HEALTH AND LIFESTYLE AMONG OFFICE AND CONSTRUCTION WORKERS: INSIGHTS FOR FORMING FUTURE INTERVENTION STRATEGIES.

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A Doctoral Thesis

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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February 2025

Abstract

Background

Non-communicable diseases are increasingly imposing a significant burden globally, with modifiable lifestyle factors like physical inactivity, unhealthy diets, excessive alcohol consumption, and smoking being important contributors to the risk. Preventing these diseases necessitates a comprehensive understanding of such lifestyle behaviours across different domains, including both office and manual (e.g. construction) workplace settings. This knowledge is essential to tailor and guide future preventative strategies effectively. Consequently, this PhD project is focused on exploring lifestyle behaviours and related aspects, such as mental health and well-being, among individuals in office settings and, more specifically, in construction workers—a demographic notably underrepresented in existing research, to help inform and direct future workplace interventions.

Methods

To achieve the intended aim of this PhD project, four main studies were conducted and are as follows:

i) A cross-sectional secondary data analysis of a large data set of employees from a public sector organisation (Office workers) to look at demographic, social, organisational, health and behavioural factors and whether they were associated with employee absenteeism and presenteeism to help inform potential targets for future interventions to improve health (Chapter 2).

ii) A systematic review to identify previously undertaken workplace-based health interventions (physical activity, diet, weight, and smoking) in construction workers targeting improvement in physical activity, diet,

weight, and smoking to see what has been previously done and the degree of its effectiveness. (Chapter 3).

iii) A cross-sectional study quantifying demographic, physical and mental health risk factors, and lifestyle-related health behaviours amongst construction workers (workers at Multiplex and their subcontractors) to help guide future interventions by highlighting which health behaviours to target for interventions (Chapter 4).

iv) A qualitative study with the aim to further build up on findings from the prior cross-sectional study (Objective iii) explaining the lifestyle choices of people working in the construction industry and the potential barriers and facilitators towards improving their current lifestyle choices, and in addition, their views on available workplace health promotion programs provided by their organisation. (Chapter 5).

Results

In Chapter 2, the cross-sectional secondary data analysis of office workers (N = 2846) revealed a number of health concerns. 8.1% were current smokers, and elevated blood pressure was observed in 13.9% of participants, with the majority, 47.6%, falling into the Stage 1 hypertension category. Similarly, a high number, 36.1%, were classified as overweight. Mental health concerns were also prevalent, with 19.1% and 31.8% of workers showing borderline abnormal and abnormal levels of anxiety, respectively, and 23.6% and 13.9% showing symptoms of borderline abnormal and abnormal depression. Key predictors of sickness absence included stress, depression, or anxiety (Coef = 2.653), lower levels of physical activity (Coef = -0.024), and smoking habits (Coef = -0.113). Additionally, stress, depression, or anxiety (Coef =

6.786) and long working hours (Coef = -0.038) were identified as significant predictors of increased presenteeism days. Despite these concerns, physical activity levels were in line with the NHS's recommendations, with an average of 1240.8 MET.min/week.

In Chapter 3, the systematic review, moderate evidence of workplace interventions' effectiveness was noted in physical activity and exercise-related outcomes. Two workplace intervention studies contributed to the improvement of physical activity, in which one identified a significant increase in recreational physical activity, while the other reported a significant increase in meeting public health guidelines for vigorous physical activity. Similarly, two intervention studies reported improvement in exercise-related outcomes, as one intervention reported that 30 minutes of daily exercise was linked with a significant increase in muscle strength or muscle tone, while the other intervention study noted a significant increase in the maximum rate of oxygen consumption (Vo2max) among the participants. Similar moderate evidence of workplace interventions' effect on the reduction of sugar-sweetened beverage consumption, as one study noted a significant decrease in sugar-sweetened beverage intake by one glass per week, whereas the control group demonstrated an increase in consumption, and similarly, the other intervention study reported a significant reduction in sugary drinks consumption.

In Chapter 4, the cross-sectional study on construction workers (N = 43) showed that 20.0% were smokers and a significant portion, 51.7%, had elevated blood pressure, with 30.2% categorised under Stage 1 hypertension. Additionally, 32.6% of the workers were classified under overweight. In terms of mental health, the majority, 74.3%, fell into the medium mental well-being category as per the WEMWBS scale, while 57.1% exhibited minimal depression signs as per the PHQ-9 questionnaire. Despite these health concerns, the study found that physical activity levels met the NHS's recommendations, with an average time spent in moderate physical activity of 253.1 ± 97.5 minutes per day on weekdays (194.8 ± 92.4 minutes during working hours and 58.2 ± 15.6 minutes during leisure time) and 183.3 ± 54.2 minutes on weekends.

In Chapter 5, the qualitative study, data were obtained through interviewing 14 participants working in the construction industry. The findings from this chapter indicated that healthier eating habits were closely linked to an active lifestyle or when meals are prepared by a partner (female). Individuals who have a more active lifestyle (intense exercises) were usually driven to improve their fitness level, sports performance, mental health, and physical appearance, whereas individuals engaging in less intensive forms of physical activity were often hindered by reported barriers to exercise, which was only work. Work-related stress, pressure, and anxiety were the primary contributors to mental health concerns. Moreover, work-related factors such as long working hours and job strain not only exacerbated mental health issues but were also associated with unhealthy dietary choices, smoking retention, reduced physical activity, and sleep disturbances, highlighting the intricate relationship between the work environment and overall health and well-being. Finally, there was a notable dissatisfaction or lack of awareness regarding workplace health programs, even with the presence of a number of them, such as cycle schemes, sedentary behaviour prevention, and mental health initiatives, suggesting a gap in support or communication by the organisation.

Conclusion

The PhD project uncovered that both office and construction workers grapple with mental health challenges exacerbated by work-related factors — particularly in construction workers — alongside prevalent issues of elevated and high blood pressure, being overweight, and smoking, which notably emerged as a more common habit among construction workers. Although the prevalence of these health issues may not reach the levels observed in the broader UK population, particularly concerning overweight, obesity, and hypertension, these insights may elevate the potential of future workplace health promotion programmes to enhance the health of both office and construction workers. Such interventions could not only foster a healthier, more productive workforce but may also contribute to reducing the overall prevalence of these risk factors in the general population.

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Acknowledgement

Here I am, after a continuous journey at the University of Glasgow since October 2016, where I studied my English course and completed my MSc by November 2018, to this day, as I work towards completing my PhD. It has been an arduous journey, filled with the ups and downs, moments of sadness and stress, and the joy of each hard-won achievement. To all the people who have been part of this path, who invested their time in teaching and guiding me, I thank you from the bottom of my heart. You have helped shape a better, more competent version of myself, elevated my knowledge, and deepened my desire to learn. You have taught me to never settle and to always aspire, for the sky truly is the limit. Thank you for this beautiful journey, which will forever remain a beacon of light within me.

Prince Sattam Bin Abdulaziz University – my sponsors; thank you for giving me this opportunity to continue my growth, as this would never be possible.

Professor Jason Gill – my brilliant supervisor, a unique person who guided me over the years with his never-ending ideas and encouragement, a mind that knows no limit, a gentle soul, who was always there for me during difficult times; thank you for providing me with the pleasure of being one of your students.

Professor Emilie Combet – a lovely and supportive person, you helped guide me through new areas I've never been to before; your advice helped me navigate my way through the nutrition field.

Professor Cindy Gray – a teacher who held my hand and helped me navigate my way in the field of qualitative research, a listening ear to my never-ending questions and arguments.

Professor Stuart Gray – the moderator, you have been the voice of calmness during my studies; you always had the time for me to answer my questions and helped me voice out my opinion; your opinions were always balanced, and you always had my back during our supervisory meetings; thank you.

Dr Ahmed Alhowimel - a friend and a mentor who came to my aid when needed. His advice and support were and are always there.

Dr Mazyad Alotaibi - a good friend and a calming spirit; always a pleasure to talk to.

My family – to my mother, thank you for being my mother and for your never-ending support and encouragement; your voice was always with me, whispering in my ears and calming me during difficult times. To my older brother, Mohammed, your support and encouragement are always there; you always have my back. To my brother Marwan, thank you for all the responsibility you have taken on your shoulders for me to continue my journey; you have been and continue to be a solid rock in a streaming river that never budges. To the youngest brother, the sweetest one, your smile is always a source of joy for me.

My uncle, Dr Mohammed Alotaibi – thank you for being part of my life and for your continuous advice and support through this journey.

My daughter – who joined the journey late but, nevertheless, with a joy that never ends.

My wife – thank you for being part of my life, a soul that lit my loneliness in a faraway country, a voice that calmed me during stressful times.

Last but not least, to the person whose physical presence left me far too early in life—my father—your memory has never faded from my mind. Your words of wisdom have guided me through the darkest times, and your incredible journey from an orphan to a renowned doctor has ignited a fire within me to never give up and always strive to be my best. You were a symbol of dedication, a tree that gave without measure. My greatest wish is for you to witness the end of this journey, standing proud with your head held high. You will forever be with me, until the very end.

* Author’s Declaration

This presented thesis is the author’s own work unless stated in an acknowledgement or reference to published literature and has not been used or submitted for another degree at another institution.

Hesham Abdullah F Alfeheid

Abbreviations

Body mass index	BMI
Blood pressure	BP
Coefficient	Coef
Confidence interval	CI
Diastolic blood pressure	DBP
Heart rate	HR
Hypertension	HTN
Metabolic equivalent of task	MET
Mean arterial pressure	MAP
Odds ratio	OR
Prospective randomised trials	PRCT
Quasi experimental design	QE
Randomised controlled trial	RCT
Relative risk	RR
Systolic blood pressure	SBP
Standard error	SE
Standard deviation	SD
Maximal oxygen uptake	VO2max
Waist circumference	WC

“So truly where there is hardship, there is also ease”

Quran 94:5

Chapter 1 General introduction

Chapter overview

This chapter offers a comprehensive exploration of non-communicable diseases (NCDs), highlighting their significant health burdens and economic repercussions on individuals, organisations, and national economies. This is achieved by examining the various risk factors contributing to the development of NCDs, placing particular emphasis on those that can be modified and those linked to occupational settings. Additionally, we aim to offer insights into effective strategies for preventing and combating the development of NCDs.

1.1 The public health burden of non-communicable diseases

Non-communicable diseases (NCDs) are defined as non-infectious diseases that develop over time and may require long-term management and care (World Health Organisation, 2014; World Health Organization, 2013). NCDs are chronic diseases that generally have a slow progression over a long period (World Health Organization, 2005, 2022b) and may progress to severe and life-threatening conditions if left undiagnosed or untreated (Aikins and Agyemang, 2016). NCDs are attributed to a combination of behavioural, environmental, physiological and genetic factors (World Health Organization, 2022b). In relation to their mortality and morbidity rates, the main NCD types are cardiovascular diseases, which include heart diseases and strokes, cancers, diabetes, and chronic respiratory diseases, which include asthma and chronic obstructive pulmonary disease (World Health Organization, 2022b) and in addition mental health (Stein et al., 2019). NCDs are diseases that are mainly the outcome of modifiable lifestyle behaviours such as physical inactivity, sedentary behaviour, unhealthy diet, excessive alcohol consumption, and tobacco use (smoking) (World Health Organization, 2022b).

