

Nudging construction workers towards better sun safety behaviour

Report submitted to the IOSH Research Committee

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Abstract

Excessive exposure to solar ultra-violet (UV) radiation can cause skin cancer. However, inadequate exposure to sunlight limits the production of vitamin D. There is very little research on understanding the barriers to adopting sun-safe behaviours in the workplace and encouraging behaviours that ensure vitamin D sufficiency. We report findings from a text messaging (SMS) and supportive smartphone app intervention, that aimed to reduce UV exposure in the summer and promote appropriate dietary changes and/or supplement intake to boost vitamin D status in the winter. Sixty-six adult construction workers were recruited from central Scotland and southern England from nine construction sites. A randomised control crossover trial design was used, with randomisation to the intervention at site level. The intervention messages were delivered daily to participants' smartphone along with a supportive app and appropriate supportive measures such as vitamin D supplements during the winter intervention and sunscreen during summer. The main outcome measure was 25-hydroxy-vitamin D in blood, taken at the start and end of each study period. There were three waves of data collection across 2017 (winter, summer and winter) with each study period lasting 21 days. Results suggest: (i) many workers in our study had insufficient circulating vitamin D in winter, but for the intervention group vitamin D levels increased significantly compared to the control group; (ii) in the summer workers were exposed to relatively high UV levels from the sun, sufficient for many to have their risk of being diagnosed with skin cancer doubled if the exposure continued over their whole working life; few participants had insufficient levels of vitamin D during summer; (iii) the sun-safe intervention failed to reduce exposure to solar UV and failed to reduce vitamin D levels in summer, as we hypothesised; (iv) psychological aspects suggested the intervention had a positive effect on taking action to use sun protection measures in summer (e.g. sunglasses) and preparation to increase vitamin D intake during winter, but a key barrier to the success of the summer intervention appears to be the entrenched belief that a sun tan is desirable. This study provides important information about the effectiveness of a technology-based intervention to promote sun-safe and healthy behaviours. This demonstrates that text messaging and a supportive app provides an easy and accessible method to communicate with workers. We argue that a more prescriptive risk-based approach is needed to reduce the risk of skin cancer among outdoor construction workers.

Executive summary

Project overview and aims

This document reports on a research study commissioned by the Institution of Occupational Safety and Health (IOSH) to investigate the effectiveness of a technology-based intervention to ‘nudge’ construction workers towards sun safety in summer and improve vitamin D consumption in winter. The study attempted to achieve this using a text messaging and supportive smartphone App. Communicating sun safety is complicated in Britain because there is a large part of the year when workers are likely to get insufficient UV exposure to synthesise the vitamin D necessary for health, yet the risk of over exposure is high in workforces that spend prolonged periods outdoors in summer. The aim of this study was to communicate information tailored to the outdoor conditions – i.e. variable text messages to reduce exposure to UV radiation among those at risk of excessive exposure, or increase exposure/promote appropriate dietary changes among those who are likely to receive insufficient sun exposure to synthesise vitamin D. We aimed to influence behavioural choices of workers to help them make better sun safety choices, which in psychological theory is often referred to as a “nudge”.

The study had five key objectives. These were:

- Devise a way of delivering short messages to the smartphones of construction workers, which will change behaviour to minimise the risk of skin cancer and maximise the health benefits of vitamin D generated from solar UV radiation and diet.
- Develop a sun-safe and healthy mobile phone app that could be used more widely in the construction sector.
- Conduct an experimental trial to demonstrate the intervention delivers safe and healthy outcomes, based on measured serum vitamin D levels across the course of a year.
- Use personal UV monitors to support the conclusion that personal behaviour has altered as a result of the intervention.
- Develop a model strategy to change personal behaviour using smartphone technology, which could be widely applied in a workplace setting.

Protocol

To investigate the possibility of using text messages the study tested the approach at three different times across the year. The first round of data collection was from January to March 2017 – i.e. low UV period (winter) aimed at boosting vitamin D levels. Two follow-up sessions occurred from April to September, the high UV period (summer) aimed at improving sun safety behaviours and a repeat low UV period (winter) from October to December, which again focused on increasing vitamin D intake.

A daily text message was sent to participants tailored to reflect season, i.e. low UV boosting vitamin D or high UV periods sun safety. Participants were able to download the supportive App, which contained information about sun-safe actions and sources of vitamin D. During the low UV period vitamin D dietary supplement (daily tablet 10µg) was made available to the intervention group and they were advised that they could take these if they wished. Each round of data collection lasted three

weeks. Participants met the researcher at the start and end of the three-week period and completed a series of questionnaires and provided a blood sample for vitamin D analysis.

Results

The results explored changes in vitamin D levels; differences sun safe or vitamin D behaviours, if people moved from contemplating making changes to more active behaviours, and personal exposure to UV radiation. The key findings were:

- Many workers had insufficient circulating vitamin D in their blood during winter. The study showed that in the winter study periods (Wave 1 and Wave 3) vitamin D levels in the intervention group were significantly higher post intervention. Suggesting daily information and availability of a dietary supplement is likely to increase vitamin D levels during periods when UV is too low to be synthesised naturally.
- During the summer study period (Wave 2) the study failed to show a decrease in vitamin D levels in the intervention group as hypothesised; in fact, levels were higher in the intervention group. Measurements of exposure confirmed that UV exposure was higher in the intervention group than the control group. Most workers expressed the view that 'I like to have a sun tan' and this may be the main reason for the lack of behaviour change from the intervention. These results suggest that a more sustained risk-based management approach is needed to change sun safe behaviours on construction sites.
- Knowledge of sun safety measures and steps to increase vitamin D improved in both the control and intervention groups across the study periods. However, the desirability of having a sun tan remained high, thus suggesting more effort is needed to improve knowledge of the risks and attitudes to sun tanning, which is really a sign of skin damage.
- Beliefs around perceptions of control to increase vitamin D was higher in the intervention group during the low UV (winter) periods – i.e. they intended to take steps to improve their vitamin D intake during the winter. Participants also felt less social pressure to increase vitamin D, suggesting the information delivered equipped them to change beliefs. Similarly, in the high UV (summer) period, the intentions to take sun safe measures was higher in the intervention group.
- The intervention also showed positive effect on desirable behaviours. In the first low UV period (winter) the intervention group reported more contemplation regarding consumption of vitamin D rich products and by follow up at the second winter period this moved from contemplation to preparation. In the high UV period (summer) the intervention group reported higher action to wearing sunglasses for UV protection, but not sun-safe measures.

Discussion

This study highlighted the pivotal role that the construction industry should play in leading sun safety on site and promoting better health and wellbeing in the workforce. The research demonstrated the

potential of delivering health information via text messaging and how this service could serve to promote sun-safety behaviours during the summer months and help to reduce the decline in vitamin D levels during the winter period. Findings suggested vitamin D levels were, on average, higher post-study in the intervention group and that knowledge of vitamin D increased over the study period. The results also suggested that behavioural intentions were higher in those exposed to the intervention (in winter). Objective measure of UV exposure indicated that many participants spent a large part of their work shifts outdoors and that perhaps working patterns do not allow for any adjustment to sun exposure, e.g. working in the shade. Sun safety still remains a low priority on construction sites and awareness of current sun-safe measures is low.

In our opinion, there are several implications for practice from the research findings, which include:

- Providing a workforce with health promotion information on vitamin D dietary supplements over winter is likely to boost general health and vitamin D levels when UV exposure is low.
- A stricter risk-based approach should be taken to sun protection, increasing awareness of risks and facilitating measures to protect against the sun – e.g. sunscreen available on site and its use prescribed in the same way as for other forms of personal protective equipment. Employers, who already have legal obligations relating to occupational UV exposure under the Management of Health and Safety at Work Regulations, should proactively manage exposure to solar UV to reduce health risks and they should provide health surveillance to detect skin cancer in outdoor workers.
- Information communication using text messaging and supportive smartphone apps may be easily provided to help a workforce stay safe in the sun.

This research provides a model for an effective way of communicating sun-safety and other relevant health promotion messages, although on their own these messages are insufficient to reduce UV exposure. In our opinion, further employer-led risk management is needed to adequately control the cancer risk from UV exposure for outdoor construction workers.

Introduction

Exposure to sunlight can have both positive and negative health impacts. Excessive exposure to ultra-violet (UV) radiation from the sun can cause skin cancer and in Britain each year there are almost 3,000 cases of non-melanoma skin cancer caused by exposure to UV from sun at work and around 250 cases of malignant melanoma (Rushton *et al.*, 2012; Rushton and Hutchings, 2017). However, insufficient exposure to sunlight has a detrimental effect on the production of vitamin D, which may result in bone pain and osteoporosis (PHE, 2017). Low vitamin D has also been linked with increases in the risk of some cancers, cardiovascular diseases, metabolic disorders, infectious diseases and autoimmune diseases, although the evidence for causal associations is mostly still equivocal (Theodoratou *et al.*, 2014). Vitamin D insufficiency may also increase the risk of elevated blood pressure and vascular events, both heart attacks and stroke (Kent *et al.*, 2014). It is unclear whether these effects are due to circulating levels of vitamin D or to exposure to sunlight (UVA rather than the UVB involved in vitamin D production), or because people have low vitamin D because of their illness (Liu, Fernandez and Hamilton, 2014).

Many adults in northern latitude countries show insufficiency in vitamin D, particularly during winter months. A study in Germany has shown that during winter and spring, serum vitamin D levels were insufficient in about a third of the adult population (Rabenberg *et al.*, 2015), with rates of insufficiency in other European countries ranging from 30 – 60% (Spiro and Buttriss, 2014). Similar problems have been seen in British adult populations, with the issue being greater in Afro-Caribbean and Asian groups where levels of deficiency were more than three times those in Caucasians (Ford, Graham and Wall, 2006). This is due to darker skin tones requiring higher levels of UV exposure to naturally synthesise vitamin D (Webb, 2006).

Previous research in the British construction sector, funded by IOSH, has shown that sun-safety in the sector is poor and that an educational intervention using video materials could improve behaviour (Houdmont and Madgwick, 2015). This research also showed that commitment to a good sun-safe culture by employers and the regulator (HSE) would further enhance effectiveness of interventions. A range of intervention strategies are available to reduce occupational UV exposure for outdoor workers. Typically, these are based around education or training programmes promoting actions such as covering-up, use of sunglasses, brimmed hats and sunscreen. There is no information about awareness of vitamin D deficiency among construction workers in Britain, although there is information to suggest that among the general population there is a poor understanding of the importance of vitamin D for good health or the importance of sun in its synthesis (Webb *et al.*, 2016).

Communicating information about sun safety is complicated in Britain because there is a large part of the year when workers are likely to get insufficient UV exposure to synthesise the vitamin D necessary for health. For example, from around October to April in southern England the UVI¹ level is less than 2, which is considered sufficiently low to require no sun protection measures and there is little vitamin D synthesis. The main source of vitamin D during these periods is diet, e.g. fish oils, fatty fish, mushrooms, beef liver, cheese and egg yolks are high in vitamin D (PHE, 2017). In essence, the message for sun safety needs to be tailored to the outdoor conditions in a way that is impossible in a

¹ UVI is a categorical UV scale developed by the World Meteorological Organisation and the World Health Organisation for risk communication: ranging from 1 to 11+

single training intervention. The use of a variable set of messages to promote safe behaviour, delivered by smartphone, is an attractive alternative approach.

The research evidence shows that health and safety training on its own is unlikely to change worker behaviour. In a systematic review of the available literature, Robson *et al.* (2011) concluded that there was 'either no, uncertain, or low effectiveness of training in preventing illness and injury when delivered as a lone intervention'. They suggested that more than just simple information and training is required for success. Additionally, there are many specific barriers to the uptake of sun-safe behaviours, including the perception of a tan as being healthy, the practical difficulties in covering up or wearing sun protective cream, in addition to the attitudes of fellow workers, employers and regulators (Day *et al.*, 2014). It is likely that changing behaviour will require sustained communication, ideally addressing these and other barriers to safe and healthy behaviour.

Health-related behaviours occur within complex systems of different interacting influences, including demographic, psychological and social factors. Attempts to influence positive health behaviour change must therefore take into consideration the various factors impacting performance of the behaviour of interest. A number of models have been developed within the field of health psychology, which take account of these (Glanz and Bishop, 2010). One such model, which has been applied successfully to the prediction of health-related behaviour in relation to diet and sun safety, is the Theory of Planned Behaviour (TPB) (Ajzen, 2006). The TPB states that behavioural intention, the primary determinant of behaviour, is predicted by a combination of factors. These include the individual's own attitudes towards the behaviour (Attitudes) and the social norms governing performance of the behaviour (Subjective Norms). The perceived ability of the individual to engage in the desired behaviour is also taken into consideration (Perceived Behavioural Control) because there may be internal, e.g. skills, information, or external, e.g. resources, opportunities, dependence on others, that constrain or facilitate behaviour. In general, the more favourable the individual's Attitudes and Subjective Norms, and the greater their Perceived Behavioural Controls, the stronger their Intentions towards performing the target behaviour should be.

Mobile phone SMS messages have been shown to be effective in health promotion intervention studies (Montes *et al.*, 2012; Wong *et al.*, 2013; Armanasco, Miller and Fjeldsoe, 2017). A systematic review has found interventions using SMS or multi-media messages generally produced statistically significant positive behavioural change (Buhi, Trudnak and Martinasek, 2012). For example, a small study designed to increase physical activity using messages delivered via the Internet and mobile phone technology showed increases in moderate activity and increased loss of body fat in the test group (Hurling *et al.*, 2007). To date, there are only a small number of research studies that have investigated SMS messaging in relation to skin cancer risks. Hingle *et al.* (2014) studied the effect of text messages on sun protection and skin self-examination among children in the USA, showing statistically significant increases in reported sunscreen use, wearing a hat and sunglasses and finding shade around midday. Youl *et al.* (2015) studied adults in Australia and also found that messages were effective in inducing protective behaviour and in encouraging self-examination for skin cancer. These studies suggest the use of SMS messaging may be an appropriate way to tailor sun-safety and vitamin D messages for construction workers in Britain.

The aim of the current project was to investigate whether the combination of short messages delivered to the smartphones of construction workers, along with appropriate organisational support, can influence the workers' behaviour to reduce exposure to UV radiation among those at risk of excessive exposure, or increase exposure / promote appropriate dietary changes among those who are likely to receive insufficient sun exposure to synthesise vitamin D. We aimed to influence behavioural choices of workers to help them make better sun safety choices, which in psychological theory is often referred to as a "nudge"².

Specific objectives were:

- Devise a way of delivering short messages to the smartphones of construction workers, which will change behaviour to minimise the risk of skin cancer and maximise the health benefits of vitamin D generated from solar UV radiation and diet.
- Develop a sun-safe and healthy mobile phone app that could be used more widely in the construction sector.
- Conduct a randomised controlled trial to demonstrate that the devised intervention delivers safe and healthy outcomes, based on measured serum vitamin D levels (as 25-hydroxy-vitamin D, or 25(OH)D³ throughout a 12-month period.
- Use personal UV monitors to support the conclusion that personal behaviour has altered as a result of the intervention.
- Develop a model strategy to change personal behaviour using smartphone technology, which could be widely applied to promote sun-safe and healthy behaviour, and positive behaviour in relation to other health and safety risks, e.g. wearing personal protective equipment.

² Nudge theory suggests human behaviour can be influenced by small "nudging" suggestions and positive reinforcements. For a fuller description of the theory see Thaler & Sunstein (2012) Nudge. Improving decisions about health, wealth and happiness. Penguin Books.

³ The body converts vitamin D to 25(OH)D, which is also known as calcifediol. Measuring 25(OH)D in blood can be used to monitor whether vitamin D levels are sufficient for good health.

Methods

The study protocol has been published in the scientific literature (Nioi *et al.*, 2018). The development of the study methodology and the measurement is briefly summarised below. Ethical approval to carry out this research was granted by Heriot-Watt University Engineering and Physical Sciences Ethics Committee (approval number 2016-164).

Formative work for the TPB tool

Use of the TPB in the research required some prior formative research to determine the beliefs most commonly held by the target population. In this case, outdoor construction workers' beliefs about sun safety and healthy eating in relation to increasing vitamin D levels were elicited through their participation in focus groups and using postal questionnaires.

Two focus groups were held in central Scotland with five participants in each and lasting approximately 1.5 hours. Data were audio-recorded and subsequently transcribed. Due to the complex and time-consuming logistics of setting up focus groups, additional postal questionnaires were issued. Both methods of elicitation are commonly used in TPB studies, and the choice of which to use is a pragmatic one. Questionnaires were distributed to 94 construction workers in Scotland and southern England. Sixty-six completed questionnaires (70%) were returned.

Participants who took part in focus groups and who completed questionnaires were asked the same questions. The elicitation questions were designed to identify (i) the most commonly held beliefs in relation to the advantages and disadvantages of performing the target behaviours; (ii) the most important individuals or groups of people who would approve or disapprove of performing the target behaviours; and (iii) factors perceived to facilitate or constrain performance of the target behaviours. Half of the participants who received the questionnaire answered questions on sun safety first and then healthy eating to increase vitamin D, and the other half answered in the reverse order.

The most commonly held beliefs were then used to construct a draft questionnaire, which comprised of a series of seven-point Likert-type items designed to measure all of the TPB theoretical constructs. This draft was piloted on a further 46 construction workers. Item-total correlations were calculated for those sets of items comprising measures of behavioural intention, attitude, subjective norm and perceived behavioural control. To ensure a high degree of internal consistency of each of the measures, any item with an item-total correlation of less than 0.3 was dropped from the final questionnaire.

Recruitment and eligibility

At the start of the project we issued a press release to raise awareness of the forthcoming research. This gained useful coverage in national and specialist press and helped raise the profile of the research. The study's Principal Investigator also gave a radio interview on Good Morning Scotland, BBC Radio Scotland.

Three key construction companies were contacted to get support for the project (BAM Nuttall Ltd, Laing O'Rourke, and Bovis Homes). Additional construction companies were identified via a networking event at the Health in Construction Leadership Group (http://www.healthinconstruction.co.uk/about_us), utilising the research network with IOSH, and by contacting key health and safety professionals at large companies with active construction sites in

central Scotland and southern England. These included Morrison Construction/Galliford Try, Balfour Beatty, Multiplex (and by extension their subcontractors Keltbray and Crummock). The final study sites are shown in Figure 1 (site details shown in Appendix 1).

