thus lists PM_{2.5} particulates as class 1 carcinogens (194) (perhaps through oxidative stress or other inflammatory processes (195,196)).

Diet

The western diet (typified by a high intake of ultra-processed foods, sucrose, fat and refined grains, but with little fresh fruit and vegetables or fibre) is strongly associated with risk of developing colorectal cancer (197). In contrast, the Mediterranean diet reduces all-cause cancer mortality, and risk of developing colorectal, head and neck, lung, gastric, bladder and liver cancers (198). This benefit might, in part, be mediated through impacts on obesity: 11% of European colorectal cancer (the third most diagnosed and second most lethal cancer globally) cases are due to obesity (199). However, the benefits of a Mediterranean diet on colorectal cancer risk persist in those of normal weight studies.

Observational studies show that consumption of plant-based diets is associated with reduced (especially colorectal and breast) cancer risk (200). However, prospective RCTs are needed to confirm causality.

Physical Activity

Active transport reduces cancer risk: ~150 minutes of walking or 90 minutes of cycling per week reduces the risk of endometrial, colorectal and breast cancers by up to 30%, with benefit increasing with greater exercise (201,202). Exercise also improves tolerance of cancer chemotherapy and radiotherapy (203), and of completing treatment courses (204).

Different measures of physical strength have shown to predict mortality in patients with cancer, such as the six minute walking test and grip strength (205). In a meta-analysis of 15 studies including 350 patients, (cancer) pre-operative exercise training reduced the length of hospital stay by almost five days and decreased post-operative complications (206). Exercise at the start of cancer treatment is thus endorsed by bodies such as Cancer Research UK.

Endocrine Diseases

Pollution

While the impact of pollution on cardiovascular and respiratory disease is well established, it also contributes to disease burden across the life course starting *in utero*, including endocrine diseases.

Early Life Exposures

Gestational exposure to air pollution is linked to adverse foetal, neonatal and maternal outcomes. These include maternal gestational diabetes mellitus (GDM), pre-eclampsia and hypertension, and neonatal low birthweight, preterm birth, and neonatal mortality. An umbrella review of studies examining PM_{2.5} found that these associations varied by trimester (207). A 2023 review of 31 cohort studies found that exposure to PM_{2.5}, PM₁₀, NO₂, and SO₂ was associated with increased risk of GDM predominantly in the first trimester (208). Analysis of specific PM components showed that black carbon exposure in the second trimester and NO₃⁻ exposure in the first trimester increase risk of GDM.

Childhood and adolescence

In childhood, ambient pollution is associated with higher risk of being overweight and obese. A meta-analysis of 15 studies examined childhood exposure to air pollutants and found a positive association between PM₁₀, PM_{2.5}, and PM_{0.1} with both obesity and BMI (209). A 2024 meta-analysis demonstrated that for every 10 µg/m³ increase in PM (PM₁, PM_{2.5}, and PM₁₀), nitrogen oxide species, and O₃, the odds of being overweight and obese in childhood and adolescence (<19 years) increased by 6-23% depending on the pollutant (210). Insulin sensitivity and glucose tolerance were also reduced, and blood lipid concentrations increased. Consistent with this, prenatal maternal exposure to PM_{2.5} was associated with an increased risk of childhood obesity (211).

Adulthood

These associations persist in adulthood. A 10 µg/m³ increase in PM_{2.5} and PM₁₀ concentration is associated with a 15.9% and 9.2% increase in obesity incidence respectively (211). Similar results are reported for NO₂, SO₂, and O₃ (209). An increase of 5 µg/m³ in annual average PM_{2.5} or PM₁₀ concentration was associated with 14% or 9% increases of metabolic syndrome (the presence of abdominal obesity, hypertension, hyperglycaemia, high triglycerides, and low HDL) risk, respectively (212).

Several studies have linked air pollution with T2DM. A study following 1.7 million US Medicare participants reported a 15% increased risk of developing T2DM per 10 µg/m³ in long-term PM_{2.5} exposure, even after controlling for individual and environmental confounders (213). Similarly, meta-

analysis of studies in Europe and North America showed an increased risk of T2DM of 8-10% per 10 $\mu\text{g}/\text{m}^3$ of $\text{PM}_{2.5}$ or NO_2 (214). Mechanistic evidence supports a causal relationship with insulin resistance in children and adults noted with even short periods of exposure to air pollution (215). This appears to be consistent across $\text{PM}_{2.5}$, PM_{10} , NO_2 , and SO_2 . Studies exploring diabetes-related mortality demonstrate increased risk with increasing pollution, even at low levels, and over short and long-term exposure periods (215). The American Cancer Prevention Study found an 18% increase in diabetes-related mortality per 10 $\mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$. These studies provide convincing evidence of the impact of air pollution on T2DM. A 2024 global burden of disease study estimated that 20% of all diabetes-related deaths and DALYs globally are attributable to $\text{PM}_{2.5}$ (216).

Although Type 1 Diabetes (T1DM) is less studied than T2DM, a 2022 meta-analysis of six studies demonstrated a significantly increased risk of T1DM per 10 $\mu\text{g}/\text{m}^3$ increase in O_3 (OR 1.51; 95% CI 1.26-1.80) and a more modest increase in risk per 10 $\mu\text{g}/\text{m}^3$ increase in $\text{PM}_{2.5}$ (OR 1.03; 95% CI 1.01, 1.05) (217).

Emerging evidence links air pollution to increased disease risk of thyroid disease (studies predominantly focused on prenatal exposure (218), male and female infertility (219), and osteoporosis) (220).

Diet

Evidence for the impact of diet on endocrine disease is predominantly focussed on weight loss and diabetes, with fewer studies examining bone fracture risk, or diabetic complications such as chronic kidney disease (CKD). Dietary variables in research can broadly be divided into *patterns* (e.g. vegetarian, Mediterranean, Ketogenic) where the definition specifies the type and amounts of different foods, *food groups* (e.g. meat, dairy, legumes) or *nutrients* (e.g. fibre, protein, fats). Additionally, some studies examine the “healthiness” of dietary intake to create a composite score (e.g. the plant-based index).

Obesity

Obesity is a major risk factor for multiple NCDs. Adherence to plant-based, vegetarian, and vegan diets are associated with lower weight and BMI. A meta-analysis of eleven trials found that vegan diets were associated with greater weight loss and reduced BMI compared to a range of control diets (including habitual diets and specified alternatives such as the Mediterranean diet), with a mean difference of 4.1kg ($p<0.001$) and 1.38kg/ m^2 ($p<0.001$) respectively (221). Lipid profiles (including lower total cholesterol and LDL-C) also improved. This was consistent with other meta-analyses of vegetarian diets (222,223). Huang et al. (222) included twelve RCTs, and demonstrated a mean weight loss of 2kg compared with non-vegetarian diets. Subgroup analysis demonstrated greater weight loss in vegans than lacto-ovo-vegetarians. A second meta-analysis of overweight or obese adults demonstrated significantly reduced LDL-C, total cholesterol and HbA1C in those consuming vegetarian diets (223). Evidence in adults combining vegetarian diets with aerobic exercise showed superior glycaemic control, and lower fasting plasma glucose, waist circumference, BMI, and insulin resistance compared with either intervention alone (224). A limitation of many of these studies is the short duration of follow up. However, the Adventist Health Study 2 (a large cohort with a high proportion of vegetarians followed since 2002) reveals a dose-response relationship, BMI falling with diet stringency: vegans have a mean BMI of 23.6kg/ m^2 compared with non-vegetarians (28.8 kg/ m^2) (225).

A systematic review of nine cohort studies examining plant-based diets took food quality into account (226). Plant-based diets were associated with lower body adiposity than diets with higher animal-source foods, whilst healthier plant-based diets (using index scoring) were more strongly associated with weight loss than less healthy plant-based diets (which had either a null or adverse association). There is a paucity of research on the health impact of poultry consumption, with most comparing red meat and plant-based foods. No RCTs assessed processed poultry foods (227). A systematic review and meta-analysis of 21 trials studying the impact of pulse consumption on body

weight found significant weight reduction in pulse-containing diets even when matched for energy intake ($p=0.03$) (228).

Increasing recognition of the dual benefits of plant-based diets for health and sustainability have led to several studies examining sustainable dietary patterns and weight. A meta-analysis of eight studies demonstrated that high adherence to sustainable diets (defined as diets that provided sustainability measures such as the EAT-Lancet diet) was associated with a reduced risk of overweight (RR 0.69) or obesity (RR = 0.61) (229). Lastly, interventional research aiming to prevent life-long poor dietary habits has focused largely on childhood interventions. A systematic review of 137 interventions (72% aiming to increase fruit and vegetable consumption) found that behavioural insights were effective at improving children's diets in 74% of the included interventions (230). Most effective approaches were using incentives, changing defaults, and modifying the physical environment whereas providing information in isolation was least effective.

Children

Childhood obesity has been an area of growing concern in the UK, where one in three children leave primary school overweight (231). A meta-analysis of 15 studies in children, found that both diet only or 'diet and exercise' resulted in weight loss and metabolic profile improvement, with combination interventions delivering greater changes (232). Dietary interventions predominantly focused on calorie restriction although some increased dietary fibre or fruit and vegetable consumption. Increasing numbers of children are consuming plant-based, vegetarian or vegan diets with 8% of children in the UK reporting to be vegan, 13% vegetarian, and 21% likely to become vegetarian (233). A systematic review of health outcomes in vegan or vegetarian children consistently found no evidence that vegetarian children had no difference in growth compared to omnivores, although iron, iodine and vitamin B12 levels did seem slightly lower (234). For vegans, growth, body fat, iron, iodine, vitamin B12 and bone health were all reduced, but a lower cardiovascular disease risk was also evident with more favourable lipid profiles. The impact of supplementation, varying risk by developmental stage, and long-term impact into adulthood require further research.

Diabetes

The relationship of several dietary patterns with T2DM have been examined, including the Mediterranean, Dietary Approaches to Stop Hypertension (DASH), Portfolio (cholesterol lowering), Nordic, and vegetarian diets. All improved HbA1c, fasting glucose and fasting insulin (235). A meta-analysis of 17 studies found that high adherence to a plant-based diet reduced the risk of T2DM by 18% compared to low adherence with a stronger inverse association seen when healthy plant-based foods were emphasised, such as vegetables, fruits, wholegrains and legumes (58). This is supported by evidence of lower risk with consumption of whole plant-based foods, while refined grains and sugar sweetened beverages are associated with higher risk of T2DM (236).

Vegetarian diets are associated with multiple health benefits. An umbrella review identified 20 meta-analyses reporting on 34 health outcomes and found beneficial effects for cholesterol, BMI, diabetes and ischaemic heart disease risk, and several cancers (237). A meta-analysis of 14 observational studies reported lower risk of diabetes compared to non-vegetarians (238). A vegan diet is also associated with a lower T2DM prevalence and incidence, and improved glucose homeostasis in diabetics (239). These associations may result from the higher fibre content in plant-source foods: a meta-analysis of 359,167 participants found a 19% lower risk of T2DM with high total fibre intake compared to low intake and a dose response relationship demonstrating a 6% decreased risk of T2DM per 2g/day increment in fibre intake (240).

Given these reported benefits, studies have examined the impact of substituting animal-source foods or proteins for plant-equivalents. Two 2023 systematic reviews focus on this approach. One systematic review and meta-analysis examined 24 prospective cohort studies (241). An inverse association with T2DM incidence was found substituting red meat with wholegrains or cereals or nuts and a larger reduction in T2DM incidence when substituting processed meat with nuts. Additionally, a lower T2DM incidence was seen when replacing poultry with wholegrains or replacing

eggs with nuts or wholegrains. These findings were reported alongside beneficial effects on CVD and all-cause mortality when substituting animal source meats, dairy, and eggs with plant-equivalents. A second systematic review examined substituting protein from animal to plant sources (242). Included studies predominantly focused on protein isolates rather than whole foods. Conclusions were limited by high risk of bias but suggested a lower T2DM incidence substituting animal protein for plant protein.

Evidence supports the consumption of sustainable diets for reducing diabetes risk. The EAT-Lancet diet (plant-based, with an emphasis on whole foods and limited animal-based food and refined sugar intake), aims to provide a reference diet that can mitigate both malnutrition and unsustainable agricultural practices for better human and planetary health. A systematic review examining the association between the EAT-Lancet diet and diabetes in five studies (four focused exclusively on T2DM incidence) (243) identified a decreased risk of T2DM onset (i.e. preventative role) and a dose-response relationship (higher adherence associated with lower risk of T2DM). One study, following a UK Biobank cohort of individuals without a prior diagnosis of diabetes over 10 years, found that each incremental increase in adherence score was associated with a 6% decrease in risk of T2DM (244). Analysis revealed that 44% of this association was mediated by BMI.

Gestational Diabetes

Maternal diets are important for foetal health. Gestational diabetes (GDM, diabetes during gestation that was not detected prior to pregnancy) can result in high risk of hypertension, caesarean section, neonatal hypoglycaemia and macrosomia (245). Furthermore, women diagnosed with GDM have more than seven times higher risk of T2DM compared with normoglycaemic women and children are more likely to develop insulin sensitivity and pancreatic beta-cell dysfunction in later life (246,247). A meta-analysis of ten prospective cohort studies found that plant-based dietary patterns were associated with a lower risk of GDM (RR=0.85) (245). Data from two studies demonstrated that higher adherence to a plant-based diet was associated with a lower risk of GDM.

Metabolic Syndrome

Diets (such as the Mediterranean and DASH diets) associated with reduced risk of obesity and diabetes are likely to be associated with lower risk of metabolic syndrome (248). A 2024 review revealed beneficial effects of plant-based diets on individual metabolic syndrome components, although the diverse range of diets studies and variable supplement protocols limited the conclusions that could be drawn (249).

Fracture Risk

While deficiency in vitamin B12 is easily remedied with supplementation, vegetarian and vegan diets are associated with 9% and 43% higher risk of bone fractures respectively compared with meat eaters in the EPIC-Oxford cohort (60). Adjusting for dietary calcium only partially accounted for this elevated risk, and some evidence suggests that adequate vitamin D, calcium and protein-rich foods in the diet may counteract this, highlighting the need to provide adequate guidelines to those transitioning to a plant-based diet (250).