1.1.1 The health burden of physical non-communicable diseases

Communicable diseases were the major leading cause of death worldwide for an extended period of time; however, the advancement in research, prevention, detection, and treatment has led to the medical development of vaccines and antibiotics that have aided in mitigating and controlling most communicable diseases (Boutayeb and Boutayeb, 2005). This is not the case for NCDs, as they are becoming more prominent with each decade worldwide. The trend of NCDs increased from 18.7% during the 1990s to 25.0% in the 2000s (Boutayeb and Boutayeb, 2005). Currently, and according to the World Health Organization (2022b), 41 million people die annually due to NCDs, accounting for 74% of all deaths worldwide, and in addition, 17 million people die each year before the age of 70 due to NCDs, with 86% of these deaths occurring in low and middle-income countries. Cardiovascular disease is the leading NCD in terms of mortality, with 17.9 million deaths annually, then cancer with 9.3 million deaths annually, chronic respiratory diseases with 4.1 million deaths annually, and diabetes with 2 million deaths annually (World Health Organization, 2022b). In addition, The Global Burden of Disease 2010 estimated that 54% of the disability-adjusted life years (the total years lived with disability and years of life lost from premature death) globally in 2010 were attributed to NCDs, a 43% increase from the 1990s, with disability-adjusted life-years due cardiovascular diseases, cancer, and diabetes rising to 22.6%, 27.3%, and 69.0% between the years 1990 and 2010 (Murray et al., 2012). Furthermore, among the top causes of disability-adjusted life years, NCDs such as stroke and ischaemic heart disease rose in their global burden, with ischaemic heart disease leading these causes, according to The Global Burden of Disease study (2010) (Murray et al., 2012). In the United Kingdom, NCDs deaths account for 88% of mortality, which translates to 541700 mortalities attributed to NCDs, and with a 10% premature death probability (World Health Organization, 2022d).

1.1.2 The health burden of mental health

Mental health disorders have been considered within the literature as part of the NCDs due to the significant association with cardiovascular diseases (Batelaan et al., 2016; Cohen, Edmondson and Kronish, 2015), diabetes (Vancampfort et al., 2016), and cancer (Watts et al., 2014; Caruso et al., 2017). Nevertheless, mental health disorders have been, and continue to be, a major burden in terms of mortality, morbidity, and disability-adjusted life years. According to Walker, McGee and Druss's (2015) systematic review and meta-analysis of mental health disorders and mortality from 148 studies, the pooled relative risk for all-cause mortality was 2.22 (95% confidence interval (CI), 2.12-2.33), with 135 studies reporting significantly higher mortality in people with mental health disorders compared to those without mental health disorders, and concluded that an estimated 14.3% of mortalities worldwide, which accounts for 8 million deaths per year, are attributed to mental health disorders.

Although mental health disorders are linked to a concerning mortality rate burden worldwide, they have also been linked to disability-adjusted life years. Vigo, Thornicroft and Atun’s (2016) global estimation study of the true burden of mental illness reported that mental illnesses’ global burden accounts for 13.0% of disability-adjusted life years and 32.4% of years lived with disability. They further added that current approaches to quantifying the global burden of mental illnesses underestimate it by more than a third, and in their estimation, mental illnesses burden in terms of disability-adjusted life years and of years lived with disability are among the major burdens similar to cardiovascular diseases. This was further investigated and confirmed by Arias, Saxena and Verguet’s (2022) study quantifying the burden of mental health disorders worldwide, where mental health disorders were responsible for an estimated 418 million disability-adjusted life years, encompassing a total of 16.5% of the global disability-adjusted life years. This indicates that mental health disorders were and are becoming a major threat worldwide.

1.2 The economic burden of non-communicable diseases

The impact of NCDs' economic consequences is immense due to the accumulated burden on healthcare costs, as well as lost productivity due to sickness or premature death (Hunter and Reddy, 2013). According to the World Economic Forum, NCDs and mental health illnesses are projected to cause a cumulative economic loss of 47 trillion dollars between 2011 and 2030, with cardiovascular disease, cancer, chronic pulmonary diseases, and diabetes responsible for about 30 trillion dollars (Bloom et al., 2011). Additionally, these diseases stifle economic development via productivity and production losses due to disability and the continuous informal care by family and others (Muka et al., 2015).

1.2.1 Non-communicable diseases cost individuals (patients)

NCDs are chronic diseases that are lengthy in nature and, due to this, require expensive, prolonged care and treatment, which would largely impact the patient's personal expenditure. NCDs-related healthcare cost per patient varies depending on the country and region, as well as the type of NCDs (Muka et al., 2015). According to Muka et al. (2015) systematic review of the global impact of NCDs, cardiovascular disease and cancer had the highest annual cost per patient, with the average annual cost for cardiovascular disease ranging from 1643 US dollars to 69440 for European countries. They further added that the annual cost of cancer treatment was dependent largely on the cancer site, with costs ranging from 2208 to 197722 US dollars for colorectal cancer, 4964 to 161048 US dollars for lung cancer, 4595 to 82794 US dollars for breast cancer, and an average estimate of 8049 US dollars for cervical cancer. In addition, individuals diagnosed with diabetes incur average medical expenditures of around 16750 US dollars per year, with around 9600 US dollars solely attributed to diabetes expenses (American Diabetes Association, 2018).

NCD-associated healthcare-related costs marked an increase over time; for instance, in the United States, although there was a 19% decline in acute myocardial infarction hospitalisation, the overall healthcare increased from 1998 to 2008 by 17% per patient, with a 65% increase in the use of outpatient services (Likosky et al., 2013). Similarly, In the United States, the total cost of diabetes for patients in 2012 was estimated to be 245 billion US dollars, which is a 21% increase since 2007 (Diabetes Care, 2013), with the majority of the increase occurring due to the rising costs of prescribe drugs (Zhuo et al., 2015). Further to this, in the United States, a 73% increase in the mean treatment cost for colorectal cancer from 2005 to 2009, primarily due to the use of new treatment methods and updated protocols, which included radiation therapy and a higher probability of surgery (Seal et al., 2013).

Poverty reduction in low-income countries is likely to be hindered due to the rapid rise of NCDs and the increased healthcare cost, as healthcare costs associated with NCDs can rapidly drain household resources due to the high cost of treatment, which can be long; thus, expensive, which in turn forces millions into poverty, losing jobs and impeding development (World Health Organization, 2022b). In addition, socially disadvantaged people, as well as vulnerable people, get sicker; thus, they may die earlier due to limited access to healthcare services and are at a higher risk of being exposed to unhealthy products, unhealthy dietary practices and tobacco use (World Health Organization, 2022b).

Unhealthy lifestyle behaviour increases the risk profile for NCDs; this occurs to a more significant extent in developing countries as well as developed countries (Vandenberghe and Albrecht, 2020). An unhealthy diet, such as the consumption of high amounts of fat-rich foods, processed foods, foods with high sugar content as well as physical inactivity, all contribute to overweight and obesity. These unhealthy lifestyles increase the number of people suffering from one chronic disease and, in addition, may increase the number of chronic diseases in one person, which is referred to as co-morbidity (Vandenberghe and Albrecht, 2020). This accumulation in risk factors and co-morbidities increases healthcare expenditure at an individual level, as people with co-morbidity require a different combination of treatment and drugs (Brunner-La Rocca et al., 2016), as well as at the healthcare level, as patients require expensive treatments with prolonged individualised care that are adjusted for each patient and delivered by a specialised healthcare services (Muka et al., 2015).

The economic impact of NCDs not only affects people's personal income at a personnel level, but it also extends to a country's national income level with healthcare expenditures and productivity loss, which is attributed mainly to absenteeism, disability, and the inability to work.

1.2.2 The economic burden of non-communicable diseases on organisational and national levels

When addressing the economic burden of NCDs, two terms are needed to clearly describe the source of the burden: direct cost, which refers to the costs associated with the diagnosis and treatment of NCDs in the healthcare system, and indirect costs, which refers to the income loss due to mortality, disability, absence, and early retirement leading to productivity loss (Bloom et al., 2011).

Several studies were conducted in different countries analysing the economic impact of cardiovascular disease on a national level. In the United States, between 2017 and 2018, the average annual direct and indirect cost of cardiovascular disease was estimated at 378.0 billion US dollars, with direct healthcare expenditure (direct cost) accounting for 226.2 billion US dollars and 151.8 billion US dollars due to productivity loss (indirect costs) attributed to premature cardiovascular disease mortality (Tsao et al., 2022). In the European Union, in 2003, cardiovascular diseases were estimated to cost 169 billion euros annually, with healthcare costs accounting for 62%, productivity losses accounting for 21%, and informal care accounting for

17% of the total cost (Leal et al., 2006). According to Vandenberghe and Albrecht (2020), in a later systematic review, the annual direct cost of cardiovascular disease in the European Union in 2017 was 112.9 billion euros, divided as 8.6 billion euros for primary care, 12.8 billion euros for outpatient services, 51.1 billion euros for inpatient service, 25.3 billion euros for drugs, and 2.2 billion euros for accident and emergency. Furthermore, the annual indirect cost associated with cardiovascular disease in 2017 reported in their systematic review was 101.3 billion euros, with 53.9% due to productivity loss (mortality, 31.8 billion euros and morbidity, 22.8 billion euros). In the UK, in 2004, cardiovascular diseases cost 29.1 billion UK pounds, with 8.5 billion UK pounds (29%) and 8.0 billion UK pounds (27%) attributed to coronary heart diseases and cerebral vascular diseases, respectively, and with the majority of these expenses resulting from cardiovascular diseases related healthcare, accounting for 60% of the total cost, and followed by productivity loss as a result of morbidity and mortality, which accounted for 17% and 23%, receptively (Luengo-Fernandez et al., 2006).

The cost of cancer is growing with each decade (Seal et al., 2013). According to Hofmarcher et al. (2020), the total cost of cancer in the European Union and the United Kingdom in 2018 was 199 billion euros, with 103 billion euros attributed to health expenditure, which included 32 billion euros spent on cancer drugs and in addition, a 70 billion euros loss was due to cancer-related productivity loss, with 50 billion euros attributed to premature mortality and a 20 billion attributed to morbidity. In Europe, in 2018, Germany suffered the highest economic impact from cancer, with a total economic loss of 46.6 billion euros, with 25.5 billion euros attributed to health expenditure and a 15.9 billion euros loss in productivity due to premature death (11.5 billion euros) and morbidity (4.4 billion euros), whereas, in the United Kingdom, the total cost attributed to cancer was 23 billion euros, with 11.7 billion euros attributed to healthcare expenditure and a total of 8.1 billion euros loss in productivity due to premature mortality and morbidity, divided as 6.6 billion euros and 1.5 billion, respectively (Hofmarcher et al., 2020). In the United States, in 2017, healthcare expenditure was estimated to be 161.2 billion US dollars, with a productivity loss of 181 billion US dollars due to morbidity (30.3 billion US dollars) and premature mortality (150.7 billion US dollars) (Jemal *et al.* (Eds), 2019). In addition, globally, the economic loss due to new cancer cases in 2009 was 286 billion US dollars, divided into 151 billion US dollars as healthcare expenditure, 66 billion US dollars as informal care, and 69 billion US dollars as productivity loss (Beaulieu et al., 2009).