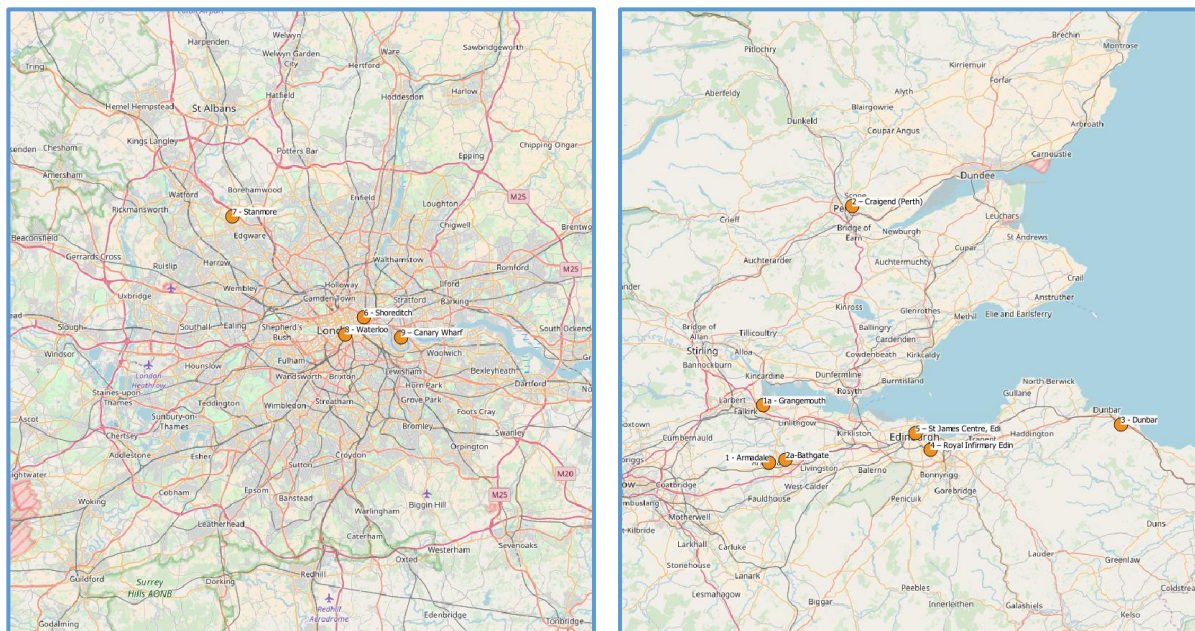


Figure 1 Study site locations – South England (Greater London) and Scotland

Once a key contact was established the researchers met with representatives of the companies to explain more about the study and the expectation from participants. This became the catalyst to access the site and potential participants. The study was then explained to prospective participants during an information session (Appendix 2). The eligibility criteria were: adult male or female employees in the construction industry, residing in Britain, either indoor or outdoor workers and owning a mobile phone, with no restriction on age or ethnicity.

Study design

The study was a randomised control crossover trial (RCCT). Details are registered with the ISRCTN clinical trials registry, which is recognised by the World Health Organization and the International Committee of Medical Journal Editors (ICMJE) and accepts all clinical research studies. Details can be found at www.isrctn.com/ISRCTN15888934.

Participants were randomised to the intervention at site level and completed both control and intervention conditions. Recruitment was for three waves of data collection. Figure 2 illustrates the data collection and the number of participants taking part in each wave, with each study period or epoch lasting 21 days. The data collection spanned 2017, capturing two low UV exposure periods (Wave 1 and 3) and one high UV exposure period (Wave 2). The pattern of the intervention was restricted because of the project timeline. Participants at a site were randomised to either the control (Ctrl) or intervention (Intr) groups in Wave 1. The intervention group from the first low UV wave was the control group in the high UV wave and the control group in the second low UV wave. While the control group in the first low UV wave was the intervention group for the high UV wave and the intervention group in the second low UV wave. This protocol determined whether the intervention to increase vitamin D levels in winter was sustained in the absence of any further interventions, and the

vitamin D status in the intervention group in the first low UV wave was replicated in a different intervention group in the second low UV wave.

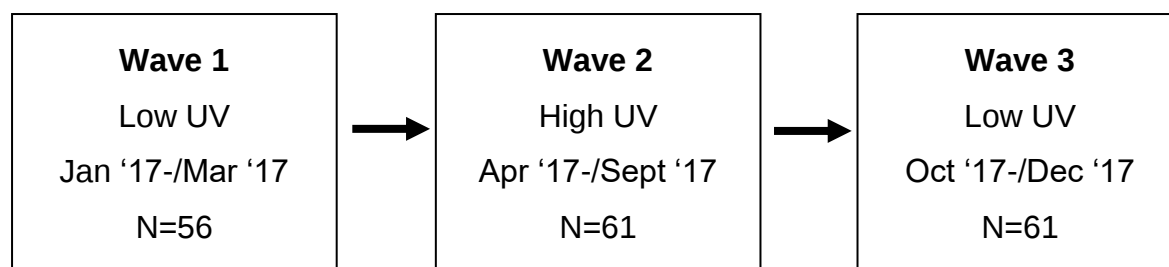


Figure 2 Study design diagram

Where it was not possible to retain the same participant at a site between waves, due to leaving the job or some other reason, a substitute participant was recruited. The aim was to maintain, as closely as possible, the total number of participants at each site.

Study conditions

The intervention was delivered to the workers via a mobile phone short message service (SMS). A daily message was sent to participants, tailored to reflect season, i.e. low UV (boosting vitamin D) or high UV (sun-safety). The supportive phone app contained information about sun-safe actions and sources of vitamin D. During the low UV intervention period participants were issued with a vitamin D dietary supplement (daily 10µg) and advised that, if they wished, they could take these during the three-week study period. The number of supplements consumed during the study was recorded at the follow-up visits.

During the control periods participants did not receive the intervention daily text messaging service or prompts to view the sun-safe and healthy behaviour App.

Measure of vitamin D level

The main outcome measure was participant 25(OH)D concentration in blood⁴, collected using a simple non-invasive method (Nioi *et al.*, 2018). 25(OH)D was measured by high-performance liquid chromatography using dried blood spots obtained with a self-administered sampling kit. Four blood spots taken from the tip of the finger, via the 'pin-prick' method, then placed on a test card. These samples were collected at the start and end of each wave. Test cards were posted to the laboratory for analysis on the day of collection. Participants provided written consent that their blood sample could be analysed at the Pathology Department, City Hospital, Birmingham, (www.cityassays.org.uk). An additional consent form ensured participants agreed to the results being available to the research team. The NHS laboratory carries a CE mark (i.e. a Declaration of Conformity to EU Directives for Conformity Assessment Procedures and quality assurance). Results from the blood-spot analysis

⁴ 25-hydroxyvitamin D (abbreviated 25(OH)D), also known as Calcifediol, is a pre-hormone produced in the liver by hydroxylation of vitamin D3. This biomarker is widely used to determine a patient's vitamin D status.

closely align to serum results and the ranges from serum and blood spot are comparable. Results were emailed to participants and the research team. They were clearly shown along with the reference intervals and vitamin D status. The reference intervals are (1) <15nmol/l = Severe Deficiency, (2) 15-30nmol/l = Deficiency, (3) 30.1-50nmol/l = Insufficiency, and (4) >50.1 nmol/l = Adequate. Interpretation of the results were simplified using a 'traffic light' system. Participants could see where their result was in comparison to the health ranges (see Appendix 2 for an example).

Sample size calculations

Sample size calculations were based on change in 25(OH)D levels as the primary study outcome. Previous research studies have reported between individual variability in 25(OH)D levels, with inter-individual standard deviations ranging from around 16-27 nmol/l – most individuals have mean 25(OH)D levels between about 30 and 90 nmol/l (Purdon *et al*, 2013). Within-individual change in 25(OH)D level is likely to have a lower variability as it adjusts for some of the between-individual differences. The change in 25(OH)D was assumed to have a standard deviation of 16 nmol/l (at the low end of the reported range). Statistical power calculations showed that the study would have 80% power to detect differences of 10 nmol/l or more change in 25(OH)D between the intervention group and the controls in each of the two seasons. This is in the context of sufficiency corresponding to a 25(OH)D level of 50 nmol/l.

Measure of personal UVB radiation exposure

During the high UV period (Wave 2) participants were issued with a UVB (230-320nm erythemally-weighted) wearable sensor, which was capable of logging measurements throughout a workshift. There are many ways that UVB exposure can be summarised. For example, the standard erythemal dose (SED), where 1 SED is equivalent to an erythemal radiant exposure of 100 J/m². For this study SED was the chosen measure.⁵ This is a measure of exposure and is independent of skin type and so the same exposure in SED that causes erythema in someone with fair skin may have no effect on darker skin people. It is a cumulative measure, which involves multiplying the erythemally-weighted irradiance by the time intervals between measurements (two-minutes) and accumulating these together for a work shift (eight hours).

The raw data from the UV sensors was converted to give UV erythemally-weighted irradiance in Watt/m². This was done using the calibration coefficients supplied by the sensor manufacturer: an equation of the form $Ax^2 + Bx$, where x is the extracted UV data and the result is in W/m². These data were then used to estimate the SED.

On each site five individuals wore the sensor mounted to their hard hat (Figure 3). These participants acted as a proxy measures for the remainder of the cohort, owing to limited equipment available for

⁵ The World Meteorological Organization (WMO) defines the UV Index (UVI), which is commonly used in public health communications and is available from weather forecasts. UVI can also be calculated using the calibrated data from the sensor and multiplying the value by 40. For example, an irradiance of 0.2 W/m² (erythemal) equals a UVI of 8. UVI can be a useful measure when communicating with workers and others, but it is not a cumulative measure of exposure, i.e. it reflects the intensity of exposure at a point in time.

the study. The sensor was located at the nape of the hat to capture UV radiation broadly reflective of the exposure experienced by the face.



Figure 3 A UVB sensor attached to the rear of a hard hat

Satellite UV radiation

Global 5km irradiance data is available from the Japan Aerospace Exploration Agency using MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data provided by NASA. Downward irradiance measures (i.e. combined direct and diffuse radiation on a horizontal plane) for UVA (315nm–400nm) and UVB (280–315 nm) are available at a daily time resolution from 2000 onwards. A batch processing method was developed to download, extract (binary to csv), interpolate (via inverse distance weighting method) and aggregate UV data to points or areas of interest for the present study. UVA and UVB measures in W/m^2 were assigned for each study site location for the study dates.

When downloading the data, there were gaps because satellite data were unavailable. To address this the 2000–2010 UV data for each site was extracted, which could be used to fill in the missing data via multiple imputation. The calculated values are the irradiance in W/m^2 and so not directly comparable to the dose in SED. To obtain a comparable measure we multiplied the irradiance in W/m^2 by 86,400 (the number of seconds in 24 hours) and divided by 1,000 to get a value in kJ/m^2 . These data are useful in understanding the change of UV during the study period and give a measure of the maximum dose that could be experienced. The estimates have not been validated with ground-based measures but are congruent to other model-based estimates (<https://fastrt.nilu.no>).

Theory of Planned Behaviour

The theoretical framework was used to determine, at the start of the intervention, the intended behaviours over the 21-day study period (Pre-intervention), and again at the end of the study to identify the behaviours (Post-intervention) that were actually performed. Questionnaires were tailored to reflect season, i.e. those administered in the low UV period reflected vitamin D behaviours (Appendices 3 and 4) and sun-safe behaviours in the high UV period (Appendices 5 and 6). The theoretical framework was used to inform the development of the bank of SMS sent as part of the intervention.

Once the study had begun it was clear that the state of sun safety and vitamin D knowledge amongst many of the workers was limited, and as a consequence we extended our theoretical underpinning to include the Transtheoretical or Stages of Change Model.

The Transtheoretical or Stages of Change Model

Several factors may influence an employee's sun-safety, and these may reflect stages of change (Prochaska & DiClemente, 1983). Explicitly, these may include: Pre-contemplation (whether they have a fundamental awareness of the over- and under-exposure risks); Contemplation (if workers are considering making behavioural changes, perhaps along with knowledge of what measures will be effective to mediate such risks); Preparation (getting ready to take actual steps to change behaviour); Action (changing behaviour to mediate risks), or Maintenance (attempting to ensure ongoing behavioural change). Willingness to progress through these stages may be influenced by external considerations. For example, personal autonomy to enact any changes, organisational support for sun-safe measures or whether the underlying safety culture within the organisation promotes any such changes.

The Transtheoretical Model (Prochaska & DiClemente, 1983) incorporates stages of change as outlined above. The model has been applied extensively to promote positive change, in for example substance abuse (Connors, DiClemente, Velasquez, & Donovan, 2013; Schulz, Kremers, & de Vries, 2012), occupational health and safety (Lansdown & Deighan, 2011), and healthcare (Rhodes *et al*, 2003). Stages of change provides a framework within which to consider the effectiveness of interventions.

The Stages of Change instrument (as used previously by Houdmont, Madgwick, & Randall, 2015), consisted of ten behaviours concerning sun safety, e.g., wearing sunglasses, minimising work in direct sunlight in the middle of the day, or using sunscreen. This was supplemented (for Waves 1 and 3) with six additional vitamin D-related behaviour questions. For example, taking supplements, exposing skin for 10–15 minutes or eating vitamin D-rich foods. The Stages of Change instrument is shown in Appendix 8.

Participant profile and knowledge questionnaire

Participants completed a socio-demographic profile, documenting age, gender, occupation, ethnicity and self-reported skin type. Knowledge of sun-safe behaviour and vitamin D was recorded using 'tick-box' questions (Appendix 9).

Smartphone app

A smartphone application (mobile App) was developed to provide study participants with general information and guidance about UV exposure, sun-safety, dietary health advice and the daily UV Index

(UVI) forecast for the user's locality. The information was presented in a set of related screens (tabs) which included:

- *Home* – Introduction pop-up screen to provide brief information about the study and mobile App, with messages and facts on skin cancer and vitamin D.
- *UV Forecast* – The forecast for that day from the Met Office on UV levels in the user's locality with the ability to search over 5,000 Met Office Data-point locations across the UK.
- *Eat Healthy* – Information about a healthy balanced diet.
- *Protect Me* – Information on how to protect yourself from harmful UV rays.
- *Skin Info* – Information about skin types and risks of skin cancer.
- *Check Your Skin* – Guidance on checking for signs of skin cancer.
- *Vitamin D* – Information about balancing the risks of UV rays and vitamin D deficiency.
- *UV Index* – UV Index on the scale of low, medium, high risks of UV exposure.
- *About Us* – Further information about the study and researcher contact details.
- *FAQs* – Frequently asked questions about the study on UV sun-safe behaviour and vitamin D.

Selected screen shots from the app are shown in Figure 4. The app design was themed to be consistent with the IOSH No Time To Lose (NTTL) occupational cancer campaign.



Figure 4 Selected screen-shots from the smart phone App

The app was developed using the 'Alpha Anywhere' system (www.alphasoftware.com/), which is a Rapid Mobile Application Development (RMAD) software platform for developing highly functional, customised, cross-platform online and offline Apps. The platform provides an integrated graphical development and programming environment for building HTML5 Hybrid Mobile Apps. It includes connectors for numerous common back-end data systems (SQL/NoSQL databases, and APIs) and combines various client/server and cloud development features. The output generated is primarily built using HTML5, CSS and JavaScript code. These are wrapped together into a container using the 'Adobe PhoneGap Build' service, giving access to native platform features for Apple iOS, Android and Windows devices. Adobe PhoneGap Build is the most popular and functional container for creating Hybrid mobile Apps. A web-based Microsoft SQL Server database was designed to store the UV forecast data, which was presented in the 'UV Forecast' tab of the mobile App.

The app was made available only to the research participants through a direct email/SMS invitation, and by providing direct downloadable URLs for Android and iOS users. It was not widely published on public App stores or websites. This avoided it being perceived or distributed as an 'official' IOSH app during the course of the research, thus respecting IOSH's branding and other potential quality assurance concerns. This was discussed and agreed at start of the project.

For Android users, it was simple to download the app using the downloadable link provided by researchers and allowed the 'Download app from Unknown Sources' option in Android Device settings. For iOS users, the app was distributed using Apple's developer test feature, which allows up to 2,000 external users to download and use the App, without using the Apple Store, by registering the iOS device with the App Developer system. To register the device, participants used a free third-party app to e-mail a unique device identifier (UDID) to the developers, who generated an Apple distribution certificate, allowing the iOS user to download the app directly from IOM. This by-passed the Apple Store. A web-hosted version of the mobile application was also available to participants, if for any reason, they were unable to download and install the mobile version.

The data for UV forecasts were imported from the Met Office DataPoint service, which provides access to freely available Met Office data feeds in a format suitable for application development. An API key was generated, and an online application developed to regularly import the data feeds from the Met Office. This application was hosted on an Institute of Occupational Medicine (IOM) server and ran each hour to download data to the Microsoft SQL Server back-end database.⁶ The mobile app connected to this via the Web, so that each time the mobile application was opened or the 'UV Forecast' tab was accessed, a fresh call back to the IOM server was made to retrieve the latest UV forecast data. This feature ensured that the most up-to-date data was available to users at all times.

As the app was used to provide information and supporting material to the participants of the study no personal or confidential information, cookies or stats data were collected or stored by the App. The only potentially sensitive information sought was in establishing the users' current geo-location, which was then used to select and present the nearest physical UV exposure forecast. However, this geo-location information was only accessed and used momentarily at run-time and was not stored in

⁶ Microsoft SQL Server is a relational database management system developed by Microsoft. It is one of the most popular databases with the primary function of storing and retrieving data as requested by other applications.

the app or any database. Users were made aware of this use at sign-up and as part of their informed consent to participate in the study.

A support email address (admin@sun-safe.construction) was set up and provided in the app and its website (www.sun-safe.construction) for users to send any queries regarding the study or technical issues and feedback. Users were briefed on the relevant details at sign-up and consent. Contact details of Heriot-Watt University and IOM researchers were also provided by the app and Website.

Text messaging system

The intervention was delivered to the participant construction workers via a mobile phone short message service (SMS) with texts containing brief, simple messages, and (for some of these messages) also hyperlinks/URL to relevant further information. Messages were not branded with the NTTL logo or other NTTL material. Only plain text messages, with some texts including links to relevant external websites, were sent. The messages are shown in Appendix 10.

A third-party SMS delivery service (www.Textmarketer.co.uk) was used, through a web-based interface, to send bulk SMS to multiple recipients. The service enabled the management of contact details categorised by site. Other benefits included automatic scheduling of future SMS delivery (e.g. staged or delayed automatic dispatches, to optimise delivery times in the evenings, etc.) and SMS delivery results reporting. To manage the contact lists, participants' names and mobile numbers were uploaded to the online service, protected by user authentication. Passwords were only available to approved members of the research team administering the service. Offline details were stored on Excel sheets on a secured drive, managed only by relevant members of the project team. Participants were informed of the data management arrangements and consented to this at sign-up. No statistics on the users were collected or used for SMS service other than SMS delivery confirmations.

Data analysis

For each wave, differences between start and end levels of vitamin D were calculated for each participant. Comparison of change in 25(OH)D between the intervention group and the control group used a two-group t-test to determine whether there was a statistically significant difference between the two groups. Levels of change in vitamin D were also examined in relation to responses to the questionnaires, using multiple linear regression methods. Potential explanatory variables were included in the models singly and simultaneously to determine if there was any confounding or interaction between the variables. These analyses were carried out separately for each of the three waves of data collection. Some analysis of data collected in the winter period (Waves 1 and 3) was carried out for individuals during their earliest participation in the study, i.e. Wave 1 participants plus participants in Wave 3 who had not attended Waves 1 or 2.

UV data were summarised using several exposure metrics including average daily UVI, average daily total standard erythemal dose (SED) and proportion of days for which SED > 2 (only SED data are reported here). UV data were available only for Wave 2 (the summer wave). UV levels were compared between the intervention and control groups using 2-group t-tests and the association between UV exposure and potential explanatory variables was examined using multiple linear regression methods. In particular, UV exposure levels were compared between workers at sites in the North and South of

Britain, and between workers who worked predominantly indoors or outdoors. The regression analyses also tested for possible interactions between the explanatory variables.

Analyses of the TPB data aimed to determine whether any changes had occurred in intentions to perform the target behaviour – increase vitamin D levels in Waves 1 and 3 and take sun-protective measures in Wave 2 – and the other key predictors of behaviour (Attitudes, Subjective Norms (SNs) and Perceived Behavioural Control (PBC)) as a result of our intervention.

Data corresponding to each wave were analysed using the same statistical methods, and are reported separately below. Specifically, these were paired sample t-tests and multiple regression techniques.

Results

Sample characteristics

Table 1 summarises, across three waves, the number of sites in each location, under each condition and the number of participants assigned to that condition. The table includes only those participants who provided blood samples. At Wave 1, eight sites participated in the study (five in Scotland and three in London), in Waves 2 and 3, nine sites participated (five in Scotland and four in London). From the original cohort, 61% of participants returned to participate in Wave 2 of data collection and 40% of participants completed all three waves of data collection.