Physical Activity

Obesity and Diabetes

Aerobic active transport uses oxygen to generate energy. Intense exercise (e.g. intense cycling) supplements this with anaerobic metabolism (derives energy without using oxygen).

Low intensity aerobic exercise (and thus 'gentle active commuting') is beneficial to health. Walking reduces lower body fat, BMI and cholesterol levels (251). A systematic review and meta-analysis of adult RCTs showed that walking decreased waist circumference, weight, body fat, and BMI (252). In children and adolescence, a consistent inverse association is seen between walking step count and obesity (253). RCT evidence also supports walking as a means to reduce fasting blood glucose,

HbA1c, postprandial blood glucose and fasting insulin (254). A dose-response relationship is reported with lower risk of T2DM with faster walking speeds (255).

In prediabetic patients, meta-analysis of ten RCTs shows a significant reduction in BMI, HbA1c and fasting blood glucose levels with aerobic exercise compared to control (256). In overweight or obese patients, moderate continuous or high intensity training are equally effective in significantly reducing body fat and waist circumference (257). In sarcopenic obesity (low muscle mass and high body fat with higher metabolic risk) (258), aerobic exercise decreases body weight and fat mass. Similar benefits are seen for T2DM risk. Aune et al. (259) reported an inverse association between physical activity and T2DM risk, noting that this was consistent across light, moderate, and vigorous activity as well as resistance exercise.

Active commuting, by foot, bicycle or other non-motorised means has gained attention as a low-cost, healthy, and climate friendly approach to daily travel. Observational research shows an association between active commuting and obesity and diabetes. A meta-analysis of 28 observational studies showed a 12% and 18% reduction in risk of obesity and diabetes respectively compared with inactive commuting (260). Workplace environments have become increasingly sedentary and several interventional studies have focused on increasing activity whilst working using treadmill, cycling, stepping or standing desks. A systematic review demonstrated improved glycaemic control and body weight with treadmill desk use (261).

Gestational Diabetes Mellitus (GDM)

Insulin resistance is higher during pregnancy and some women develop GDM with higher risk of adverse neonatal outcomes and later development of T2DM. Exercise is an insulin sensitiser, but historical concerns around preterm birth have led to low levels of awareness amongst women on the safety of exercise in pregnancy. Observational studies show that physically demanding work including prolonged standing and heavy lifting were associated with higher risk of miscarriage and preterm delivery (262). However, evidence does not support these concerns for exercise with several systematic reviews of RCTs finding a reduction in caesarean section rates and no change or even a lower risk in pre-term birth risk (263,264). Aerobic or resistance exercise reduce the risk of developing GDM, and reduce insulin requirements, fasting glucose levels and HbA1c (264,265).

Polycystic Ovarian Syndrome (PCOS)

PCOS is a common endocrine disorder characterised by reduced frequency or lack of ovulation, higher circulating androgens, and polycystic ovaries visualised on ultrasound. It is associated with reduced fertility, obesity and insulin resistance (266). Across seven RCTs, regular aerobic exercise improved menstrual patterns, shifting from amenorrhea to oligomenorrhea or normal menstruation and an improvement in ovulation rate. Hyperandrogenism features improved, testosterone level reduced, and lower rates of anxiety and depression were found in the intervention groups. Small sample sizes, short intervention duration, and lack of standardised outcome measures prevent identification of optimal duration, intensity or type of exercise for PCOS (266).

Osteoporosis

Physical activity is beneficial for bone health and osteoporosis prevention across the life-course. Exercise interventions increase bone mineral density (BMD) in prepubertal children (267) although, with active transport in mind, such benefits relate to weight bearing exercise such as walking/running (268). In adults aged >65 years, physical activity improves lumbar and hip bone mineral density (269). Higher doses of physical activity combining multiple exercise types were most effective. Exercise also reduces the risk of osteoporotic fractures (46). A meta-analysis of studies on post-menopausal women found similar associations between exercise training and BMD (270). More data is required to understand the impact on male osteoporosis risk (271).

Mental Health Disorders

Pollution

Cognitive Impairment

Evidence supports an association between both short- and long-term exposures to ambient pollution and cognitive impairment. A systematic review and meta-analysis found that long-term PM_{2.5} exposure was associated with a significant increase in the risk of all-cause dementia (pooled OR 1.3), Alzheimer's (OR 1.65) and Parkinson's disease (OR 1.17) (272). Additionally, PM₁₀ exposure was associated with an increased risk of vascular dementia (OR 1.12). Similar results have been reported for other pollutants including NO_x, NO₂, and O₃ (273). For Alzheimer's disease, a dose-response relationship has been noted with higher incidence of Alzheimer's disease in regions with higher pollution (274).

Childhood Neurodevelopmental Disorders

In utero exposure has also been linked to subsequent cognitive impairment and behavioural changes in childhood, including inattention, lower IQ scores, and symptoms of anxiety and depression (275). Prenatal exposure to pollutants is associated with increased risk of autism spectrum disorder (ASD) in epidemiological studies, with higher susceptibility reported in boys. Plausible biological mechanisms include damage to the blood-placental barrier and transfer of PM to the immature foetal brain, increased neuroinflammation and oxidative stress (276).

Post-natal traffic-related pollution exposure is similarly associated with structural brain changes in neuroimaging studies, as well as higher risk of ADHD and ASD (276). Higher pollution exposure across childhood is associated with lower academic achievement and cognitive performance.

Mood Disorders

A US study estimating exposure using residential address for children found that increased NO_x exposure was associated with a significant increase in symptoms of anxiety and depression at age 18, even after adjusting for confounders including socioeconomic status (277).

Both short- and long-term exposure to PM_{2.5} and NO₂ are associated with an increased risk of depression (278). A meta-analysis of cohort studies on long-term exposure air pollution included 23 articles on depression and five on anxiety in adults (279). Analysis of PM_{2.5} and risk of anxiety did not demonstrate a significantly increased risk, however PM_{2.5} and NO₂ were associated with an increased relative risk of depression (PM_{2.5} (RR: 1.10, 95% CI [1.00, 1.20]) and NO₂ (RR: 1.17, 95% CI [1.06, 1.31])). While no associations were found for CO, PM₁₀, SO₂ or O₃ pollutants, short-term exposure to these pollutants has been shown to increase risk of depression (278). An in-depth analysis of 30 studies on stress and anxiety disorders was consistent with Cao et al.'s (279) meta-analysis finding no significant increase in risk of anxiety or psychological stress with PM₁₀, PM_{2.5} or NO₂ (280).

Furthermore, short-term increases in exposure to PM_{2.5} and PM₁₀ of 10 µg/m³ are associated with 2% and 1% increases in risk of attempted suicide respectively (281).

In analysis of three cohorts, exposure to PM₁₀ in the second trimester is associated with an increased odds of postpartum depression (OR 1.26) (282).

Psychosis

A meta-analysis of ten studies found a highly statistically significant (albeit small effect size) increased risk of hospital admission for schizophrenia per 10 µg/m³ increase in short-term exposure to NO₂ (RR 1.029, 95% CI 1.016-1.041 p<0.001) (283).

Sleep Disorders

We did not identify any systematic review or meta-analysis on pollution and sleep disorders, however a cross-sectional study in the UK Biobank cohort found that PM_{2.5} was associated with an increased risk of sleep disorders (OR 2.39; 95% CI 1.64-3.48 per 10 µg/m³) (284). Both PM_{2.5} and PM₁₀ were associated with a significant reduction in sleep duration which remained after adjusting for co-variables including BMI, alcohol consumption, education level, and residential noise level. While these results should be interpreted with caution given the cross-sectional study design, insomnia is associated with a 27% higher risk of cognitive disorders (95% CI 1.16-1.39), providing a plausible

biological mechanism for the reported association between pollution and cognitive impairment (285).

Diet

Nutritional psychiatry is a relatively recent field of research, emerging from several studies that link dietary patterns to mental health. Emerging evidence suggests that the gut microbiome may modulate the 'gut-brain axis' - the two-way network connection between the central nervous system and the intestine (286). Many foods contain molecules that may influence brain development and neural signalling (287). Recent interventional studies provide evidence of the beneficial effect of plant-based diets, and diets with higher intake of fibre or polyphenols, on mental health. The epidemiological and experimental evidence is summarised below.

Depression

Epidemiological studies have identified an association between dietary patterns such as the Mediterranean diet, plant-based diets and lower risk of depression. An umbrella review identified sixteen meta-analyses of observational studies and two meta-analyses of RCTs reporting on the Mediterranean diet, DASH, vegetarian, Dietary Inflammatory Index (DII), Western diet, and low calorie or low fat diets (288). Higher adherence to the Mediterranean diet or a lower dietary inflammatory index (lower intake of inflammation-associated foods) was associated with lower risk of depression. Weak or no evidence was found for the DASH, vegetarian, Western or other diets. O'Neil et al. (289) performed a systematic review of 12 cross-sectional or prospective cohort studies that looked at children and adolescents (age range 4.5-18 years). Higher diet quality was associated with significantly better mental health, and unhealthy dietary patterns were associated with worse mental health, although the predominantly cross-sectional design of these studies cannot rule out reverse causality. In adults, a meta-analysis of 13 observational studies demonstrated a significant association between a healthy diet pattern (higher fruit, vegetable, fish and wholegrain intake) and reduced odds of depression (OR 0.84| 95% CI 0.76-0.92 $p < 0.001$) (290). Observational studies on the Mediterranean diet have also been synthesised (291). High adherence to a Mediterranean diet was associated with reduced risk for depression (RR 0.68).

Interventional trials demonstrate that following a Mediterranean diet and/or adding Mediterranean-like supplements can reduce the risk of depression, and improve depressive symptoms (292–295). A systematic review of RCTs on low carbohydrate and ketogenic diets found no evidence that either diet was superior to control in modifying mood, fatigue, or QoL (296). An RCT with six-month follow up distributed food hampers and provided workshops to encourage a Mediterranean diet alongside fish oil supplements, while a control group attended social group events (292). Authors reported a significantly higher consumption of fruit, vegetables, nuts, legumes, and wholegrains and less red meat and poultry in the intervention group at three months. The intervention group had significantly reduced depressive symptoms at three months, and this was sustained at six months ($p = 0.03$). Secondary analyses demonstrated a correlation between reduced depression and increased Mediterranean diet adherence and increased consumption of vegetables and nuts.

The SMILES trial was a 12-week RCT where 33 participants with moderate to severe depression received either dietary support or social support sessions (293). Whilst criticised for its reporting of blinding and recruitment methods as well as its small sample size, it demonstrated a significant decrease in interviewer-determined depression symptoms and an increase in remission rates in those receiving nutritional counselling and advice compared to the control group with a number needed to treat of 4.1 (297).

Lastly, a 14-day RCT randomised young adults to receive either usual diet (control), prompted consumption (text reminders and fruit and vegetable voucher), or fruit and vegetable delivery with two additional daily servings on top of their normal diet. Self-reported depression and anxiety symptoms improved in the fruit and vegetable delivery group (295).

Cognitive Impairment

Epidemiological evidence links dietary patterns to cognitive impairment. A meta-analysis of 22 observational studies demonstrated that high adherence to a Mediterranean diet was consistently associated with a reduced risk of cognitive impairment (RR 0.60 95% CI 0.43-0.83) (291). The evidence for dietary components of the EAT-Lancet reference diet on cognition have been summarised by Dalile et al. (298). They concluded that lack of evidence limits definitive conclusions but that wholegrains, fruit and vegetables, and nuts may improve cognitive function. Longitudinal cohort studies support the beneficial relationship between fruit and vegetable intake and improved cognition (299).

Two international trials provided an adult cohort of 27,860 participants with high cardiovascular risk to examine diet quality (using a healthy eating index) and cognition (mini-mental state examination score) (300). Healthier, higher scoring foods included vegetables, fruits, nuts, and soy proteins. During the 56 month follow up, those in the healthiest dietary quintile had a significantly reduced risk of cognitive decline compared with the unhealthiest quintile (HR 0.76). Another study examined polyphenol dietary intake by measuring excretion in urine (301). The cross-sectional study of 447 asymptomatic elderly adults with high cardiovascular risk analysed food intake, urinary polyphenols, and cognitive scores. They found that increased intake of antioxidant-rich foods and in particular polyphenols, was associated with better cognitive function.

This evidence has led to a proposed new dietary combination known as the Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) – a mix of anti-hypertensive and Mediterranean diet patterns that focuses on foods that might protect against neurodegeneration by increasing plant-based foods (vegetables, fruits, leafy greens, berries, nuts, beans, poultry, fish, olive oil) and reducing unhealthy foods (red meat and other foods high in saturated and trans-fat) (302). Greater adherence to it is associated with a slower rate of cognitive decline across cognitive domains ($p < 0.0001$), even after adjustment for cardiovascular disease risk factors, depression, obesity and age. This positive association has been replicated in a 12-year longitudinal cohort study of Australian 60- to 64-year-olds, in whom high adherence to the MIND diet is associated with a lower odds of 12-year cognitive impairment (adjusted OR 0.47) compared to medium and low intake (303). These studies suggest that diet may play a role in both preventing and delaying the onset of dementia. Conducting RCTs on whole dietary patterns and long-term outcomes such as cognition can be challenging, and few such trials exist. Evidence is strongest for the Mediterranean diet. RCT evidence demonstrates the benefit of a Mediterranean diet on cognition compared to a low-fat control diet (304). Valls-Pedret et al. allocated participants to consume the Mediterranean diet with either antioxidant rich foods (extra virgin olive oil 1L/week) or mixed nuts (30g/day) or control (advice) in Spain. The Mediterranean diet and olive oil group scored better on composite frontal and global cognition scores compared with control ($p = 0.003$ and $p = 0.005$ respectively). The Mediterranean diet and nuts group performed significantly better compared with control for memory composite scores ($p = 0.04$). The NU-AGE trial (running over a year in five European countries with 612 participants (305)) found that adherence to a Mediterranean diet was correlated with changes in the gut microbiome, with increases in certain bacterial taxa that favour lower inflammatory markers and better cognition.

Most RCTs are spread thinly across different foods or food-extracts including flavonoids, fruit extracts, cocoa, and nuts with weak or conflicting results (299). A matched non-randomised control experiment included 23 overweight but otherwise healthy elderly participants in each group (306). Resveratrol, a plant-based polyphenol, was taken for 26 weeks versus placebo and demonstrated improved retention of words over 30 mins compared to baseline ($p = 0.038$).

