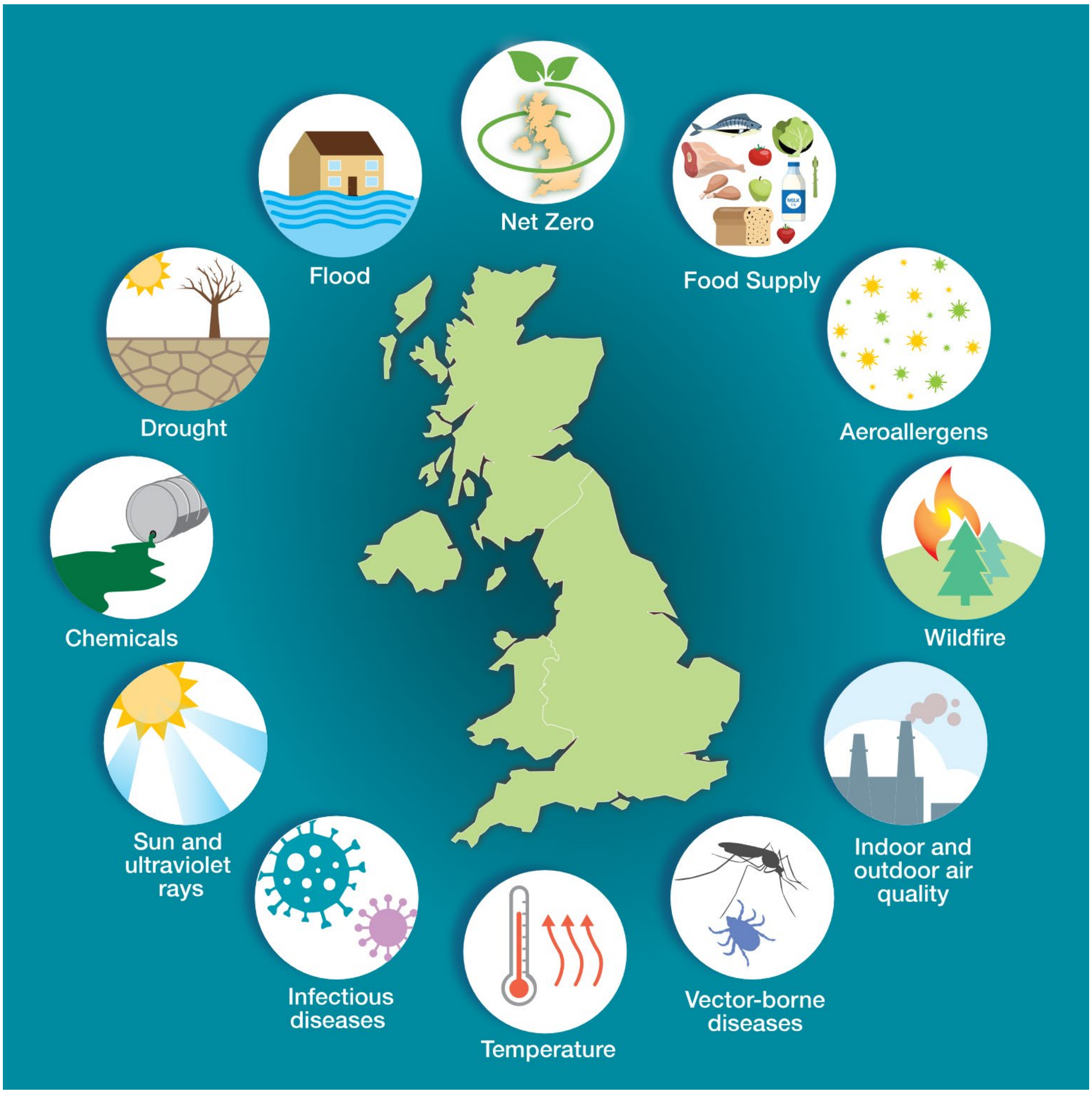
UK Health Security Agency

Health Effects of Climate Change (HECC) in the UK: 2023 report

Chapter 13. Solar radiation and public health



Summary

Sunlight has numerous benefits for health, but excessive exposure can cause sunburn and increase risk of some cancers. Chapter 13 examines the relationship between exposure to solar radiation and health, and how our changing climate may affect these risks. The chapter provides an updated synthesis of new evidence published since the last 'Health Effects of Climate Change in the UK' report and was written by scientific experts from the UK Health Security Agency (UKHSA).