Table 1 *Study overview: Number of sites, participants, and blood samples by wave*

	Wave 1 (8 sites)		Wave 2 (9 sites)		Wave 3 (9 sites)	
Variable	Cntrl	Intr	Cntrl	Intr	Cntrl	Intr
<i>Location and group assignment</i>						
Scotland [#sites (#participants)]	2 (12)	3 (18)	3 (17)	2 (18)	3 (18)	2 (12)
England [#sites (#participants)]	1 (9)	2 (17)	2 (18)	2 (14)	2 (17)	2 (14)
<i>Blood samples collected</i>						
New	100% (56)		39% (24)		35% (21)	
Repeat samples (2 waves)	-		61% (37)		25% (15)	
Repeat samples (3 waves)	-		-		40% (25)	
Total samples	56		61		61	

Table 2 summarises the characteristics of the study population. Across each wave the largest percentage of participants were aged between 31 and 50 years and were predominantly male. The most frequently self-reported skin type was Fair/pale or Fair/beige. Darker skin types (i.e. Olive/light brown or Black) were less common, typically making up less than a third of participants in any specific data collection wave. In Waves 1 and 2, the majority of participants worked in an on-site operative role, while in Wave 3 on-site professionals made up the largest portion of participants (see Appendix 11 for further breakdown of occupational characteristics).

Of the 56 participants in Wave 1, 42 (75%) completed the surveys at both the start and the end of the survey period. There were no statistically significant differences in the age, gender or ethnicity of those completing the wave compared to those who did not complete it. Similarly, three (5%) of Wave 2 participants did not complete both questionnaires and again there were no statistically significant differences in age, gender or ethnicity between those completing or not completing the study. Only one (2%) participant in Wave 3 did not complete the full study,

Table 2. Description of study participants, percentage (n)

Variable	Wave 1 (8 sites)	Wave 2 (9 sites)	Wave 3 (9 sites)
Age (years)			
18–30	21.4% (12)	31.2% (19)	34.4% (21)
31–50	57.1% (32)	47.5% (29)	47.5% (29)
51–65	21.4% (12)	21.3% (13)	18.0% (11)
Gender			
Male	96.4% (54)	96.7% (59)	88.5% (54)
Female	3.6% (2)	3.3% (2)	11.5% (7)
Ethnicity			
White UK/Irish	82.1% (46)	73.8% (45)	75.4% (46)
Asian/Asian British	1.8% (1)	4.9% (3)	6.6% (4)
Black/African/Caribbean/Black British	5.4% (3)	3.3% (2)	4.9% (3)
Other	10.7% (6)	18.0% (11)	13.1% (8)
Skin type			
Very pale	-	1.6% (1)	1.6% (1)
Fair/pale	35.7% (20)	29.5% (18)	34.4% (21)
Fair/beige	42.9% (24)	34.4% (21)	34.4% (21)
Olive/light brown	16.1% (9)	31.1% (19)	26.2% (16)
Dark brown	-	-	1.6% (1)
Black	5.4% (3)	3.3% (2)	1.6% (1)
Occupation			
On-site operative	59.1% (33)	53.9% (33)	39.3% (24)
On-site professional	37.7% (21)	40.9% (25)	46% (28)
Other	3.6% (2)	4.9% (3)	14.8% (9)
Total	56	61	61

Knowledge of sun-safety and vitamin D

Participants in each wave were asked questions about their vitamin D knowledge at the start and end of each wave. Figures 5 – 10 show the percentage of respondents answering each question correctly at each time point in Waves 1, 2 and 3 respectively for the Intervention and Control Groups.

The questions asked are shown in the table 3 below.

Table 3 **Knowledge questions**

Sun safety knowledge and attitudes
UV Q1: I don't need to wear sunscreen on a cloudy/overcast day during summer
UV Q2: It is important to wear sunglasses to protect the eyes from the sun
UV Q3: Sun exposure is the most important risk factor for skin cancer
UV Q4: If I apply factor 30 sun screen, then I need only apply it once per day
UV Q5: Sun protection is important when working outside for less than one hour in the sun
Vitamin D knowledge
Vit D Q1: I can get enough vitamin D from the sun in the UK all year round
Vit D Q2: vitamin D is important for healthy eyesight and healthy skin
Vit D Q3: It's important to eat oily fish in winter to boost vitamin D intake
Vit D Q4: It's important, in winter, to eat organic food and vegetables to boost vitamin D intake
Vit D Q5: In winter, everyone in the UK should take vitamin D supplements to keep healthy
Vit D Q6: I get more vitamin D from natural food (i.e. veg, oily fish, eggs etc.) or supplements
Vit D Q7: How long do I have to be in the sun to get enough vitamin D

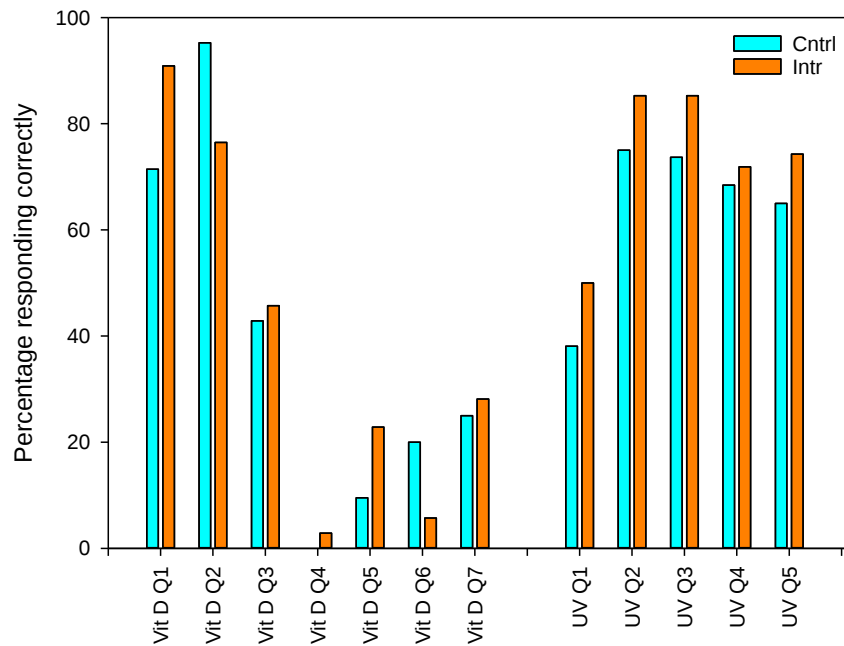


Figure 5 Wave 1: proportion responding correctly to vitamin D and UV knowledge questions

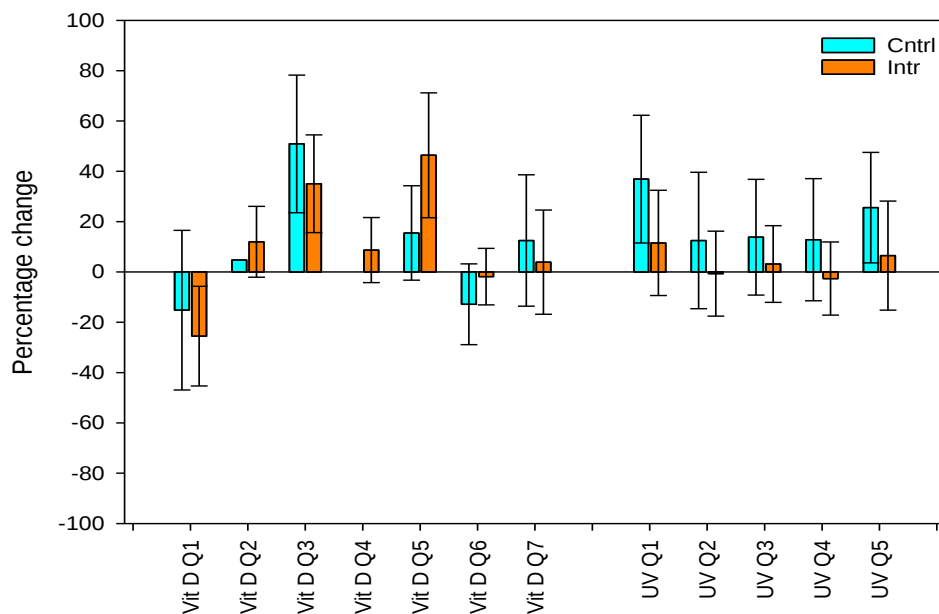


Figure 6 Wave 1: Change in proportion responding correctly to vitamin D and UV knowledge questions. A positive value represents an increase in knowledge during the wave

Note: the error bars represent the 95% confidence interval for change in the proportion responding correctly

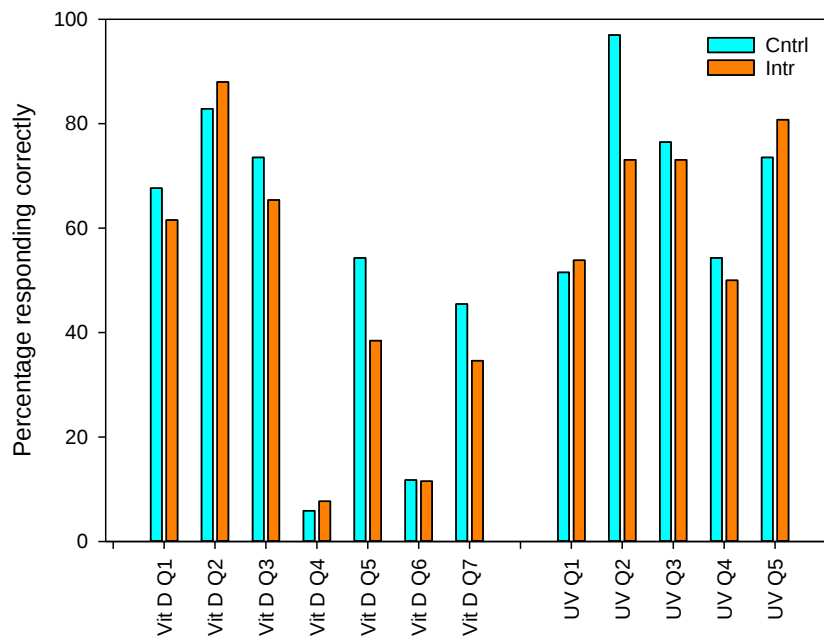


Figure 7 Wave 2: proportion responding correctly to vitamin D and UV knowledge questions

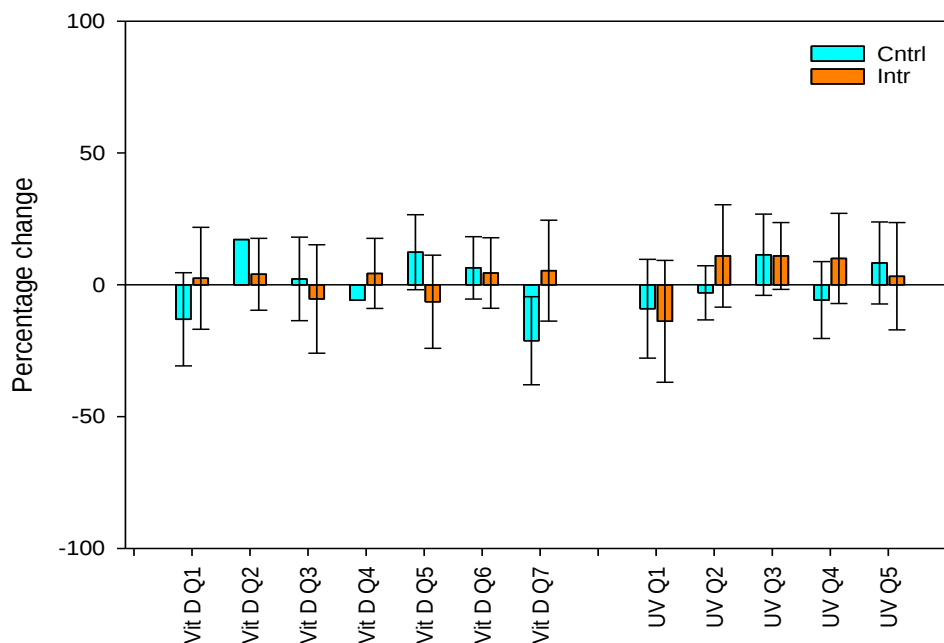


Figure 8 Wave 2: Change in proportion responding correctly to vitamin D and UV knowledge questions. A positive value represents an increase in knowledge during the wave

Note: the error bars represent the 95% confidence interval for change in the proportion responding correctly

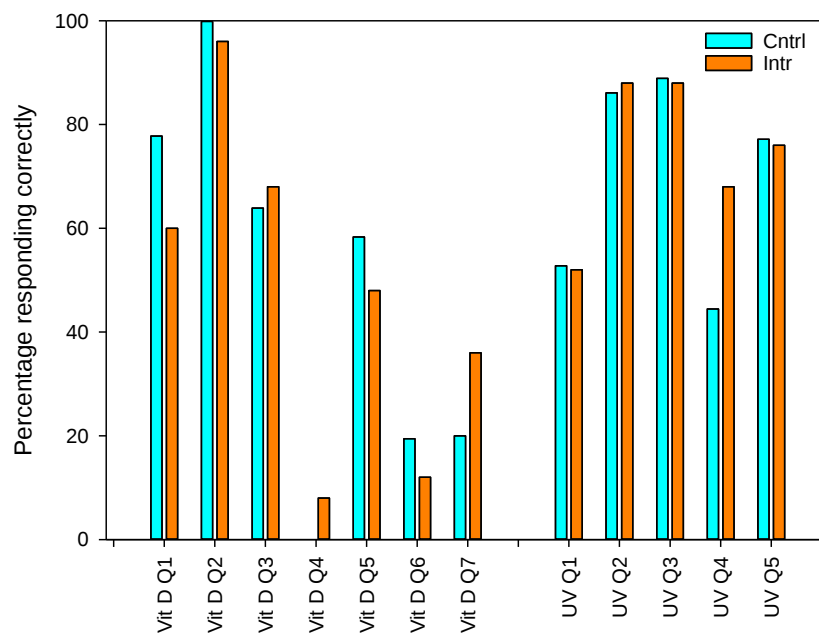


Figure 9 Wave 3: proportion responding correctly to vitamin D and UV knowledge questions

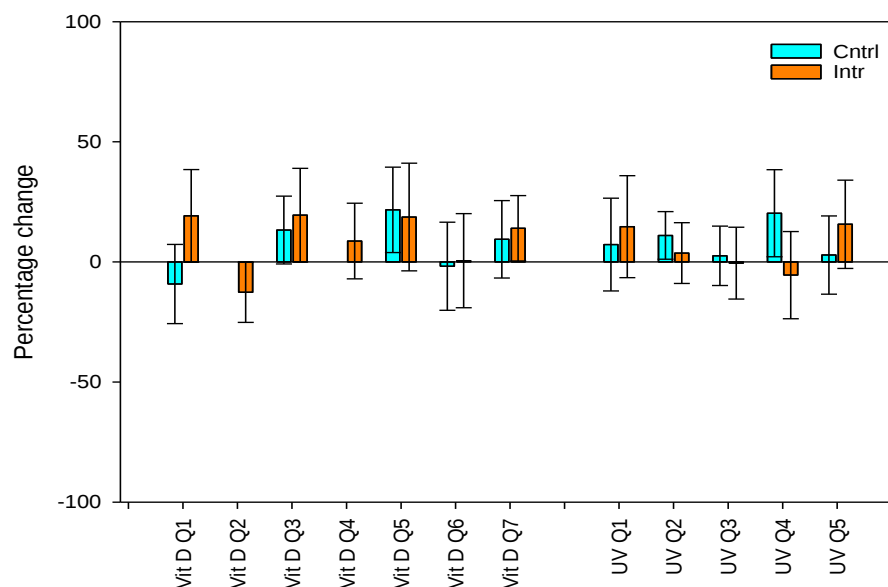


Figure 10 Wave 3: Change in proportion responding correctly to vitamin D and UV knowledge questions. A positive value represents an increase in knowledge during the wave

Note: the error bars represent the 95% confidence interval for change in the proportion responding correctly

There were relatively high correct responses to the vitamin D questions relating to whether it's possible to get enough vitamin D from the sun in Britain all year round (Vit D Q1), the importance of vitamin D for healthy eyesight and healthy skin (Vit D Q2) and oily fish as a source of vitamin D (Vit D Q3). However, the other questions on vitamin D were answered less consistently. The question on whether it is necessary to wear sunscreen on a cloudy/overcast day during summer was generally answered correctly by around half of the participants. The other UV questions were mostly answered correctly by around three-quarters of the participants. There was a general increasing in knowledge over the duration of the study, but no evidence for any clear difference between the control and intervention groups.

Participants were asked about the availability of sunscreen on site. At all sites, except one (site 3 Waterloo, London), participants reported that sunscreen was available. Awareness of availability was often higher in the southern sites (Stanmore 80%, Shoreditch 100%, and Canary Wharf 67%) compared to northern sites (Armadale, 60%, Dunbar, 86%, Edinburgh (Laing O'Rourke) 71%, Edinburgh (Crummock) 40%, and Perth, 40%). At site 3, Waterloo, nobody responded 'yes'; 75% said sunscreen was not available and 25% say they did not know if it was provided. Our findings suggest there is still ambiguity on construction sites about access to sunscreen at work, as each site (other than Shoreditch, Edinburgh [Laing O'Rourke], and Canary Wharf) had participants responding to 'don't know if sunscreen is available'. This indicates increased awareness and promoting the use of sunscreen is needed by employers on site.

In addition to the above questions we also asked participants about their preference to 'have a tan'. Seventy-five percent of respondents answered positively to this question.

Change in vitamin D level during each wave

Vitamin D levels at the start of each wave are shown in Figure 11 as a box-plot. These are subdivided into Intervention (Intr) and Control (Cntrl) groups.

The boxplot displays the distribution of vitamin D (25(OH)D) levels for each group. The box extends from the 25th to 75th percentile, with the horizontal line within the box indicating the median level. The lines outside the box extend from the 10th to the 90th percentile, with values outside these values displayed as individual points. The dotted line indicates the 'adequate' level of 50 nmol/l of 25(OH)D.

As expected, levels were higher in Wave 2, which took place during the high UV period (summer). The majority of workers were at sufficient levels of vitamin D during summer, but around half were insufficient during the winter phases.

Figure 12 shows the distribution of the change in level for the Intervention and Control groups at each data collection wave. For all three waves, the change in vitamin D levels was higher, on average, in the Intervention Group than in the Control Group.

The differences between the Control and Intervention groups were statistically significant in Waves 1 and 2 ($p < 0.05$) and of borderline statistical significance in Wave 3 ($p = 0.053$).