In summary, diet is a modifiable risk factor for depression and cognitive impairment. A paucity of interventional research limits conclusions regarding causality. Epidemiological studies of dietary patterns and food groups identify the Mediterranean, MIND diet, and fruit and vegetable intake as superior to other diets or targeted nutritional approaches.

Physical Activity

Depression

There is strong evidence that exercise is an effective treatment for depression. A meta-analysis of RCTs identified 218 studies and calculated pooled estimates by exercise type compared to active control as well as assessing the risk of dropouts to determine acceptability of the intervention (307). They found that exercise had a moderate effect on depression either alone or in combination with pharmacotherapy or cognitive behavioural therapy. The most effective modalities included jogging, and a dose-response relationship demonstrated greater benefit with increasing intensity. These results are supported by epidemiological evidence. A systematic review of 30 prospective longitudinal studies found that physical activity was associated with a lower risk of developing depression, even for brief duration, although increasing time spent exercising was associated with a greater reduction in risk supporting a preventative role (308).

The role of physical activity in grief has also been reviewed, examining experimental and observational studies (309). Physical activity was reported as beneficial in building and maintaining social relationships as well as reducing levels of depression, stress, loneliness and PTSD.

Perinatal Period

A meta-analysis of 48 RCTs showed that exercise was associated with significantly reduced perinatal depression scores compared to control ($p < 0.0001$) (310). Sub-group analyses demonstrated that exercise was effective at preventing and treating postpartum depression. Another RCT meta-analysis examined the effectiveness of exercise for treating postpartum depression: 12 RCTs including a total of 1260 women compared exercise to usual care (311). Exercise reduced depressive symptoms across all modalities compared with usual care. This included pram walking, yoga and supervised mixed exercise.

Anxiety

A systematic review and meta-analysis of 15 RCTs assessed the impact of exercise on individuals diagnosed with anxiety disorders or with heightened anxiety assessed using a validated scale (312). Aerobic exercise was found to reduce anxiety compared to waiting list controls and higher intensity exercise was found to be more effective than low intensity although few studies followed up patients long-term to determine persistence in effect.

Other Mental Illness

There is insufficient evidence on other mental health outcomes. A systematic review of eight studies examined individuals with schizophrenia, schizophrenia-like psychosis, schizoaffective disorders and bipolar affective disorder and found no evidence that exercise improved symptoms of schizophrenia or co-existing anxiety or depression (313).

Active Transport in Green Spaces

In those aged 14-24, brief exposure to green spaces such as walking through parks improves mood and reduces anxiety in the short-term, although long-term evaluation is lacking (314). Studies also suggest mental health benefits for outdoor over indoor exercise, although data are sparse. A systematic review found seven studies of which only two reported a significant association between active commuting and reduced depression symptoms (315). Only one study was included from the UK (316). This longitudinal cohort study examined the difference in depressive symptoms in adults from the Biobank cohort. Adults without pre-existing depression who changed from inactive to active commuting reported significantly milder depressive symptoms compared to those who remained inactive. Future active travel studies should evaluate mental health outcomes to determine the possible benefits and most effective modality or duration.

Cognitive Impairment

Physical activity may modify cognitive function. In healthy populations, repeated physical activity is associated with a small but significant improvement in memory test performance (317). A scoping

review of RCTs on older adults with cognitive frailty found that exercise (modalities included flexibility, resistance, or balance training, or walking or cycling) was associated with significant improvements in cognitive function, frailty, and depression (318). Similarly, a systematic review and meta-analysis of prospective cohort studies reported that high amounts of physical activity in older adults resulted in a 22% decrease in all-cause dementia risk compared with those who were physical inactive ($p < 0.05$) (319). However, evidence is conflicting for walking activity. A meta-analysis of RCTs reported that walking interventions did not result in a significant improvement in cognitive function in older adults with mild cognitive impairment (320).

A meta-analysis demonstrates that exercise significantly improves physical function and neuropsychiatric symptoms in patients with Alzheimer's Disease (321). A non-significant trend was noted for cognitive function, and secondary analyses showed that aerobic exercise was significantly associated with improved MMSE test scores. A systematic review of quantitative and qualitative studies found a small but consistently positive effect of walking on depression, mood or other behavioural and psychological symptoms in patients with dementia, and reported positive experiences such as improved sleep, well-being, and maintaining "self-hood" (322). Evidence also supports the use of exercise to improve physical strength, balance and mobility in patients with dementia (323).

Sleep disorders are an important risk factor for depression, dementia, diabetes and cardiovascular disease. RCT evidence suggests that physical activity (all types) is effective at improving sleep (324). People suffering with chronic fatigue syndrome (characterised by post-exertional fatigue and often severe cognitive symptoms, pain and mental illness) may also benefit from physical activity to improve symptoms, especially fatigue. However, available evidence suggests this benefit is no greater than cognitive behavioural therapy (325).

In summary, physical activity is an effective treatment for depression, and may improve cognitive function and lower the risk of dementia. Further research is required to determine the long-term impact of physical activity on anxiety. Combining physical activity with exposure to green spaces may provide additional mental health benefits.

Glossary & Abbreviations

Ambient pollution	Outdoor air pollution
BMI	Body Mass Index
CO	Carbon Monoxide: A poisonous gas produced by incomplete combustion of fuel.
CO ₂	Carbon Dioxide
COMEAP	Committee on the Medical Effects of Air Pollutants
CHD	Coronary Heart Disease
DASH diet	Dietary Approaches to Stop Hypertension: low in salt, rich in fruits, vegetables wholegrains, low-fat dairy and lean protein.
DALYs	Disability Adjusted Life Years
Dietary Inflammatory Index	Research-based dietary score summarising the impact of the diet on six inflammatory markers (IL1B, 4, 6, 10, TNF-alpha, and CRP). It positively scores anti-inflammatory foods such as oily fish, nuts, berries, ginger, leafy greens, green tea, tomatoes, extra virgin olive oil, dark chocolate and fibre and negatively scores processed meats, sugar sweetened beverages, high saturated fat or fried foods.
EAT-Lancet diet	A planetary health diet developed to meet both human and planetary needs. It is plant-based but does not exclude meat and dairy completely.
Fibre	Umbrella term for non-digestible carbohydrates from plants.
GBD	Global Burden of Disease
GHG	Greenhouse gas
HR	Hazard Ratio
IHME	Institute for Health Metrics and Evaluation
IHD	Ischaemic Heart Disease
IPCC	Intergovernmental Panel on Climate Change
Ketogenic Diet	A high fat, adequate protein, low carbohydrate diet that mimics the metabolism of the fasting state. Initially developed to treat epilepsy, but has gained wider attention as an approach for weight loss.
Mediterranean Diet	A diet of a type traditional in Mediterranean countries, characterized by a high consumption of vegetables and olive oil and moderate consumption of protein
MIND Diet	The Mediterranean-DASH Diet Intervention for Neurodegenerative Delay (MIND) diet: designed to target the health of the aging brain and, specifically, Dementia and Alzheimer's. Encourages increased consumption of wholegrains, vegetables, particularly green leafy vegetables, nuts, beans, berries, poultry, fish, olive oil and reduced intake of foods high unsaturated or trans-fat, alcohol or sugar.
NHS	National Health Service
NCD	Non-communicable disease
NO _x , NO ₂	Nitrogen oxides (produced from combustion processes from power stations, motor vehicles and other industrial and domestic combustion processes). NO ₂ is the most common form of nitrogen oxide in air.
O ₃	Ozone (at ground level, is a toxic air pollutant and (elsewhere) a greenhouse gas. It is a secondary pollutant from NO _x and volatile organic compounds.
OR	Odds Ratio
Plant-based	Umbrella term for diets that emphasise foods from plants with few or no ingredients from animals. Includes vegetarian, vegan and Mediterranean diets.
PM, PM _{0.1} , PM _{2.5} , PM ₁₀	Particulate Matter (where particles are less than 10 micrometres in diameter (PM ₁₀), less than 2.5 micrometres in diameter (PM _{2.5}), or ultrafine (less than 0.1 micrometer).
Polyphenols	Category of naturally occurring compounds found in plant foods with anti-oxidant properties.
RR	Relative Risk

SO ₂	Sulphur dioxide (is emitted from electricity generation, industrial, and domestic fuel combustion).
T2DM	Type II Diabetes Mellitus
Vegan	The practice of abstaining from the consumption of all foods from animal origin including meat, fish, poultry, eggs, dairy and honey.
Vegetarian	The practice of abstaining from the consumption of some foods from animal origin including meat, fish, and poultry.
Western Diet	Modern dietary pattern characterised by high intake of red meat, high fat foods, refined sugars, and processed foods.
WHO	World Health Organisation
95% CI	95% Confidence Interval

References

1. The Climate Change Act 2008 (2050 Target Amendment) Order [Internet]. 2019. [Accessed 26th January 2025]. Available from: <https://www.legislation.gov.uk/ukxi/2019/1056/introduction/made>
2. Copernicus Climate Change Service. The 2024 Annual Climate Summary: Global Climate Highlights 2024 [Internet]. 2025. [Accessed 8th April 2025]. Available from: <https://climate.copernicus.eu/global-climate-highlights-2024#:~:text=2024%20was%20the%20first%20year,above%20the%20pre%2Dindustrial%20level>
3. Hansen JE, Sato M, Simons L, Nazarenko LS, Sangha I, Kharecha P, et al. Global warming in the pipeline. *Oxford Open Climate Change*. 2023;3(1):kgad008.
4. Ipsos. Ipsos Issues Index: September 2023 [Internet]. 2023. [Accessed 8th April 2025]. Available from: <https://www.ipsos.com/en-uk/ipsos-issues-index-september-2023>
5. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 [Internet]. 2019. [Accessed 23rd January 2024]. Available from: <http://ghdx.healthdata.org/gbd-results-tool>
6. Milner J, Green R, Dangour AD, Haines A, Chalabi Z, Spadaro J, et al. Health effects of adopting low greenhouse gas emission diets in the UK. *BMJ Open*. 2015;5(4):e007364.
7. Jarrett J, Woodcock J, Griffiths UK, Chalabi Z, Edwards P, Roberts I, et al. Effect of increasing active travel in urban England and Wales on costs to the National Health Service. *Lancet*. 2012;379(9832):2198–2205.
8. Milner J, Hamilton I, Woodcock J, Williams M, Davies M, Wilkinson P, et al. Health benefits of policies to reduce carbon emissions. *BMJ*. 2020;368:l6758.
9. Williams ML, Lott MC, Kitwiroon N, Dajnak D, Walton H, Holland M, et al. The Lancet Countdown on health benefits from the UK Climate Change Act: a modelling study for Great Britain. *Lancet Planet Health*. 2018;2(5):e202–13.
10. Montgomery H. Final call: Climate change and us. *J R Coll Physicians Edinb*. 2024;54(1):101-104.
11. World Bank Organisation. The World by Income and Region. [Internet]. 2023 [Accessed 3rd February 2024]. Available from: <https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html>
12. Environmental Research Group ICL. Impacts of air pollution across the life course – evidence highlight note [Internet]. 2023. [Accessed 8th April 2025]. Available from: <https://www.london.gov.uk/sites/default/files/2023-04/Imperial%20College%20London%20Projects%20-%20impacts%20of%20air%20pollution%20across%20the%20life%20course%20%E2%80%93%20evidence%20highlight%20note.pdf>
13. Lelieveld J, Haines A, Burnett R, Tonne C, Klingmüller K, Münzel T, et al. Air pollution deaths attributable to fossil fuels: observational and modelling study. *BMJ*. 2023;383:e077784.
14. Vohra K, Vodonos A, Schwartz J, Marais EA, Sulprizio MP, Mickley LJ, Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem *Environ Res*. 2021;195:110754.
15. Blake E, Wentworth J, Parliamentary Office of Science and Technology (POST). Urban Outdoor Air Quality [Internet]. 2023. [Accessed 8th April 2025]. Available from: <https://post.parliament.uk/research-briefings/post-pn-0691/>
16. Mittal L. 2019 London Air Quality Network Summary Report [Internet]. 2021. [Accessed 8th April 2025]. Available from: https://www.londonair.org.uk/london/asp/reportdetail.asp?ReportID=2019laqnr&ReportType=Latest_Report
17. Smith RB, Fecht D, Gulliver J, Beevers SD, Dajnak D, Blangiardo M, et al. Impact of London's road traffic air and noise pollution on birth weight: retrospective population based cohort study. *BMJ*. 2017;359:j5299.