Diabetes is considered a significant health threat worldwide due to the rapid prevalence increase in the past four decades (Zhou et al., 2016). According to Bommer et al. (2017), in 2015, the global cost of diabetes was estimated to be 1.3 trillion US dollars, with productivity loss accounting for 34.7% (labour-force dropout accounts for 48.5%, and mortality accounts for 45.5%). High-income countries in 2015 suffered the highest economic burden of diabetes, with a total cost of 804.4 billion US dollars, followed by middle-income countries with a total cost of 504.9 billion US dollars, and lastly, low-income countries with 2.5 billion US dollars, and with North America having the highest economic burden from diabetes with 499.4 billion US dollars (36.3 attributed to productivity loss), followed by east Asia and the Pacific with 318.9 billion US dollars (38.2% due to productivity loss), then Europe and Central Asia with 276.3 billion US dollars (30.8% attributed to productivity loss)

(Bommer et al., 2017). In the United States, the total cost of diabetes in 2017 was 327 billion US dollars, divided as 237 billion US dollars in healthcare expenditure and 90 billion US dollars in productivity loss, with productivity loss due to increased absenteeism (3.3 billion US dollars), presenteeism (26.9 billion US dollars), reduced productivity (2.3 billion US dollars) for those who were not in the workforce, inability to work due diabetes-related disability (37.5 billion US dollars), and lost productivity due to diabetes-related premature mortality (19.9 billion US dollars) (American Diabetes Association, 2018).

In the United Kingdom, in 2010/2011, total diabetes cost was 23.7 billion UK pounds, with diabetes-related healthcare expenditure estimated to be at 9.8 billion UK pounds and indirect costs estimated at 13.9 billion UK pounds, which are attributed to mortality (Type 1 diabetes at 560 million UK pounds, and Type 2 diabetes at 4.2 billion UK pounds), sickness absences (Type 1 diabetes at 94.6 million UK pounds and Type 2 diabetes at 851 million UK pounds), presenteeism (Type 1 diabetes at 91 million UK pounds and Type 2 diabetes at 2.9 billion UK pounds), informal diabetes care (Type 1 diabetes at 153 million UK pounds and Type 2 diabetes at 4.9 billion UK pounds) (Hex et al., 2012). In addition to this, the economic burden of diabetes is heavily draining the NHS resource, and if no changes are made in the way diabetes is treated and managed, the NHS expenditure will rise 17% by the year 2035/2036 and with indirect costs reaching an estimate of 22.8 billion UK pounds (Hex et al., 2012). Similarly, the global economic burden of diabetes is expected to increase from 1.3 trillion US dollars in 2015 to 2.2 trillion US dollars by 2030 (Bommer et al., 2018).

Quantifying the global economic burden of mental health may be difficult, as data are mainly available for high-income countries, and there is a lack of studies quantifying mental health costs in low and middle-income countries (Hu, 2006). Nonetheless, Bloom et al. (2011) reported that the total cost of mental health illnesses globally in 2010 was 2.49 trillion US dollars, which was divided into 823 billion US dollars for direct costs and 1.67 trillion dollars for indirect costs. They further added that the projected cost is expected to increase more than double by the year 2030, with a total cost of 6.05 trillion US dollars (1.99 and 4.05 trillion US dollars for direct and indirect costs). Arias, Saxena and Verguet (2022) further concurred on the growing economic burden of mental health illnesses; however, they further estimated the total cost of mental health illnesses to be 4.74 trillion US dollars.

1.3 Non-communicable disease risk factors

Although NCDs may result from non-modifiable risk factors that include age, sex, race, and genetics (Choudhury et al., 2015; Borgnakke, 2016; Midha, Chawla and Garg, 2016), lifestyle factors play a significant role in their development. The major modifiable risk factors associated with NCDs are physical inactivity, unhealthy diet, tobacco use, the harmful use of alcohol (World Health Organization, 2022b), and, in addition, stress (Steptoe and Kivimäki, 2012). In addition, modifiable risk factors health burden are immense, as more than 8.5 million deaths worldwide are attributed to tobacco use which also includes second-hand smoking, 1.8 million deaths annually due to excessive sodium intake, about 830000 deaths annually linked to insufficient physical activity (Institute for Health Metrics and Evaluation, 2019), and more than 1.5 million deaths are attributable to NCDs diseases resulting from alcohol use, including conditions such as cancer (World Health Organization, 2022b).

1.3.1 Metabolic syndrome

Metabolic syndrome is known as a cluster of interconnected factors that directly increase the risk of cardiovascular disease, type 2 diabetes (Kassi et al., 2011), and certain types of cancer (Zhao et al., 2020). Metabolic syndrome factors are high blood pressure (BP), obesity and high waist circumference (WC), low high-density lipoprotein cholesterol levels, hypertriglyceridemia, and hyperglycaemia (Eckel, Grundy and Zimmet, 2005; Alberti et al., 2009).

Metabolic syndrome is associated with an increased risk of cardiovascular disease. A recent meta-analysis of observational studies on the association between metabolic syndrome and coronary artery disease revealed that when compared to individuals free from metabolic syndrome, metabolic syndrome was significantly associated with an increased risk of coronary artery disease (odds ratio of 4.03; 95% CI, 3.56-4.56), with a similar significance reported with the presence of five metabolic components (odds ratio of 3.92; 95% CI, 3.11-4.93), four metabolic components (odds ratio of 4.04; 95% CI, 2.83-5.78), three metabolic components (odds ratio of 4.09; 95% CI, 2.85-5.86), and even with two metabolic components (odds ratio of 3.93; 95% CI, 2.81-5.49), and in addition, any metabolic component was significantly correlated with an increased risk of coronary artery disease (odds ratio of 3.72; 95% CI, 3.22-4.40) (Alshammary et al., 2021). Metabolic syndrome was also linked to other cardiovascular diseases. According to Mottillo et al. (2010) meta-analysis of 87 studies, with 951083 included participants, metabolic syndrome was linked with an elevated risk of cardiovascular disease (relative risk of 2.35; 95% CI, 2.02-2.73), stroke (relative risk of 2.27; 95% CI, 1.80-2.85), myocardial infarction (relative risk of 1.99; 95% CI, 1.61-2.46), cardiovascular disease mortality (relative risk of 2.40; 95% CI, 1.87-3.08), and all-cause mortality (relative risk of 1.58; 95% CI, 1.39-1.78).

Metabolic syndrome is associated with the development of type 2 diabetes. A prospective study on the association of metabolic syndrome components and type 2 diabetes reported that type 2 diabetes risk increased with every increment of metabolic syndrome components, with an adjusted hazard ratio of 79 (95% CI, 50-127) for individuals with all five components compared to no metabolic syndrome, and every 1-cm and 1 mmol/L increase in WC and glucose level was associated with a 5% (95% CI, 4%–5%) and 32% (95% CI, 30%–34%) increase in the risk of type 2 diabetes, respectively (Marott et al., 2016). According to Ärnlöv et al. (2011) prospective study, an increased risk of diabetes was reported in obese individuals without metabolic syndrome (odds ratio of 11.72; 95% CI, 4.88-28.16; p-value = 0.001), obese individuals with metabolic syndrome (odds ratio of 10.06; 95% CI, 5.19-19.51; p-value = 0.001), overweight individuals without metabolic syndrome (odds ratio of 3.49; 95% CI, 2.26-5.42; p-value = 0.001), overweight individuals with metabolic syndrome (odds ratio of 7.77 95% CI, 4.44-13.62; p-value = 0.001).

1.3.2 Physical inactivity

Physical inactivity, defined as the failure to meet physical activity guidelines (Thivel et al., 2018), is a primary modifiable risk factor associated with NCDs; in particular, cardiovascular disease, type 2 diabetes, breast cancer, colon cancer, and in addition, other health issues such as overweight, obesity, and mental health (World Health

Organization, 2022c). Worldwide, physical inactivity is estimated to cause 6-10% of major NCDs, such as coronary heart disease, type 2 diabetes, breast cancer, and colon cancer, and in addition, accounts for 9% of premature mortality (Lee et al., 2012). A meta-analysis assessing the risk of physical inactivity from 19 prospective observational studies, with a total sample of 404840, reported that physical inactivity was associated consistently with a higher incidence of stroke (hazard ratio of 1.16; 95% CI, 1.05-1.27), coronary heart disease (hazard ratio of 1.24; 95% CI, 1.13-1.36), and diabetes (hazard ratio of 1.42; 95% CI, 1.25-1.61) (Kivimäki et al., 2019). In Lee et al. (2012) estimation study of the effects of physical inactivity on major NCDs worldwide, physical inactivity was associated with a higher incidence of coronary heart disease (relative risk of 1.16; 95% CI, 1.04-1.30), type 2 diabetes (relative risk of 1.20; 95% CI, 1.10-1.33), breast cancer (relative risk of 1.33; 95% CI, 1.26–1.42), colon cancer (relative risk of 1.32; 95% CI, 1.23-1.39), and all-cause mortality (relative risk of 1.28; 95% CI, 1.21-1.36).

Obesity development, which is a risk factor for developing cardiovascular disease (relative risk range of 1.07-2.87 for high BMI) (Dwivedi et al., 2020), type 2 diabetes (relative risks of 1.72; 95% CI, 1.65-1.81 for a 5 units increase in BMI, and a relative risk of 1.61; 95% CI, 1.52-1.70 for a 10 cm increase in WC) (Jayedi et al., 2022), and an established risk for 13 different cancer sites (Friedenreich, Ryder-Burbidge and McNeil, 2021), was strongly associated with physical inactivity. A systematic review and meta-analysis of 23 studies with a total of 638000 participants revealed that physical inactivity was significantly associated with obesity development (odds ratio of 1.52; 95% CI, 1.23-1.87) (Silveira et al., 2022).

Raising physical activity, known as any movement of the body that results in an increase in energy expenditure above a baseline metabolic rate due to the contraction of skeletal muscle and is characterised by its duration, intensity, frequency, modality, and context of practice (Caspersen, Powell and Christenson, 1985), to the recommended level of 150 minutes of moderate-intensity is protective against cardiovascular disease and diabetes. This was reported in a meta-analysis quantifying the association between cardiovascular disease and diabetes and physical activity from 36 studies with 3439874 participants, as it was associated with a lower risk of cardiovascular disease mortality by 23% (relative risk of 0.77; 95% CI, 0.71–0.84), cardiovascular disease incidence by 17% (relative risk of 0.83; 95% CI, 0.77–0.89), and type 2 diabetes incidence by 26%, (relative risk of 0.74; 95% CI,0.72–0.77) (Wahid et al., 2016). Similarly for cancer, meeting the recommended physical activity was associated with a protective effect for breast cancer (relative risk of 0.967; 95% uncertainty interval, 0.937-0.998) and colon cancer (relative risk of 0.903; 95% uncertainty interval, 0.851-0.952), and having a physical activity level of higher than 7999 MET.minutes/week was associated with a protective effect for breast cancer (relative risk of 0.863; 95% uncertainty interval, 0.829-0.900) and colon cancer (relative risk of 0.789; 95% uncertainty interval, 0.735-0.850) as per Kyu et al. (2016) systematic review and meta-analysis. This was further concurred for both cardiovascular disease and cancer by Garcia et al. (2023) meta-analysis from 196 included articles, as they reported that meeting the physical activity guidelines was associated with a lower risk of total cardiovascular disease incidence (relative risk of 0.73; 95% CI, 0.69-0.79), cardiovascular disease mortality (relative risk of 0.71; 95% CI, 0.66-0.77), total cancer incidence (relative risk of 0.88; 95% CI, 0.85-0.92), cancer mortality (relative risk of 0.85; 95% CI, 0.81-0.89), and all-cause mortality (relative risk of 0.69; 95% CI, 0.65-0.73).