Solar radiation includes visible light as well as invisible light in the form of heat we feel from the sun (infrared) and ultraviolet radiation (UVR). Sunlight exposure is required for vitamin D production which is necessary for healthy bones and immune system. Exposure to sunlight has positive effects on mental health, reduces the risk of myopia in schoolchildren and young adults and can contribute to lower blood pressure. However, over-exposure to UVR can lead to sunburn, premature skin aging and increased risk of skin cancers including non-melanoma skin cancers (NMSC) and malignant melanoma (MM).

UVR can be impacted by ozone concentration, cloud cover and air pollution, all of which may be altered by climate change. Monitoring suggests that the UV Index (a sunburn risk communication tool used in all public health sun protection guidance) has changed little and remained nearly constant since the 1920s, though there have been some more recent peaks. The impact of climate change on sunlight exposure in the UK is difficult to predict with ahigh degree of certainty since sunlight exposure is highly dependent on people's lifestyle, behaviour and age. Demographics and behaviours are likely to be stronger drivers of health outcomes than climate change.

Improving public awareness of the risks and benefits of sun exposure is critical to protect health. Most of the current public health guidance and information is focused on sun protection, but there are increasing numbers of the UK population who do not receive enough sun exposure.

This chapter highlights several research gaps and priorities, including the need to:

- monitor and assess on an ongoing basis the association between sunlight exposure and weather in the UK, based on active surveillance and review of evidence, to develop an evidence base on dose response and validate models linking sunlight exposure to health outcomes
- project how risk and relevant health outcomes might evolve using a range of warming and adaptation scenarios
- conduct studies to help identify acceptable guidelines and interventions for sunlight exposure to underpin public health messaging

Solar radiation is monitored by UKHSA through a network of solar UV monitoring stations across the UK, providing real-time data on UV levels.

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1. Introduction

1.1 Summary of previous HECC reports

The previous 'Health Effects of Climate Change in the UK (HECC)' reports included chapters on solar radiation, which outlined how solar ultraviolet radiation (UVR) reaches the Earth's surface (1) and described the detriments and potential health benefits of exposure (2). In the most recent report (3), it was noted that while climate change may affect levels of UVR in the UK, the most critical factors affecting human exposure to sunlight are lifestyle, behaviour and age. At the time, it was projected that a rise in temperatures may lead to increased time outdoors, affecting the balance of the risk of excessive and insufficient exposure from the sun. These themes are developed further in this report, alongside consideration of the broader solar spectrum, rather than including only UVR. How the emphasis has changed in the most recent reports is set out in more detail below.

The 2002 HECC report outlined that climate change is producing warmer weather and depletion of stratospheric ozone would likely lead to increased exposure to UVR in the UK (1). It was noted that if behaviour didn't change, this would lead to higher exposure to damaging UVR that may result in an increase in sunburn, skin cancers, eye damage and immune suppression. It was hypothesized that there would be thousands of extra skin cancers each year by 2050, while targeted public awareness campaigns were needed to reduce personal exposure. There was also a mention of sunlight benefits to vitamin D and appearing evidence of UV-B potential to reduce blood pressure.

The chapter in the 2008 HECC report marked a shift in focus from solely detrimental health impacts of sunlight exposure in the 2002 report, towards a more balanced approach of the benefits and health risks and the importance of patterns of human behaviour and environmental levels of UVR (2). There was convincing evidence of the importance of vitamin D in skeletal health and calcium metabolism, but further research was needed to define optimum exposures. Epidemiological studies had confirmed the role of UVR in the development of skin cancers and presented evidence that the exposure to UVR can cause cataracts, a major cause of blindness. Further concerns were also raised about the impact of exposure to UVR in reducing the effectiveness of the immune response to vaccinations against infectious diseases.