18. Ghosh R, Causey K, Burkart K, Wozniak S, Cohen A, Brauer M. Ambient and household PM_{2.5} pollution and adverse perinatal outcomes: A meta-regression and analysis of attributable global burden for 204 countries and territories. *PLoS Med.* 2021;18(9):e1003718.
19. Zhang J, Cai Z, Ma C, Xiong J, Li H. Impacts of Outdoor Air Pollution on Human Semen Quality: A Meta-Analysis and Systematic Review. *Biomed Res Int.* 2020;2020:7528901.
20. Malley CS, Kuylensstierna JC, Vallack HW, Henze DK, Blencowe H, Ashmore MR. Preterm birth associated with maternal fine particulate matter exposure: A global, regional and national assessment. *Env Int.* 2017;101:173–82.
21. Varaden D, Leidland E, Lim S, Barratt B. “I am an air quality scientist”— Using citizen science to characterise school children’s exposure to air pollution. *Environ Res.* 2021;201:111536.
22. Farzan SF, Habre R, Danza P, Lurmann F, Gauderman WJ, Avol E, et al. Childhood traffic-related air pollution and adverse changes in subclinical atherosclerosis measures from childhood to adulthood. *Env Health.* 2021;20(1):44.
23. Karamanos A, Lu Y, Mudway IS, Ayis S, Kelly FJ, Beevers SD, et al. Associations between air pollutants and blood pressure in an ethnically diverse cohort of adolescents in London, England. *PLOS ONE.* 2023;18(2):e0279719.
24. Mudway IS, Dundas I, Wood HE, Marlin N, Jamaludin JB, Bremner SA, et al. Impact of London’s low emission zone on air quality and children’s respiratory health: a sequential annual cross-sectional study. *Lancet Public Health.* 2019;4(1):e28–40.
25. Gauderman WJ, Urman R, Avol E, Berhane K, McConnell R, Rappaport E, et al. Association of improved air quality with lung development in children. *N Engl J Med.* 2015;372(10):905–13.
26. Orellano P, Quaranta N, Reynoso J, Balbi B, Vasquez J. Effect of outdoor air pollution on asthma exacerbations in children and adults: Systematic review and multilevel meta-analysis. *PLOS ONE.* 2017;12(3):e0174050.
27. Evangelopoulos D, Dajnak D, Wood D, Fecht D, Walton H. Health Impact Assessment of Current and Past Air Pollution on Asthma in London [Internet]. 2022. [Accessed 8th April 2025]. Available from: https://www.london.gov.uk/sites/default/files/hia_asthma_air_pollution_in_london.pdf
28. de Prado Bert P, Mercader EMH, Pujol J, Sunyer J, Mortamais M. The Effects of Air Pollution on the Brain: a Review of Studies Interfacing Environmental Epidemiology and Neuroimaging. *Curr Env Health Rep.* 2018;5(3):351–64.
29. Roberts S, Arseneault L, Barratt B, Beevers S, Danese A, Odgers CL, et al. Exploration of NO₂ and PM_{2.5} air pollution and mental health problems using high-resolution data in London-based children from a UK longitudinal cohort study. *Psychiatry Res.* 2019;272:8–17.
30. Ronaldson A, Arias de la Torre J, Ashworth M, Hansell AL, Hotopf M, Mudway I, et al. Associations between air pollution and multimorbidity in the UK Biobank: A cross-sectional study. *Front Public Health.* 2022;10:1035415.
31. Bakolis I, Hammoud R, Stewart R, Beevers S, Dajnak D, MacCrimmon S, et al. Mental health consequences of urban air pollution: prospective population-based longitudinal survey. *Soc Psychiatry Psychiatr Epidemiol.* 2021;56(9):1587–99.
32. Committee on the Medical Effects of Air Pollutants. Cognitive decline, dementia and air pollution: a report by the Committee on the Medical Effects of Air Pollutants [Internet]. 2022. [Accessed 8th April 2025]. Available from: <https://www.gov.uk/government/publications/air-pollution-cognitive-decline-and-dementia>
33. Yang WS, Wang X, Deng Q, Fan WY, Wang WY. An evidence-based appraisal of global association between air pollution and risk of stroke. *Int J Cardiol.* 2014;175(2):307–13.
34. Simoni M, Baldacci S, Maio S, Cerrai S, Sarno G, Viegi G. Adverse effects of outdoor pollution in the elderly. *J Thorac Dis.* 2015;7(1):34–45.
35. Walton H, Dajnak D, Beevers S, Williams M, Watkiss P, Hunt A. Understanding the Health Impacts of Air Pollution in London [Internet]. 2015. [Accessed 8th April 2025]. Available from: https://www.london.gov.uk/sites/default/files/hia_in_london_kingsreport_14072015_final.pdf

36. Committee on the Medical Effects of Air Pollutants. Long-Term Exposure to Air Pollution: Effect on Mortality [Internet]. 2009. [Accessed 8th April 2025]. Available from: <https://www.gov.uk/government/publications/comeap-long-term-exposure-to-air-pollution-effect-on-mortality>
37. European Public Health Alliance. The Public Health and Environmental Impacts of Cooking with Gas [Internet]. 2023. [Accessed 18th April 2025]. Available from: <https://epha.org/wp-content/uploads/2023/06/the-public-health-and-environmental-impacts-of-cooking-with-gas.pdf>
38. Office for Health Improvement & Disparities. Physical activity: applying All Our Health [Internet]. 2022. [Accessed 8th April 2025]. Available from: <https://www.gov.uk/government/publications/physical-activity-applying-all-our-health/physical-activity-applying-all-our-health>
39. Woodcock J, Givoni M, Morgan AS. Health impact modelling of active travel visions for England and Wales using an Integrated Transport and Health Impact Modelling Tool (ITHIM). PLOS ONE. 2013;8(1):e51462.
40. Woodcock J, Edwards P, Tonne C, Armstrong BG, Ashiru O, Banister D, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. Lancet. 2009;374(9705):1930–43.
41. Welsh C, Celis-Morales CA, Ho F, Lyall DM, Mackay D, Ferguson L, et al. Association of injury related hospital admissions with commuting by bicycle in the UK: prospective population based study. BMJ. 2020;368:m336.
42. Kelly P, Williamson C, Niven AG, Hunter R, Mutrie N, Richards J. Walking on sunshine: scoping review of the evidence for walking and mental health. Br J Sports Med. 2018;52(12):800–6.
43. Avila-Palencia I, de Nazelle A, Cole-Hunter T, Donaire-Gonzalez D, Jerrett M, Rodriguez DA, et al. The relationship between bicycle commuting and perceived stress: a cross-sectional study. BMJ Open. 2017;7(6):e013542.
44. Nogueira RC, Weeks BK, Beck BR. Exercise to improve pediatric bone and fat: a systematic review and meta-analysis. Med Sci Sports Exerc. 2014;46(3):610–21.
45. Hu K, Cassimatis M, Girgis C. Exercise and Musculoskeletal Health in Men With Low Bone Mineral Density: A Systematic Review. Arch Rehabil Res Clin Transl. 2023;6(1):100313.
46. Hoffmann I, Kohl M, von Stengel S, Jakob F, Kerschman-Schindl K, Lange U, et al. Exercise and the prevention of major osteoporotic fractures in adults: a systematic review and meta-analysis with special emphasis on intensity progression and study duration. Osteoporos Int. 2023;34(1):15–28.
47. Mueller N, Rojas-Rueda D, Cole-Hunter T, de Nazelle A, Dons E, Gerike R, et al. Health impact assessment of active transportation: A systematic review. Prev Med. 2015;76:103–14.
48. Andersen ZJ, de Nazelle A, Mendez MA, Garcia-Aymerich J, Hertel O, Tjønneland A, et al. A study of the combined effects of physical activity and air pollution on mortality in elderly urban residents: the Danish Diet, Cancer, and Health Cohort. Env Health Perspect. 2015;123(6):557–63.
49. Tainio M, de Nazelle AJ, Götschi T, Kahlmeier S, Rojas-Rueda D, Nieuwenhuijsen MJ, et al. Can air pollution negate the health benefits of cycling and walking? Prev Med. 2016;87:233–6.
50. Timmers VRJH, Achten PAJ. Non-exhaust PM emissions from electric vehicles. Atmos Environ. 2016;134:10–7.
51. Tiesto I. Carbon dioxide emissions from the transportation sector worldwide from 2000 to 2022, by sub sector [Internet]. 2024. [Accessed 8th April 2025]. Available from: [https://www.statista.com/statistics/1387814/carbon-dioxide-emissions-transport-subsector-worldwide/#:~:text=Global%20transportation%2Drelated%20emissions%20increased,of%20carbon%20dioxide%20\(GtCO%E2%82%82\)](https://www.statista.com/statistics/1387814/carbon-dioxide-emissions-transport-subsector-worldwide/#:~:text=Global%20transportation%2Drelated%20emissions%20increased,of%20carbon%20dioxide%20(GtCO%E2%82%82))
52. Department for Transport. Official Statistics: Transport and environment statistics 2022 [Internet]. 2022. [Accessed 8th April 2025]. Available from: <https://www.gov.uk/government/statistics/transport-and-environment-statistics-2022/#:~:text=transport%20is%20the%20largest%20emitting,each%20local%20authority%20in%202020>

53. Department for Transport. Official Statistics: Greenhouse gas emissions from transport in 2022 [Internet]. 2024. [Accessed 8th April 2025]. Available from: <https://www.gov.uk/government/statistics/transport-and-environment-statistics-2024/greenhouse-gas-emissions-from-transport-in-2022>
54. NHS Digital. Health Survey for England, 2021 part 1 [Internet]. 2022. [Accessed 8th April 2025]. Available from: <https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2021>
55. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019;393(10184):1958–72.
56. Henderson N, Sampson C. The impact of higher uptake of plant-based diets in England: model-based estimates of health care resource use and health-related quality of life. 2023.
57. Eustachio Colombo P, Milner J, Scheelbeek PFD, Taylor A, Parlesak A, Kastner T, et al. Pathways to “5-a-day”: modeling the health impacts and environmental footprints of meeting the target for fruit and vegetable intake in the United Kingdom. *Am J Clin Nutr*. 2021;114(2):530–9.
58. Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, et al. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. *Int J Epidemiol*. 2017;46(3):1029–56.
59. World Health Organisation. Plant-based diets and their impact on health, sustainability and the environment: a review of the evidence [Internet]. 2021. [Accessed 8th April 2025]. Available from: <https://www.who.int/europe/publications/i/item/WHO-EURO-2021-4007-43766-61591>
60. Key TJ, Papier K, Tong TYN. Plant-based diets and long-term health: findings from the EPIC-Oxford study. *Proc Nutr Soc*. 2022;81(2):190–8.
61. British Nutrition Foundation. A healthy, sustainable diet [Internet]. 2023. [Accessed 8th May 2025]. Available from: <https://www.nutrition.org.uk/creating-a-healthy-diet/eating-sustainably/>
62. Wang Y, Liu B, Han H, Hu Y, Zhu L, Rimm EB, et al. Associations between plant-based dietary patterns and risks of type 2 diabetes, cardiovascular disease, cancer, and mortality – a systematic review and meta-analysis. *Nutr J*. 2023;22(1):46.
63. Zong G, Gao A, Hu FB, Sun Q. Whole Grain Intake and Mortality From All Causes, Cardiovascular Disease, and Cancer: A Meta-Analysis of Prospective Cohort Studies. *Circulation*. 2016 Jun 14;133(24):2370–80.
64. Afshin A, Micha R, Khatibzadeh S, Mozaffarian D. Consumption of nuts and legumes and risk of incident ischemic heart disease, stroke, and diabetes: a systematic review and meta-analysis. *Am J Clin Nutr*. 2014;100(1):278–88.
65. Pan A, Sun Q, Bernstein AM, Schulze MB, Manson JE, Stampfer MJ, et al. Red meat consumption and mortality: results from 2 prospective cohort studies. *Arch Intern Med*. 2012;172(7):555–63.
66. Pan A, Sun Q, Bernstein AM, Manson JE, Willett WC, Hu FB. Changes in red meat consumption and subsequent risk of type 2 diabetes mellitus: three cohorts of US men and women. *JAMA Intern Med*. 2013;173(14):1328–35.
67. The Agriculture Mortgage Corporation. Deforestation Technical Note [Internet]. 2023. [Accessed 18th April 2025]. Available from: www.amconline.co.uk/assets/documents/pdf/AMC_Deforestation_Technical%20Note_FINAL.pdf
68. Friel S, Dangour AD, Garnett T, Lock K, Chalabi Z, Roberts I, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture. *Lancet*. 2009;374(9706):2016–25.
69. Department for Environment Food & Rural Affairs. National Food Strategy: The Plan [Internet]. 2021. [Accessed 8th April 2025]. Available from: <https://www.nationalfoodstrategy.org/>
70. Springmann M, Wiebe K, Mason-D’Croz D, Sulser TB, Rayner M, Scarborough P. Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. *Lancet Planet Health*. 2018;2(10):e451–61.
71. Nelson ME, Hamm MW, Hu FB, Abrams SA, Griffin TS. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. *Adv Nutr*. 2016;7(6):1005–25.

72. Jarmul S, Dangour AD, Green R, Liew Z, Haines A, Scheelbeek PFD. Climate change mitigation through dietary change: a systematic review of empirical and modelling studies on the environmental footprints and health effects of 'sustainable diets'. *Env Res Lett*. 2020;15:123014.
73. Scheelbeek P, Green R, Papier K, Knuppel A, Alae-Carew C, Balkwill A, et al. Health impacts and environmental footprints of diets that meet the Eatwell Guide recommendations: analyses of multiple UK studies. *BMJ Open*. 2020;10(8):e037554.
74. Springmann M, Godfray HC, Rayner M, Scarborough P. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proc Natl Acad Sci U A*. 2016;113(15):4146–51.
75. Department for Environment Food & Rural Affairs. United Kingdom Food Security Report 2021: Theme 4: Food Security at Household Level [Internet]. 2024. [Accessed 8th April 2025]. Available from: <https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021/united-kingdom-food-security-report-2021-theme-4-food-security-at-household-level>
76. Cohen AJ, Brauer M, Burnett R, Anderson HR, Frostad J, Estep K, et al. Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. *Lancet*. 2017;389(10082):1907–18.
77. Park J, Kim HJ, Lee CH, Lee CH, Lee HW. Impact of long-term exposure to ambient air pollution on the incidence of chronic obstructive pulmonary disease: A systematic review and meta-analysis. *Environ Res*. 2021;194:110703.
78. Yang BY, Qian Z, Howard SW, Vaughn MG, Fan SJ, Liu KK, et al. Global association between ambient air pollution and blood pressure: A systematic review and meta-analysis. *Environ Pollut*. 2018;235:576–88.
79. Hvidtfeldt UA, Severi G, Andersen ZJ, Atkinson R, Bauwelinck M, Bellander T, et al. Long-term low-level ambient air pollution exposure and risk of lung cancer – A pooled analysis of 7 European cohorts. *Environ Int*. 2021;146:106249.
80. Pope CA, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA*. 2002;287(9):1132–41.
81. Kim HB, Shim JY, Park B, Lee YJ. Long-Term Exposure to Air Pollutants and Cancer Mortality: A Meta-Analysis of Cohort Studies. *Int J Environ Res Public Health*. 2018;15(11):2608.
82. Gakidou E, Afshin A, Abajobir AA, Abate KH, Abbafati C, Abbas KM, et al. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390(10100):1345–422.
83. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. 2012;380(9838):219–29.
84. Kelly P, Kahlmeier S, Götschi T, Orsini N, Richards J, Roberts N, et al. Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. *Int J Behav Nutr Phys Act*. 2014;11:132.
85. Oja P, Kelly P, Pedisic Z, Titze S, Bauman A, Foster C, et al. Associations of specific types of sports and exercise with all-cause and cardiovascular-disease mortality: a cohort study of 80 306 British adults. *Br J Sports Med*. 2017;51(10):812–7.
86. Andersen ZJ, de Nazelle A, Mendez MA, Garcia-Aymerich J, Hertel O, Tjønneland A, et al. A study of the combined effects of physical activity and air pollution on mortality in elderly urban residents: the Danish Diet, Cancer, and Health Cohort. *Env Health Perspect*. 2015;123(6):557–63.
87. Intergovernmental Panel on Climate Change. Global warming of 1.5°C: An IPCC Special Report [Internet]. 2018. [Accessed 8th April 2025]. Available from: <https://www.ipcc.ch/sr15/>
88. Intergovernmental Panel on Climate Change. Climate change: a threat to human wellbeing and health of the planet. Taking action now can secure our future [Internet]. 2022. [Accessed 8th April 2025]. Available from: <https://www.ipcc.ch/2022/02/28/pr-wgii-ar6/>
89. Ripple WJ, Wolf C, Gregg JW, Rockström J, Mann ME, Oreskes N, et al. The 2024 state of the climate report: Perilous times on planet Earth. *Bioscience*. 2024;74(12):812-824.