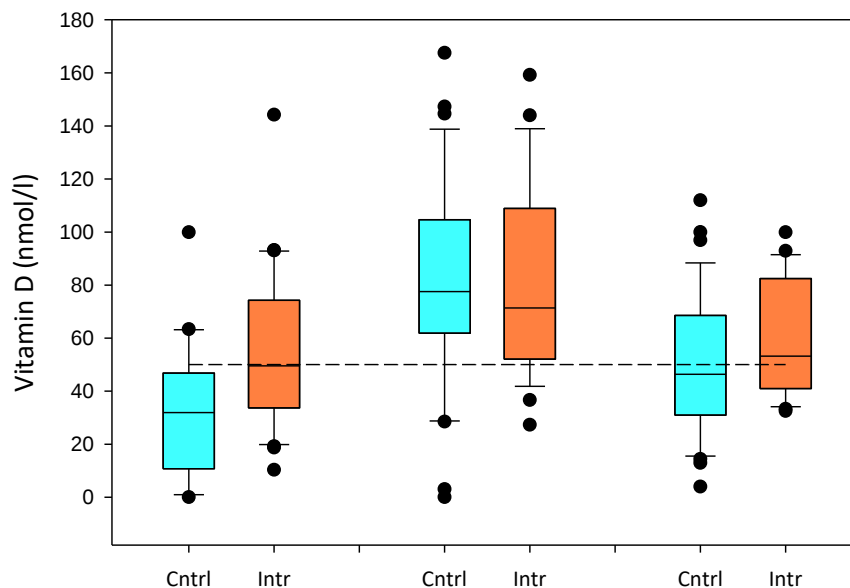


Figure 11 Boxplot of levels of vitamin D at start of each wave by control/intervention status.
The box extends from the 25th to 75th percentile, with the horizontal line within the box indicating the median level. The lines outside the box extend from the 10th to the 90th percentile, with values outside these values displayed as individual points.

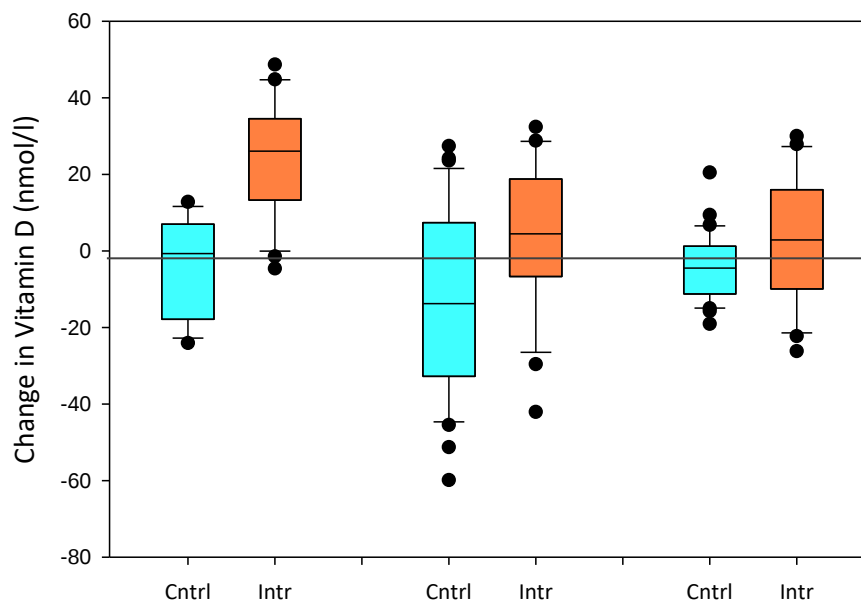


Figure 12 Boxplot of change in vitamin D levels by wave and control/intervention status
The box extends from the 25th to 75th percentile, with the horizontal line within the box indicating the median level. The lines outside the box extend from the 10th to the 90th percentile, with values outside these values displayed as individual points.

Table 4 shows the distribution of participants in each wave of the study subdivided by 25(OH)D level at the start and end of each period. Results are shown for all participants in each wave and separately for the Control and Intervention groups.

At baseline during the winter (Waves 1 and 3) 40% and 48% had 25(OH)D levels above 50 nmol/l. A small proportion of the participants were either deficient (<30 nmol/l) or severely deficient (<15 nmol/l): between three and six participants and two or three, respectively. Three participants were deficient in the summer period.

Comparison of the frequency of low levels of vitamin D with skin type of the participants showed that two of the three individuals (67%) with black skin type had vitamin D levels ≤ 30 nmol/l, followed by six of the 26 individuals (23%) with olive/light brown skin type. Among individuals with fair/pale skin 17% (six out of 35) had vitamin D levels ≤ 30 nmol/l and among individuals with fair/beige skin 11% (four out of 36) had low vitamin D levels.

After the intervention the proportion of participants with sufficient vitamin D increased: from 48% to 88% in Wave 1 and from 52% to 70% in Wave 3.

Table 4 *Distribution of participants at each wave by vitamin D group*

Vit D group	All				WAVE 1 Control group				Intervention group			
	Pre		Post		Pre		Post		Pre		Post	
≤ 15	1	2%	0	0%	0	0%	0	0%	1	3%	0	0%
>15 to ≤30	6	13%	3	8%	1	7%	3	19%	5	16%	0	0%
>30 to ≤50	20	44%	11	28%	10	71%	8	50%	10	32%	3	13%
>50	18	40%	26	65%	3	21%	5	31%	15	48%	21	88%
Total	45		40		14		16		31		24	

Vit D group	All				WAVE 2 Control group				Intervention group			
	Pre		Post		Pre		Post		Pre		Post	
≤ 15	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
>15 to ≤30	3	5%	0	0%	2	6%	0	0%	1	4%	0	0%
>30 to ≤50	3	5%	10	18%	1	3%	7	21%	2	8%	3	13%
>50	52	90%	46	82%	31	91%	26	79%	21	88%	20	87%
Total	58		56		34		33		24		23	

Vit D group	All				WAVE 3 Control group				Intervention group			
	Pre		Post		Pre		Post		Pre		Post	
≤ 15	2	3%	2	3%	2	6%	2	6%	0	0%	0	0%
>15 to ≤30	3	5%	6	10%	3	9%	6	17%	0	0%	0	0%
>30 to ≤50	25	43%	19	33%	13	39%	12	34%	12	48%	7	30%
>50	28	48%	31	53%	15	45%	15	43%	13	52%	16	70%
Total	58		58		33		35		25		23	

Predictors of vitamin D Level

Change in vitamin D was investigated using multivariate linear regression analysis. The data was split in the following ways:

- a) separately for each wave;
- b) for Wave 1 plus 'new attendees' from Wave 3.

This was done to investigate the results separately for the participants in each wave of the study and, in addition, to investigate all of the individuals participating in the two winter waves, who had not previously taken part in the study. This group comprised all participants in Wave 1 and those participants in Wave 3 who had not been included in either of Waves 1 or 2.

The following potential explanatory variables were included in the model: Age, Gender, North/South site, Indoor/Outdoor worker, and Intervention/Control group. Specific responses to the questionnaire were also included, these were: *'Have you had skin cancer?', 'Have you been on holiday in a sunny country during the study?', 'Have you used a tanning sunbed during the study?', 'Have you regularly taken vitamin D supplements during the study?', 'If we gave you vitamin D supplements, would you take them? Since the start of this study have you bought any fortified vitamin D products or bought more food rich in vitamin D?'*

Additional information was collected from the Intervention group at each wave, namely: *'Did the information in the text messages encourage you to take a vitamin D supplement?'* This was not collected for the full study group therefore, it was not included in the regression analysis, but change in vitamin D was compared with responses to this question at each wave.

Finally, from the TPB questionnaire, the following responses were included: *'How much control do you believe you have over taking measures to increase your vitamin D intake daily over the next three weeks?'* [pre-intervention] and *'How much control do you believe you had over taking measures to increase your vitamin D intake daily, over the last three weeks?'* [post-intervention]. Terms were fitted one at a time in separate models and, where more than one term was statistically significant then these terms were included simultaneously in the model to investigate any confounding or interactions.

Analysis of the summer data

In the summer data (Wave 2), the only significant variable was Intervention v Control groups, which confirmed that the change in vitamin D levels was higher in the Intervention group (there was a small increase in vitamin D in the intervention group and a decrease in vitamin D in the control group). There was also some evidence of a difference in change in vitamin D in those who had taken a holiday in the sun during the study period and those who had not, with a large decrease in vitamin D in those taking a holiday and a small decrease in those who had not (Table 5), although only seven of the 54 participants took a holiday, and so it is difficult to draw any firm conclusions from this finding.

Table 5 *Mean change in 25(OH)D (mol/l) during Wave 2 with standard error (s.e.) and number of measurements (n)*

Group	Holiday			No holiday			Total		
	Mean (mol/l)	s.e.	n	Mean (mol/l)	s.e.	n	Mean (mol/l)	s.e.	n
Control	-24.8	(10.6)	6	-8.9	(4.5)	26	-11.9	(4.2)	32
Intervention	-42.1	(-)	1	5.6	(3.6)	21	3.4	(4.1)	22
Total	-27.3	(9.3)	7	-2.4	(3.1)	47	-5.6	(3.2)	54

Analysis of the winter data

Winter data was available for two waves of the study, Waves 1 and 3, which have been analysed separately. In addition, an analysis was carried out combining participants in Wave 1 and participants in Wave 3 who had not taken part in any previous waves of the study. This latter group therefore comprised all participants for whom there could be no 'carry-over' effect from earlier study participation.

Table 6 *Results from the multi-linear regression analysis*

Explanatory variables/Models	Wave 1			Wave 3			Wave 1 + new Wave 3		
	Co-eff	s.e.	p	Co-eff	s.e.	p	Co-eff	s.e.	p
Single variable models									
Age (coefficient per year)¹	0.68	0.30	0.03	0.09	0.16	0.57	0.50	0.22	0.03
Outdoor v Indoor²	13.2	6.70	0.06	-4.36	3.55	0.22	3.42	5.53	0.54
Intervention v Control³	28.3	5.13	<0.001	6.93	3.47	0.05	22.44	4.22	<0.001
Taken vitamin D supplements during study⁴	17.9	6.50	0.01	-8.53	8.58	0.33	13.74	5.93	0.03
Control over vitamin D intake post-intervention⁵	5.0	1.79	0.01	1.13	1.07	0.30	3.80	1.32	0.01

¹Coefficient represents increase in VitD per increase of 1 year of age

²Coefficient represents increase in VitD in outdoor workers compared to indoor workers

³Coefficient represents increase in VitD in the Intervention group compared to the Control group

⁴Coefficient represents increase in VitD in those who took VitP supplements during the study compared to those who did not.

⁵ Question 19 from the TPB questionnaire: 'How much control do you believe you had over taking measures to increase your vitamin D intake daily, over the last three weeks'. Co-efficient represents increase in VitD per category increase in response to this question

The analysis showed that results for Wave 1 and for Wave 1 + 'new' Wave 3 participants were similar, which was as expected, as the majority of this group comprised attendees at Wave 1 (see Table 6). For both groups, vitamin D levels increased in older individuals and were higher in the intervention group than the control group. There was also evidence of higher vitamin D levels among those with higher self-perceived control over their vitamin D intake. For Wave 1 participants only, vitamin D levels were higher in outdoor workers than indoor workers. In contrast, analyses of Wave 3 participants showed a statistically significant association with Intervention/Control status, with higher vitamin D levels in the intervention group. No association was seen with age, outdoor/indoor worker or perception of control over vitamin D intake in this Wave 3. However, in both waves, but Wave 3 in particular, very few controls responded to the question about supplements meaning that the results include less than half of those new attendees at Wave 3 and are biased towards the intervention group.

Around 75% of the intervention group, at each wave, reported receiving the text messages had encouraged them to take a vitamin D supplement. However, there was no evidence that these individuals had an increased change in vitamin D compared to the 25% of the group who answered this question negatively.

25(OH)D levels in Northern and Southern sites

Table 7 shows the mean and median 25(OH)D levels for the participants divided between the northern (Scottish) and southern (London) sites. At each wave the median and mean 25(OH)D levels were higher in the north. This may reflect differences in skin colour or some other aspect of the work, for example time spent outdoors. (In Scotland 17% of participants reported olive, brown or black skin colour whereas the corresponding figure in the southern sites was 40%.)

Table 7 *Mean and median 25(OH)D levels for northern and southern worksites*

Wave	North/South	N	Mean (mol/l)	Median (mol/l)
Start Wave 1	North	25	55.5	49.8
	South	20	46.8	41.7
Start Wave 2	North	28	87.1	83.0
	South	30	80.6	74.6
Start Wave 3	North	29	61.8	59.4
	South	29	52.1	45.0

Personal UVB radiation exposure

UVB radiation exposure data was available for 27 participants in the summer period (Wave 2). Two different outcome variables were calculated for the personal UV data for each individual. These are:

- *daily SED – the average of the daily total SED*
- *SED proportion – the proportion of days on which the total SED > 2.*

We have chosen to analyse SED > 2 because this is the level of exposure that is commonly taken to be the threshold exposure for people with light colour skin without adaption (i.e. no tan) to show mild sunburn.

Separately we explored the use of the average UVI measurement across the study period and the average of the daily 95th percentile of the UVI measurements, but these did not provide any further insights into the data and for simplicity these data are not presented here.

Figure 13 shows the distribution of SED and Figure 14 the proportion of SED > 2 subdivided by intervention and control group and by indoor and outdoor workers. The pattern was similar for both of the UV exposure metrics, with levels higher in outdoor workers than indoor workers and higher in the intervention group than in the control group.

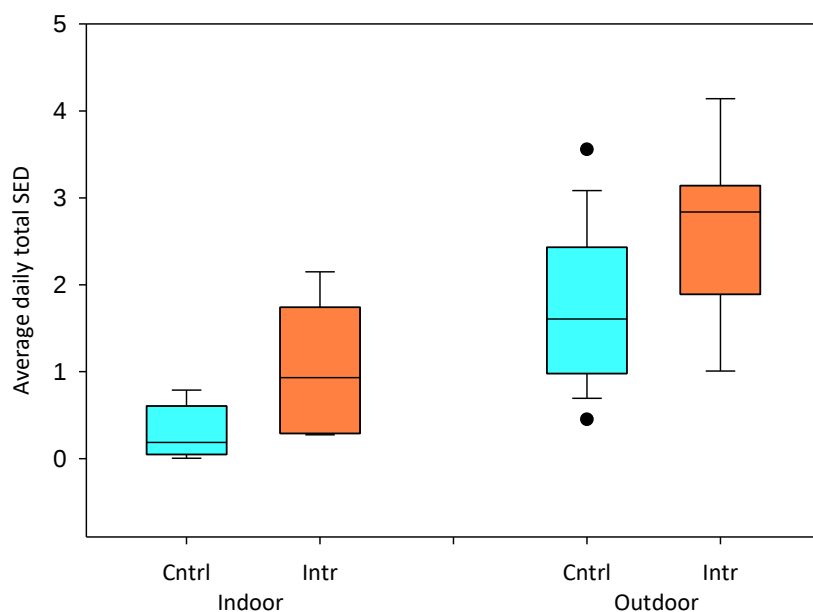


Figure 13 **Boxplot of distribution of daily SED and the proportion of days with total SED > 2**
The box extends from the 25th to 75th percentile, with the horizontal line within the box indicating the median level. The lines outside the box extend from the 10th to the 90th percentile, with values outside these values displayed as individual points.

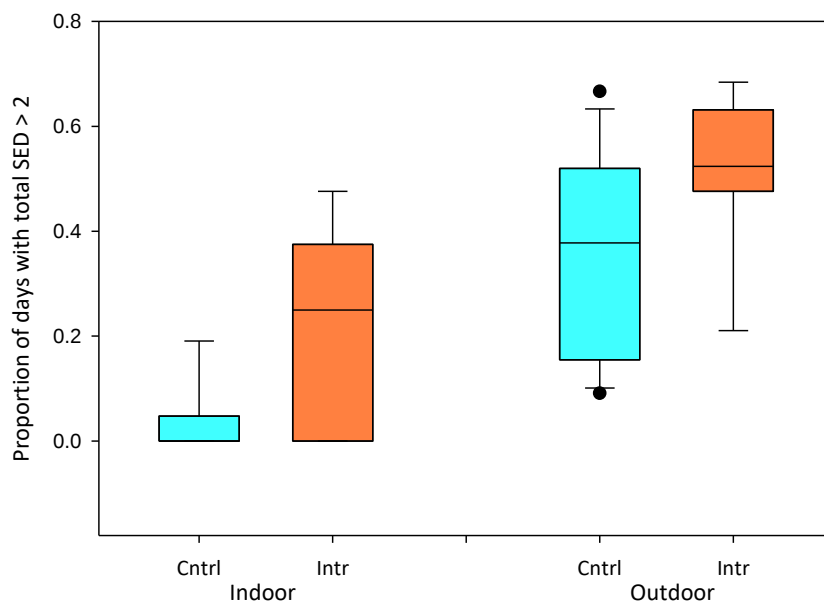


Figure 14 **Boxplot of distribution of daily SED and the proportion of days with total SED > 2**
Note: the box extends from the 25th to 75th percentile, with the horizontal line within the box indicating the median level. The lines outside the box extend from the 10th to the 90th percentile, with values outside these values displayed as individual points.

As with the average exposure (Figure 13) the proportion of measurements > 2 SED was higher for the outdoor workers compared to the indoor workers, and in each case the intervention data were higher than for the control group. For indoor workers about 40 – 50% of measurements exceeded a daily exposure of 2 SED.

Multiple linear regression analysis was carried out to investigate the association of UV levels with the following potential explanatory variables: Age, Gender, Skin type, North/South site, Indoor/Outdoor worker, Change in vitamin D across Wave 2, Ethnicity, and Intervention/Control group. Responses to the questions – from the questionnaire, *Have you had skin cancer?*, and from the Stages of Change *'Avoid/Minimise work in summer sunlight in the middle of the day'* were also included as potential explanatory variables. Again, terms were fitted one at a time in separate models, and, where more than one term was statistically significant then these terms were included simultaneously in the model to investigate any confounding/interactions.

For both outcomes, only indoor/outdoor working was significantly associated with UV exposure, with UV levels higher in outdoor workers (model 1, Table 7). However, differences were seen between the Intervention and Control groups after adjustment for Indoor/Outdoor working, with levels higher in the Intervention group (model 2, Table 8).

Table 8 *Regression analysis of the UV exposure data**

Outcome variable	Explanatory variable	Model 1			Model 2		
		Co-efficient	Standard error	P-value	Co-efficient	Standard error	P-value
Sum SED	Constant	0.690	0.208	0.002	0.326	0.243	0.188
	Outdoor v Indoor ¹	1.319	0.280	<0.001	1.487	0.270	<0.001
	Intervention v Control ²				0.688	0.274	0.017
Proportion of days with SED>2	Constant	0.1241	0.0439	0.008	0.0428	0.0506	0.404
	Outdoor v Indoor ¹	0.2761	0.0591	<0.001	0.3135	0.0563	<0.001
	Intervention v Control ²				0.1535	0.0573	0.011

*All variables included in the model are shown in the table

¹Coefficient represents increase in UV in outdoor workers compared to indoor workers

²Coefficient represents increase in UV in the Intervention group compared to the Control group

Satellite UV radiation

Illustrated in Figure 15 are the satellite UVB dose estimates at each site, across the three waves of data collection. The graph demonstrates, as expected, low UVB levels in Wave 1 (winter), a peak in UVB in Wave 2 (summer) and low exposure in Wave 3 (winter).