The 2008 report confirmed that the stratospheric ozone layer was slowly recovering due to the phase-out of ozone-depleting chemicals under the Montreal Protocol. However, higher levels of UV-B radiation (compared to pre-ozone depletion) would remain, primarily in polar regions, until approximately 2050 (4). It was suggested that climate change would overlap with the ozone recovery and that global warming could lead to a further delay, potentially increasing excess skin cancers until closer to 2065 (5). It was also postulated that if cloud cover decreases, especially in the summer, personal behaviour would change, potentially leading to increases in personal UVR exposure. It was recommended that promotional campaigns were necessary for limiting exposure to UVR, while guidance was needed to advise the public on vitamin D.

By 2012, the importance of balance of the risk of excessive or insufficient exposure was evident. The 2012 report stated that variations in cloud cover or reductions in stratospheric ozone (low ozone events) due to climate change could affect ambient levels of UVR, but human behaviour, lifestyle and age are the critical factors defining population exposures (3). It further concluded that any potential increase in outdoor temperatures leading to a change in outdoor behaviour would likely lead to an increase in the risk of prevalence of skin cancers, cataracts and sunburn. The 2012 report conclusions actively encouraged outdoor time without protection for a recommended 15 minutes at midday in the UK summer to stimulate vitamin D production, which could be combined with exercise, fresh air and help with circadian rhythm entrainment, something not previously mentioned. The report also considered evidence on other health effects such as the UVR-induced immune-suppression (6, 7). It was emphasised that guidelines needed developing which optimise the sun protection strategy throughout the UK for different population groups. This was supported by a list of research needs, including personal monitoring to understand actual population exposures, and epidemiological studies to better understand the relationship between changes in environmental UVR and sun-related behaviours.

The current chapter discusses how ground level UV has changed since the 1990’s up to 2019 and how this has been impacted by changes in the environment including air pollutants, aerosols and most notably by cloud cover and total ozone (8) in the UK. The focus of the chapter has expanded, broadening from just UVR effects to consider the entire solar spectrum at ground level. This chapter advances the previous one by discussing the need for greater awareness of the risks and benefits of sun exposure and the balance required for optimal health, and how the use of modern technologies may help the public to make their own choices on sun safety.

An understanding of the sunlight exposure dose received by an individual is important. It is complex and involves behaviour (including use of sun protection, cultural norms, body surface area exposed, body orientation), age, skin colour, demographic, location, season of the year, and time of day (through effects on ground level of UVR) that could influence exposure outcomes. Work is ongoing to investigate the impact of exposures on cardiovascular and metabolic health (9 to 12), mental health, circadian rhythm entrainment (13, 14), risk of multiple sclerosis and other autoimmune disorders (15 to 17), risk of respiratory infections (18 to 21), and more recently, childhood myopia (22, 23). Sunlight is increasingly used in medical practice, including psoriasis heliotherapy (24, 25) and daylight photodynamic therapy for actinic keratosis (AK) (26).

2. Health effects of sunlight exposure

The International Commission on Illumination (27) divides optical radiation received from the sun into infrared at 780nm to 1mm (which we perceive as warmth), visible radiation at 400nm to 780nm (which allows us to see and is essential for circadian entrainment) and UVR at 100nm to 400nm (UVR below 280nm is absorbed by the atmosphere and doesn't reach the Earth's surface).

The health effects of sun exposure are governed not only by environmental levels of sunlight, but are critically dependent on behaviour, which itself varies according to socio-demographic factors, such as constraints of employment or education, lifestyle factors, and cultural or religious norms. Ambient temperature and outdoor conditions may also play a role when planning to go outdoors, for how long and what is worn (28), which in turn affects the skin and eye exposure to sunlight.

A balanced approach to sunlight exposure is necessary. Historically, skin cancers, sunburn (erythema), cataracts, premature skin aging and affecting immune response to skin cancers and some viral infections due to over-exposure to the sun have been the focus of policies and public health interventions (29). However, insufficient sunlight also has negative health consequences (13, 30) and may result in a burden on the health services (31). Sunlight exposure increases vitamin D status and promotes healthy bones (32), it may improve cardiovascular and metabolic health (9, 33 to 38), and is essential for melatonin regulation for better quality sleep and serotonin regulation for improved mental health (39). Insufficient exposure to daylight due to reducing time spent outdoors may relate to the rapid increase in prevalence of myopia in schoolchildren and young adults which the World Health Organization (WHO) recently recognised as an emerging global health risk (40).