1.3.3 Sedentary behaviour

Sedentary behaviours are one of the major contributors to NCDs. Sedentary behaviour known as any waking behaviours in a sitting, reclining or lying posture characterised by an energy expenditure ≤1.5 MET (Tremblay et al., 2017); this includes activities such as watching television for an extended period of time, playing video games, sitting on a computer, driving for a long time. A systematic review and meta-analysis investigating the relationship between cardiovascular disease events and sedentary behaviours with a total of 720425 participants (42.9% males and 57.1% females) from 9 prospective cohort studies and with a median follow-up of 11 years reported that participants classified in the higher sedentary time category (median 12.5 hours/day) had an increased risk of cardiovascular disease (hazard ratio of 1.14; 95% CI, 1.09-1.19) compared to the lowest sedentary time category (median 2.5 hours/day) (Pandey et al., 2016). This association was further asserted by Jingjie et al. (2022) in their systematic review and meta-analysis of 17 prospective cohort studies and 2 cross-sectional studies that included 1451730 participants. In this meta-analysis, an increased risk of cardiovascular disease morbidity (pooled relative risk, 1.24; 95% CI, 1.21-1.27) was found in participants with the highest sedentary time category (median, 10.5 hours/day) compared to the lowest sedentary time category (median, 2.75 hours/day), and similarly, an increased risk of cardiovascular disease mortality (pooled hazard ratio, 1.29; 95% CI, 1.13-1.47) in participants classified in the highest sedentary time category compared to the lowest sedentary time category.

Sedentary behaviours are, in addition, linked to cancer development. Although the link is inconsistent, Lynch, Mahmood and Boyle (2018) reported in their review that sedentary behaviours were linked to elevated risks of ovarian cancer by 32%, endometrial cancer by 36%, as well as an increase in the risk of colorectal cancer mortality by 61% for post-diagnosis sitting time and 38% for pre-diagnosis sitting time, and of all-cancer mortality by 13%; whereas, they reported inconsistent evidence of breast cancer, colorectal cancer, and lung cancer. However, in Hermelink et al. (2022) umbrella review and meta-analysis regarding the association of sedentary behaviours and cancer from 14 included meta-analyses reported that high levels of sedentary behaviours were associated with an increased risk of ovarian cancer (relative risks of 1.29; 95% CI, 1.08–1.56), endometrial cancer (relative risks of 1.29; 95% CI, 1.16–1.45), colon cancer (relative risks of 1.25; 95% CI, 1.16–1.33), breast cancer (relative risks of 1.08; 95% CI, 1.04–1.11), prostate cancer (relative risks of 1.08; 95% CI, 1.00–1.17), rectal cancers (relative risks of 1.07; 95% CI, 1.01–1.12), and cancer mortality (relative risks of 1.18; 95% CI, 1.09–1.26).

Sedentary behaviours are also linked to the development of diabetes. Watching television is significantly associated with type 2 diabetes, and long periods of sitting time, either at work or home, are significantly associated with the development of diabetes (Hu et al., 2003). A meta-analysis assessing the association between sedentary behaviours and diabetes, cardiovascular disease and death from 16 prospective and two cross-sectional studies, with 794577 participants, reported a significant predictive effect for diabetes, with a 112% increase in relative risk of diabetes (2.12; 95% credible interval, 1.61, 2.78) from the highest sedentary time compared to the lowest (Wilmot et al., 2012). In Guo et al. (2020) meta-analysis of

23 studies assessing the association of sedentary behaviours and type 2 diabetes reported a pooled relative risk of 1.35 (95% CI, 1.23-1.47) when comparing the longest and shortest total sedentary behaviours and similarly, a pooled relative risk of 1.46 (95% CI 1.26-1.69) when comparing the longest TV viewing times with the shortest. They further added that the risk of type 2 diabetes was increased by 5% with every 1-hour increase per day in total sedentary time (relative risk of 1.05; 95% CI, 1.04-1.07), and with a pooled relative risk for every 1-hour increase per day in TV viewing of 1.08 (95% CI 1.06-1.10).

1.3.4 Diet

Diet is a vital modifiable risk factor for NCDs, in particular, cardiovascular disease, certain types of cancer, and diabetes (Kraemer et al., 2016). Diet plays a significant role in the development of metabolic syndrome, a cluster of disorders that includes dyslipidaemia, hypertension, abdominal obesity, and disrupted glucose or insulin metabolism (Alberti, Zimmet and Shaw, 2005). Metabolic syndrome presence also elevates the risk of developing cardiovascular disease, cancer, diabetes, and chronic respiratory disease (Grundy et al., 2005; Agyei-Mensah and de-Graft Aikins, 2010).

Across all ages, there is a decrease in fruit and vegetable consumption (Kelishadi, 2019). A sufficient intake of fruits and vegetables is associated with a reduced risk of many NCDs (Pem and Jeewon, 2015). A systematic review and meta-analysis on the association of fruit and vegetable consumption and the risk of cardiovascular disease, cancer and all-cause mortality reported a reduced risk per 200 grams/day of combined fruit and vegetable consumption in coronary heart disease (relative risk of 0.92; 95% CI, 0.90-0.94), stroke (relative risk of 0.84; 95% CI, 0.76-0.92), cardiovascular disease (relative risk of 0.92; 95% CI, 0.90–0.95), total cancer (relative risk of 0.97; 95% CI, 0.95-0.99), and all-cause mortality (relative risk of 0.90; 95% CI, 0.87-0.93), and with reduction observed up to 600 grams/day (Aune et al., 2017).

In contrast to fruit and vegetables, a higher intake of meat, processed meat, and poultry is linked to a number of NCDs (Abete et al., 2014; Micha et al., 2017). According to Zhong et al. (2020) study analysing data of participants from 6 prospective studies, 2 servings of processed meat per week (1 serving = 113.4g) compared to 0 servings was significantly associated with cardiovascular disease (hazard ratio of 1.07; 95% CI,1.04-1.11) and all-cause mortality (hazard ratio of 1.03; 95% CI, 1.02-1.05), and similarly, the incidence of cardiovascular disease and all-cause mortality was significantly associated with each additional 2 servings (226.8g) per week of unprocessed red meat (hazard ratio of 1.03; 95% CI, 1.01-1.06, and hazard ratio of 1.03; 95% CI,1.01-1.05, respectively), whereas, poultry was only significantly associated with cardiovascular disease incidence for each additional 2 servings per week (hazard ratio of 1.04; 95% CI, 1.01-1.06).

Similar to cardiovascular disease, total meat consumption is associated with cancer incidence. According to Farvid et al. (2021) recent meta-analysis of 148 articles, higher red meat consumption was significantly linked with an elevated risk of breast cancer (relative risk of 1.09; 95% CI, 1.03-1.15), lung cancer (relative risk of 1.26; 95% CI, 1.09-1.44), colon cancer (relative risk of 1.17; 95% CI, 1.09-1.25), colorectal cancer (relative risk of 1.10; 95% CI, 1.03-1.17), rectal cancer (relative risk of 1.22; 95% CI, 1.01-1.46), endometrial cancer (relative risk of 1.25; 95% CI, 1.01-1.56), and hepatocellular carcinoma (relative risk of 1.22; 95% CI, 1.01-1.46), and every 100g per day was associated with a higher risk of 11% for breast cancer, 29% for lung cancer, 17% for colon cancer, 14% for colorectal cancer, and 26% for rectal cancer. They further added that higher processed meat consumption was significantly linked with an elevated risk of breast cancer (relative risk of 1.06; 95% CI, 1.01-1.12), lung cancer (relative risk of 1.12; 95% CI, 1.05-1.20), colon cancer (relative risk of 1.21; 95% CI, 1.13-1.29), colorectal cancer (relative risk of 1.18; 95% CI, 1.13-1.24), and rectal cancer (relative risk of 1.22; 95% CI, 1.09-1.36), and every 50g per day was associated with a higher risk of 17% for colon cancer, 16% for colorectal cancer, 25% for rectal cancer, and 8% renal cell cancer.

Type 2 diabetes and meat consumption are positively associated, according to previous meta-analyses of observational studies (Pan et al., 2011; Schwingshackl et al., 2017). This was further solidified by Yang et al. (2020) in a more recent meta-analysis of 28 studies that when comparing the highest and lowest meat consumption categories, the summary relative risk of type 2 diabetes for total meat consumption was 1.33 (95% CI, 1.16-1.52), for red meat consumption 1.22 (95% CI, 1.16-1.28), for processed meat consumption 1.25 (95% CI, 1.13-1.37), and for poultry consumption 1.00 (95% CI, 0.93-1.07), and concluded that the risk of type 2 diabetes increased by 36% (95% CI, 1.23-1.49), 31% (95% CI, 1.19-1.45), and 46% (95% CI, 1.26-1.69) with every additional 100g per day of total meat and red meat consumption and 50g per day of processed meat consumption.

Fat intake and its association with the development of NCDs have been the subject of debate within the literature; nonetheless, according to Bray et al. (2002), the type of fat consumed may be the determinant factor of disease development. Zhu, Bo and Liu (2019) revealed in their meta-analysis on the association between dietary fat intake and cardiovascular disease that when comparing the highest and lowest categories of fat or fatty acids consumption, there was no significant association between saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, total fat, and the risk of cardiovascular disease, whereas, higher intake of trans fatty acids was associated with an increased risk of cardiovascular disease (relative risk of 1.14; 95% CI, 1.08–1.21), and every 2% energy/day intake of trans fatty acids was associated with a 16% increase in the risk of cardiovascular disease. In contrast, inconclusive evidence regarding the association between fat intake and the risk of cancer (Shen and Yao, 2015; Cao, Hou and Wang, 2016; Zhao et al., 2016; Ruan, Cheng and Zhu, 2020; Liu et al., 2021) or type 2 diabetes (de Souza et al., 2015; Neuenschwander et al., 2020). Nonetheless, Guasch-Ferré et al. (2017), in their prospective cohort study on the association between dietary fat intake and risk of type 2 diabetes, reported that participants in the highest saturated and animal fat category intake had a higher risk of type 2 diabetes (hazard ratio of 2.19; 95% CI, 1.28-3.73) compared the lowest, with about 2 times greater risk in developing type 2 diabetes.