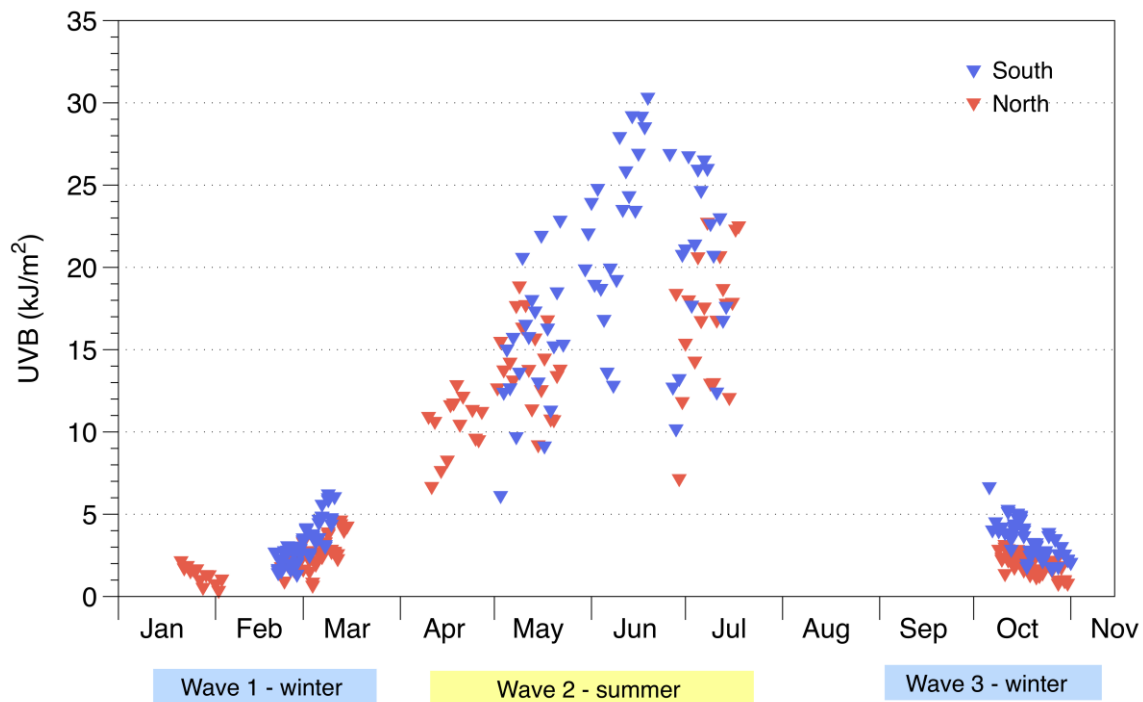


Figure 15 Daily UVB irradiance at each study sites

The position of the sun varies with latitude, season and time of day (defined by solar zenith angle – SZA). At latitudes closer to the equator, months around the summer solstice and times around midday UVB is higher. This explains high UVB recorded at sites at lower latitudes and summer months (e.g. Waterloo) and very low UVB for the study sites at higher latitudes in winter months (e.g. Armadale). At sites where UVB was recorded at the same time of year (e.g. Shoreditch and Bathgate), there tends to be higher UVB recorded in the sites at lower latitudes, but this is not the case for every day. At a local level a series of extrinsic factors such as cloud cover, elevation, terrestrial albedo, and environmental aerosols/pollutants (e.g. sulphate haze and tropospheric ozone from industrial emissions and vehicle exhausts) can affect the attenuation or reflection coefficient and resulting level of ambient UVB (Webb *et al.* 2006).

Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB), posits that Attitudes, Subjective Norms (SNs), and Perceived Behavioural Control (PBC) together predict Behavioural Intentions, which are a close determinant of actual behaviour. These constructs are defined as follows:

- Attitudes are the degree of favourableness and unfavourableness of an individual's feeling towards performing a particular behaviour.
- Subjective Norms (SNs) are the individual's perception of the likelihood that the group or individuals may approve or disapprove of performing the given behaviour.
- Perceived Behavioural Control (PBC) is an individual's perception of the ease or difficulty in performing the behaviour of interest.

Data corresponding to each wave were analysed using the same statistical methods and are reported separately below.

Analysis Wave 1 data (winter)

Pre-intervention, in Wave 1 (i.e. the vitamin D intervention period) the individual items in the TPB questionnaire suggested that 25% of participants planned to take measures to increase their vitamin D, with 39% reporting access to vitamin D at work would make this 'extremely easy'. 60% of participants also reported they had 'complete control' over their vitamin D consumption.

Post-intervention, 19% reported taking steps every day to increase their vitamin D and 30% reported taking no action. The ability to control vitamin D consumption rose to 64%. Only 10% of participants agreed that it was difficult to access sources of vitamin D at work.

Paired samples t-tests found that only Attitudes expressed in the TPB questionnaire were statistically significant, with participants' attitudes to take measures to increase their vitamin D levels being *less* positive post intervention (mean of the Likert scale scores (M) = 5.78, standard deviation (SD) = 1.55) than pre-intervention ($M=6.38$, $SD=0.86$; $t=2.25$, $df=20$, $p=0.04$).

Multiple regression analyses were conducted to determine the predictive strength of the TPB model in relation to behavioural change associated with the vitamin D intervention. Direct measures of Attitude, SNs and PCBs were entered as predictors, with Behavioural Intentions as the outcome variable.

Pre-intervention, the three predictors accounted for 36% of the variance in the Behavioural Intentions, and the overall model predicted participants' Intention to increase vitamin D levels, ($F(3,50) = 9.41$, $p<0.0001$). Both Attitudes and SNs made significant contributions to the model ($\beta=0.388$, $p<0.01$; $\beta=0.355$, $p=0.01$, respectively).

Post-intervention, Attitudes, SNs and PBC accounted for 66% of the variance in the model, which was statistically significant ($F(3, 17) = 10.99$, $p<0.001$). However, only PBC was a significant contributor to the model ($\beta=0.46$, $p<0.05$).

Analysis Wave 3 data (winter)

Pre-intervention, the individual items in the TPB questionnaire suggested that 26% of participants planned to take measures to increase their vitamin D, with 39% reporting access to vitamin D at work would make this 'extremely easy'. 57% of participants also reported they had 'complete control' over their vitamin D consumption.

Post intervention, 20% reported taking steps every day to increase their vitamin D and 10% reported taking no action. The ability to control vitamin D consumption rose to 60%. 30% of participants agreed that it was difficult to access sources of vitamin D at work.

Paired samples t-tests found only SNs to be significant, with participants feeling *less* social pressure to take measures to increase their vitamin D levels post-intervention ($M=5.90$, $SD=1.43$) in comparison to pre-intervention ($M=6.35$, $SD=0.73$; $t=2.18$, $df=23$, $p=.04$, two-tailed).

At pre-intervention, the three predictors (Attitudes, SN and PBCs) accounted for 19.4% of the variance in the outcome variable, and the overall model significantly predicted Intention to increase vitamin D

levels ($F(3,46) = 3.40, p < .05$). However, none of the predictors individually made a significant contribution to the model. Post-intervention, the overall model was not statistically significant ($P > 0.05$).

Analysis Wave 2 data (summer)

Pre-intervention, in Wave 2 (i.e. the sun-safe intervention period) the individual items in the TPB questionnaire suggested that 56% 'extremely agreed' with the statement '*I expect sunscreen to be supplied by my employer every time I work in the sun*', this was echoed by 38% of participants reporting that their employers support would make it 'extremely easy' to be safe in the sun. There was awareness that taking sun-safety precautions would reduce the risk of developing skin cancer (i.e. 38% reporting this to be 'extremely likely'). However, the intention to do this over the three-week intervention period was lower, with 28% of the cohort reporting this to be 'extremely likely'.

Post intervention, the statement '*I expect sunscreen to be supplied by my employer every time I work in the sun*' decreased slightly to 50%, as did the view on employers support (32%). However, 57% of participants strongly agreed that it was up to them to take sun-safe behaviours and that this action would be extremely beneficial (57% of responses).

Paired samples t-tests found no significant differences ($p > 0.05$).

Multiple regression analyses were undertaken to determine the significance of the TPB model to behaviour change in relation to the sun-safety intervention. At pre-intervention, the three predictors accounted for 49% of the variance in the expressed Behavioural Intention, and the overall model significantly predicted Intentions to take sun protective measures ($F(3,57) = 18.48, p < 0.0001$). All three predictors made significant contributions. In decreasing order from strongest to weakest, these were SNs, Attitudes and PCBs ($\beta = 0.41, p < 0.0001$; $\beta = 0.34, p < 0.01$; $\beta = 0.20, p < 0.05$, respectively). At post-intervention the overall model was significant with 39.9% variance explained ($F(3, 24) = 5.31, p < 0.01$). Only direct measures of SNs and PBC were significant predictors (SN $\beta = 0.46, p < 0.05$; and PBC $\beta = 0.36, p < 0.05$).

Stages of Change

Each data collection wave was considered, comparing the reported Stages of Change data for pre- and post-intervention, for each respondent. Wilcoxon Signed-Ranks (one-tailed) were used for analysis.

Stages of change data were compared pre- and post-intervention for each respondent, for each wave of the study. For Wave 1 (winter), both Control and Intervention groups were found to significantly progress toward more desirable behaviours, although not sufficiently to move from the Contemplation stage. The Intervention group reported significantly more Contemplation regarding taking vitamin D during the winter ($Z = -2.03, p = 0.022$). The Control group were found to report significantly more Contemplation regarding 'consumption of vitamin D enriched dairy products, during the winter' ($Z = -1.73, p = 0.042$). In Wave 2 (summer), the only significant finding was an increase in Action regarding the wearing of sunglasses, for the Intervention group. The group significantly progressed, although remained within the Action stage ($Z = -1.73, p = 0.042$). In the final wave, Wave 3 (winter), the Intervention group significantly progressed into the Preparation stage. Both 'increased consumption of vitamin D supplements' and 'limiting exposure to the sun for 10-15 minutes' were found to significantly progress ($Z = -3.01, p = 0.001$ and $Z = -1.74, p = 0.01$ respectively). However, preparations to 'regularly eat vitamin D rich foods' was found to significantly decrease during Wave 3

for the intervention group ($Z = -1.74$, $p = 0.042$). Considered overall, the interventions can be seen to have had a significant positive effect of desirable behaviours with respect to both vitamin D intake and Sun Safety.

Further analysis investigated Stage of Change as a predictor of UV exposure (SED) and vitamin D levels. No significant relationships emerged with respect to UV exposure. Multiple linear regressions were calculated to predict vitamin D levels from Stage of Change variables. Change values were calculated by subtracting ratings taken at the end of the Intervention waves from those collected at the start. Thus, values represent shifts through Stages of Change. For Wave 3, for the Intervention Group, a significant regression equation was found ($F(5,21) = 3.35$, $p < 0.05$), with an R^2 of 0.51. Shifts in behaviour regarding consumption of a dietary vitamin D supplement (during the winter) was the single significant contributor to the model ($t = 3.51$, Standardised Beta = 0.71, $p < 0.005$); positively predicting vitamin D levels. Stage of Change was not found to be a significant predictor of consumption of vitamin D supplements for the Control group in Wave 3. Further, no significant relationships were identified for Wave 1 or 2 with respect to vitamin D.

Smartphone App

To estimate the effectiveness of the app in addition to other feedback, we sent a short survey to all 112 recruited participants. The short six-question survey asked:

- a) My mobile phone platform is – (Android / Apple / Other)
- b) I downloaded and used the UV app on my phone – (Yes / No / Don't Know)
- c) I used the online version <http://mob.sun-safe.construction> – (Yes / No / Don't Know)
- d) How often have you used the app – (Once / Occasionally / Frequently)
- e) I found the app useful for getting UV forecast and information about UV exposure – (Yes / No / Don't Know)
- f) Additional comments

We received 26 responses (approximately 23%). Twelve participants used the Android operating system, 13 iOS, and one used a Windows mobile device. Sixteen participants successfully downloaded and installed the mobile app onto their devices and 11 participants used the online version of the app. Around half (12) used it occasionally and 13 participants used it just once. 65% of the respondents found the app very useful for getting UV forecast and UV exposure information. However, two users did not find it useful (one user had Windows phone system which wasn't supported for this purpose); and six users answered, 'don't know' (didn't use enough and needed to explore more). Overall, a positive response was received in the comments about the usefulness of the information provided and the UV forecasts provided, as features of the mobile App.

The smartphone app successfully provided the general information about UV exposure, sun-safety, dietary health advice and the UV Index (UVI) forecast for the user's locality, with the latter effectively updated hourly. Using the SMS workflow and messages devised it also successfully delivered the messages appropriately targeted at research participants. This was backed up with a web-hosted version of the mobile application available to participants and could be browsed by others interested in the study.

In future, the app could be modified and extended to include more advanced features and increased user interactivity (e.g. allowing users to create user profile, customised info based on skin colour, sending notifications, publishing native versions on Apple and Android App stores etc.).

Discussion

Vitamin D and sunlight

Exposure to sunlight is the main way the body synthesises vitamin D; diet provides a smaller contribution to our needs. In Britain, and other northern latitude countries, solar UV levels vary considerably throughout the year, i.e. high in summer and low in winter. During the winter months there is insufficient UV exposure for vitamin D synthesis. In our study, at the start of the two winter investigation periods, 60% and 52% of our participants had serum vitamin D levels (measured as 25(OH)D) that are considered insufficient for good health (<50 nmol/l) and 7 and 5 participants in these two waves (15% and 8%) were at levels that were deficient (<30 nmol/l). Overall three people had measured 25(OH)D levels that were severely deficient (<15 nmol/l). These data are comparable to the general population in several parts of Europe: 30% insufficient in Austria, 41% in France, 57% in Germany (Spiro and Buttriss, 2014). However, they are somewhat surprising as these workers typically spent a large part of their time working outdoors.

Several factors are associated with vitamin D status, including age, skin colour, amount of clothing worn and latitude. In a sample of the Scottish adult population the average vitamin D level was 37.5 nmol/l, with around 12% (95% confidence interval 10 – 14%) who were severely deficient in vitamin D (i.e. <15 nmol/l) (Purdon *et al.*, 2013). Purdon and colleagues also reported vitamin D did not importantly vary with age or sex but did decrease with increasing socio-economic deprivation in the population (45.7 nmol/l in the least deprived to 31.3 nmol/l in the most deprived) and body mass index (41 nmol/l for BMI<25 kg/m² to 33.3 nmol/l for BMI>30 kg/m²). The latter finding is plausible since vitamin D is fat-soluble and therefore more likely to be sequestered in those with higher BMI. The authors also analysed blood samples collected throughout the year reporting clear seasonal trends with average vitamin D levels in Spring 36.1 nmol/l, Autumn 34.9 nmol/l and in Winter 27.9 nmol/l. We also found seasonal trends, with the median baseline level in winter being between about 40 and 50 nmol/l and in summer around 75 nmol/l, although we did not have data on deprivation or BMI for our subjects.

Ward *et al* (2011) studied over 6,000 middle-aged working men and women to assess the influence of lifestyle and socioeconomic factors on vitamin D status. Blood samples were collected through different seasons, although in the final statistical analysis they adjusted for season and several other factors. Mean vitamin D level was 52.9 nmol/l in those who were in paid work, with 40.5% with vitamin D level below 50 nmol/l. In men in this study, working at night did not influence average vitamin D level, although levels were slightly lower in those who worked less than 35 hours per week. There was no statistically significant difference in vitamin D levels between those in manual jobs compared to other occupations.

The effects of latitude in research studies can be masked to some extent by variation in skin colour and dietary habits. In a large meta-analysis of published studies, Hagenau *et al* (2009) identified a statistically significant decrease in serum vitamin D with latitude for Caucasians (-0.69 ± 0.30 nmol/l per degree) but not for non-Caucasians. On this basis it might be expected that on average the difference in average vitamin D between the northern and southern worksites included in our study might be around 3 nmol/l, with lower levels in Scotland. However, the pattern in our data was consistently in the opposite direction, with median levels 8 to 14 nmol/l higher in the north than the south. This is most likely due to subtle differences in skin colour.

Hagenau *et al* (2009) also found that Caucasians had on average 21.2 ± 5.1 nmol/l higher serum 25(OH)D levels than non-Caucasians. Again, the relationship between serum vitamin D and skin colour can be complex because of differences in behaviour in the sun, clothing and diet. Experimental studies where subjects with different skin colour were artificially irradiated with UV show equivocal results (Xiang *et al*, 2015). It remains unclear to what extent skin pigmentation affects vitamin D production. We found evidence of the impact of skin colour in our study with two of the three participants with black skin and about a quarter of those with olive/light brown skin being deficient in vitamin D compared with about 10% of those with fair/beige skin colour, where we had 40% of those in the south reporting they had olive, brown or black skin colour compared with 17% in Scotland.

Webb *et al* (2010) discuss the role of UV in sunlight in maintaining vitamin D levels. Their prospective study included 125 adults in Manchester who had circulating 25(OH)D measured monthly for 12 months along with dietary and UV exposure assessments. Mean vitamin D levels were highest in September (mean 71 nmol/l, with 28% optimal), and lowest in February (mean 46 nmol/l, 7% optimal, and 5% deficient – in this study defined as <12.5 nmol/l). They found that a 25(OH)D level of 87 nmol/l in late summer was needed to ensure optimal vitamin D levels throughout the year. At the start of the summer wave of measurements only about a third of our participants had above this level of 25(OH)D in their blood, which underlines that it is unlikely they will maintain a sufficient level of vitamin D throughout the following winter.

Scragg and colleagues (2016) studied 500 New Zealand adults from different ethnic backgrounds and measured both their exposure to solar UV (measured as SED) and 25(OH)D levels over eight weeks. They found that there was a non-linear relationship between SED and 25(OH)D, with most of the increase in vitamin D levels at exposures <2 SED per week; the first 2 SED increased 25(OH)D by 25.5 nmol/l, but 10 SED per week resulted in an increase of 33 nmol/l. It was concluded that vitamin D status is most influenced by regular small sun exposures, and that higher exposures produce only a small additional increase in 25(OH)D. Webb *et al* (2018a and 2018b) recommended that white Caucasians in Britain need nine minutes of daily sunlight around midday between March to September while non-Caucasians (skin type V) need around 25 minutes daily exposure to maintain 25(OH)D levels above 25 nmol/L during winter. Our subjects had much longer exposures with sufficient intensity during the summer period to easily achieve this target. The outdoor workers had around half their measurements above 2 SED, and while there were less than 25% of the days when indoor workers experienced similar exposures they should mostly have exceeded 25 minutes outdoor exposure. Therefore, it is surprising that the outdoor workers struggled to maintain sufficiency throughout the winter.

Worker exposure to UV radiation

In the summer months in Britain solar UV levels can be sufficient to cause acute effects, such as sun burn (erythema). Over long periods this exposure increases the risk of skin cancer, both non-melanoma skin cancer (NMSC) and the more serious malignant melanoma (Rushton *et al.*, 2012; Rushton and Hutchings, 2017). The risk for NMSC is thought to be related to cumulative UV exposure (generally measured as SED) while malignant melanoma is likely caused by repeated high exposures that give rise to erythema (Milon *et al*, 2013). Skin colour (phototype) is important in determining the erythema risk and skin cancer risk, and so is an important factor to consider in terms risk assessment.

People who work indoors can typically experience about 300 SED over a year (on average around 0.8 SED per day) from solar radiation (ICNIRP, 2010). This exposure is mostly from time spent outdoors at

weekends and on holidays. Outdoor workers can have about three to five times these exposures, e.g. >1,000 SED per year or around 4 SED or more on working days averaged over a year (ICNIRP, 2010). Ocular exposure outdoors, which is a risk for damage to the eyelids, cornea, lens, or retina, rarely exceeds the ICNIRP guideline for daily exposure (ICNIRP, 2004); the main issues with ocular exposure arises from high UV exposure due to reflections from water or snow. A person with a light skin colour (skin photo-types I and II) with no adaption, i.e. without a tan, would show mild sunburn after exposure to between 2 SED and at 5 SED with adaption. Those with darker skin, even without adaption, are more able to tolerate higher UV doses before showing signs of erythema, e.g. phototype III or IV 5 SED, phototype V 10 SED and phototype VI 15 SED. The International Commission on Non-ionising Radiation guidelines limit daily exposures for the most sensitive skin photo-types, to 30 J/m² (ICNIRP, 2004), which is equivalent to 0.3 SED per day.