Sunburn is a common symptom of excessive sun exposure. In the short-term, the level of sunburn can range from reddening of the skin with little impact to the individual, to peeling or blistering of the skin which can last for days. Longer-term, exposure to UVR may impact the structural properties of the proteins in the dermis leading to skin photoaging, with an increased level of wrinkling and, more importantly, to an increased risk of developing skin cancers. In the UK, data on sunburn cases reported to doctors is obtainable via the NHS. An increasing trend of sunburn injuries over the 10-year period for patients presenting to the Manchester Adult and Paediatric Specialist Burn Services followed the pattern replicated in national data from England and Wales (41).

Excessive exposure to UVR caused around 1.2 million new cases of non-melanoma skin cancers (NMSC) and 325,000 malignant melanomas (MM) worldwide in the year 2020, with 64,000 premature deaths from NMSC and 57,000 from MM (42). Malignant melanoma is the fifth most common cancer in the UK and accounts for 4% of all new cancer cases (43). On average during 2016 to 2018, the number of new registered cases of MM was 16,744 and 155,985 of NMSC, and for the period of 2017 to 2019, there were 2,341 deaths due to MM and

1,115 due to NMSC (43). In the last decade, MM incidence rates increased by 32% (females = 27% and males = 38%). Each year, 29% of all new cases of MM have been diagnosed in those aged over 75, with rates highest in 85- to 89-year-olds, while it is projected that there will be a 7% (32 cases per 100,000) rise in diagnosed cases in the UK between 2014 and 2035 (43). MM accounts for 1% of all cancer deaths, with 48% of these deaths during 2017 to 2019 in people aged over 75 (43). Since the early 1970's, MM mortality rates have increased by 141% (females = 76% and males = 219%), and over the past decade, mortality rates have remained stable in the UK for men, while the rates for females have decreased by 9% (43). It is projected that between 2014 and 2035, mortality rates of MM will decrease by 15% to 4 deaths per 100,000 cases by 2035 (43). A systematic review of national incidences of NMSC concluded that the rates in the UK increased compared to the rest of Europe, with South West England having the highest rates per person and London the lowest (44). The authors noted that if this increase continues at this rate, it will represent a major public health risk placing a significant burden on the NHS (44). Kwiatkowskia and colleagues updated this report and for the first time estimated the incidence and epidemiological trends of keratinocyte cancers in the UK covering the period of 2013 to 2018 (45). It was noted that the incidence of cutaneous squamous cell carcinomas (cSCC) increased, but basal cell carcinomas (BCC) incidence varied across nations in the UK but was not statistically significant (45). A key conclusion from the findings was that 1 in 5 people will develop BCC, cSCC or other NMSC in their lifetime, significantly higher than melanoma risk of 1 in 36 for males and 1 in 47 for females (45). This further supports previous estimates of an increase in the disease burden posed by these cancers in the UK (44).

Incidence and mortality rates of both MM and NMSC are lower in people of non-White minority ethnicity compared with the White ethnic group (46). Thus, the 2013 to 2017 annual average number of new MM cases in White ethnic group is 12,120, compared with 22 cases in each of Asian and Black ethnicities (47). It should also be noted that case-fatality rates and morbidity are higher in non-White ethnic groups compared to White ethnic groups (48, 49).

As is the case for the skin, excessive exposure of eyes to UVR can lead to a range of diseases, these include pterygium and age-related macular degeneration and cataracts, which is the leading cause of impaired vision worldwide (50).

The best-known benefit of sunlight exposure is the synthesis of vitamin D. Adequate vitamin D status (commonly considered to be a blood concentration of 25-hydroxyvitamin D (25(OH)D) of 50nmol/L or higher) is required for the maintenance of a healthy musculoskeletal system and supports a healthy immune system. To date, the strongest evidence of a benefit of vitamin D is for upper respiratory tract infections (51). The level of vitamin D produced (52, 53) depends on the dose of UV-B radiation received, the skin surface area exposed to the sun, and a range of metabolic factors. Efficiency of vitamin D synthesis can be lower in people with darker skin pigmentation (54) and in older people (55 to 57). In 2016, the Scientific Advisory Committee on Nutrition (SACN) updated the report on vitamin D and health made several recommendations, including that the UK population's serum 25(OH)D concentration should not fall below 25nmol/L throughout the year, most notably in population groups who have minimal sunshine exposure such as the elderly, institutionalised people, those who customarily cover most of their skin while outdoors and those from minority ethnic groups with dark skin (58). SACN were unable to recommend the amount of sunlight exposure required in the UK to meet these needs. Recommendations for further research included considerations of different ethnic groups, effects of diet, body weight, age, and efficiency of vitamin D production on serum 25(OH)D concentration levels.