Ready-to-eat ultra-processed foods are becoming more dominant, mainly in high-income countries (Popkin, 2006). Ultra-processed foods are defined as a formulation of multisource ingredients driven from additives and foods mixed with substances such as colouring, sweeteners, flavouring, and emulsifiers (Ares et al., 2016). According to the evidence, ultra-processed foods are linked with the incidence of NCDs (Lane et al., 2021). In the Framingham offspring study on the association between ultra-processed foods and cardiovascular disease, an increase in the risk of cardiovascular disease, coronary heart disease, overall cardiovascular disease, and cardiovascular disease mortality, respectively, was observed, and in addition, a 5% increased risk of overall cardiovascular disease (95% CI, 1.02-1.08), and a 9% increased risk of cardiovascular-related mortality (95% CI, 1.02-1.16) was associated with every additional daily serving of ultra-processed foods (Juul et al., 2021). A similar association was also reported with cancer. Chang et al. (2023) revealed in their UK biobank study on the association between ultra-processed foods and cancer that every 10% increase in ultra-processed foods consumption was associated with an increased incidence of overall cancer (hazard ratio of 1.02; 95% CI, 1.01-1.04) and ovarian cancer (hazard ratio of 1.19; 95% CI, 1.08-1.30), and in addition, an increased risk of overall cancer (hazard ratio of 1.06; 95% CI, 1.03-1.09), ovarian cancer (hazard ratio of 1.30; 95% CI, 1.13-1.50), and breast cancer (hazard ratio of 1.16; 95% CI, 1.02-1.32) related mortalities. As for diabetes, a systematic review and meta-analysis on the association of ultra-processed foods and the risk of diabetes revealed that an increased risk of type 2 diabetes was significantly associated with higher ultra-processed foods consumption (relative risk of 1.74; 95% CI, 1.36-2.22), with a 15% higher risk of type 2 diabetes (relative risk of 1.15; 95% CI, 1.06-1.26) was reported with every 10% increase in ultra-processed foods consumption (Moradi et al., 2021).

1.3.5 Alcohol consumption

The overconsumption of alcohol is a contributing factor to many diseases and a range of mental and behavioural disorders, with 5.3% of deaths worldwide attributed to the harmful use of alcohol, and 5.1% of the global burden of disease was in addition attributed to alcohol (World Health Organization, 2022a). Overconsumption of alcohol is one of the major avoidable risk factors associated with NCDs, including different cancers and cardiovascular diseases (Awuah, Afrifa-Anane and Agyemang, 2016).

Two terms are used to describe the overconsumption of alcohol: hazardous drinking and harmful drinking (Barclay et al., 2008). Hazardous 'at risk' drinking is a term used for describing alcohol drinking that may increase the risk of developing alcohol-related adverse effects and is quoted by a weekly consumption of 22 to 50 units for males and 15 to 35 units for females (Barclay et al., 2008). Harmful 'problem' drinking is a term used when there is clear evidence that alcohol consumption is responsible or largely contributes to psychological or physical harm, which includes dysfunctional behaviour or impaired judgement that may cause disability or adverse interpersonal relationship consequences (World Health Organization, 1992). A weekly consumption of over 50 units of alcohol for males and 35 units for females is considered a harmful use of alcohol (Farrell, 2001). The recommended weekly limit of alcohol intake, according to the NHS, is no more than 14 units, equivalent to 10 small glasses of low-strength wine or 6 pints of average-strength beer. The weekly limit is considered low-risk drinking, as there is no safe drinking threshold (NHS, 2022).

Low to moderate alcohol intake has been associated with a protective effect against a number of cardiovascular diseases, whereas high consumption is associated with an increased risk. A meta-analysis of 23 studies that included 29457 participants revealed that an immediately higher risk of cardiovascular risk was associated with moderate alcohol consumption which was attenuated after 24 hours of consumption and was protective against haemorrhagic stroke and myocardial infarction (relative risk of 30% lower risk; ≈2-4 drinks/day) and after 1 week for ischemic stroke (relative risk of 19% lower risk; ≈6 drinks/week), whereas a higher cardiovascular risk the following day and week was associated with heavy alcohol consumption (relative risk of 1.3-2.3; ≈6-9 drinks/day, and relative risk of 2.25-6.2; ≈19-30 drinks/week, respectively) (Mostofsky et al., 2016). In association with stroke types, Larsson et al. (2016) revealed in their meta-analysis of 27 prospective studies that a lower risk of ischemic stroke was associated with light (relative risk of 0.90; 95% CI, 0.85-0.95, for less than 1 drink/day) and moderate (relative risk of 0.92; 95% CI, 0.87-0.97, for 1-2 drinks/day) alcohol consumption, whereas an increased risk was associated with high (relative risk of 1.08; 95% CI, 1.01-1.15, for more than 2-4 drinks/day) and heavy drinking (relative risk of 1.14; 95% CI, 1.02-1.28, for more than 4 drinks/day).

The association between alcohol intake and the risk of cancer has been established within the literature (Zhong et al., 2022). According to Rumgay et al. (2021), worldwide in 2020, an estimated 4.1% (95% uncertainty interval, 3.1-5.3), or 741300 (95% uncertainty interval, 558500-951200) of all new cancer cases were attributed to alcohol intake. A meta-analysis of 572 studies, with a total of 486538 cancer cases, reported an increased risk of oral and pharyngeal cancer (relative risk of 5.13; 95% CI, 4.31-6.10), oesophageal squamous cell carcinoma (relative risk of 4.95; 95% CI, 3.86-6.34), colorectal cancer (relative risk of 1.44; 95% CI, 1.25-1.65), laryngeal cancer (relative risk of 2.65; 95% CI, 2.19-3.19), and breast cancer (relative risk of 1.61; 95% CI, 1.33-1.94) when comparing heavy drinkers to non-drinkers and occasional drinkers, and in addition, heavy drinkers had a significantly higher risk of liver cancer (relative risk of 2.07; 95% CI, 1.66-2.58), stomach cancer (relative risk of 1.21; 95% CI, 1.07-1.36), pancreas cancer (relative risk of 1.19; 95% CI, 1.11-1.28), gallbladder cancer (relative risk of 2.64; 95% CI, 1.62-4.30), and lung cancer (relative risk of 1.15; 95% CI, 1.02-1.30) (Bagnardi et al., 2015). Furthermore, light drinking is in addition linked to an increased risk of cancer. According to a meta-analysis by Bagnardi et al. (2013), Light drinking (up to 1 drink/day) was associated with the risk of breast cancer (relative risk of 1.05; 95% CI, 1.02-1.08), oropharyngeal cancer (relative risk of 1.17; 95% CI, 1.06-1.29), and oesophageal squamous cell carcinoma (relative risk of 1.30; 95% CI, 1.09-1.56).

1.3.6 Smoking tobacco

More than 200 million deaths over the past 30 years have been attributed to tobacco smoking (Murray et al., 2020), with an annual economic cost exceeding 1 trillion US dollars (Goodchild, Nargis and Tursan d'Espaignet, 2018). In 2019, worldwide, 7.69 million deaths (95% uncertainty interval, 7.16-8.20) and 200 million disability-adjusted life-years were attributed to tobacco smoking, and in addition, was the main risk for mortality among males (20.2%; 95% uncertainty interval, 19.3-21.1) (Reitsma et al., 2021). Tobacco is one of the major modifiable risk factors linked to NCDs development (Kelishadi, 2019).

Smoking tobacco has been extensively linked to the development of cardiovascular disease. According to Banks et al. (2019) large prospective study addressing the association between smoking and 36 cardiovascular disease subtypes in 188167 cardiovascular disease-free and cancer-free participants, current smokers had a significant incidence increase rate for 29 of them, with an adjusted hazard ratio compared to non-smokers of 1.63 (95% CI, 1.56-1.71) for any major cardiovascular disease, 2.75 (95% CI, 2.37-3.19) for total cardiovascular disease mortality, 2.23 (95% CI, 1.96-2.53) for heart failure, 2.16 (95% CI, 1.93-2.42) for cerebrovascular disease, 2.26 (95% CI, 1.65-3.10) for cerebrovascular disease mortality, 2.45 (95% CI, 2.22-2.70) for acute myocardial infarction, 2.79 (95% CI, 2.04-3.80) for acute myocardial mortality, 5.06 (95% CI, 4.47-5.74) for peripheral arterial disease, 1.50 (95% CI, 1.24-1.80) for paroxysmal tachycardia, 1.31 (95% CI, 1.20-1.44) for atrial fibrillation/flutter, 1.41 (95% CI, 1.17-1.70) for pulmonary embolism. Furthermore, A meta-analysis on the impact of smoking and smoking cessation on cardiovascular events and mortality for older adults revealed that the summary hazard ratio cardiovascular mortality for current smokers was 2.07 (95% CI, 1.82-2.36) and 1.37 (95% CI, 1.25-1.49) for previous smokers compared to non-smokers, and the estimated advancement period for mortality was 5.50 years (95% CI, 4.25-6.75) for current smokers and 2.16 years (95% CI, 1.38-2.39) for previous smokers (Mons et al., 2015).

A direct association between smoking tobacco and type 2 diabetes cannot be established with certainty due to other factors, such as physical activity levels, diet, stress, and body fat (Campagna et al., 2019). Nonetheless, a systematic review and meta-analysis of 88 prospective studies including around 6 million participants revealed that the pooled relative risk of type 2 diabetes compared with non-smokers was 1.37 (95% CI, 1.33-1.42) for current smokers and 1.14 (95% CI, 1.10-1.18) for past smokers, with a dose-response relative risk for light smokers 1.21 (95% CI, 1.10-1.33; <10 cigarettes/day), moderate smokers 1.34 (95% CI, 1.27-1.41; 10-19 cigarettes/day), and 1.57 (95% CI, 1.47-1.66; ≥20 cigarettes/day) for heavy smokers, and estimated that 10.3% of men and 2.2% of women diagnosed with type 2 diabetes were attributed to cigarette smoking (Pan et al., 2015). A later systematic review and meta-analysis concurred on these findings, where they reported a pooled relative risk of type 2 diabetes compared with non-smokers of 1.38 (95% CI, 1.28-1.49) for current smokers and 1.19 (95% CI, 1.09-1.31) for past smokers, with a 16% increase in the risk of type 2 diabetes for every increment of 10 smoked cigarettes per day, and concluded that an estimated 18.8% of men and 5.4% of women diagnosed with type 2 diabetes were attributed to cigarette smoking (Akter, Goto and Mizoue, 2017).

Similar to cardiovascular disease, cancer incidence is heavily linked to tobacco smoking. A systematic review and meta-analysis on the association of smoking with lung cancer reported that the pooled multiple-adjusted lung cancer relative risk was 7.33 (95% CI, 4.90-10.96) in men and 6.99 (95% CI, 5.09-9.59) in women, and with an increased relative risk for both sexes according to the number of cigarettes smoked to a maximum of 14.61 (95% CI, 8.33-25.59) for men and 17.09 (95% CI, 12.11-24.11) for women for 20 or more cigarettes per day (O'Keeffe et al., 2018). Smoking was, in addition, linked to other cancer sites as per Gandini et al. (2008) meta-analysis, where they reported that current smokers had a relative risk of 6.98 (95% CI, 3.14-15.52) for laryngeal cancer, 6.76 (95% CI, 2.86-15.98) for pharyngeal cancer, 3.57 (95% CI, 2.63-4.84) for upper digestive tract cancer, (3.43; 95% CI, 2.37-4.94) for oral cancer, and 2.50 (95% CI, 2.00, 3.13) for oesophagus cancer.

1.3.7 Psychological stress

Psychological stress occurs when demands and tasks exceed an individual's adaptive capacity or psychological resources (Steptoe and Kivimäki, 2012). Measuring psychological stress response is vital as it may impact physical health; therefore, different measurement methods have been developed, such as self-reported measures, psychological measures, or behavioural measures (Crosswell and Lockwood, 2020). An example of these tools is the Perceived Stress Scale, a self-reported measure constructed to capture the degree to which a situation in an individual's life is regarded as stressful (Reis, Hino and Añez, 2010).