Epidemiological studies among outdoor workers have demonstrated a clear increased risk for both squamous cell carcinoma (SCC) and basal cell carcinoma (BCC), which are the main forms of NMSC (IIAC, 2018). There are few studies that have quantified the risk of skin cancer in relation to exposure. However, a recent SCC case-control study from Germany quantified UV exposure using a job-exposure matrix (Schmitt *et al*, 2018). They found a doubling of the risk for SCC for a lifetime occupational exposure of 6,348 SED. For someone who worked in an outdoor job for 45 years that would correspond to an annual exposure of around 140 SED or around 1.5 SED on working days when there was potential exposure to solar radiation, i.e. late spring to early autumn.

There is a small number of studies of occupational UV exposure that have been undertaken, but ours is the first study of British workers (latitude 51.5-56N). We found that in summer, construction workers who predominantly worked outdoors were exposed to on average 2.0 SED and those who worked partly indoors and partly outdoors 0.69 SED. In the outdoor workers around 40% of the daily exposures exceeded 2 SED while about 12% of the exposures for the indoor workers were above 2 SED. Our measurements were made on the head of the subjects (hard-hat).

Grandahl *et al* (2018) describe measurements of UV exposure on Danish (latitude 55-57N) workers made with wristwatch dosimeters. The median daily exposure for outdoor workers throughout the summer months was 2.0 SED, for those worked partly outdoors and partly indoors 1.1 SED and for indoor workers 0.7 SED. The highest average exposures were measured in May: 2.4 SED for the outdoor workers. An earlier study of Danish workers found similar low-level exposure in indoor workers (mean 0.5 SED per day). Thieden *et al* (2005) compared the exposure of Danish (55.7N) and Irish (53N) gardeners using a wrist dosimeter. They found higher exposures among the Danish workers: median 1.6 vs 1.0 SED (maximum 3.8 and 2.7 SED, respectively). Peters *et al* (2016) carried out a similar investigation among Canadian (latitude 47N) outdoor construction workers using a wrist dosimeter. They measured exposure of 73 workers (318 measurements) and found the geometric mean exposure was 1.18 SED, with a geometric standard deviation of 3.84.

UV exposures have also been assessed for workers in more southerly latitudes. Serrano *et al* (2013 and 2014) describe two small surveys of workers in Valencia (39.5N) using sensitive spore-film filter-type personal dosimeters (VioSpor). The median exposures were 3.1 and 6.1 SED, with the main difference being the amount of time workers spent outdoors: three hours and nine hours per day, respectively. The maximum measured exposure was 24.5 SED.

Serrano and colleagues made their measurements on different body locations and found that median exposure measured on the head was around 75% higher than on the wrist (8.9 vs 5.2 SED).

Measurements at various anatomical sites have illustrated how solar UV exposure varies over the body in different conditions; for example, Wright *et al* (2004) showed that the exposure on the top of the head was around 50% higher than the back of the hand under clear skies and about 27% higher on overcast days when indirect UV radiation makes up a greater part of overall exposure. However, exposure on the forehead or top of the ear were more comparable to the hand. Clearly this needs to be considered when comparing measurements made with different strategies, although it is not straightforward to correct for sampling body location.

Overall, our measurements are comparable or a little higher than corresponding data from outdoor workers in other northern latitude countries and lower than in southern latitude countries; those who work indoors were less exposed than outdoor workers. These findings are unremarkable, but differences within northern Europe appear to be less influenced by differences in latitude and are more dependent on other factors such as work practices. In our own study we found that the ambient UV was generally higher at the lower latitudes, but this is not for every day due to the influence of cloud cover, pollution or other environmental factors. Our personal exposure measures were not significantly different between the London and Scottish sites, which must reflect the variation in behaviour of workers, while vitamin D was lower among the southern subjects in our study. Overall the data underline the risk of skin cancer for outdoor workers and confirm that such exposures over a working lifetime probably more than double the risk of non-melanoma skin cancer (Schmitt *et al*, 2018).

Intervention to increase vitamin D in winter

This study has demonstrated the feasibility of using daily text messaging and a smartphone app to deliver complex health information aimed at changing behaviours. The intervention successfully increased vitamin D status of workers in the intervention group. In particular, during the first wave of our study when levels were generally low and awareness of the need to maintain adequate levels was limited among the construction workers. In Britain, UV exposure is too low in the winter periods to synthesise vitamin D naturally, even within populations that spend longer periods outdoors during the working day. During the low UV period workers were encouraged to improve their diet and to take vitamin D supplements, which were provided as part of the intervention. This result is supported by published research suggesting a dietary supplement is likely to increase 25(OH)D concentration in blood level, but also recognising that dietary changes alone are unlikely to result in adequate vitamin D levels (Pludowski *et al*, 2018).

Vitamin D levels within the intervention group increased by around 25% compared with the control group in Wave 1 was around 10% greater in Wave 3. Post intervention in the first wave found 88% of the intervention group had adequate vitamin D compared to 44% in the control group. Corresponding figures for Wave 3 were 70% and 52%. Webb *et al* (2010) recommended that a 25(OH)D level of 87 nmol/l in late summer was required to sustain optimal vitamin D levels throughout winter. Despite experiencing relatively high UV levels, only a small proportion of our workers achieved this level during Wave 2 and so it is likely that the majority of construction workers need to take supplements to achieve adequate vitamin D levels. Prolonged intake over the winter months would also have additional benefit as serum 25(OH)D levels continue to rise for up to around 120 days for a specific dose before reaching a steady-state concentration (Heaney *et al*, 2003).

Our questionnaire assessment suggested that we were able to improve knowledge of vitamin D among the participants: in the winter waves the knowledge increased in four questions for the control group

compared to six questions for the intervention group. However, there was still lack of awareness about appropriate sources of dietary vitamin D. Across all three waves, the fewest number of correct responses from all participants were 'It's important, in winter, to eat organic food and vegetables to boost vitamin D intake' (correct response: No) and 'I get more vitamin D from natural food (i.e. veg, oily fish, eggs etc.) or supplements' (correct answer: Supplements).

The Stages of Change data (i.e. the readiness to move towards healthier behaviour) revealed modest, but significant, shifts toward more sun-safe behaviours. Positive movements through the Stages of Change were further found significantly to predict increased vitamin D levels. This finding was additionally corroborated by assayed vitamin D measurements. Thus, our study provides support for SMS-based interventions to promote positive behaviours for vitamin D, but not for harmful UV exposure. Considered overall, participants' Stages of Change data revealed a generally low level with respect to positive behaviours. For example, most participants were in the Contemplation or Preparation stages, and only one group reported progressing to Action (in the summer UV wave).

Analysis of data relating to the Theory of Planned Behaviour suggests a fundamentally robust model with respect to Intentions to increase levels of vitamin D. At post-intervention, the explanatory value of the model almost doubled by comparison to pre-intervention. Moreover, the significant contributors to the model were different. The only significant predictor post-intervention was Perceived Behaviour Control, for example, the belief that vitamin D supplements will be readily available in the workplace. The provision of vitamin D to individuals in the Intervention Group may have meaningfully increased participants' perceptions of control over behaviour.

As our study progressed we considered it was possible that all the workers, those in both the intervention and control groups, increased their awareness of these issues as a consequence of the study questionnaires and other materials. For example, in Wave 1 the proportion responding correctly to the questions about eating oily fish and taking vitamin D supplements increased in both groups. This may in part explain the increase in 25(OH)D levels between Wave 1 and 3, and the smaller benefit of the intervention.

Our study findings could have important implications for health and wellbeing practices on construction sites. Specifically, to maintain bone health and other possible diseases (PHE, 2017) employees need to make changes to their diet or take supplements. The available evidence from a comprehensive review of the scientific literature suggests that 10–20 µg per day of vitamin D can reduce all-cause mortality and cancer mortality in middle-aged and older people, and that it may help prevent upper respiratory tract infections and symptoms exacerbations among those with asthma (Autier *et al.*, 2017). Evidence of other health benefits of vitamin D supplementation, e.g. in relation to cardiovascular disease, remain equivocal. However, Cherrie *et al.* (2018) have recently shown increased prevalence of asthma in older adults in Britain with lower serum vitamin D.

Overall our intervention increased knowledge of the importance of vitamin D for health and provided a convenient framework to deliver increases in 25(OH)D levels.

Intervention to decrease exposure to UV radiation in summer

The intervention delivered appropriate messages about sun-safety during the summer months, which had a small positive effect on increasing knowledge about the risk of skin cancer from sun exposure. There were more questions where knowledge increased over the study period, than where knowledge

decreased, although often the changes were small and could have been due to chance. However, overall there were good levels of awareness of the harm that may be caused by overexposure to the sun.

The higher vitamin D levels in the intervention group during summer were not as anticipated and demonstrate that the intervention was unsuccessful. We had hypothesised that vitamin D levels would be lower in the intervention group during high UV exposure on the basis that sun protection methods and staying out of direct sunlight limits vitamin D synthesis (Holick and Chen, 2008). However, 25(OH)D levels increased slightly in the intervention group and decreased slightly in the control group, with the difference being just statistically significant. The UV measurements corroborate the 25(OH)D findings with the UV exposures being higher in the intervention group compared with the control group. It is unclear why this was the case, but it is notable that around three-quarters of our participants had a positive attitude to obtaining a sun tan. The knowledge questionnaire lends some insights into why this was observed as 75% of participants self-report agreement in 'I like to have a sun tan'. This demonstrates there is still a positive relationship between the psychological benefit of being sun tanned and the limited knowledge or perceived risks in tanning is in fact a marker of sun damage. It is clear that a more sustained approach is needed to change perceptions on sun tanned skin. Similarly, in the summer wave 30–40% responded to not requiring sunscreen on cloudy days, which might indicate there is still an attitude towards only applying sunscreen when it is hot and/or sunny.

One limitation of our study design may have been a consequence of administering questionnaires. Participants were given the same questionnaire at each of the waves of data collection. This may have resulted in some carry over knowledge. Participants may also have been confused about the switch in message, which was recognised as a challenge in relation to sun safety and vitamin D. This was due to participants being encouraged to see sun exposure as a valuable source of vitamin D in the low UV period, but in the summer the opposite is the case and prolonged sun exposure is harmful.

While the Stages of Change showed positive support for the vitamin D intervention, no significant changes were seen with respect to the SED measures. However, in the high UV period, the intervention group were in an active state to take measures to wear sunglasses as a means of sun protection. Other actions, such as covering up in the sun or wearing sunscreen were not actively under consideration by the workers. This shows some awareness of adopting sun protective measures, yet more work is needed to align additional protective measures. For example, covering exposed skin and seeking shade have been advocated to reduce skin cancer risks as opposed to only wear eye protection. As noted above, the Theory of Planned Behaviour appeared to be a robust indicator of intention to act, although mainly in relation to Perceived Behaviour Control, e.g. the provision of sunscreen in the workplace facilitating protective measures. Our knowledge results suggested that between 40 and 100% of participants were aware this was already available on-site.

A key to understanding why the sun safety intervention was ineffective may be the fundamental conflict for large numbers of our participants between their expressed views regarding 'wanting a tan' (75% of participants reported a preference for having a tan) and lack of autonomy regarding the recommended practical steps to engage in more protective behaviours (for example working in the shade). As Hiom (2006) noted, questionnaire surveys have clearly shown the British as a 'nation of sun lovers reluctant to cover up or find shade, especially when on home soil'. The expressed attitudes to harmful 'sun seeking' are predominantly associated with younger people, particularly those under 45

years. Around 46% of people surveyed felt 'a suntan makes me look more attractive' and about 60% reported 'a suntan makes me look healthier' (Hiom, 2006).

Similar attitudes prevail among outdoor workers in Britain. Houdmont and Madgwick (2014) identified that in general outdoor workers are largely unaware of the link between sun exposure and skin cancer and are not receptive to efforts to change their behaviour in the sun. They suggested that the main strategies used by British workers to protect against the effects of solar radiation were the use of sunscreen and wearing long sleeve shirts and long trousers. However, in their questionnaire study they found that about 60% of construction workers had experienced one or more incidence of sunburn in the previous year, and 70% reported they 'like to have a tan'. In a Stages of Change analysis in our study, 79% of participants were classified as being in a 'pre-action' stage, i.e. not yet ready to take preventative actions.

It is clear that attempting to change sun-safety behaviour of outdoor workers through information or training faces serious barriers. While there is a general legal imperative to manage risks from solar UV under the requirements of the Management of Health and Safety at Work Regulations, this does not appear to be interpreted strictly. None of the employers in our study had a written risk assessment for solar radiation or appropriate arrangements for health surveillance. The arrangements to protect workers were mostly based on simple policy measures, such as requiring clothing that covered the majority of the body, basic information for employees about the risks and provision of sunscreen. There was no active management of the risks. This is similar to the situation found by Houdmont and Madgwick (2014), who identified ambiguity in the attitudes of managers about whether the employer or employee were responsible to sun safety, reluctance to pay for the costs of protective measures, and a general perception that sun-safety was irrelevant in the British climate.

During the last decade the way in which information is accessed and/or reaches audiences has changed significantly (Leiner *et al.*, 2009). In particular, the ownership and usage of mobile phone technology has increased. Our study was a timely opportunity to capitalise on technology-based interventions. A review of the effectiveness of occupational skin cancer prevention interventions has identified that they can improve sun-safe behaviours, although the strength of the evidence was insufficient to say whether they were effective in preventing a risk of skin cancer through training delivery alone (Glanz, Buller and Saraiya, 2007). Specifically, the authors stated that barriers to uptake in sun protective measures might be caused by attitudes and knowledge. For example, tanning is desirable and remembering to adhere to sun protection is difficult in a busy work environment. A key aspect of our study was to address attitudes and behaviours around sun safety and vitamin D. The text messages approach pushed beyond simple sun safety training and directed information at attitudes with the intention to alter behaviour.

Previous research has assessed text messaging in health promotion, suggesting reminders can encourage weight loss (Patrick *et al.*, 2009), support for health conditions such as diabetes (Waller *et al.*, 2006), as well as providing a health notification service (Park *et al.*, 2008). Findings from the current study demonstrated similar potential to increase knowledge in relation to vitamin D, generate behavioural change with UV exposure in summer, but also extend this to balance the risk of vitamin D deficiency in winter. Research by Armstrong *et al.* (2009) demonstrated the effectiveness of sun safe information delivered via text and sunscreen application to teenagers in the USA. Results found those exposed to the text information had approximately 56% success rate in adhering to sunscreen use compared to about 30% in control conditions. Additional studies in Australia (Gold *et*

al., 2011) found change in behaviours more limited (e.g. no change in sun protective steps, such as hat-wearing). Gold et al. suggested despite knowledge of the cancer risk due to over exposure to UV tanning is still desirable. Our study was met with the same barrier despite text messages being targeted at this belief. To date, construction workers have primarily received sun safety training via standalone presentations (Madgwick, Houdmont and Randall, 2011). Despite some of the limitations in our study we have demonstrated that consistent and reinforced information via text messaging is likely to alter behaviours. We would recommend that additional employer support is required to continue to change UV exposure at work.

What should employers and others do about sun exposure and vitamin D

This study highlighted the key role that the construction industry should play in leading changes in sun safety practice and workforce health and wellbeing. The research clearly demonstrated the potential to deliver health and safety information via text messaging and mobile phone app, and how this type of service could promote sun-safety behaviours during the summer months and help to reduce the decline in vitamin D levels during the winter period. We recommend that construction employers take a more proactive approach to managing sun safety and enforce the use of necessary protective measures, both personal protection and modification of work processes.

Currently sun safety is generally seen as an issue of personal choice for workers with the role of the employer being to promote good practice. The guidance from HSE⁷ emphasises employers should provide training, 'encouraging' workers to cover up and use sunscreen, and to 'consider' organising work to minimise exposure. Health surveillance is left to the discretion of workers. The general impression is that this is a public health issue rather than a health and safety risk that requires active management. We suggest the regulator should provide a stronger role in promoting a risk-based management approach to UV, which we believe is already required under the provisions of the Management of Health and Safety at Work Regulations. In our opinion, health surveillance of outdoor workers to detect skin cancer is already a legal obligation on employers.

IOSH has instigated the 'No Time To Lose' campaign⁸ to increase understanding and help businesses take action on carcinogenic exposures at work. A large part of the campaign has focussed on sun safety with free information and resources for workers and employers. Much of the material aims to change attitudes of workers, for example stressing that there is 'no such thing as a healthy tan'. This is very valuable resource, and our project has run alongside NTTL and, for example, our project website was hosted on the campaign website. We encourage IOSH to continue with its campaign, taking account of the findings from our research.

Vitamin D deficiency is a public health issue in Britain and most other northern latitude countries. It is not specifically a workplace health issue. A large proportion of the construction workers in our study had insufficient vitamin D in winter, and it is surprising that workers who spend many hours outdoors during summer do not get enough UV exposure to maintain sufficient vitamin D levels throughout the year. Employers could make important contributions to tackling this issue through health promotional campaigns at work, which will benefit the health and wellbeing of their workforce. From our research there is a lack of knowledge about vitamin D among construction workers and many are not yet ready

⁷ <http://www.hse.gov.uk/pubns/indg337.pdf>

⁸ <https://www.notimetolose.org.uk/about-the-campaign/>

to act to increase their vitamin D intake. Information campaigns and support in the workplace by providing options to consume food fortified with vitamin D or vitamin D supplements would provide further benefit.

The positive and negative effects of sun exposure at work are important health issues, particularly for outdoor workers. This research provided an effective way of communicating sun-safety and other relevant health promotion messages. The methodology can be easily replicated by employers and it provides a valuable strategy to communicate with employees.

Conclusion

In conclusion, this study highlighted the pivotal role that the construction industry should play in leading sun-safety on site and in taking an initiative on workforce health and wellbeing related to vitamin D. The research demonstrates the potential of delivering health information via text messaging and how this approach could serve to promote sun-safety behaviours during the summer months and help to reduce the decline in vitamin D levels during the winter period. During the summer, workers in our study experienced relatively high UV levels from the sun, and over a working life these would increase risk of being diagnosed with skin cancer. Disappointingly, the intervention did not reduce solar UV exposure or vitamin D levels, as we originally hypothesised. The main reason for this seems to be a deeply entrenched perceived benefit of sunlight and a sun tan among the British population. A high proportion of workers in our study had insufficient circulating vitamin D in winter, which is not uncommon in Britain, but is rather unexpected in an outdoor working population. The intervention had a positive impact on vitamin D levels during the winter, which were increased significantly compared to the control group. This study provides important information about the effectiveness of a technology-based intervention to promote sun-safe and healthy behaviours. Demonstrating text messaging and supportive app as an easy and accessible method to communicate with workers. We suggest that a more prescriptive risk-based approach is needed to reduce the risk of skin cancer among outdoor construction workers.

Summary of key findings

- The study showed that in winter study periods (Wave 1 and Wave 3) serum vitamin D levels were low, and a large proportion of the construction workers had insufficient levels with some clinically deficient in vitamin D. The text and phone intervention significantly increased vitamin D levels during winter (the proportion categorised as insufficient decreased from around 50% to 20%). Daily nudging information delivered to workers and the availability of a dietary supplement is likely to increase vitamin D levels during periods when UV is too low to synthesis naturally.
- The study showed that in the summer study period (Wave 2) vitamin D levels in the intervention group were higher post intervention and not lower than the control group as anticipated. Solar UV exposures were also higher in the intervention group. The main barrier to change appears to be positive attitudes to having a sun tan among the workers.
- The TPB showed changes in beliefs around perceptions of control.
 - In Wave 1 (low UV period) there was a significant difference in PBC post study in the intervention group in the intentions to increase vitamin D.
 - In Wave 2 (high UV period) there was a significant difference in SNs and PBC post study in the intervention group in the intentions to take sun protective measures.
 - Paired samples t-tests found only SNs to be significant with participants feeling *less* social pressure to take measures to increase their vitamin D levels post intervention.
- The Stages of Change showed that the intervention had a significant positive effect on desirable behaviours with respect to vitamin D intake and sun-safety.
 - In Wave 1 and 3 (low UV period) the intervention group reported significantly more contemplation regarding consumption of vitamin D rich products and by Wave 3 this moved from Contemplation to Preparation.
 - In Wave 2 (high UV period) the intervention group reported signification higher action to wearing sunglasses for UV protection.
- A text messaging system is an easy and accessible way to deliver complex health messages directly to the intended population, nudging them towards better health choices.
- A mobile app can successfully deliver supporting information and guidance, and could be extended functionally for construction workers, or analogous situations, workers or exposures, more widely in future.
- Reducing the risk of skin cancer among outdoor construction workers will necessitate a more prescriptive risk management regime.