Heart and circulatory diseases are the second cause of all deaths in the UK (28%) (59). There is increasing scientific evidence that blood pressure can be reduced by sunlight exposure, by the UV-induced nitric oxide release independently from vitamin D pathway (9, 33, 35, 38). Whilst it is possible that seasonal variation in nitric oxide availability may contribute to increased blood pressure in the winter months, the overall impact on cardiovascular health is complex and remains to be determined.

For several decades, UVR (UV-C and UV-B in particular) has been used for disinfection of air (60 to 63), water (64), surfaces (61, 62) and food (64 to 66). Whilst UV-C is blocked by the atmosphere, UV-B and UV-A radiation reaching the ground level may contribute to infection control of surfaces and air (63). The COVID-19 pandemic renewed practical considerations of sunlight in the range of environmental factors affecting infection rate (67 to 71). Using the data from the UKHSA solar network, it has been shown that from October to March, sunlight is unlikely to contribute to significant viral inactivation outdoors in the UK (72). In late spring and summer months, 90% viral inactivation may be achieved in tens of minutes under a clear sky, but there are many factors that could increase viral inactivation times so these results should be treated with caution. In addition to high levels of UVR in sunlight, temperatures, high humidity and strong winds may also affect viral spread (73). The lower solar radiation in winter, amongst other environmental factors such as lower temperature and humidity and people spending more time indoors in closer contact with each other, may contribute to the increased risk of respiratory infections (including coronavirus) in winter (74).

Health effects of visible solar radiation is an area of increasing understanding, with evidence growing rapidly (22, 75 to 77). The risks from insufficient exposure in the visible region are often as important as the risks from over-exposure, and the impact of exposures can also depend on the time of day. Light at night and before bed can negatively impact health by disrupting sleep and circadian rhythms (78), but too little exposure during the day can increase the sensitivity to these effects. Reduced exposure to daylight due to reducing time spent outdoors may increase the risk of development myopia in children and young adults (22).

Natural sunlight is increasingly used for medical treatment of psoriasis (24, 25, 79) or for photodynamic therapy in AK. Some 25% of over 60-year-olds in Europe are affected by AK, and if left untreated, there is a reported 0.1% to 20% annual risk of transforming into invasive cSCC (26). Smartphone-based applications using satellite imagery and computational algorithms to provide real-time guidance on effective AK treatment were developed recently (80, 81) and are increasingly used in clinical practice.

3. Public communication tools

For the communication of risks associated with sun exposure and to provide guidance on protection measures, the Global Solar UV Index was developed by the WHO jointly with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO) and the International Commission on Non-Ionizing Radiation Protection (82). The UV Index is reported on a scale of 1 (or ‘Low’) to 11 and higher (or ‘Extreme’). The higher the index value, the greater the potential for damage to the skin and eye, and the less time it takes for harm to occur. The WHO recommends that sun protection is used when the UV Index is 3 or greater (82). The UV Index is an important tool to provide an estimate of the maximum sun exposure that could be experienced so that an individual can make an informed decision over their protection. The maximum UV Index is at the solar noon when the sun is highest in the sky. In the UK, it is rare that the UV Index exceeds 8. However, for popular destinations where UK holidaymakers may spend 1 or 2 weeks of recreation per year, the UV Index may exceed 11 (classified as ‘extreme’) and at the equator it may reach 16. The UV Index data collected by 10 UKHSA and 2 University of Manchester solar monitoring stations are displayed online (83).

Radiative transfer models based on satellite imagery are widely used to report real-time and short-term forecasted ground level of sunlight in different spectral bands including the UV Index (84). Development of satellite technology, data retrieval algorithms using multi-source data and validation of models against direct ground measurements under all weather conditions continue to improve accuracy (85, 85) and broaden the range of applications using satellite data (87, 88).