Stress has been recognised as a potentially modifiable risk factor for cardiovascular disease. A number of studies have linked stress with the development of cardiovascular disease, primarily long-term stress, as it is likely to cause harmful reactions in affected people, which includes stress due to personal life factors, such as financial difficulties and marital and family problems, and work-associated factors, such as work demands (Steptoe and Kivimäki, 2012). A meta-analysis on the association of stress with cardiovascular disease revealed an increased risk of coronary heart disease among adults experiencing social isolation by 1.5-fold (95% CI, 1.2-1.9) and by 1.3-fold (95% CI, 1.2-1.5) for workplace stress, and with a pooled relative risk of 2.5 (95% CI, 1.8-3.5) for acute coronary syndrome onset following stress (Steptoe and Kivimäki, 2013). A similar association was reported in a large prospective cohort study that included 118706, where they reported that when compared to individuals with no stress, individuals with low stress and high stress had an increased risk of coronary heart disease (hazard ratio of 1.09; 95% CI, 1.01-1.18, and a hazard ratio of 1.24; 95% CI, 1.08-1.42), and death (hazard ratio of 1.09;

95% CI, 1.03-1.16, and a hazard ratio of 1.17; 95% CI, 1.06-1.29), and in addition, high stress was associated with stroke (hazard ratio of 1.30; 95%CI, 1.09-1.56) and cardiovascular disease (hazard ratio of 1.22; 95% CI, 1.08-1.37) (Santosa et al., 2021).

1.3.8 Work-related risk factors

Individuals spend a substantial portion of their time at work, which can significantly impact their health (Shin et al., 2021). The influence of working conditions on health varies depending on the type of occupation. This PhD project investigates two distinct occupational categories: white-collar and blue-collar jobs. According to the Cambridge Dictionary, white-collar workers are typically employed in office settings, performing tasks that primarily require cognitive effort, whereas blue-collar workers engage in occupations necessitating physical strength or manual skills. These occupational categories are associated with different job characteristics and consequently expose individuals to varying working conditions and environments. Such exposures and conditions may contribute to the development of non-communicable diseases (NCDs), serving as risk factors irrespective of the type of work involved.

White-collar jobs generally involve more desk hours compared to other occupations. Studies have consistently shown that these positions often require long periods of sedentary activity, primarily due to the nature of the work being desk-bound (Chu et al., 2016; Waters et al., 2016; Sarkar and Thomas, 2016; Prince et al., 2019). Biernat and Piątkowska’s (2023) study addressing sedentary behaviour as a lifestyle risk factor in white and blue-collar jobs from 2127 individuals revealed a significant disparity between the two job categories. On average, the total sitting time was 1958.5 minutes per week, with white-collar workers sitting significantly more, averaging 2130.3 minutes per week, compared to 1824.2 minutes per week for blue-collar workers, and during weekdays, white-collar workers sat for an average of 241.1 minutes per day, whereas blue-collar workers sat for 206.5 minutes per day. Additionally, 20.2% of white-collar workers reported sitting for more than 7.5 hours daily, a stark contrast to the 9% observed among blue-collar workers, with a notable difference observed in the time spent sitting in vehicles, where white-collar workers sat for an average of 482.4 minutes per week, markedly higher than the 326.8 minutes per week reported by blue-collar workers. This data suggests that occupational factors significantly influence sedentary time, which is strongly associated NCDs development.

In a similar way, white-collar and blue-collar jobs show distinct differences in terms of physical workload and occupational physical activity. Blue-collar jobs typically involve higher physical demands, resulting in greater occupational physical activity compared to white-collar jobs. This was noted by Väisänen et al. (2020) Study assessing lifestyle-associated health risks across different occupations with a total of 72855 workers as they revealed that blue-collar workers experience significantly higher physical workload demands, with odds ratios (OR) for physically demanding work reaching up to 45.74, compared to up to 1.32 for white-collar workers. This was concurred by Trzmiel et al. (2021) cross-sectional study, where they evaluated lifetime work-related and non-work physical activity in white-collar and blue-collar retires that included 200 participants aged 60 and above and noted that blue-collar retirees had higher mean total MET/week/year values (140.48 ± 55.13) compared to white-collar retirees (100.75 ± 35.98), with significant differences in work-related MET/week/year (blue-collar: 96.54 ± 53.11 and white-collar: 52.57 ± 34.98). Similarly, Clays et al. (2020) cross-sectional study assessing occupational physical activity using accelerometers in 198 individuals from various blue-collar jobs revealed that The average working time measured was 8.6 hours per day, with 5.6 hours spent on feet and 1.5 hours in moderate to vigorous physical activity, more specifically, construction workers spend 53.7% of their working day on their feet, with 14.1% spent in moderate to vigorous physical activity.

Although physical activity is widely recognised for its protective effects against NCDs, particularly cardiovascular diseases, several studies challenge this assertion, mainly in the context of occupational physical activity among untrained and unhealthy individuals. A cross-sectional study examining the relationship between occupational physical activity and cardiovascular disease prevalence among 16974 employed adults revealed that individuals who reported "always" performing total occupational activity had nearly double the odds of having cardiovascular disease compared to those who "never" performed such activities (OR 1.99; 95% CI 1.12 to 3.53) (Quinn et al., 2021). Specifically, occupational exertion and occupational standing and walking were significantly associated with higher odds of cardiovascular disease (OR 2.15; 95% CI 1.45 to 3.19, and OR 1.84; 95% CI 1.07 to 3.17, respectively), with similar odds between men who "always" performed total occupational activity (OR 2.47; 95% CI 1.04 to 5.91) and women who "always" performed occupational exertion (OR 2.32; 95% CI 1.37 to 3.93). The study did not find any significant association between leisure-time physical activity and cardiovascular disease prevalence overall; however, participants who performed less than 150 minutes per week of leisure-time physical activity had significantly higher odds of cardiovascular disease when “always” performing total occupational activity (OR 10.87; 95% CI 2.87 to 41.15), occupational exertion (OR 4.78; 95% CI 1.86 to 12.27), and occupational standing and walking (OR 5.21; 95% CI 1.52 to 17.79). Interestingly, Quinn et al. (2021) noted that even in a restricted sample of never-smokers, the odds for cardiovascular disease were notably higher for those “always” performing total occupational activity (OR 3.00; 95% CI 1.38 to 6.51) and occupational exertion (OR 3.00; 95% CI 1.80 to 5.02).

This elevated cardiovascular disease risk may be attributed to socioeconomic status, as high occupational physical activity jobs are frequently associated with lower socioeconomic status, which is correlated with higher rates of smoking, poor diet, and inadequate healthcare access (Popham and Mitchell, 2007; Nocon, Keil and Willich, 2007). These unhealthy lifestyle factors (as mentioned previously) significantly contribute to the increased risk of cardiovascular diseases. Additionally, untrained and unhealthy individuals - those with underlying metabolic syndrome - face a heightened risk of adverse cardiovascular events during physical exertion (Hansen et al., 2018). Vigorous activity, which increases the heart rate to 70-85% of its maximum, can lead to a substantial rise in myocardial oxygen demand, which, if unmet due to compromised cardiovascular health, can result in ischemia or infarction, and thus, the risk of acute myocardial infarction during strenuous activity can be 3 to 6 times higher in untrained individuals and significantly more in those with cardiovascular risk factors (Mittleman et al., 1993). Generally, strenuous physical activity elevates cardiovascular responses and, thus, may heighten the risk of cardiovascular diseases during these activity types in untrained individuals, and this risk is significantly higher in those with cardiovascular risk factors (Huang et al., 2013).

Higher smoking prevalence within blue-collar jobs compared to white-collar jobs has been well documented in the literature. A cross-sectional study by de Castro et al. (2010) that included 1528 participants examined smoking prevalence, with a particular focus on occupational classification, revealed that smoking prevalence overall was significantly higher among blue-collar workers (32%) compared to white-collar workers (10%) and even when comparing males and females from the two job categories, as male blue-collar workers had a smoking prevalence of 45%, while female blue-collar workers had a prevalence of 18.2%, whereas, male and female white-collar workers had smoking prevalences of 13.7% and 4.8%, respectively. Higher percentages were also noted by Landstedt and San Sebastian (2018) cross-sectional study aimed to describe the prevalence of daily smoking within the adult Swedish population, specifically examining the intersection of gender and occupational class from 61316 individuals and revealed that the overall prevalence of daily smoking was found to be 10.21%, with rates differing significantly among the categories; 6.70% in white-collar men, 7.79% in white-collar women, 13.75% in blue-collar men, and 16.63% in blue-collar women, with an absolute joint disparity of 9.96 percentage points, primarily driven by occupational class. They further added that the odds ratio of being a current smoker was higher among blue-collar jobs compared to white-collar jobs. This was noted by both de Castro et al. (2010) and Väisänen et al. (2020) previously mentioned studies indicating that blue-collar workers had significantly higher odds (OR = 2.52 and 5.12, respectively) of being current smokers compared to white-collar workers.

The higher prevalence of smoking among blue-collar workers compared to white-collar workers may be influenced by a variety of occupational, social, and economic factors. Economic and educational disparities are more pronounced in lower socioeconomic statuses, which are prevalent among blue-collar workers, thus often resulting in reduced access to smoking cessation resources and health education, exacerbating smoking rates in this demographic (Lee et al., 2007). Additionally, blue-collar workers frequently experience higher levels of job stress and demands, leading them to adopt smoking as a coping mechanism (Cunradi, Lipton and Banerjee, 2007). The elevated smoking prevalence among blue-collar workers poses a significant health threat, underscoring the urgent need for targeted interventions and reforms to address this issue comprehensively.

Despite the above, some risk factors are universal across the two job categories, such as long working hours (Shin et al., 2021) and job stress (Aginsky et al., 2017). Long working hours are an occupational risk factor, and thus, different guidelines have emerged to limit this exposure, such as The Working Time Regulations 1998 initiated by the UK Government (1998). Nonetheless, long working hours remain a prevalent organisational risk factor according to Pega et al. (2021) systematic analysis that involved data from 2324 cross-sectional surveys and 1742 quarterly survey datasets (covering 467 million observations) where they noted that 8.9% (95% uncertainty range 8.6 - 9.1) of the population worldwide, or 488 million people (95% uncertainty range 472 - 503 million) were exposed to working long hours (>54 hours/week). Long working hours are considered risk factors due to their health implication, as they are linked to the development of cardiovascular disease. A systematic review and meta-analysis by Kivimäki et al. (2015) aimed to assess the association between long working hours and the risk of coronary heart disease and stroke from 25 studies across 24 cohorts (Europe, the USA, and Australia), encompassing a total of 603838 individuals free from coronary heart disease and 528908 individuals free from stroke at baseline. Results indicated that compared to standard working hours (35 to 40 hours/week), working long hours (≥55 hours per week) was associated with a modest increase in the risk of coronary heart disease, with a relative risk of 1.13 (95% CI 1.02-1.26; p=0.02) and a more substantial increase in the risk of stroke with a relative risk of 1.33 (95% CI 1.11-1.61; p=0.002). A dose-response relationship was, in addition, observed for stroke, with a relative risk of 1.10 (95% CI 0.94-1.28; p=0.24) for 41-48 working hours, 1.27 (95% CI 1.03-1.56; p=0.03) for 49-54 working hours, and 1.33 (95% CI 1.11-1.61; p=0.002) for ≥55 working hours per week compared to standard working hours.