Implications for practice

- Employers should consider health promotion initiatives to nudge workers towards healthier dietary choices, including dietary supplements over winter, to boost serum vitamin D levels in their workers.
- Sun-safety remains a low priority on construction sites and awareness of current sun-safe measures is low. Employers should adopt a risk-based approach to proactively manage exposure to solar UV where risk management measures should be prescribed and the use of these measures should be enforced.
- Employers should provide health surveillance to detect skin cancers among outdoor workers because of the likely high UV exposure and the consequent increased risk of skin cancer.
- Nudging messages can be easily delivered via text messages or location driven phone Apps to help a workforce stay safe in the sun.

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Appendix 1 – Study sites

	Company	Site location
Scotland	Morrison Construction	Armadale
		Perth
	Interserve	Dunbar
	Crummock (Mulitplex)	Edinburgh
	Laing O'Rourke	Edinburgh
London		
	Balfour Beatty	Stanmore
		Stratford
	Skanska/Crossrail	Waterloo
	Keltbray (Mulitplex)	Shoreditch

Appendix 2 – Participant information sheet

INTERESTED IN IMPROVING YOUR HEALTH AND SAFETY AT WORK?



Are you interested in helping research?

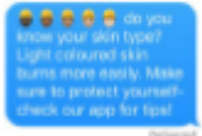


We are a group of scientists at Heriot-Watt University and the Institute of Occupational Medicine. We're investigating if a text messaging service and our smartphone app can help you on site to make better choices about sun-safety and healthier eating whilst you're at work.

We need you!

Still interested?Great! Here's what it takes.....

We'd like to send you a text message (on work days only) for 3 weeks. These will be like the example below and cover information about sun-safety or healthy eating habits. These will arrive from your buddy 'Sunny D'!



We'd also like you to install our smartphone app. It has tips for sun-safety and healthy eating at work.

This is the boring part! We'd really like it if you could complete some simple 'tick box' forms for us too. Your researcher will bring these to site to be completed at the start and the end of the study period.



Don't worry – any issues with this your researcher will help!

LAST of all – we'd like to measure your Vitamin D level. This is done by a 'pin-prick' to the tip of the finger and spots of blood dropped onto a test card – THAT'S ALL IT TAKES!



What's in it for me? Each time you provide the Vitamin D sample we'll give you a **£10 Love2Shop Voucher**

How do I sign up? Contact your site foreman or HS officer and we'll do the rest – We also need you to sign the consent form overleaf!

We hope you'll help, but know you might have questions –

- 1) *Do you sell my personal details?* No your mobile number and any personal details are kept strictly confidential and are made anonymous when we look at the results.
- 2) *Will my Vitamin D sample tell you if I have other health conditions?*No all we see is a Vitamin D reading. The blood spots will not flag any other health conditions or be used for testing anything other than your Vitamin D level.
- 3) *Contact us?* Dr Amanda Nioi, Heriot-Watt University, School of Engineering and Physical Sciences, Edinburgh, EH14 4SA, Tel: 0131 451 4502 or Email: A.Nioi@hw.ac.uk

*Appendix 3 – Example of Vitamin D results***Your Results:****Total Vitamin D : 115.5 nmol/L****Status: ADEQUATE** (25-hydroxyvitamin D₃ : 112.7 nmol/L, 25-hydroxyvitamin D₂ : 2.8 nmol/L)**Interpretive Guide:**

Total Vitamin D Reference Interval (nmol/L)	Vitamin D status	
Less than 15	Severe Deficiency	
15 – 30	Deficiency	
30.1 – 50	Insufficiency	
Greater than 50	Adequate	

Total vitamin D levels above 220 nmol/L are considered 'High' and increase the risk of vitamin D toxicity.

Appendix 4 – Sun safe Pre intervention questionnaire

Safe Working and the Sun

Background

We are interested in the implications of the sun on the way you work. The amount of sun you are exposed to may have implications for your health. During Summer, many workers risk over-exposure to the sun. This questionnaire concerns things you may do to protect yourself from the sun.

The questionnaire should take about fifteen minutes to complete.

Sun Protective Measures

Potential sun protective measures include:

using 'high factor' sunscreen, e.g., Sun Protection Factor (SPF) 30 or more

working in the shade or indoors, if possible

wearing a hat, with/out a neck shade

wearing overalls, or

long sleeved tops and trousers, not shorts, and/or

using sunglasses.

Your Behaviours and Opinions

For the following statements, please...

Place your mark where it best reflects your opinion. For example, the following statement, 'the weather in London in July is...', was rated as 'quite good', by marking it as follows.

Good _____ : _____ / _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

Please respond to ALL statements, do not miss any out.

Please do not put more than one mark for each statement.

I expect sunscreen to be provided by my employer, every time I work in the sun, in the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

Decreasing my chances of getting skin cancer is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

When it comes to taking sun-protective measures, how much do you want to do what your health and safety advisor thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

When it comes to taking sun-protective measures; how much do you want to do what your family thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

My employer's support for working out of the sun, will make it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take sun-protective measures, in the next three weeks.

My family thinks that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take sun-protective measures every time I work in the sun, over the next three weeks.

My co-workers think that taking sun-protective measures, every time they work in the sun, over the next three weeks, is a good thing to do.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

When it comes to taking sun-protective measures, how much do you want to do what your doctor thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

My taking sun-protective measures every time I work in the sun, over the next three weeks will decrease my chances of getting skin cancer.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

I intend to take sun-protective measures every time I work in the sun, over the next three weeks.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

Most of my co-workers will take sun-protective measures, every time they work in the sun, over the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

It is mostly up to me whether I take sun-protective measures every time I work in the sun, over the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

My health and safety advisor thinks that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take sun-protective measures every time I work in the sun, over the next three weeks.

I think I should perform some sun protective measures, in the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

Many people like me take sun-protective measures every time they work in the sun.

Likely _____ : _____ : _____ : _____ : _____ : _____ : _____ Unlikely

I expect my employer to enable me to work in the shade or indoors, rather than in the sun, if needed, in the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

I plan to take sun-protective measures every time I work in the sun, over the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

Celebrities always seem to have a tan.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

Sunscreen provided by my employer will make it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take sun-protective measures, every time I work in the sun, in the next three weeks.

I will try to take sun-protective measures every time I work in the sun, over the next three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

If I wanted to, I could take sun-protective measures every time I work in the sun, over the next three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

Please estimate how often you have taken sun protective measures when working in the sun, over the last three weeks.

Never _____ : _____ : _____ : _____ : _____ : _____ : _____ Everyday

I can think of many celebrities who do not have a tan

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

How many of your co-workers would think that taking sun-protective measures every time you work in the sun, over the next three weeks is a good thing to do? Please circle the appropriate response.

- none
- a few
- nearly half
- around half
- more than half
- almost all
- all.

It is expected of me that I will take sun-protective measures every time I work in the sun, over the next three weeks.

Likely _____ : _____ : _____ : _____ : _____ : _____ : _____ Unlikely

Performing sun safety measures is something that I should do, in the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

Most people who are important to me take sun-protective measures every time they work in the sun.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

How many times, in the last three weeks, have you taken sun protective measures when working in the sun? Please circle the appropriate response.

- on every occasion
- on almost every occasion
- on most occasions
- on around half the occasions
- on nearly half the occasions

a few times

never.

The people in my life whose opinions I value...

Do not take _____ : _____ : _____ : _____ : _____ : _____ : _____ Take

...sun-protective measures every time they work in the sun.

For me to take sun-protective measures every time I work in the sun, over the next three weeks is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

Harmful _____ : _____ : _____ : _____ : _____ : _____ : _____ Beneficial

Pleasant _____ : _____ : _____ : _____ : _____ : _____ : _____ Unpleasant

Enjoyable _____ : _____ : _____ : _____ : _____ : _____ : _____ Unenjoyable

On how many days in the last three weeks did you take sun protective measures, when working in the sun?

_____ days.

My doctor thinks that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take sun-protective measures every time I work in the sun, over the next three weeks.

How many of your co-workers would take sun-protective measures every time they work in the sun, over the next three weeks? Please circle the appropriate response.

_____ none

a few

nearly half

around half

more than half

almost all

all.

Appendix 5 – Sun safe Post Intervention Questionnaire

Safe Working and the Sun

Background

We are interested in the implications of the sun on the way you work. The amount of sun you are exposed to may have implications for your health. During Summer, many workers risk over-exposure to the sun. This questionnaire concerns things you may do to protect yourself from the sun.

The questionnaire should take about fifteen minutes to complete.

Sun Protective Measures

Potential sun protective measures include:

- using 'high factor' sunscreen, e.g., Sun Protection Factor (SPF) 30 or more
- working in the shade or indoors, if possible
- wearing a hat, with/out a neck shade
- wearing overalls, or
- long sleeved tops and trousers, not shorts, and/or
- using sunglasses.

Your Behaviours and Opinions

For the following statements, please...

- Place your mark where it best reflects your opinion. For example, the following statement, 'the weather in London in July is...', was rated as 'quite good', by marking it as follows.

Good _____ : _____ / _____ : _____ : _____ : _____ : _____ Bad

- Please respond to ALL statements, do not miss any out.
- Please do not put more than one mark for each statement.

1. I expect sunscreen to be provided by my employer, every time I work in the sun, in the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

2. Decreasing my chances of getting skin cancer is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

3. When it comes to taking sun-protective measures, how much do you want to do what your health and safety advisor thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

4. When it comes to taking sun-protective measures; how much do you want to do what your family thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

5. My employer's support for working out of the sun, will make it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take sun-protective measures, in the next three weeks.

6. My family thinks that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take sun-protective measures every time I work in the sun, over the next three weeks.

7. My co-workers think that taking sun-protective measures, every time they work in the sun, over the next three weeks, is a good thing to do.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

8. When it comes to taking sun-protective measures, how much do you want to do what your doctor thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

9. My taking sun-protective measures every time I work in the sun, over the next three weeks will decrease my chances of getting skin cancer.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

10. I intend to take sun-protective measures every time I work in the sun, over the next three weeks.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

11. Most of my co-workers will take sun-protective measures, every time they work in the sun, over the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

12. It is mostly up to me whether I take sun-protective measures every time I work in the sun, over the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

13. My health and safety advisor thinks that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take sun-protective measures every time I work in the sun, over the next three weeks.

14. I think I should perform some sun protective measures, in the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

15. Many people like me take sun-protective measures every time they work in the sun.

Likely _____ : _____ : _____ : _____ : _____ : _____ : _____ Unlikely

16. I expect my employer to enable me to work in the shade or indoors, rather than in the sun, if needed, in the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

17. I plan to take sun-protective measures every time I work in the sun, over the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

18. Celebrities always seem to have a tan.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

19. Sunscreen provided by my employer will make it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take sun-protective measures, every time I work in the sun, in the next three weeks.

20. I will try to take sun-protective measures every time I work in the sun, over the next three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

21. If I wanted to, I could take sun-protective measures every time I work in the sun, over the next three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

22. Please estimate how often you have taken sun protective measures when working in the sun, over the **last** three weeks.

Never _____ : _____ : _____ : _____ : _____ : _____ : _____ Everyday

23. I can think of many celebrities who do **not** have a tan

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

24. How many of your co-workers would think that taking sun-protective measures every time you work in the sun, over the next three weeks is a good thing to do?
Please circle the appropriate response.

none

a few

nearly half

around half

more than half

almost all

all.

25. It is expected of me that I will take sun-protective measures every time I work in the sun, over the next three weeks.

Likely _____ : _____ : _____ : _____ : _____ : _____ : _____ Unlikely

26. Performing sun safety measures is something that I should do, in the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

27. Most people who are important to me take sun-protective measures every time they work in the sun.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

28. How many times, in the **last** three weeks, have you taken sun protective measures when working in the sun? Please circle the appropriate response.

on every occasion

on almost every occasion

on most occasions

on around half the occasions

on nearly half the occasions

a few times

never.

29. The people in my life whose opinions I value...

Do not take _____ : _____ : _____ : _____ : _____ : _____ : _____ Take
...sun-protective measures every time they work in the sun.

30. For me to take sun-protective measures every time I work in the sun, over the next three weeks is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

Harmful _____ : _____ : _____ : _____ : _____ : _____ : _____ Beneficial

Pleasant _____ : _____ : _____ : _____ : _____ : _____ : _____ Unpleasant

Enjoyable _____ : _____ : _____ : _____ : _____ : _____ : _____ Unenjoyable

31. On how many days in the **last** three weeks did you take sun protective measures, when working in the sun?

days.

32. My doctor thinks that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ Should

...take sun-protective measures every time I work in the sun, over the next three weeks.

33. How many of your co-workers would take sun-protective measures every time they work in the sun, over the next three weeks? Please circle the appropriate response.

none

a few

nearly half

around half

more than half

almost all

all.

Appendix 6 – Vitamin D Pre Intervention Questionnaire

Safe Working and the Sun

Background

We are interested in the implications of the sun on the way you work. The amount of sun you are exposed to may have implications for your health. During Winter, many workers are unable to get the Vitamin D they require from the Sun. This questionnaire concerns your Vitamin D intake.

The questionnaire should take about fifteen minutes to complete.

Vitamin D Intake

Potential sources of Vitamin D include:

- taking dietary supplements, e.g., tablets
- eating oily fish
- spending 15 minutes in the sun
- eating eggs or cheese, or
- taking fortified produce, e.g., milk or cereal.

Your Behaviours and Opinions

For the following statements, please...

- d. Place your mark where it best reflects your opinion. For example, the following statement, 'the weather in London in July is...', was rated as 'quite good', by marking it as follows.

Good _____ : _____ / _____ : _____ : _____ : _____ : _____ : _____ Bad

- e. Please respond to ALL statements, do not miss any out.
f. Please do not put more than one mark for each statement.

34. I plan to increase my Vitamin D intake, every day, over the next three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

35. If I wanted to, I could take measures to increase my Vitamin D intake daily, over the next three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

36. When it comes to taking measures to increase your Vitamin D intake; how much do you want to do what your Health Care Professional thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

37. For me to increase my Vitamin D intake, every day, over the next three weeks is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

Harmful _____ : _____ : _____ : _____ : _____ : _____ : _____ Beneficial

Worthless _____ : _____ : _____ : _____ : _____ : _____ : _____ Valuable

38. Health Care Professionals think that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take measures to increase my Vitamin D intake daily.

39. Most people who are important to me take measures to increase their Vitamin D intake daily.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

40. Making my bones healthier is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

41. My friends/family think that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take measures to increase my Vitamin D intake daily.

42. Increasing my Vitamin D intake, every day, over the next three weeks will promote healthy bones.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

43. I think the cost of increasing my Vitamin D will make it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take measures to increase my Vitamin D intake daily, over the next three weeks.

44. The people in my life whose opinions I value...

Disapprove _____ : _____ : _____ : _____ : _____ : _____ : _____ Approve

...of me take measures to increase my Vitamin D intake, every day, over the next three weeks.

45. I intend to increase my Vitamin D intake, every day, over the next three weeks.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

46. Taking measures to increase my Vitamin D intake daily, over the next three weeks will be costly for me.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

47. When it comes to taking measures to increase your Vitamin D intake; how much do you want to do what your friends/family think you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

48. Access to sources of Vitamin D while at work, will make it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take measures to increase my Vitamin D intake daily, over the next three weeks.

49. It is mostly up to me whether I take measures to increase my Vitamin D intake daily, over the next three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

50. How much control do you believe you have over taking measures to increase your Vitamin D intake daily, over the next three weeks.

None _____ : _____ : _____ : _____ : _____ : _____ : _____ Complete

51. It will be difficult to get sources of Vitamin D whilst at work.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

52. Most people who are important to me think that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take measures to increase my Vitamin D intake, every day, over the next three weeks.

53. I will try to increase my Vitamin D intake, every day, over the next three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

Appendix 7 – Vitamin D Post Intervention Questionnaire

Safe Working and the Sun

Background

We are interested in the implications of the sun on the way you work. The amount of sun you are exposed to may have implications for your health. During Winter, many workers are unable to get the Vitamin D they require from the Sun. This questionnaire concerns your Vitamin D intake.

The questionnaire should take about fifteen minutes to complete.

Vitamin D Intake

Potential sources of Vitamin D include:

taking dietary supplements, e.g., tablets

eating oily fish

spending 15 minutes in the sun

eating eggs or cheese, or

taking fortified produce, e.g., milk or cereal.

Your Behaviours and Opinions

Over the last three weeks how often have you taken measures to increase your Vitamin D intake?
Please circle the appropriate response.

every day

on almost every day

on most days

on around half the days

on nearly half the days

a few days

Never.

For the following statements, please...

Place your mark where it best reflects your opinion. For example, the following statement, 'the weather in London in July is...', was rated as 'quite good', by marking it as follows.

Good _____ : _____ / _____ : _____ : _____ : _____ : _____ Bad

Please respond to ALL statements, do not miss any out.

Please do not put more than one mark for each statement.

For me to increase my Vitamin D intake, every day, over the last three weeks was...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

Harmful _____ : _____ : _____ : _____ : _____ : _____ : _____ Beneficial

Worthless _____ : _____ : _____ : _____ : _____ : _____ : _____ Valuable

Making my bones healthier is...

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

I planned to increase my Vitamin D intake, every day, over the last three weeks.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

Health Care Professionals think that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take measures to increase my Vitamin D intake daily.

On how many days in the last three weeks did you take measures to increase your Vitamin D intake?

days.

If I wanted to, I could take measures to increase my Vitamin D intake daily, over the last three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

Most people who are important to me take measures to increase their Vitamin D intake daily.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

When it comes to taking measures to increase your Vitamin D intake; how much do you want to do what your Health Care Professional thinks you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

My friends/family think that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take measures to increase my Vitamin D intake daily.

Increasing my Vitamin D intake, every day, over the last three weeks promoted healthy bones.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

I think the cost of increasing my Vitamin D made it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take measures to increase my Vitamin D intake daily, over the last three weeks.

The people in my life whose opinions I value...

Disapproved _____ : _____ : _____ : _____ : _____ : _____ : _____ Approved

...of me taking measures to increase my Vitamin D intake, every day, over the last three weeks.

I intended to increase my Vitamin D intake, every day, over the last three weeks.

Unlikely _____ : _____ : _____ : _____ : _____ : _____ : _____ Likely

Taking measures to increase my Vitamin D intake daily, over the last three weeks was costly for me.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

When it comes to taking measures to increase your Vitamin D intake; how much do you want to do what your friends/family think you should do?

Completely _____ : _____ : _____ : _____ : _____ : _____ : _____ Not at all

Access to sources of Vitamin D while at work, made it...

Easy _____ : _____ : _____ : _____ : _____ : _____ : _____ Difficult

...for me to take measures to increase my Vitamin D intake daily, over the last three weeks.