90. Intergovernmental Panel on Climate Change. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Internet]. 2023. [Accessed 8th April 2025]. Available from: <https://www.ipcc.ch/assessment-report/ar6/>
91. Copernicus. Copernicus: June 2024 marks 12th month of global temperature reaching 1.5°C above pre-industrial [Internet]. 2024 [Accessed 8th April 2025]. Available from: <https://climate.copernicus.eu/copernicus-june-2024-marks-12th-month-global-temperature-reaching-15degc-above-pre-industrial>
92. Xu C, Kohler TA, Lenton TM, Svenning JC, Scheffer M. Future of the human climate niche. *Proc Natl Acad Sci USA*. 2020; 117(21):11350-11355.
93. Romanello M, di Napoli C, Green C, Kennard H, Lampard P, Scamman D, et al. The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *Lancet*. 2023;402(10419):2346-2394.
94. Lloyd's. Lloyd's new data tool highlights vulnerability of the global economy to extreme weather [Internet]. 2023. [Accessed 8th April 2025]. Available from: <https://www.lloyds.com/about-lloyds/media-centre/press-releases/lloyds-new-data-tool-highlights-vulnerability-of-the-global-economy-to-extreme-weather>
95. Jennings N, Fecht D, De Matteis S. Co-benefits of climate change mitigation in the UK: What issues are the UK public concerned about and how can action on climate change help to address them? [Internet]. 2019. [Accessed 8th April 2025]. Available from: <https://www.imperial.ac.uk/grantham/publications/all-publications/co-benefits-of-climate-change-mitigation-in-the-uk-what-issues-are-the-uk-public-concerned-about-and-how-can-action-on-climate-change-help-to-address-them.php#:~:text=Benefits%20of%20climate%20change%20mitigation%20for%20the%20UK%20include%20improvements,redution%20in%20poverty%20and%20inequality>
96. Committee on Climate Change. Reducing UK emissions: 2018 Progress Report to Parliament [Internet]. 2018. [Accessed 8th April 2025]. Available from: <https://www.theccc.org.uk/wp-content/uploads/2018/06/CCC-2018-Progress-Report-to-Parliament.pdf>
97. Marmot M AJ. Health Equity in England: The Marmot Review 10 Years On [Internet]. 2020. [Accessed 8th April 2025]. Available from: <https://www.instituteofhealthequity.org/resources-reports/marmot-review-10-years-on>
98. Olsen JR, Mitchell R, Mutrie N, Foley L, Ogilvie D. Population levels of, and inequalities in, active travel: A national, cross-sectional study of adults in Scotland. *Prev Med Rep*. 2017 Dec;8:129–34.
99. Rivas I, Kumar P, Hagen-Zanker A. Exposure to air pollutants during commuting in London: Are there inequalities among different socio-economic groups? *Env Int*. 2017;101:143–57.
100. Dowler EA, Kneafsey M, Lambie H, Inman A, Collier R. Thinking about 'food security': engaging with UK consumers. *Crit Public Health*. 2011;21(4):403–16.
101. Office for National Statistics. Dataset: The impact of winter pressures on different population groups in Great Britain: impacts of the cost of living on behaviours and health [Internet]. 2024. [Accessed 8th April 2025]. Available from: <https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/datasets/theimpactofwinterpressuresondifferentpopulationgroupsingreatbritainimpactsofthecostoflivingonbehavioursandhealth>
102. Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, et al. Lancet and University College London Institute for Global Health Commission: Managing the health effects of climate change. *Lancet*. 2009;373(9676):1693–733.
103. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, et al. Standardization of Spirometry 2019 Update: An Official American Thoracic Society and European Respiratory Society Technical Statement. *Am J Respir Crit Care Med*. 2019;200(8):e70–88.
104. Schultz ES, Litonjua AA, Melén E. Effects of Long-Term Exposure to Traffic-Related Air Pollution on Lung Function in Children. *Curr Allergy Asthma Rep*. 2017;17(6):41.

105. Zhang W, Ma R, Wang Y, Jiang N, Zhang Y, Li T. The relationship between particulate matter and lung function of children: A systematic review and meta-analysis. *Environ Pollut.* 2022;309:119735.
106. da Silveira Fleck A, Sadoine ML, Buteau S, Suarathana E, Debia M, Smargiassi A. Environmental and Occupational Short-Term Exposure to Airborne Particles and FEV1 and FVC in Healthy Adults: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health.* 2021;18(20):10571.
107. Atkinson CE, Kesic MJ, Hernandez ML. Ozone in the Development of Pediatric Asthma and Atopic Disease. *Immunol Allergy Clin North Am.* 2022;42(4):701–13.
108. Chen Z, Salam MT, Eckel SP, Breton CV, Gilliland FD. Chronic effects of air pollution on respiratory health in Southern California children: findings from the Southern California Children’s Health Study. *J Thorac Dis.* 2015;7(1):46–58.
109. Bettiol A, Gelain E, Milanesio E, Asta F, Rusconi F. The first 1000 days of life: traffic-related air pollution and development of wheezing and asthma in childhood. A systematic review of birth cohort studies. *Environ Health.* 2021;20(1):46.
110. Gehring U, Wijga AH, Koppelman GH, Vonk JM, Smit HA, Brunekreef B. Air pollution and the development of asthma from birth until young adulthood. *Eur Respir J.* 2020;56(1):2000147.
111. Zanobetti A, Ryan PH, Coull BA, Luttmann-Gibson H, Datta S, Blossom J, et al. Early-Life Exposure to Air Pollution and Childhood Asthma Cumulative Incidence in the ECHO CREW Consortium. *JAMA Netw Open.* 2024;7(2):e240535.
112. Korten I, Ramsey K, Latzin P. Air pollution during pregnancy and lung development in the child. *Paediatr Respir Rev.* 2017;21:38–46.
113. Sun BZ, Gaffin JM. Recent Insights into the Environmental Determinants of Childhood Asthma. *Curr Allergy Asthma Rep.* 2024;24(5):253–60.
114. Peden DB. Respiratory Health Effects of Air Pollutants. *Immunol Allergy Clin North Am.* 2024;44(1):15–33.
115. Saxena K. Association Between Maternal Prenatal Exposure to Household Air Pollution and Child Respiratory Health: A Systematic Review and Meta-analysis. *Yale J Biol Med.* 2024;97(1):29–40.
116. Agache I, Canelo-Aybar C, Annesi-Maesano I, Cecchi L, Rigau D, Rodríguez-Tanta LY, et al. The impact of outdoor pollution and extreme temperatures on asthma-related outcomes: A systematic review for the EAACI guidelines on environmental science for allergic diseases and asthma. *Allergy.* 2024;79(7):1725–60.
117. Wu K, Ho HC, Su H, Huang C, Zheng H, Zhang W, et al. A systematic review and meta-analysis of intraday effects of ambient air pollution and temperature on cardiorespiratory morbidities: First few hours of exposure matters to life. *EBioMedicine.* 2022;86:104327.
118. Bronte-Moreno O, González-Barcala FJ, Muñoz-Gall X, Pueyo-Bastida A, Ramos-González J, Urrutia-Landa I. Impact of Air Pollution on Asthma: A Scoping Review. *Open Respir Arch.* 2023;5(2):100229.
119. McDonald VM, Archbold G, Beyene T, Brew BK, Franklin P, Gibson PG, et al. Asthma and landscape fire smoke: A Thoracic Society of Australia and New Zealand position statement. *Respirol Carlton Vic.* 2023;28(11):1023–35.
120. Wilgus ML, Merchant M. Clearing the Air: Understanding the Impact of Wildfire Smoke on Asthma and COPD. *Healthc Basel Switz.* 2024;12(3):307.
121. Park J, Kim HJ, Lee CH, Lee CH, Lee HW. Impact of long-term exposure to ambient air pollution on the incidence of chronic obstructive pulmonary disease: A systematic review and meta-analysis. *Environ Res.* 2021;194:110703.
122. Shin S, Bai L, Burnett RT, Kwong JC, Hystad P, van Donkelaar A, et al. Air Pollution as a Risk Factor for Incident Chronic Obstructive Pulmonary Disease and Asthma. A 15-Year Population-based Cohort Study. *Am J Respir Crit Care Med.* 2021;203(9):1138–48.
123. Liu S, Jørgensen JT, Ljungman P, Pershagen G, Bellander T, Leander K, et al. Long-term exposure to low-level air pollution and incidence of chronic obstructive pulmonary disease: The ELAPSE project. *Environ Int.* 2021;146:106267.

124. Guo C, Zhang Z, Lau AKH, Lin CQ, Chuang YC, Chan J, et al. Effect of long-term exposure to fine particulate matter on lung function decline and risk of chronic obstructive pulmonary disease in Taiwan: a longitudinal, cohort study. *Lancet Planet Health*. 2018;2(3):e114–25.
125. Sinharay R, Gong J, Barratt B, Ohman-Strickland P, Ernst S, Kelly FJ, et al. Respiratory and cardiovascular responses to walking down a traffic-polluted road compared with walking in a traffic-free area in participants aged 60 years and older with chronic lung or heart disease and age-matched healthy controls: a randomised, crossover study. *Lancet*. 2018;391(10118):339–49.
126. Li J, Sun S, Tang R, Qiu H, Huang Q, Mason TG, et al. Major air pollutants and risk of COPD exacerbations: a systematic review and meta-analysis. *Int J Chron Obstruct Pulmon Dis*. 2016;11:3079–91.
127. Dominici F, Peng RD, Bell ML, Pham L, McDermott A, Zeger SL, et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. *JAMA*. 2006;295(10):1127–34.
128. Huangfu P, Atkinson R. Long-term exposure to NO₂ and O₃ and all-cause and respiratory mortality: A systematic review and meta-analysis. *Environ Int*. 2020;144:105998.
129. World Health Organization. Ambient air pollution [Internet]. 2024. [Accessed 28th November 2024 2024]. Available from: <https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/ambient-air-pollution>
130. Sheppard N, Carroll M, Gao C, Lane T. Particulate matter air pollution and COVID-19 infection, severity, and mortality: A systematic review and meta-analysis. *Sci Total Environ*. 2023;880:163272.
131. Horne BD, Joy EA, Hofmann MG, Gesteland PH, Cannon JB, Lefler JS, et al. Short-Term Elevation of Fine Particulate Matter Air Pollution and Acute Lower Respiratory Infection. *Am J Respir Crit Care Med*. 2018;198(6):759–66.
132. Nhung NTT, Amini H, Schindler C, Kutlar Joss M, Dien TM, Probst-Hensch N, et al. Short-term association between ambient air pollution and pneumonia in children: A systematic review and meta-analysis of time-series and case-crossover studies. *Environ Pollut*. 2017;230:1000–8.
133. Yee J, Cho YA, Yoo HJ, Yun H, Gwak HS. Short-term exposure to air pollution and hospital admission for pneumonia: a systematic review and meta-analysis. *Environ Health*. 2021;20(1):6.
134. Majewski S, Piotrowski WJ. Air Pollution-An Overlooked Risk Factor for Idiopathic Pulmonary Fibrosis. *J Clin Med*. 2020;10(1):77.
135. Conti S, Harari S, Caminati A, Zanobetti A, Schwartz JD, Bertazzi PA, et al. The association between air pollution and the incidence of idiopathic pulmonary fibrosis in Northern Italy. *Eur Respir J*. 2018;51(1):1700397.
136. Singh N, Singh S. Interstitial Lung Diseases and Air Pollution: Narrative Review of Literature. *Pulm Ther*. 2021;7(1):89–100.
137. Singh S, Collins BF, Bairwa M, Joshi JM, Talwar D, Singh N, et al. Hypersensitivity pneumonitis and its correlation with ambient air pollution in urban India. *Eur Respir J*. 2019;53(2):1801563.
138. Sesé L, Nunes H, Cottin V, Sanyal S, Didier M, Carton Z, et al. Role of atmospheric pollution on the natural history of idiopathic pulmonary fibrosis. *Thorax*. 2018;73(2):145–50.
139. Johansson KA, Vittinghoff E, Lee K, Balmes JR, Ji W, Kaplan GG, et al. Acute exacerbation of idiopathic pulmonary fibrosis associated with air pollution exposure. *Eur Respir J*. 2014;43(4):1124–31.
140. Winterbottom CJ, Shah RJ, Patterson KC, Kreider ME, Panettieri RA, Rivera-Lebron B, et al. Exposure to Ambient Particulate Matter Is Associated With Accelerated Functional Decline in Idiopathic Pulmonary Fibrosis. *Chest*. 2018;153(5):1221–8.
141. Miao H, Li X, Wang X, Nie S. Air pollution increases the risk of pulmonary embolism: a meta-analysis. *Rev Environ Health*. 2022;37(2):259–66.
142. Liu J, Wu T, Liu Q, Wu S, Chen JC. Air pollution exposure and adverse sleep health across the life course: A systematic review. *Environ Pollut*. 2020;262:114263.
143. Billings ME, Gold D, Szpiro A, Aaron CP, Jorgensen N, Gassett A, et al. The Association of Ambient Air Pollution with Sleep Apnea: The Multi-Ethnic Study of Atherosclerosis. *Ann Am Thorac Soc*. 2019;16(3):363–70.