Job stress is another organisational risk factor linked to cardiovascular disease development. Workers in highly demanding jobs that they cannot control are considered to be in a job strain situation, and if this continues, it may elevate the risk of stress-related diseases, including cardiovascular diseases (Steptoe and Kivimäki, 2012). Other workplace stress sources include an imbalance between effort and reward in terms of respect and income (Siegrist, 1996), and unfair treatment due to organisational injustice (Kivimäki et al., 2005). A meta-analysis examining the relationship between job strain and coronary heart disease incorporated data from 13 European cohort studies (Finland, Sweden, Denmark, the Netherlands, Belgium, France, and the UK), including both published and unpublished research, and involved 197473 participants who were employed and free of coronary heart disease at baseline (Kivimäki et al., 2012). The findings indicated that compared to no job strain, job strain was associated with a modest but statistically significant increased risk of coronary heart disease, with an age- and sex-adjusted hazard ratio of 1.23 (95% CI 1.10-1.37). Furthermore, analyses that excluded coronary heart disease events occurring within the first 3 and 5 years of follow-up to minimise reverse causation showed a slightly higher hazard ratio of 1.31 (95% CI 1.15-1.48) and 1.30 (95% CI 1.13-1.50), respectively. The population-attributable risk for job strain was calculated to be 3.4%, indicating that the proportion of coronary heart disease cases could be attributed to job strain if the association were causal. Another meta-analysis on the association of job strain with stroke in 190000 working males and females reported the adjusted hazard ratio for job strain compared to no job strain was 1.09 (95% CI 0.94-1.26) for overall stroke, 1.01 (95% CI 0.75-1.36) for haemorrhagic stroke, and 1.24 (95% CI 1.05-1.47) for ischemic stroke, with around a 20% increase in the risk of acute ischemic stroke (Fransson et al., 2015). Other sources of workplace stress were measured in a prior meta-analysis of 14 studies with a total of 83014 and revealed an increase in the risk of coronary heart disease for high versus a low job strain (relative risk of 1.43; 95% CI 1.15-1.84), high efforts and low rewards (relative risk of 1.58; 95% CI 0.84–2.97), and for organisational injustice (relative risk of 1.62; 95% CI 1.24-2.13) (Kivimäki et al., 2006).

Risk factors in the workplace may differ by job categories due to variations in the work environment and with similarities due to organisational demands. Given this context, research on multi-behavioural factors in both job categories remains limited, particularly for blue-collar workers. There is a notable lack of studies examining specific job types within the blue-collar workforce, with construction workers being especially underrepresented in the literature despite comprising a significant portion of the UK workforce, as employment in the construction sector rose to 2.2 million in 2022 (Statista, 2022). The variation in job roles under the term construction workers — ranging from hybrid positions involving both off-site (desk-based) and on-site duties (e.g., engineers) to exclusively on-site roles (i.e., on-site workers, such as manual labourers) — introduces complexities that are often overlooked in research. Addressing these gaps is essential for a more comprehensive understanding of blue-collar workers, as well as the distinct challenges associated with different job types in this sector.

1.3.9 NCDs risk factors; conclusion

The overwhelming body of literature unequivocally identifies modifiable risk factors — including physical inactivity, sedentary behaviour, poor diet, excessive alcohol consumption, smoking, stress, and work-related conditions — as pivotal contributors to the global NCDs burden. Empirical evidence consistently demonstrates that these factors not only exacerbate the risk of developing NCDs but also compound their severity and mortality rates. The preponderance of evidence underscores the critical need for targeted public health interventions and policy measures aimed at mitigating these risk factors. Prioritising lifestyle modifications and creating supportive environments — especially within the workplace — that promote physical activity, healthy eating, smoking cessation, and stress management may help reduce the incidence and impact of NCDs. The urgency of addressing these modifiable risks cannot be overstated, as they represent a key lever in the global fight against NCDs, ultimately improving population health outcomes and reducing healthcare burdens.

1.4 lifestyle behaviour interventions to combat the development of non-communicable diseases

Lifestyle behaviour interventions have been implemented to combat the growing burden of NCDs. Lifestyle interventions are implemented at different levels, such as at the individual and community levels; however, one growing and promising aspect is the organisational level, also referred to as the workplace level. Currently, research activities on workplace health promotion and primary prevention program and their effectiveness are abundant, as the workplace provides the opportunity to reach a large population due to the amount of time people spend at work (Dishman et al., 1998; Hutchinson and Wilson, 2012). In addition, these types of interventions may help organisations shed down the indirect costs related to NCDs.

1.4.1 The concept of workplace health promotion programs and mitigating unhealthy lifestyle behaviour

Physical and mental health are connected in different ways, especially in those engaging in physically demanding occupations. Work environment factors such as work demands, work stress, and shift work (long periods of working hours) may directly affect employees' overall health, well-being, and health choices (Steptoe and Kivimäki, 2012; Shin et al., 2021). From an economic point of view, employees' health status may be a strong determinant of their productivity. Poor health status may lead to a reduction in productivity via increased absenteeism, lost working days, and sick leaves, thus influencing the profitability of an organisation (Cancelliere et al., 2011). Therefore, implementing a well-structured workplace health promotion and primary prevention program may further aid in maintaining employees' health and preserving work performance and profitability.

Unhealthy lifestyle behaviours such as physical inactivity, unhealthy diet, tobacco use, the harmful use of alcohol (World Health Organization, 2022), and being overweight or obese are major risk factors for chronic illnesses (Reilly et al., 2003). As a result, workplace health promotion and primary prevention programs have been utilised as a countermeasure to the increasing burden of diseases as well as, from an economic point of view, high levels of sick leaves. At the current stage, workplace health promotion and primary prevention programs are becoming increasingly prevalent; however, the degree of their effectiveness remains to be determined, especially for physically demanding occupations (Hulls et al., 2022).

Workplace health promotion can be utilised in two different ways. It can either target individuals (behavioural intervention or prevention) by encouraging a healthier lifestyle via healthier nutrition, promoting physical activity, or stress management training (Anderson et al., 2009). Alternatively, workplace health promotion may be applied to the workplace environment (relational intervention or prevention) by improving working conditions, providing healthier eating choices, and implementing health consultations and physical activity classes (Anderson et al., 2009; McEachan et al., 2011; Makrides et al., 2008).

1.4.1.1 Workplace health promotion program and promoting physical activity

Physical activity as a workplace health promotion program has been evaluated in numerous randomised controlled trials (RCTs), with the results synthesised in systematic reviews. A systematic review by Malik, Blake and Suggs (2014) investigated the potential positive impact of workplace physical activity interventions on activity levels. This review included 58 studies with sample sizes ranging from 32 to 798 participants, categorising the interventions into three types: physical activity and exercise interventions (6 interventions; 5 in white-collar jobs and 1 in blue-collar jobs), counselling and support interventions (13 interventions; 9 in white-collar jobs and 4 in blue-collar jobs), and health promotion messages and information interventions (39 interventions; 29 in white-collar jobs, 8 in blue-collar jobs, 1 in mixed-collar, and 1 unspecified job). Of the 58 studies, 32 reported a significant increase in at least one measure of physical activity; specifically, 3 studies within the physical activity and exercise interventions (all in white-collar jobs), 6 studies in the counselling and support interventions (4 in white-collar jobs and 2 in blue-collar jobs), and 23 studies in the health promotion messages and information interventions (17 in white-collar jobs, 5 in blue-collar jobs, and 1 in mixed job types). The majority of the study designs within this review were RCTs (56%), followed by non-RCTs (31%) and prospective randomised trials (PRTs) (13%), with 38% of the follow-up periods lasting less than a year, 28% more than a year, and 34% did not report the follow-up period. Additionally, out of 58 intervention studies, only 22% were conducted in blue-collar jobs, suggesting limited application of workplace interventions in these professions.

Three main limitations were identified in the intervention studies within this review by Malik, Blake and Suggs (2014): firstly, a significant proportion (88%) of the studies reporting a significant improvement relied on self-reported measures, with 41% using non-validated, self-constructed questionnaires, which are not without their inherent limitations, such as social desirability bias. Secondly, the lack of long-term follow-up raises questions about the sustainability of the interventions' effects. Lastly, although studies were categorised under three categories in this review, interventions varied significantly. Given these limitations, the conclusiveness of the evidence as a whole may be hindered, and the result should be interpreted with caution. Therefore, further robust intervention studies with validated measures and extended follow-up periods are needed to accurately determine the long-term effects of workplace physical activity interventions on activity levels. Appendix C1.A presents an overview of workplace interventions targeting blue-collar occupations identified in Malik, Blake and Suggs's (2014) systematic review.

1.4.1.2 Workplace health promotion program and weight management

Workplace health promotion programmes and weight management have been extensively researched, particularly in the contexts of physical activity, nutrition, and cardiovascular diseases. A systematic review published in 2009 examined the effectiveness of workplace physical activity and nutrition intervention programmes in promoting healthy weight among employees (Anderson et al., 2009). This review included 47 studies, predominantly RCTs (64%) and non-RCTs (30%), with a median sample size of 141 participants, ranging from 29 to 3728. Notably, one study had a sample size of 63732 participants conducted across multiple countries by the World Health Organization. The majority of the interventions were multi-component (57%), focusing primarily on diet and physical activity and aimed at cardiovascular disease risk reduction, weight control, and physical fitness. These goals were pursued through informational and behavioural programmes or environmental changes. Studies that reported a significant improvement in at least one weight-rated outcome were prominently multi-component interventions (58%). In addition, the results of their meta-analysis indicated modest improvements in employees' weight, with a pooled effect estimate of -2.8 lb in nine RCTs and a -0.5 decrease in BMI in six RCTs. However, the majority of interventions were conducted in white-collar settings (51%), with fewer applications in blue-collar environments (30%). Among the studies conducted in blue-collar jobs, only 57% showed significant improvements in weight-related outcomes. Despite this, nearly all intervention studies included in the review utilised objectively measured anthropometric data (95%) and demonstrated positive outcomes in weight management. Appendix C1.B presents an overview of workplace interventions targeting blue-collar occupations identified in Anderson et al. (2009) systematic review.

A similar pattern of Interventions (multi-component) and results were noted in a more recent systematic review and meta-analysis where interventions that included both physical activity and diet significantly reduced body weight (-2.61 kg; 95% CI, -3.89 to -1.33), BMI (-0.42 kg/m^2; 95% CI, -0.69 to -0.15) and waist circumference (-1.92 cm; 95% CI, -3.25 to -0.60) (Mulchandani et al., 2019). In a similar pattern to Anderson et al. (2009), the majority of intervention studies included in Mulchandani et al. (2019) review were conducted in white-collar jobs (56%) with limited application in blue-collar jobs (33%, 1 study conducted in construction workers), and among those conducted in blue-collar jobs, 55% elicited a significant improvement in at least one weight-related outcomes. Additionally, nearly all intervention studies used objective measured anthropometric data, aiding the strength of findings within the included intervention studies. Appendix C1.C presents an overview of workplace interventions targeting blue-collar occupations identified in Mulchandani et al. (2019) systematic review and meta-analysis.