In addition to a range of WHO resources on sun safety (82), a new mobile phone application (app) that provides localized information on levels of UVR was launched in June 2022 in co-operation with the WMO, the UNEP and the International Labour Organization. The SunSmart Global UV app (89) provides 5-day UV and weather forecasts at searchable locations. It highlights time periods when sun protection is required, to reduce the global burden of skin cancers and UV-related eye damage. Advice includes adequate clothing, hats, use of sunscreens, wearing sunglasses and seeking shade, especially for the 4-hour period around solar noon.

The NHS provides guidance on sun safety (90), including advice on protection of babies and children, and holiday travel. The importance of sun protection is recognised in the Education, Relationships and Sex Education (RSE) guidance and Health Education Statutory guidance issued by Department of Education for primary and secondary schools, aimed at their governing bodies, proprietors, head teachers, principals, senior leadership teams and teachers (91). The Sun Safe Schools (92) and Sun Safe Nurseries (93) annual accreditation schemes launched in the UK in 2013 by Skcin (the Karen Clifford Melanoma and Skin Cancer Charity) provide the tools, advice, guidance, resources and support to assist schools in their duty of care to safeguard children against UV exposure and prevent skin cancer through education (94). Promotion and dissemination of knowledge of sun protection is a focus of UK charities, such as

Cancer Research UK, British Association of Dermatologists, Melanoma UK, Melanoma Action and Support Scotland (MASScot), British Skin Foundation and others.

Daylight measurements indoors can inform and validate models used by architects and lighting designers to predict the visual environment and to understand the need for artificial lighting, for instance in offices and schools. As well as aiming to design an environment to support visual tasks and avoid glare, it is now recognised that natural daylight provides a healthier environment indoors, and daylighting is included in some design practices (95). There are recommendations for minimum levels of light during the day, when there is risk of is too little exposure to light, and maximum levels during the evening and at night, from daylight and artificial light (77) (see also Chapter 5).

4. Climate effects impacting solar radiation

Climate change is one of the challenges currently facing the UK and worldwide as has been discussed throughout chapters in this report. It is expected that changes in cloud cover, temperature, total ozone and air pollution, including UV-absorbing tropospheric gases, and particulates that affect the aerosol optical depth, may alter levels of solar radiation at ground level. A previous study considered that increases in UVR observed in northern mid-latitudes since the mid-1990s are accounted for by decreases in cloud cover and aerosols, rather than changes in stratospheric ozone (96). However, the increase in UV at ground level doesn't necessarily mean increased population exposure due to other critical factors affecting human exposure, such as lifestyle and behaviour. As climate change goals are worked towards which involve the improvement in air quality through the result of reduction in aerosols, this may result in higher levels of UVR as has been predicted (96, 97).

For decades, solar radiation has been monitored by UKHSA (and predecessor organisations) across the UK at 10 monitoring sites (98). Long-term variations of UV Index (99) and the effects of total ozone, cloud cover and aerosols optical depth on levels of UVR for the period of 1991 to 2015 have been investigated at Chilton, Oxfordshire (8). It was shown that the period was best characterised into 2 sub-periods: 1991 to 2004, and 2004 to 2015. For 1991 to 2004, cloud cover played a more prominent role in the trend to higher ground levels of UVR than total ozone, whereas during 2004 to 2015, the trend towards lower UV Index was more associated with total ozone and its recovery, and less associated with changes in cloud cover (8). Overall, the change for the period of 1991 to 2015 is relatively small, less than 5%, similar to the change of sunshine observed for the summer months, which has remained nearly constant since the 1920's (100). However, inter-annual variations over this period could be significantly higher. For example, in the summer of 2018, the environmental availability of UV was 25% above the long-term average. As population exposures to UV are critically dependent on behaviour, socio-demographic variables and lifestyle, the health impacts of environmental variations of UV at these levels can only be hypothesized and are difficult to predict with any degree of certainty. Over the last 30 years, the significant decrease of outdoor working, increasing indoor lifestyle, and diversifying ethnic backgrounds of the UK population may have changed the exposure landscape much more than the levels of UVR reaching the earth's surface.