144. Shen YL, Liu WT, Lee KY, Chuang HC, Chen HW, Chuang KJ. Association of PM_{2.5} with sleep-disordered breathing from a population-based study in Northern Taiwan urban areas. *Environ Pollut.* 2018;233:109–13.
145. Lappharat S, Taneepanichskul N, Reutrakul S, Chirakalwasan N. Effects of Bedroom Environmental Conditions on the Severity of Obstructive Sleep Apnea. *J Clin Sleep Med.* 2018;14(4):565–73.
146. Cassol CM, Martinez D, da Silva FABS, Fischer MK, Lenz M do CS, Bós ÂJG. Is sleep apnea a winter disease?: meteorologic and sleep laboratory evidence collected over 1 decade. *Chest.* 2012;142(6):1499–507.
147. Julia V, Macia L, Dombrowicz D. The impact of diet on asthma and allergic diseases. *Nat Rev Immunol.* 2015;15(5):308–22.
148. Lin YP, Kao YC, Pan WH, Yang YH, Chen YC, Lee YL. Associations between Respiratory Diseases and Dietary Patterns Derived by Factor Analysis and Reduced Rank Regression. *Ann Nutr Metab.* 2016;68(4):306–14.
149. Alwarith J, Kahleova H, Crosby L, Brooks A, Brandon L, Levin SM, et al. The role of nutrition in asthma prevention and treatment. *Nutr Rev.* 2020;78(11):928–38.
150. Wood LG, Garg ML, Smart JM, Scott HA, Barker D, Gibson PG. Manipulating antioxidant intake in asthma: a randomized controlled trial. *Am J Clin Nutr.* 2012;96(3):534–43.
151. Garcia-Larsen V, Del Giacco SR, Moreira A, Bonini M, Charles D, Reeves T, et al. Asthma and dietary intake: an overview of systematic reviews. *Allergy.* 2016;71(4):433–42.
152. Jensen ME, Gibson PG, Collins CE, Hilton JM, Wood LG. Diet-induced weight loss in obese children with asthma: a randomized controlled trial. *Clin Exp Allergy J Br Soc Allergy Clin Immunol.* 2013;43(7):775–84.
153. Yusoff NAM, Hampton SM, Dickerson JWT, Morgan JB. The effects of exclusion of dietary egg and milk in the management of asthmatic children: a pilot study. *J R Soc Promot Health.* 2004;124(2):74–80.
154. Fischer A, Johansson I, Blomberg A, Sundström B. Adherence to a Mediterranean-like Diet as a Protective Factor Against COPD: A Nested Case-Control Study. *COPD J Chronic Obstr Pulm Dis.* 2019;16(3–4):272–7.
155. Salari-Moghaddam A, Milajerdi A, Larijani B, Esmailzadeh A. Processed red meat intake and risk of COPD: A systematic review and dose-response meta-analysis of prospective cohort studies. *Clin Nutr.* 2019;38(3):1109–16.
156. Lee EN, Kim MJ. Meta-analysis of the Effect of a Pulmonary Rehabilitation Program on Respiratory Muscle Strength in Patients with Chronic Obstructive Pulmonary Disease. *Asian Nurs Res.* 2019;13(1):1–10.
157. Lu HY, Chen CF, Lee DL, Tsai YJ, Lin PC. Effects of Early Pulmonary Rehabilitation on Hospitalized Patients with Acute Exacerbation of Chronic Obstructive Pulmonary Disease: A Systematic Review and Meta-Analysis. *Int J Chron Obstruct Pulmon Dis.* 2023;18(null):881–93.
158. He W, Wang J, Feng Z, Li J, Xie Y. Effects of exercise-based pulmonary rehabilitation on severe/very severe COPD: a systematic review and meta-analysis. *Ther Adv Respir Dis.* 2023;17:17534666231162250.
159. Rysø CK, Godtfredsen NS, Kofod LM, Lavesen M, Mogensen L, Tobberup R, et al. Lower mortality after early supervised pulmonary rehabilitation following COPD-exacerbations: a systematic review and meta-analysis. *BMC Pulm Med.* 2018;18(1):154.
160. Rugbjerg M, Iepsen U, Jørgensen KJ, Lange P. Effectiveness of pulmonary rehabilitation in COPD with mild symptoms: a systematic review with meta-analyses. *Int J Chron Obstruct Pulmon Dis.* 2015;10:791–801.
161. Andrianopoulos V, Klijn P, Franssen FME, Spruit MA. Exercise Training in Pulmonary Rehabilitation. *Pulm Rehabil Role Adv.* 2014;35(2):313–22.
162. Jácome C, Marques A. Pulmonary Rehabilitation for Mild COPD: A Systematic Review. *Resp Care.* 2014;59(4):588-594.

163. Bajwah S, Ross JR, Peacock JL, Higginson IJ, Wells AU, Patel AS, et al. Interventions to improve symptoms and quality of life of patients with fibrotic interstitial lung disease: a systematic review of the literature. *Thorax*. 2013;68(9):867.
164. Lei S, Li X, Xie Y, Li J. Clinical evidence for improving exercise tolerance and quality of life with pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis: A systematic review and meta-analysis. *Clin Rehabil*. 2022;36(8):999–1015.
165. Paixão C, Rocha V, Brooks D, Marques A. Unsupervised physical activity interventions for people with COPD: A systematic review and meta-analysis. *Pulmonology*. 2024;30(1):53–67.
166. Xiang X, Huang L, Fang Y, Cai S, Zhang M. Physical activity and chronic obstructive pulmonary disease: a scoping review. *BMC Pulm Med*. 2022;22(1):301.
167. Hansen ESH, Pitzner-Fabricsius A, Toennesen LL, Rasmusen HK, Hostrup M, Hellsten Y, et al. Effect of aerobic exercise training on asthma in adults: a systematic review and meta-analysis. *Eur Respir J*. 2020;56(1):2000146.
168. Valkenborghs SR, Anderson SL, Scott HA, Callister R. Exercise Training Programs Improve Cardiorespiratory and Functional Fitness in Adults With Asthma: A systematic review and meta-analysis. *J Cardiopulm Rehabil Prev*. 2022;42(6).
169. Leggio M, Fusco A, Limongelli G, Sgorbini L. Exercise training in patients with pulmonary and systemic hypertension: A unique therapy for two different diseases. *Eur J Intern Med*. 2018;47:17–24.
170. Chandia-Poblete D, Cole-Hunter T, Haswell M, Heesch KC. The influence of air pollution exposure on the short- and long-term health benefits associated with active mobility: A systematic review. *Sci Total Environ*. 2022;850:157978.
171. de Nazelle A, Nieuwenhuijsen MJ, Antó JM, Brauer M, Briggs D, Braun-Fahrlander C, et al. Improving health through policies that promote active travel: A review of evidence to support integrated health impact assessment. *Environ Int*. 2011;37(4):766–77.
172. Riiser A, Bere E, Andersen LB, Nordengen S. E-cycling and health benefits: A systematic literature review with meta-analyses. *Front Sports Act Living*. 2022;4.
173. Ezzati M, Lopez AD, Rodgers A, Murray CJL. Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors [Internet]. [Accessed 28th November 2024]. Available from: <https://www.who.int/publications/i/item/9241580313>
174. Crouse DL, Peters PA, van Donkelaar A, Goldberg MS, Villeneuve PJ, Brion O, et al. Risk of nonaccidental and cardiovascular mortality in relation to long-term exposure to low concentrations of fine particulate matter: a Canadian national-level cohort study. *Environ Health Perspect*. 2012;120(5):708–14.
175. Peralta AA, Link MS, Schwartz J, Luttmann-Gibson H, Dockery DW, Blomberg A, et al. Exposure to Air Pollution and Particle Radioactivity With the Risk of Ventricular Arrhythmias. *Circulation*. 2020;142(9):858–67.
176. Cai Y, Zhang B, Ke W, Feng B, Lin H, Xiao J, et al. Associations of Short-Term and Long-Term Exposure to Ambient Air Pollutants With Hypertension: A Systematic Review and Meta-Analysis. *Hypertens*. 2016;68(1):62–70.
177. Rajagopalan S, Landrigan PJ. Pollution and the Heart. *N Engl J Med*. 2021;385(20):1881–92.
178. Orlich MJ, Singh PN, Sabaté J, Jaceldo-Siegl K, Fan J, Knutsen S, et al. Vegetarian dietary patterns and mortality in Adventist Health Study 2. *JAMA Intern Med*. 2013;173(13):1230–8.
179. Crowe FL, Appleby PN, Travis RC, Key TJ. Risk of hospitalization or death from ischemic heart disease among British vegetarians and nonvegetarians: results from the EPIC-Oxford cohort study. *Am J Clin Nutr*. 2013;97(3):597–603.
180. Martínez-González MÁ, Hernández Hernández A. Effect of the Mediterranean diet in cardiovascular prevention. *Rev Espanola Cardiol Engl Ed*. 2024;77(7):574–82.
181. Bouvard V, Loomis D, Guyton KZ, Grosse Y, Ghissassi FE, Benbrahim-Tallaa L, et al. Carcinogenicity of consumption of red and processed meat. *Lancet Oncol*. 2015;16(16):1599–600.
182. Kiecolt-Glaser JK. Stress, food, and inflammation: psychoneuroimmunology and nutrition at the cutting edge. *Psychosom Med*. 2010;72(4):365–9.

183. Sakkas H, Bozidis P, Touzios C, Kolios D, Athanasiou G, Athanasopoulou E, et al. Nutritional Status and the Influence of the Vegan Diet on the Gut Microbiota and Human Health. *Med Kaunas Lith.* 2020;56(2):88.
184. World Health Organization. WHO Guidelines on Physical Activity and Sedentary Behaviour [Internet]. 2020. [Accessed 9th May 2025]. Available from: <https://iris.who.int/bitstream/handle/10665/336656/9789240015128-eng.pdf>
185. Banach M, Lewek J, Surma S, Penson PE, Sahebkar A, Martin SS, et al. The association between daily step count and all-cause and cardiovascular mortality: a meta-analysis. *Eur J Prev Cardiol.* 2023;30(18):1975–85.
186. Kyu HH, Bachman VF, Alexander LT, Mumford JE, Afshin A, Estep K, et al. Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013. *BMJ.* 2016;354:i3857.
187. Bailey DP, Hewson DJ, Champion RB, Sayegh SM. Sitting Time and Risk of Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis. *Am J Prev Med.* 2019;57(3):408-416.
188. Pinto AJ, Bergouignan A, Dempsey PC, Roschel H, Owen N, Gualano B, et al. Physiology of sedentary behavior. *Physiol Rev.* 2023;103(4):2561–622.
189. Lee LL, Mulvaney CA, Wong YKY, Chan ES, Watson MC, Lin HH. Walking for hypertension. *Cochrane Database Syst Rev.* 2021;2(2):CD008823.
190. Pritchett N, Spangler EC, Gray GM, Livinski AA, Sampson JN, Dawsey SM, et al. Exposure to Outdoor Particulate Matter Air Pollution and Risk of Gastrointestinal Cancers in Adults: A Systematic Review and Meta-Analysis of Epidemiologic Evidence. *Environ Health Perspect.* 2022;130(3):36001.
191. Turner MC, Andersen ZJ, Baccarelli A, Diver WR, Gapstur SM, Pope CA, et al. Outdoor air pollution and cancer: An overview of the current evidence and public health recommendations. *CA Cancer J Clin.* 2020.
192. Hassanipour S, Nikbakht HA, Amrane A, Arab-Zozani M, Shojaie L, Rostami S, et al. The Relationship between Air Pollution and Brain Cancer: A Systematic Review and Meta-Analysis. *Ann Glob Health.* 2023;89(1):45.
193. Navarrete-Meneses MDP, Salas-Labadía C, Gómez-Chávez F, Pérez-Vera P. Environmental Pollution and Risk of Childhood Cancer: A Scoping Review of Evidence from the Last Decade. *Int J Mol Sci.* 2024;25(6):3284.
194. World Health Organization. WHO global air quality guidelines: particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide [Internet]. 2021. [Accessed 7th November 2024]. Available from: <https://www.who.int/publications/i/item/9789240034228>
195. D'Amico G, Santonocito R, Vitale AM, Scalia F, Marino Gammazza A, Campanella C, et al. Air Pollution: Role of Extracellular Vesicles-Derived Non-Coding RNAs in Environmental Stress Response. *Cells.* 2023;12(11):1498.
196. Hill W, Lim EL, Weeden CE, Lee C, Augustine M, Chen K, et al. Lung adenocarcinoma promotion by air pollutants. *Nature.* 2023;616(7955):159–67.
197. Brenner H, Kloor M, Pox CP. Colorectal cancer. *Lancet Lond Engl.* 2014;383(9927):1490–502.
198. Morze J, Danielewicz A, Przybyłowicz K, Zeng H, Hoffmann G, Schwingshackl L. An updated systematic review and meta-analysis on adherence to mediterranean diet and risk of cancer. *Eur J Nutr.* 2021;60(3):1561–86.
199. Bardou M, Barkun AN, Martel M. Obesity and colorectal cancer. *Gut.* 2013;62(6):933–47.
200. DeClercq V, Nearing JT, Sweeney E. Plant-Based Diets and Cancer Risk: What is the Evidence? *Curr Nutr Rep.* 2022;11(2):354–69.
201. Thu W, Woodward A, Cavadino A, Tin Tin S. Associations between transport modes and site-specific cancers: a systematic review and meta-analysis. *Environ Health.* 2024;23(1):39.
202. Schmid D, Behrens G, Keimling M, Jochem C, Ricci C, Leitzmann M. A systematic review and meta-analysis of physical activity and endometrial cancer risk. *Eur J Epidemiol.* 2015;30(5):397–412.