It was mostly up to me whether I take measures to increase my Vitamin D intake daily, over the last three weeks.

Agree _____ : _____ : _____ : _____ : _____ : _____ : _____ Disagree

How much control do you believe you had over taking measures to increase your Vitamin D intake daily, over the last three weeks.

None _____ : _____ : _____ : _____ : _____ : _____ : _____ Complete

It was difficult to get sources of Vitamin D whilst at work.

Disagree _____ : _____ : _____ : _____ : _____ : _____ : _____ Agree

Most people who are important to me thought that I...

Should not _____ : _____ : _____ : _____ : _____ : _____ : _____ Should

...take measures to increase my Vitamin D intake, every day, over the last three weeks.

I tried to increase my Vitamin D intake, every day, over the last three weeks.

True _____ : _____ : _____ : _____ : _____ : _____ : _____ False

Please estimate how often you have taken measures to increase your Vitamin D intake over the last three weeks.

Never _____ : _____ : _____ : _____ : _____ : _____ : _____ Everyday

Appendix 8 – Stages of Change Questionnaires

Sun safe

(Please tick or complete the response where indicated)

	I don't do this and I'm not thinking about starting (precontemplation)	I don't do this but I'm thinking about starting (contemplation)	I don't do this, but I'm planning to start in the next month (planning)	I do this and began to do it in the last 12 months (action)	I do this and have done so for more than a year (maintenance)
Avoid/minimise work in summer sunlight in the middle of the day					
Swap jobs to minimise the amount of time working in the sun					
Use a shade/cover when working in the sun					
Wear long sleeved, loose fitting tops and trousers on sunny days					
Wear neck protection with my safety helmet in the sun					
Wear sunglasses					
Use sunscreen on sunny days					

Drink plenty of water					
Check the UV index forecast for the day					
Regularly check my skin for moles or unusual changes					

Vitamin D and healthy habits

(Please tick or complete the response where indicated)

	I don't do this and I'm not thinking about starting (<i>precontemplation</i>)	I don't do this but I'm thinking about starting (<i>contemplation</i>)	I don't do this, but I'm planning to start in the next month (<i>planning</i>)	I do this and began to do it in the last 12 months (<i>action</i>)	I do this and have done so for more than a year (<i>maintenance</i>)
Take a Vitamin D dietary supplement during the winter					
Have my Vitamin D levels checked by a health professional					
Regularly eat Vitamin D rich foods, i.e. mushrooms, oily fish, eggs					
Eat Vitamin D fortified cereals, e.g. Weetabix, ReadyBrek, Bran Flakes					
Have Vitamin D fortified dairy products, e.g. Alpro soya milk,					
Expose my skin to only 10-15 mins of sun to get my natural dose of Vitamin D					

Appendix 9 – General Questionnaire

Sun-safety and healthy behaviours at work (START questionnaire)



Name: _____

ID: _____

Date of birth: _____

Study start date: _____

Mobile number: _____

Email: _____

Vitamin D ID: _____

Type (I or C) _____

If you have any issues completing this form you can contact:

Dr Amanda Nioi (Research Associate)

Heriot-Watt University

School of Engineering and Physical Sciences

Department of Human Health

William Perkins, Room 3.12

T: +44 (0) 131 451 4502

Email: A.Nioi@hw.ac.uk

Part 1 YOURSELF

(Please tick or complete the response where indicated)

1. Gender ☐ Male ☐ Female ☐ Not specified	2. Skin type ☐ Very pale ☐ Fair/pale ☐ Fair/beige ☐ Olive/light brown ☐ Dark brown ☐ Black	3. Location where you work ☐ South East ☐ London ☐ South West ☐ East Anglia ☐ Midlands ☐ North East ☐ North West ☐ Scotland ☐ Wales ☐ Northern Ireland ☐ Not specified
4. Age ☐ ≤20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ ≥61	5. Ethnicity ☐ White UK/Irish ☐ Mixed / Multiple ethnic groups ☐ Asian / Asian British ☐ Black / African / Caribbean / Black British ☐ Other ethnic group.....	
6. Occupation characteristics		
☐ Apprentice ☐ Asbestos remover ☐ Banksman ☐ Bricklayer ☐ Civil engineer ☐ Cladder	☐ Plant/Machine operator ☐ Plasterer ☐ Plater ☐ Rigger ☐ Roofer ☐ Scaffolder	

- | | |
|---|--|
| ☐ Customer care | ☐ Snr Construction Manager |
| ☐ Diamond driller | ☐ Sign maker/fitter |
| ☐ Electrician | ☐ Site engineer |
| ☐ Fence erector | ☐ Site foreman |
| ☐ Fireproofers | ☐ Site office staff |
| ☐ Fork lift driver | ☐ Site manager |
| ☐ Ground worker | ☐ Site supervisor |
| ☐ Health and safety professional | ☐ Steel fixer |
| ☐ Insulator | ☐ Storeman |
| ☐ Joiner | ☐ Teacher / instructor |
| ☐ Labourer | ☐ Tiler |
| ☐ Lift engineer | ☐ Traffic management |
| ☐ Mech Tech / Plumber | ☐ Welder |
| ☐ Painter | ☐ Window fitter |
| ☐ Plant fitter | ☐ Other, please specify |

Part 2 KNOWLEDGE

(Please tick or complete the response where indicated)

1. Skin cancer experience

In the last 12 months how many times have you had a red sunburn that lasted a day or more?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ more than 5

Have you had skin cancer?

☐ Yes ☐ No If so, when

Have any members of your family or close friends had skin cancer?

☐ Yes ☐ No

In the last month have you (please tick all that apply).....

☐ been on holiday in a sunny country, if so when and where.....

☐ used a tanning sunbed, if so how often.....

☐ regularly taken vitamin D supplements

2. Skin checking

Have you ever had your skin checked for cancer by a health professional?

☐ Yes ☐ No

In the last 12 months have you checked your whole body for moles or skin changes?

☐ Yes ☐ No

In the last 12 months have you checked areas of your body regularly exposed to the sun for moles or skin changes?

☐ Yes ☐ No

3. Training and sunscreen provision

Is sunscreen supplied in your workplace?

☐ Yes ☐ No ☐ Don't know

Have you ever had training on the risks of working in the sun?

☐ Yes ☐ No

Sun safety knowledge and attitudes

I don't need to wear sunscreen on a cloudy/overcast day during summer?

☐ Agree ☐ Disagree ☐ Don't know

It is important to wear sunglasses to protect the eyes from the sun?

☐ Agree ☐ Disagree ☐ Don't know

Sun exposure is the most important risk factor for skin cancer?

☐ Agree ☐ Disagree ☐ Don't know

If I apply factor 30 sun screen, then I need only apply it once per day?

☐ Agree ☐ Disagree ☐ Don't know

I like to have a suntan

☐ Agree ☐ Disagree ☐ Don't know

I think I am at risk of skin cancer

☐ Agree ☐ Disagree ☐ Don't know

Sun protection is important when working outside for less than one hour in the sun

☐ Agree ☐ Disagree ☐ Don't know

4. Vitamin D knowledge

I can get enough vitamin D from the sun in the UK all year round?

☐ Yes ☐ No

Vitamin D is important for healthy eyesight and healthy skin?

☐ Yes ☐ No

I've experienced vitamin D deficiency?

☐ Yes ☐ No ☐ Don't know

Have any members of your family or close friends had experienced vitamin D deficiency?

☐ Yes ☐ No ☐ Don't know

It's important to eat oily fish in winter to boost vitamin D intake?

☐ Yes ☐ No ☐ Don't know

It's important, in winter, to eat organic food and vegetables to boost vitamin D intake?

☐ Yes ☐ No ☐ Don't know

In winter, everyone in the UK should take vitamin D supplements to keep healthy?

☐ Yes ☐ No ☐ Don't know

I get more vitamin D from natural food (i.e. veg, oily fish, eggs etc.) or supplements?

☐ Natural food ☐ Dietary supplements

How long do I have to be in the sun to get enough vitamin D?

☐ 5 mins

☐ 10-15 mins on a sunny day

☐ 15-30 mins

☐ 1-3 hours

☐ All morning

☐ All day

Appendix 10 – Text messages

Introductory texts

Hi- this is Sunny D, thanks for helping in the Heriot-Watt uni study. You'll receive messages from me over the next 3 weeks on works days only.
Hi- this is Sunny D, thanks for helping in the Heriot-Watt uni study. You'll receive messages from me over the next 3 weeks on works days only. I'll send you a text soon so you can download the app on Android or view the website if you're on iPhone :)
Hi {FirstName} here's the app info: If you have an Android phone download the app using this link. http://s3.amazonaws.com/android.phonegap/slicehost-production/apps/2cf798ce-7503-11e6-b008-0693b2485689/.SunSafeConstruction-debug.apk For now iPhone users can view it on this weblink http://88.98.48.153/uv/www/index.html
Hi {FirstName} - thanks for taking part in our study. We really appreciate your help! We will be in touch soon with feedback from the study :) thanks again Sunny D
Hi {FirstName} here is the app info for iPhone. You must register your device first: Go To Apps Store Search for UDID Download/Install the app UDID Sender developed by Ned Kubica Open the app from home screen and use one of the following options to send UDID 1 - Send UDID via mail to admin@sunsafe.construction 2 - Copy and Send UDID via SMS 07886391934 Then you can click this link: itms-services://?action=download-manifest&url=https://s3.amazonaws.com/AA_plist/2550918/app.plist
Hi {FirstName} here is the app info for iPhone. You must register your device first: Go To Apps Store Search for UDID Download/Install the app UDID Sender developed by Ned Kubica Open the app from home screen and use one of the following options to send UDID 1 - Send UDID via mail to admin@sunsafe.construction 2 - Copy and Send UDID via SMS 07886391934 Then you can click this link: itms-services://?action=download-manifest&url=https://s3.amazonaws.com/AA_plist/2550918/app.plist
Hi {FirstName} here is the app info: If you have an Android phone download the app using this link. http://s3.amazonaws.com/android.phonegap/production/apps/f1983a6a-1618-11e7-8a08-06fdfed975b4/.SunsafeConstruction-debug.apk
Hi- {FirstName} I will send you a text soon so you can download the app. Remember - if you are an android user you can download from the URL link and if you are an iphone user you will need to register your device with us as described in the next text I'll send you!
Hi {FirstName}, check out this video our funder IOSH made about working safely in the sun https://www.youtube.com/watch?v=i1vEuLdOgnw

Spring messages

We are finally into Spring! That means the days are longer and the sun is warming up. Its time to starting thing about sun safety at work.
Do you know your skin type? Light coloured skin burns more easily. Make sure to protect yourself – check our app for tips!
Sunburn puts you at risk of developing skin cancer. Protect yourself with sunscreen, cover with clothing & seek shade
The UV Index is low - you can safely stay outside
It's not only you who suffers if you develop skin cancer – what about your family? Protect yourself from the sun.
Free sunscreen on site? Take advantage and protect your skin from sun damage
There's no healthy way to suntan. Tanning = skin damage. Protect your skin
Healthcare professionals recommend applying sunscreen daily over summer to protect the skin from sun damage
Burnt skin puts you at a higher risk of developing cancer. Cover up with clothing & sunscreen
Sunscreen is not just for holidays – it's for life!
Every day in summer, apply sunscreen to all sun-exposed areas of the body
Are you taking steps to protect yourself from the sun? Good work!
Taking sun protective measures will help reduce your chances of developing skin cancer
Excessive sun exposure ages your skin - protect is with sunscreen
Our sun safety and Vitamin D app has some great information about working safer in the sun - check it out!

High summer messages

Sun's out, guns out? Think again, protect your skin with sunscreen & cover up
Sun tanning ages skin and puts you at risk of skin cancer – see our app for info on sun-safety
Do you know your skin type? Light coloured skin burns more easily. Make sure to protect yourself – check our app for tips!
The UV Index is high today. Remember your sunscreen. Check the app for more info on sun protection advice
Sunburn puts you at risk of developing skin cancer. Protect yourself with sunscreen, cover with clothing & seek shade
When its hot out there – stay hydrated and drink plenty of water!
Oi! Have you put sunscreen on today? It's sunny out there!
Free sunscreen on site? Take advantage and protect your skin from sun damage
Are you taking steps to protect yourself from the sun? Good work!
There's no healthy way to suntan. Tanning = skin damage. Protect your skin
Healthcare professionals recommend applying sunscreen daily over summer to protect the skin from sun damage
Burnt skin puts you at a higher risk of developing cancer. Cover up with clothing & sunscreen
It's not only you who suffers if you develop skin cancer – what about your family? Protect yourself from the sun.
Sunscreen is not just for holidays – it's for life!
Every day in summer, apply sunscreen to all sun-exposed areas of the body
The UV Index is moderate - take care during midday hours and don't spend too much time in the sun unprotected
The UV Index is high – seek shade during midday hours, cover up & wear sunscreen
The UV Index is very high – stay in the shade, if you can, between 10am and 3pm, covering up & sunscreen essential!

Low summer messages

We are coming to the end of summer - don't be fooled some days the UV Index is still high. Check the weather in advance and apply sunscreen if you need too!
Do you know your skin type? Light coloured skin burns more easily. Make sure to protect yourself – check our app for tips!
Sunburn puts you at risk of developing skin cancer. Protect yourself with sunscreen, cover with clothing & seek shade
Its not only you who suffers if you develop skin cancer – what about your family? Protect yourself from the sun.
Sunburn puts you at risk of developing skin cancer. Protect yourself with sunscreen, cover with clothing & seek shade
Free sunscreen on site? Take advantage and protect your skin from sun damage
There's no healthy way to suntan. Tanning = skin damage. Protect your skin
Healthcare professionals recommend applying sunscreen daily over summer to protect the skin from sun damage
Burnt skin puts you at a higher risk of developing cancer. Cover up with clothing & sunscreen
Sunscreen is not just for holidays – its for life!
Every day in summer, apply sunscreen to all sun-exposed areas of the body
Are you taking steps to protect yourself from the sun? Good work!
Taking sun protective measures will help reduce your chances of developing skin cancer
Excessive sun exposure ages your skin - protect is with sunscreen
Our sun safety and Vitamin D app has some great information about working safer in the sun - check it out!

Vitamin D introductory messages

Hi- this is Sunny D, thanks for helping in the Heriot-Watt uni study. You'll receive messages from me over the next 3 weeks on works days only. I'll send you a text soon so you can download the app on Android or view the website if you're on iPhone :)

Hi {FirstName} here's the app info: If you have an Android phone download the app using this link. <http://s3.amazonaws.com/android.phonegap/slicehost-production/apps/2cf798ce-7503-11e6-b008-0693b2485689/.SunSafeConstruction-debug.apk> For now iPhone users can view it on this weblink <http://88.98.48.153/uv/www/index.html>

Hi {FirstName} - thanks for taking part in our pilot study. We really appreciate your help! We will be in touch soon with feedback from the study :) thanks again Sunny D

Vitamin D messages

A good way to boost your Vitamin D is eating oily fish!
Been eating more oily fish and eggs to boost your Vitamin D, well done!
Did you know there are dairy-free alternatives that are fortified with vitamin D? Try Alpro Soy Milk or Oatmeal milk!
Did you know Weetabix and ReadyBrek are a good source of vitamin D?
Get your 5-a-day, add lots fruit & veg to your diet and take vitamins!
Try a boiled egg for breakfast – it's a good source of protein & vitamin D + it'll give you more energy!
Health professionals recommend Vitamin D supplements during winter – have you had yours today?
In winter we don't get enough sun in the UK to make Vitamin D - food supplements help
It's cold out there today – start your day with a hot bowl of porridge with fortified Vitamin D milk!
It's not just your own health that improves with a healthy diet – your family will benefit too!
Vitamin D supplements aren't as expensive as you might think – try Boots own brand £4.99 for 3 months! http://www.boots.com/en/Boots-Vitamin-D-25-g-90-Tablets-_1127509/
Morning brew? Why not try fortified milk in it. Get an easy Vitamin D boost!
Mushrooms are a good source of Vitamin D – try this (link to recipe?)
Taking your Vitamin D supplement today was a great step to boost your health over winter!
Vitamin D builds stronger bones and teeth. Try fortified milk on your cereal
Hi {FirstName} just a reminder to download our app on Android here: http://s3.amazonaws.com/android.phonegap/slicehost-production/apps/2cf798ce-7503-11e6-b008-0693b2485689/.SunSafeConstruction-debug.apk or check the webpage on iPhone here: http://88.98.48.153/uv/www/index.html

Vitamin D messages

In winter we don't get enough sun in Scotland (England) to produce vitamin D. Take a supplement <link to http://www.bbc.co.uk/news/health-36846894 >
Eat oily fish to boost your vitamin D <link to http://www.bbc.co.uk/news/health-36846894 >
It's cold out there today – start your day with a hot bowl of porridge with fortified Vitamin D milk!
Did you know Weetabix and ReadyBrek are a good source of vitamin D?
Get your 5-a-day, add lots fruit & veg to your diet and take vitamins!
Taking your Vitamin D supplement today was a great step to boost your health over winter!
Many workers don't get enough Vitamin D, which can weaken teeth and bones. Try eating more oily fish or fortified foods.
Vitamin D builds stronger bones and teeth. Try fortified milk on your cereal
Did you know there are dairy-free alternatives that are fortified with vitamin D? Try Alpro Soy Milk or Oatmeal milk!
Morning brew? Why not try a fortified milk alternative - Arol soya milk- Get an easy Vitamin D boost!
Health professionals recommend Vitamin D supplements during winter – have you had yours today?
The Doc recommends vitamin D supplements during winter – have you had yours today?
Mushrooms are a good source of Vitamin D – try this them on toast!
Been eating more oily fish and eggs to boost your Vitamin D, well done!
It's not just your own health that improves with a healthy diet – your family will benefit too!

Appendix 11 – Occupational characteristics

		Percent (N)		
Variable		Wave 1 (8 sites)	Wave 2 (9 sites)	Wave 3 (9 sites)
<i>On-site operatives</i>	<i>Occupation</i>			
	Apprentice	3.6% (2)	4.9% (3)	6.6% (4)
	Asbestos remover	-	1.6% (1)	3.3% (2)
	Banksman	7.1% (4)	6.6% (4)	1.6% (1)
	Bricklayer	-	1.6% (1)	-
	Ground worker	26.8% (15)	18% (11)	11.5% (7)
	Insulator	1.8% (1)	1.6% (1)	1.6% (1)
	Joiner	5.4% (3)	6.6% (4)	3.3% (2)
	Labourer	3.6% (2)	4.9% (3)	3.3% (2)
	Painter	-	1.6% (1)	-
	Plant/machine operator	5.4% (3)	3.3% (2)	4.9% (3)
	Rigger	-	-	1.6% (1)
	Steel Fixer	1.8% (1)	-	-
	Storeman	1.8% (1)	1.6% (1)	-
	Traffic Manager	1.8% (1)	1.6% (1)	1.6% (1)
<i>On-site professional</i>	Civil engineer	17.9% (10)	13.1% (8)	11.5% (7)
	Health and Safety professional	3.6% (2)	3.3% (2)	6.6% (4)
	Snr Construction Manager	-	3.3% (2)	-
	Sign maker/fitter	-	1.6% (1)	1.6% (1)
	Site Engineer	1.8% (1)	1.6% (1)	3.3% (2)
	Site Foreman	3.6% (2)	6.6% (4)	8.2% (5)
	Site office staff	1.8% (1)	1.6% (1)	4.9% (3)
	Site Manager	5.4% (3)	4.9% (3)	3.3% (2)
	Site Supervisor	3.6% (2)	4.9% (3)	6.6% (4)
	Other	3.6% (2)	4.9% (3)	14.8% (9)
Total		56	61	61

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