Springtime is likely to have the most noticeable impact on population sun exposure, even though the UV Index reaches its maximum around the summer solstice and is higher in general in summer than during spring. There is widespread misapprehension that high UV levels are associated with hot weather, but the UV Index in spring is often higher than is perceived by using ambient temperatures as a guidance. Temperature and the presence of sunshine could impact sunlight exposure as these 2 factors may influence time spent outdoors (28) and type of clothing worn. An upward trend (+15%) of sunshine hours during UK springtime has been observed recently (100) which may result in an increase in time spent outdoors. In spring 2018, unseasonably high temperatures in Chilton, Oxfordshire coincided with high environmental daily doses of sunlight, up to 75% above the average in 1991 to 2017 for that time of year (101) and the population were likely to have experienced excessive UV exposure on unacclimatised skin, causing sunburn and potentially increasing the risk of skin cancers. In spring, the risk of over-exposure may be higher than in peak summer when heatwave warning systems are likely to be triggered (102). However, no health alerts were raised in spring 2018 as they occurred outside the heatwave alerting period. This example demonstrates the importance of timely and appropriate public health advice (101).

In conclusion, the UVR reaching the Earth's surface depends on factors such as stratospheric ozone concentration, cloud cover and air pollution which are all impacted by climate change. To evaluate potential health impacts on the population in the future, a good understanding of the effect of climate change on these factors is essential to predict changes in the ground UVR level. As population exposures to UVR are critically dependent on behaviour, socio-demographic variables and lifestyle, the health impacts of climate change through sun exposure related pathways can only be hypothesized and need more research.

5. Discussion in terms of policy, current gaps in adaptation and future priorities

Currently there are no UK policies that specifically cover exposure to solar radiation. Guidance on sun protection is included in the Climate Change Act 2008 (103), heatwave plans (104) and environmental quality (105). When UVR is mentioned, the impact of sunlight exposure is limited to a potential increase in the prevalence of skin cancers, cataracts, and a reduction of crops in agricultural production.

The 'Third UK Climate Change Risk Assessment' (CCRA3) states that increasing temperatures due to climate change may influence the use of outdoor spaces and physical outdoor activity (106), helping to improve mental health. It has also been concluded that behaviour change is likely to result in increasing exposure to UVR, which may act to balance the benefit of vitamin D (though limited to vitamin D only) and the health risks of skin cancers and sunburn (106), especially in outdoor workers (107).

Improving public awareness and targeted communication are equally important. In the UK, current public information and guidance are often biased towards sun protection, based on the Australian model of successful campaigns of skin cancer reduction. For the UK conditions, this approach urgently needs revising, especially with the increasing numbers of the UK population not receiving enough exposure to sunlight. It has been identified that public sun protection messaging may often be too late in the year (101) and should be communicated earlier in spring and outside of the heatwave alerting period, when the risk of sunburn is high due to a rapidly increasing UV Index, there is reduced skin adaptation after the winter months, the common misconception that heat means high UV level (and thus that cool means low UV level), and there are frequent episodes of low ozone events earlier in the year.

Over the past few decades, population exposure to solar radiation reflects societal changes in lifestyle and work patterns, religious and cultural norms. Indoor employment in the UK is substantially higher compared with outdoor occupations, and children have a growing reliance on technology for education and socialising – both factors reduce sunlight exposures. These societal changes in behaviour may have significantly stronger implications for an individual's sun exposure than variation in UVR levels in the outdoor environment.

A balanced approach to sun exposure is necessary, addressing not only the health risks associated with over-exposure but also consequences of insufficient sunlight (30), which may result in a greater burden of ill-health and pressure on health services (31). Climate change adaptation strategy in public health should consider the health outcomes of sunlight exposure for different socio-demographic groups, including children, the elderly and people in residential healthcare and outdoor workers, as well as the complex ethnic profile of the UK. The whole spectrum of solar radiation, from infrared through visible to ultraviolet, has effects on body physiology. This complex situation calls for a nuanced approach to sunlight exposure advice.

Acronyms and abbreviations

Abbreviation	Meaning
AK	actinic keratosis
BCC	basal cell carcinoma
cSCC	cutaneous squamous cell carcinoma
HECC	Health Effects of Climate Change in the UK report
MM	malignant melanomas
NMSC	non-melanoma skin cancers
SACN	Scientific Advisory Committee on Nutrition
UNEP	United Nations Environment Programme
UVR	ultraviolet radiation
WHO	World Health Organization
WMO	World Meteorological Organization

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