203. Mishra SI, Scherer RW, Geigle PM, Berlanstein DR, Topaloglu O, Gotay CC, et al. Exercise interventions on health-related quality of life for cancer survivors. *Cochrane Database Syst Rev*. 2012;2012(8):CD007566.
204. Cave J, Paschalis A, Huang CY, West M, Copson E, Jack S, et al. A systematic review of the safety and efficacy of aerobic exercise during cytotoxic chemotherapy treatment. *Support Care Cancer*. 2018;26(10):3337–51.
205. Nakano J, Fukushima T, Tanaka T, Fu JB, Morishita S. Physical function predicts mortality in patients with cancer: a systematic review and meta-analysis of observational studies. *Support Care Cancer*. 2021;29(10):5623–34.
206. Ni HJ, Pudasaini B, Yuan XT, Li HF, Shi L, Yuan P. Exercise Training for Patients Pre- and Postsurgically Treated for Non-Small Cell Lung Cancer: A Systematic Review and Meta-analysis. *Integr Cancer Ther*. 2017;16(1):63–73.
207. Song S, Gao Z, Zhang X, Zhao X, Chang H, Zhang J, et al. Ambient fine particulate matter and pregnancy outcomes: An umbrella review. *Environ Res*. 2023;235:116652.
208. Liang W, Zhu H, Xu J, Zhao Z, Zhou L, Zhu Q, et al. Ambient air pollution and gestational diabetes mellitus: An updated systematic review and meta-analysis. *Ecotoxicol Environ Saf*. 2023;255:114802.
209. Huang C, Li C, Zhao F, Zhu J, Wang S, Sun G. The Association between Childhood Exposure to Ambient Air Pollution and Obesity: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. 2022;19(8).
210. Zheng J, Zhang H, Shi J, Li X, Zhang J, Zhang K, et al. Association of air pollution exposure with overweight or obesity in children and adolescents: A systematic review and meta-analysis. *Sci Total Environ*. 2024;910:168589.
211. Lin L, Li T, Sun M, Liang Q, Ma Y, Wang F, et al. Global association between atmospheric particulate matter and obesity: A systematic review and meta-analysis. *Environ Res*. 2022;209:112785.
212. Ning J, Zhang Y, Hu H, Hu W, Li L, Pang Y, et al. Association between ambient particulate matter exposure and metabolic syndrome risk: A systematic review and meta-analysis. *Sci Total Environ*. 2021;782:146855.
213. Bowe B, Xie Y, Li T, Yan Y, Xian H, Al-Aly Z. The 2016 global and national burden of diabetes mellitus attributable to PM_{2.5} air pollution. *Lancet Planet Health*. 2018;2(7):e301–12.
214. Eze Ikenna C., Hemkens Lars G., Bucher Heiner C., Hoffmann Barbara, Schindler Christian, Künzli Nino, et al. Association between Ambient Air Pollution and Diabetes Mellitus in Europe and North America: Systematic Review and Meta-Analysis. *Environ Health Perspect*. 2015;123(5):381–9.
215. Rajagopalan S, Brook RD, Salerno PRVO, Bourges-Sevenier B, Landrigan P, Nieuwenhuijsen MJ, et al. Air pollution exposure and cardiometabolic risk. *Lancet Diabetes Endocrinol*. 2024;12(3):196–208.
216. Landrigan PJ, Fuller R, Acosta NJR, Adeyi O, Arnold R, Basu N (Nil), et al. The Lancet Commission on pollution and health. *Lancet*. 2018;391(10119):462–512.
217. Mozafarian N, Hashemipour M, Yazdi M, Zavareh MHT, Hovsepian S, Heidarpour M, et al. The Association between Exposure to Air Pollution and Type 1 Diabetes Mellitus: A Systematic Review and Meta-Analysis. *Adv Biomed Res*. 2022;28(11):103.
218. O'Donnell C, Campbell EJ, McCormick S, Anenberg SC. Prenatal exposure to air pollution and maternal and thyroid function: a systematic review of the epidemiological evidence. *Environ Health*. 2024;23:78.
219. Carré J, Gatimel N, Moreau J, Parinaud J, Léandri R. Does air pollution play a role in infertility?: a systematic review. *Environ Health*. 2017;16:82.
220. Torkashvand J, Jonidi Jafari A, Pasalari H, Shahsavani A, Oshidari Y, Amoohadi V, et al. The potential osteoporosis due to exposure to particulate matter in ambient air: Mechanisms and preventive methods. *J Air Waste Manag Assoc*. 2022;72(9):925–34.
221. Termannsen AD, Clemmensen KKB, Thomsen JM, Nørgaard O, Díaz LJ, Torekov SS, et al. Effects of vegan diets on cardiometabolic health: A systematic review and meta-analysis of randomized controlled trials. *Obes Rev*. 2022;23(9):e13462.

222. Huang RY, Huang CC, Hu FB, Chavarro JE. Vegetarian Diets and Weight Reduction: a Meta-Analysis of Randomized Controlled Trials. *J Gen Intern Med*. 2016;31(1):109–16.
223. Xu Y, Mo G, Yao Y, Li C. The effects of vegetarian diets on glycemia and lipid parameters in adult patients with overweight and obesity: a systematic review and meta-analysis. *Eur J Clin Nutr*. 2023;77(8):794–802.
224. Long Y, Ye H, Yang J, Tao X, Xie H, Zhang J, et al. Effects of a vegetarian diet combined with aerobic exercise on glycemic control, insulin resistance, and body composition: a systematic review and meta-analysis. *Eat Weight Disord - Stud Anorex Bulim Obes*. 2023;28(1):9.
225. Orlich MJ, Fraser GE. Vegetarian diets in the Adventist Health Study 2: a review of initial published findings¹²³⁴. *Am J Clin Nutr*. 2014;100:353S–358S.
226. Jarvis SE, Nguyen M, Malik VS. Association between adherence to plant-based dietary patterns and obesity risk: a systematic review of prospective cohort studies. *Appl Physiol Nutr Metab*. 2022;47(12):1115–33.
227. Connolly G, Clark CM, Campbell RE, Byers AW, Reed JB, Campbell WW. Poultry Consumption and Human Health: How Much Is Really Known? A Systematically Searched Scoping Review and Research Perspective. *Adv Nutr*. 2022;13(6):2115–24.
228. Kim SJ, de Souza RJ, Choo VL, Ha V, Cozma AI, Chiavaroli L, et al. Effects of dietary pulse consumption on body weight: a systematic review and meta-analysis of randomized controlled trials¹⁻³. *Am J Clin Nutr*. 2016;103(5):1213–23.
229. Reger C, Leitzmann MF, Rohrmann S, Kühn T, Sedlmeier AM, Jochem C. Sustainable diets and risk of overweight and obesity: A systematic review and meta-analysis. *Obes Rev*. 2024;25(5):e13707.
230. Chambers T, Segal A, Sassi F. Interventions using behavioural insights to influence children’s diet-related outcomes: A systematic review. *Obes Rev*. 2021;22(2):e13152.
231. Department of Health & Social Care. Obesity Profile [Internet]. 2025. [Accessed 19th April 2025]. Available from: <https://fingertips.phe.org.uk/profile/national-child-measurement-programme>
232. Ho M, Garnett SP, Baur LA, Burrows T, Stewart L, Neve M, et al. Impact of Dietary and Exercise Interventions on Weight Change and Metabolic Outcomes in Obese Children and Adolescents: A Systematic Review and Meta-analysis of Randomized Trials. *JAMA Pediatr*. 2013;167(8):759–68.
233. BBC. BBC Good Food Nation: Survey looks at children’s eating habits [Internet]. 2021. [Accessed 5th August 2024]. Available from: <https://www.bbc.co.uk/newsround/58653757#comments>
234. Desmond MA, Fewtrell MS, Wells JCK. Plant-Based Diets in Children: Secular Trends, Health Outcomes, and a Roadmap for Urgent Practice Recommendations and Research—A Systematic Review. *Nutrients*. 2024;16(5).
235. Kahleova H, Salas-Salvadó J, Rahelić D, Kendall CW, Rembert E, Sievenpiper JL. Dietary Patterns and Cardiometabolic Outcomes in Diabetes: A Summary of Systematic Reviews and Meta-Analyses. *Nutrients*. 2019;11(9).
236. Xi P, Liu RH. Whole food approach for type 2 diabetes prevention. *Mol Nutr Food Res*. 2016;60(8):1819–36.
237. Oussalah A, Levy J, Berthezène C, Alpers DH, Guéant JL. Health outcomes associated with vegetarian diets: An umbrella review of systematic reviews and meta-analyses. *Clin Nutr*. 2020;39(11):3283–307.
238. Lee Y, Park K. Adherence to a Vegetarian Diet and Diabetes Risk: A Systematic Review and Meta-Analysis of Observational Studies. *Nutrients*. 2017;9(6).
239. Pollakova D, Andreadi A, Pacifici F, Della-Morte D, Lauro D, Tubili C. The Impact of Vegan Diet in the Prevention and Treatment of Type 2 Diabetes: A Systematic Review. *Nutrients*. 2021;13(6).
240. Yao B, Fang H, Xu W, Yan Y, Xu H, Liu Y, et al. Dietary fiber intake and risk of type 2 diabetes: a dose–response analysis of prospective studies. *Eur J Epidemiol*. 2014;29(2):79–88.
241. Neuenschwander M, Stadelmaier J, Eble J, Grummich K, Szczerba E, Kiesswetter E, et al. Substitution of animal-based with plant-based foods on cardiometabolic health and all-cause mortality: a systematic review and meta-analysis of prospective studies. *BMC Med*. 2023;21(1):404.

242. Lamberg-Allardt C, Bärebring L, Arnesen EK, Nwaru BI, Thorisdottir B, Ramel A, et al. Animal versus plant-based protein and risk of cardiovascular disease and type 2 diabetes: a systematic review of randomized controlled trials and prospective cohort studies. *Food Nutr Res.* 2023;67:9003.
243. Lin X, Wang S, Huang J. The Association between the EAT–Lancet Diet and Diabetes: A Systematic Review. *Nutrients.* 2023;15(20).
244. Xu C, Cao Z, Yang H, Hou Y, Wang X, Wang Y. Association Between the EAT-Lancet Diet Pattern and Risk of Type 2 Diabetes: A Prospective Cohort Study. *Front Nutr.* 2022;8:784018.
245. Zhu Y, Zheng Q, Huang L, Jiang X, Gao X, Li J, et al. The effects of plant-based dietary patterns on the risk of developing gestational diabetes mellitus: A systematic review and meta-analysis. *PLOS ONE.* 2023;18(10):e0291732.
246. Kelstrup L, Damm P, Mathiesen ER, Hansen T, Vaag AA, Pedersen O, et al. Insulin Resistance and Impaired Pancreatic β -Cell Function in Adult Offspring of Women With Diabetes in Pregnancy. *J Clin Endocrinol Metab.* 2013;98(9):3793–801.
247. Bellamy L, Casas JP, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet.* 2009;373(9677):1773–9.
248. Sánchez-Sánchez ML, García-Vigara A, Hidalgo-Mora JJ, García-Pérez MÁ, Tarín J, Cano A. Mediterranean diet and health: A systematic review of epidemiological studies and intervention trials. *Maturitas.* 2020;136:25–37.
249. Wiśniewska K, Okręglińska KM, Nitsch-Osuch A, Oczkowski M. Plant-Based Diets and Metabolic Syndrome Components: The Questions That Still Need to Be Answered—A Narrative Review. *Nutrients.* 2024;16(1).
250. Kraselink A. Risk of Bone Fracture on Vegetarian and Vegan Diets. *Curr Nutr Rep.* 2024;13(2):331–9.
251. Hanson S, Jones A. Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. *Br J Sports Med.* 2015;49(11):710.
252. Murtagh EM, Nichols L, Mohammed MA, Holder R, Nevill AM, Murphy MH. The effect of walking on risk factors for cardiovascular disease: An updated systematic review and meta-analysis of randomised control trials. *Prev Med.* 2015;72:34–43.
253. Miguel-Berges ML, Reilly JJ, Moreno Aznar LA, Jiménez-Pavón D. Associations Between Pedometer-Determined Physical Activity and Adiposity in Children and Adolescents: Systematic Review. *Clin J Sport Med.* 2018;28(1):64-75.
254. Dhali, Biswajit, Chatterjee, Sridip, Das, Sudip Sundar, D Cruz, Mary. Effect of Yoga and Walking on Glycemic Control for the Management of Type 2 Diabetes : A Systematic Review and Meta-analysis. *J ASEAN Fed Endocr Soc.* 2023;38(2):113–22.
255. Jayedi A, Zargar MS, Emadi A, Aune D. Walking speed and the risk of type 2 diabetes: a systematic review and meta-analysis. *Br J Sports Med.* 2024;58(6):334.
256. Wang Y, Li H, Yang D, Wang M, Han Y, Wang H. Effects of aerobic exercises in prediabetes patients: a systematic review and meta-analysis. *Front Endocrinol.* 2023;14:1227489.
257. Wewege M, van den Berg R, Ward RE, Keech A. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis. *Obes Rev.* 2017;18(6):635–46.
258. Hsu KJ, Liao CD, Tsai MW, Chen CN. Effects of Exercise and Nutritional Intervention on Body Composition, Metabolic Health, and Physical Performance in Adults with Sarcopenic Obesity: A Meta-Analysis. *Nutrients.* 2019;11(9).
259. Aune D, Norat T, Leitzmann M, Tonstad S, Vatten LJ. Physical activity and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis. *Eur J Epidemiol.* 2015;30(7):529–42.
260. Wu J, Li Q, Feng Y, Bhuyan SS, Tarimo CS, Zeng X, et al. Active commuting and the risk of obesity, hypertension and diabetes: a systematic review and meta-analysis of observational studies. *BMJ Glob Health.* 2021;6(6):e005838.
261. Josaphat KJ, Kugathasan TA, E.R. Reid R, Begon M, Léger PM, Labonté-Lemoyne E, et al. Use of Active Workstations in Individuals with Overweight or Obesity: A Systematic Review. *Obesity.* 2019;27(3):362–79.

262. Cai C, Vandermeer B, Khurana R, Nerenberg K, Featherstone R, Sebastiani M, et al. The impact of occupational activities during pregnancy on pregnancy outcomes: a systematic review and metaanalysis. *Am J Obstet Gynecol*. 2020;222(3):224–38.
263. Keating N, Coveney C, McAuliffe FM, Higgins MF. Aerobic or Resistance Exercise for Improved Glycaemic Control and Pregnancy Outcomes in Women with Gestational Diabetes Mellitus: A Systematic Review. *Int J Environ Res Public Health*. 2022;19(17):10791.
264. Magro-Malosso ER, Saccone G, Di Mascio D, Di Tommaso M, Berghella V. Exercise during pregnancy and risk of preterm birth in overweight and obese women: a systematic review and meta-analysis of randomized controlled trials. *Acta Obstet Gynecol Scand*. 2017;96(3):263–73.
265. Díaz-Burrueco JR, Cano-Ibáñez N, Martín-Peláez S, Khan KS, Amezcua-Prieto C. Effects on the maternal-fetal health outcomes of various physical activity types in healthy pregnant women. A systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol*. 2021;262:203–15.
266. Butt MS, Saleem J, Zakar R, Aiman S, Khan MZ, Fischer F. Benefits of physical activity on reproductive health functions among polycystic ovarian syndrome women: a systematic review. *BMC Public Health*. 2023;23(1):882.
267. Specker B, Thiex NW, Sudhagani RG. Does Exercise Influence Pediatric Bone? A Systematic Review. *Clin Orthop Relat Res*. 2015;473(11):3658–3672.
268. Abrahin O, Rodrigues RP, Marçal AC, Alves EAC, Figueiredo RC, de Sousa EC. Swimming and cycling do not cause positive effects on bone mineral density: a systematic review. *Rev Bras Reumatol Engl Ed*. 2016;56(4):345–51.
269. Pinheiro MB, Oliveira J, Bauman A, Fairhall N, Kwok W, Sherrington C. Evidence on physical activity and osteoporosis prevention for people aged 65+ years: a systematic review to inform the WHO guidelines on physical activity and sedentary behaviour. *Int J Behav Nutr Phys Act*. 2020;17(1):150.
270. Hejazi K, Askari R, Hofmeister M. Effects of physical exercise on bone mineral density in older postmenopausal women: a systematic review and meta-analysis of randomized controlled trials. *Arch Osteoporos*. 2022;17(1):102.
271. Ashe MC, Santos IK dos, Edward NY, Burnett LA, Barnes R, Fleig L, et al. Physical Activity and Bone Health in Men: A Systematic Review and Meta-Analysis. *J Bone Metab*. 2021 Feb 28;28(1):27–39.
272. Gong Y, Zhang X, Zhao X, Chang H, Zhang J, Gao Z, et al. Global ambient particulate matter pollution and neurodegenerative disorders: a systematic review of literature and meta-analysis. *Environ Sci Pollut Res*. 2023;30(14):39418–30.
273. Abolhasani E, Hachinski V, Ghazaleh N, Azarpazhooh MR, Mokhber N, Martin J. Air Pollution and Incidence of Dementia. *Neurology*. 2023;100(2):e242–54.
274. Fu P, Yung KKL. Air Pollution and Alzheimer’s Disease: A Systematic Review and Meta-Analysis. *J Alzheimer’s Dis*. 2020;77(2):701–14.
275. Yi C, Wang Q, Qu Y, Niu J, Oliver BG, Chen H. In-utero exposure to air pollution and early-life neural development and cognition. *Ecotoxicol Environ Saf*. 2022;238:113589.
276. Ha S. Air pollution and neurological development in children. *Dev Med Child Neurol*. 2021;63(4):374–81.
277. Reuben A, Arseneault L, Beddows A, Beevers SD, Moffitt TE, Ambler A, et al. Association of Air Pollution Exposure in Childhood and Adolescence With Psychopathology at the Transition to Adulthood. *JAMA Netw Open*. 2021;4(4):e217508–e217508.
278. Borroni E, Pesatori AC, Bollati V, Buoli M, Carugno M. Air pollution exposure and depression: A comprehensive updated systematic review and meta-analysis. *Environ Pollut*. 2022;292:118245.
279. Cao T, Tian M, Hu H, Yu Q, You J, Yang Y, et al. The relationship between air pollution and depression and anxiety disorders – A systematic evaluation and meta-analysis of a cohort-based study. *Int J Soc Psychiatry*. 2024;70(2):241–70.
280. Trushna T, Dhiman V, Raj D, Tiwari RR. Effects of ambient air pollution on psychological stress and anxiety disorder: a systematic review and meta-analysis of epidemiological evidence. *Reviews on Environ Health*. 2021;36(4):501–21.

281. Liu Q, Wang W, Gu X, Deng F, Wang X, Lin H, et al. Association between particulate matter air pollution and risk of depression and suicide: a systematic review and meta-analysis. *Environ Sci Pollut Res.* 2021;28(8):9029–49.
282. Pourhoseini SA, Akbary A, Mahmoudi H, Akbari M, Heydari ST. Association between prenatal period exposure to ambient air pollutants and development of postpartum depression: a systematic review and meta-analysis. *Int J Environ Health Res.* 2024;34(1):455–65.
283. Xu J, Lan Z, Xu P, Zhang Z. The association between short-term exposure to nitrogen dioxide and hospital admission for schizophrenia: A systematic review and meta-analysis. *Medicine.* 2023;102(39).
284. Li L, Zhang W, Xie L, Jia S, Feng T, Yu H, et al. Effects of atmospheric particulate matter pollution on sleep disorders and sleep duration: a cross-sectional study in the UK biobank. *Sleep Med.* 2020;74:152–64.
285. Xu W, Tan CC, Zou JJ, Cao XP, Tan L. Sleep problems and risk of all-cause cognitive decline or dementia: an updated systematic review and meta-analysis. *J Neurol Neurosurg Amp Psychiatry.* 2020;91(3):236.
286. Horn J, Mayer DE, Chen S, Mayer EA. Role of diet and its effects on the gut microbiome in the pathophysiology of mental disorders. *Transl Psychiatry.* 2022;12(1):164.
287. Borrego-Ruiz A, Borrego JJ. Human gut microbiome, diet, and mental disorders. *Int Microbiol.* 2025;28:1-15.
288. Gianfredi V, Dinu M, Nucci D, Eussen SJPM, Amerio A, Schram MT, et al. Association between dietary patterns and depression: an umbrella review of meta-analyses of observational studies and intervention trials. *Nutr Rev.* 2023;81(3):346–59.
289. O’Neil A, Quirk SE, Housden S, Brennan SL, Williams LJ, Pasco JA, et al. Relationship Between Diet and Mental Health in Children and Adolescents: A Systematic Review. *Am J Public Health.* 2014;104(10):e31–42.
290. Lai JS, Hiles S, Bisquera A, Hure AJ, McEvoy M, Attia J. A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. *Am J Clin Nutr.* 2014;99(1):181–97.
291. Psaltopoulou T, Sergentanis TN, Panagiotakos DB, Sergentanis IN, Kosti R, Scarmeas N. Mediterranean diet, stroke, cognitive impairment, and depression: A meta-analysis. *Ann Neurol.* 2013;74(4):580–91.
292. Parletta N, Zarnowiecki D, Cho J, Wilson A, Bogomolova S, Villani A, et al. A Mediterranean-style dietary intervention supplemented with fish oil improves diet quality and mental health in people with depression: A randomized controlled trial (HELFIMED). *Nutr Neurosci.* 2019;22(7):474–87.
293. Jacka FN, O’Neil A, Opie R, Itsiopoulos C, Cotton S, Mohebbi M, et al. A randomised controlled trial of dietary improvement for adults with major depression (the ‘SMILES’ trial). *BMC Med.* 2017;15(1):23.
294. Sánchez-Villegas A, Martínez-González MA, Estruch R, Salas-Salvadó J, Corella D, Covas MI, et al. Mediterranean dietary pattern and depression: the PREDIMED randomized trial. *BMC Med.* 2013;11(1):208.
295. Conner TS, Brookie KL, Carr AC, Mainvil LA, Vissers MCM. Let them eat fruit! The effect of fruit and vegetable consumption on psychological well-being in young adults: A randomized controlled trial. *PLOS ONE.* 2017;12(2):e0171206.
296. Sindler D, Kastovska B, Dostal T, Cipryan L, Elavsky S. The effects of carbohydrate-restricted diet on psychological outcomes: a systematic review of randomized controlled trials. *Nutr Rev.* 2024;82(2):228–39.
297. Molendijk ML, Fried EI, Van der Does W. The SMILES trial: do undisclosed recruitment practices explain the remarkably large effect? *BMC Med.* 2018;16(1):243.
298. Dalile B, Kim C, Challinor A, Geurts L, Gibney ER, Galdos MV, et al. The EAT–Lancet reference diet and cognitive function across the life course. *Lancet Planet Health.* 2022;6(9):e749–59.
299. Haskell-Ramsay CF, Docherty S. Role of fruit and vegetables in sustaining healthy cognitive function: evidence and issues. *Proc Nutr Soc.* 2023;82(3):305–14.
300. Smyth A, Dehghan M, O’Donnell M, Anderson C, Teo K, Gao P, et al. Healthy eating and reduced risk of cognitive decline. *Neurology.* 2015;84(22):2258–65.

301. Valls-Pedret C, Lamuela-Raventós RM, Medina-Remón A, Quintana M, Corella D, Pintó X, et al. Polyphenol-Rich Foods in the Mediterranean Diet are Associated with Better Cognitive Function in Elderly Subjects at High Cardiovascular Risk. *J Alzheimers Dis.* 2012;29(4):773–82.
302. Morris MC, Tangney CC, Wang Y, Sacks FM, Barnes LL, Bennett DA, et al. MIND diet slows cognitive decline with aging. *Alzheimers Dement.* 2015;11(9):1015–22.
303. Hosking DE, Eramudugolla R, Cherbuin N, Anstey KJ. MIND not Mediterranean diet related to 12-year incidence of cognitive impairment in an Australian longitudinal cohort study. *Alzheimers Dement.* 2019;15(4):581–9.
304. Valls-Pedret C, Sala-Vila A, Serra-Mir M, Corella D, de la Torre R, Martínez-González MÁ, et al. Mediterranean Diet and Age-Related Cognitive Decline: A Randomized Clinical Trial. *JAMA Intern Med.* 2015;175(7):1094–103.
305. Ghosh TS, Rampelli S, Jeffery IB, Santoro A, Neto M, Capri M, et al. Mediterranean diet intervention alters the gut microbiome in older people reducing frailty and improving health status: the NU-AGE 1-year dietary intervention across five European countries. *Gut.* 2020;69(7):1218.
306. Witte AV, Kerti L, Margulies DS, Flöel A. Effects of Resveratrol on Memory Performance, Hippocampal Functional Connectivity, and Glucose Metabolism in Healthy Older Adults. *J Neurosci.* 2014;34(23):7862.
307. Noetel M, Sanders T, Gallardo-Gómez D, Taylor P, del Pozo Cruz B, van den Hoek D, et al. Effect of exercise for depression: systematic review and network meta-analysis of randomised controlled trials. *BMJ.* 2024;384:e075847.
308. Mammen G, Faulkner G. Physical Activity and the Prevention of Depression: A Systematic Review of Prospective Studies. *Am J Prev Med.* 2013;45(5):649–57.
309. Williams J, Shorter GW, Howlett N, Zakrzewski-Fruer J, Chater AM. Can Physical Activity Support Grief Outcomes in Individuals Who Have Been Bereaved? A Systematic Review. *Sports Med - Open.* 2021;7(1):26.
310. Ji M, Li R, Xu Y. Meta-analysis of the effect of different exercise modalities in the prevention and treatment of perinatal depression. *J Affect Disord.* 2024;350:442–51.
311. Wang J, Carru C, Sedda S, Fiori PL, Li Z, Chen Z. Comparative impact of exercise-based interventions for postpartum depression: A Bayesian network meta-analysis. *Int J Gynecol Obstet.* 2024;165(1):67–75.
312. Aylett E, Small N, Bower P. Exercise in the treatment of clinical anxiety in general practice – a systematic review and meta-analysis. *BMC Health Serv Res.* 2018;18(1):559.
313. Pearsall R, Smith DJ, Pelosi A, Geddes J. Exercise therapy in adults with serious mental illness: a systematic review and meta-analysis. *BMC Psychiatry.* 2014;14(1):117.
314. Bray I, Reece R, Sinnott D, Martin F, Hayward R. Exploring the role of exposure to green and blue spaces in preventing anxiety and depression among young people aged 14–24 years living in urban settings: A systematic review and conceptual framework. *Environ Res.* 2022;214:114081.
315. Marques A, Peralta M, Henriques-Neto D, Frasquilho D, Rubio Gouveira É, Gomez-Baya D. Active Commuting and Depression Symptoms in Adults: A Systematic Review. *Int J Environ Res Public Health.* 2020;17(3).
316. Knott CS, Panter J, Foley L, Ogilvie D. Changes in the mode of travel to work and the severity of depressive symptoms: a longitudinal analysis of UK Biobank. *Prev Med.* 2018;112:61–9.
317. Rathore A, Lom B. The effects of chronic and acute physical activity on working memory performance in healthy participants: a systematic review with meta-analysis of randomized controlled trials. *Syst Rev.* 2017;6(1):124.
318. Li X, Zhang Y, Tian Y, Cheng Q, Gao Y, Gao M. Exercise interventions for older people with cognitive frailty—a scoping review. *BMC Geriatr.* 2022;22(1):721.
319. Lee J. The Relationship Between Physical Activity and Dementia: A Systematic Review and Meta-Analysis of Prospective Cohort Studies. *J Gerontol Nurs.* 2018;44(10):22–9.

320. Lin JC, Chen IH, Cheng FY. Review articles (Meta-Analyses) effects of walking on cognitive function in individuals with mild cognitive impairment: a systematic review and meta-analysis. *BMC Geriatr.* 2023;23(1):500.
321. López-Ortiz S, Valenzuela PL, Seisdedos MM, Morales JS, Vega T, Castillo-García A, et al. Exercise interventions in Alzheimer's disease: A systematic review and meta-analysis of randomized controlled trials. *Ageing Res Rev.* 2021;72:101479.
322. Junge T, Ahler J, Knudsen HK, Kristensen HK. The effect and importance of physical activity on behavioural and psychological symptoms in people with dementia: A systematic mixed studies review. *Dementia.* 2020;19(3):533–46.
323. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical exercise improves strength, balance, mobility, and endurance in people with cognitive impairment and dementia: a systematic review. *J Physiother.* 2018;64(1):4–15.
324. Huang HH, Stubbs B, Chen LJ, Ku PW, Hsu TY, Lin CW, et al. The effect of physical activity on sleep disturbance in various populations: a scoping review of randomized clinical trials. *Int J Behav Nutr Phys Act.* 2023;20(1):44.
325. Larun L, Brurberg K, Odgaard-Jensen J, Price J. Exercise therapy for chronic fatigue syndrome. *Cochrane Database Syst Rev.* 2019;(10).