Both systematic reviews demonstrated significant heterogeneity among the included studies, particularly concerning sample size and intervention components. Despite this variability, most interventions in both reviews employed multi-component approaches that incorporated both dietary and physical activity elements. These interventions consistently yielded positive results in terms of weight-related outcomes. The consistent positive findings across diverse studies suggest that multi-component workplace interventions could be a dependable strategy for addressing weight-related issues. Although the application of workplace interventions targeting weight-related outcomes in blue-collar occupations, particularly among construction workers, is limited, this evidence provides a strong foundation for the broader implementation of such interventions to enhance weight-related health metrics in workplace settings.

1.4.1.3 Workplace health promotion program and dietary behaviour

Poor dietary behaviour may significantly impact individual health, contributing to conditions such as obesity, diabetes, cardiovascular diseases, and various types of cancers (Ezzati et al., 2002). Given that individuals spend a considerable portion of their time at work, workplace health promotion programmes have the potential to enhance dietary habits. A systematic review and meta-analysis of 121 studies, encompassing a median of 413 (mean 1231) participants and interventions lasting a median of 9 months (mean 13.3 months), demonstrated that workplace wellness programmes (interventions were heterogeneous and ranged from educational initiatives, environmental changes, food labelling, financial incentives, and physical activity) improved dietary outcomes. Specifically, these programmes increased overall fruit and vegetable consumption by 0.27 servings per day, fruit consumption by 0.20 servings per day, and reduced total fat intake by 1.18% of daily energy intake and saturated fat intake by 0.70% of daily energy intake (Peñalvo et al., 2021). The majority of the intervention studies included in this review were RCTs (68%), quasi-experiments (32%), and 51% were classified as high-quality intervention studies. These studies were predominantly conducted within white-collar jobs (54%), while a quarter were within blue-collar jobs (25%, "57%" were high quality), with two studies specifically focused on construction workers. Among the intervention studies conducted within blue-collar jobs, 18 studies included analyses of dietary outcomes. Of these, 16 studies reported significant improvements in at least one diet-related outcome, with one of these studies focusing on construction workers. Unlike measures of weight and blood pressure, dietary assessment primarily relies on self-reported measures. Consequently, the vast majority of intervention studies predominantly utilised self-reported tools derived from a variety of validated questionnaires. Appendix C1.D presents an overview of workplace interventions targeting blue-collar occupations identified in Peñalvo et al. (2021) systematic review and meta-analysis.

Evaluating dietary intake is acknowledged as a complex and challenging task. Nelson (1997) emphasised that dietary assessment methods are often subject to significant inaccuracies, with no current technique capable of precisely quantifying nutrient intake at either the individual or population level. Shim, Oh and Kim (2014) similarly concluded that no single method can perfectly assess dietary intake or exposure. Despite these challenges and the limited application of workplace interventions targeting dietary outcomes in blue-collar occupations, particularly among construction workers, the findings from Peñalvo et al. (2021) offer promising prospects. The intervention studies examined by Peñalvo et al. (2021) suggest potential for effective implementation in workplace settings, indicating a positive direction for future research and practical applications in improving dietary habits among this demographic.

1.4.1.4 Workplace health promotion program and smoking cessation

The relationship between smoking and NCDs is well-documented and highlights the critical need for public health initiatives and, in addition, health interventions to reduce smoking rates. Preventive measures, education, and smoking cessation programs are essential strategies in combating the prevalence of NCDs linked to smoking. Of these initiatives and interventions, workplace health promotion programs are emerging as a promising domain to improve smoking cessation rates. A systematic review examined 57 studies encompassing 61 comparisons of workplace interventions for smoking cessation environments (Cahill and Lancaster, 2014). The intervention studies in this review were divided into two main categories: interventions aimed at individual smokers and those targeting the workplace environment. The types of interventions assessed included group therapy, individual counselling, self-help materials, pharmacological treatments such as nicotine replacement therapy (NRT), and comprehensive health promotion programs that incorporated multiple strategies. The majority of the studies were RCTs (53%) and primarily applied in white-collar jobs (40%), with limited application in blue-collar jobs (23%, only 3 interventions in construction workers). The effectiveness of smoking cessation interventions varied, as Individual-level interventions such as group therapy (OR 1.71, 95% CI 1.05 to 2.80), individual counselling (OR 1.96, 95% CI 1.51 to 2.54), and pharmacotherapies (OR 1.98, 95% CI 1.26 to 3.11) significantly increased smoking cessation rates compared to control groups, and multiple intervention programs focusing mainly on smoking cessation also showed positive outcomes (OR 1.55, 95% CI 1.13 to 2.13). However, the absolute number of smokers who quit remained low, and self-help materials were less effective (OR 1.16, 95% CI 0.74 to 1.82).

When looking deeper into the intervention studies in Cahill and Lancaster's (2014) systematic review, half of the included interventions (51%) relied on self-reported data to measure cigarette consumption and cessation rates, with the other half utilising biochemical validation methods such as breath, blood or urine tests to verify smoking cessation. In more depth, intervention studies included in their review applied to blue-collar jobs elicited a number of significant improvements; however, 69% relied only on self-reported measures for smoking-related outcomes. Additionally, high turnover rates and the transient nature of work in these sectors posed challenges for sustaining interventions and maintaining long-term cessation. This variability underscores the need for targeted strategies that account for the unique challenges faced by blue-collar workers. Specifically, interventions targeting construction workers did not elicit any intervention effect and only employed self-reported measures for smoking-related outcomes. Appendix C1.E presents an overview of workplace interventions targeting blue-collar occupations identified in Cahill and Lancaster's (2014) systematic review.

An observation noted in the literature is that smoking cessation was likely to be more effective if the participants were well beyond the contemplation stage in the stages of change models (refer to image C1.1 for the stages of change model). Fishwick et al. (2013) noted in a review article that for an intervention to yield greater effectiveness, the included participants should already have moved past the contemplation stage. An intervention study by Gunes, Ilgar and Karaoglu (2007) investigated the effectiveness of a smoking cessation education programme utilising The Stages of Change Model of behaviour change. Initial assessments showed that 36% of the intervention group was in the pre-contemplation stage, indicating no intention to quit smoking within six months. Although the intervention group saw a significant reduction post-intervention in the pre-contemplation stage from 36% to 20%, immediate quit rates (action stage) did not see notable changes. The findings suggest that while the education programme effectively increased the intentions and preparations to quit smoking, it had limited immediate impact on actual cessation. Similar initial effectiveness was also noted in Smedslund et al. (2004) systematic meta-analysis, with effectiveness diminishing with time with no effect beyond 12 months.

Workplace health promotion programmes focusing on smoking cessation have shown potential; however, their effectiveness is notably limited among blue-collar workers, particularly in the construction sector. According to Noonan and Duffy (2014), the prevalence of smoking is disproportionately high in blue-collar occupations compared to other occupational groups. This disparity highlights the urgent need for more robust and high-quality workplace health promotion programmes tailored specifically to this demographic. Implementing such targeted interventions is crucial for mitigating the adverse health effects associated with smoking in blue-collar work environments.

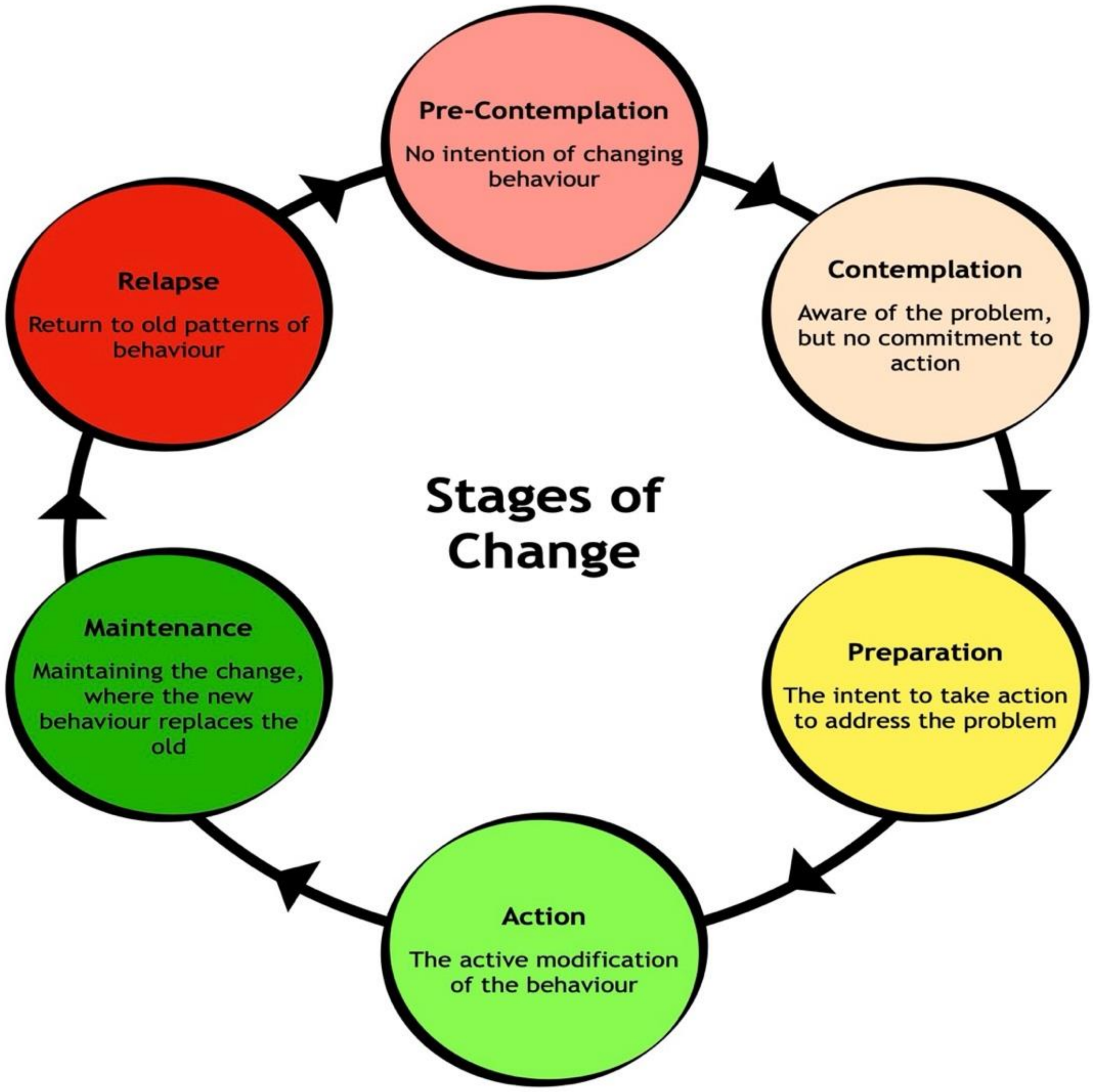


Image C1.1: Stages and processes of self-change as per Prochaska and DiClemente (1983)

1.4.1.4 Workplace health promotion program and mental health

Mental health is currently a focal research point within the literature due to its impact on both individuals' health and economic impact, as previously stated. Mental health issues can arise from a variety of factors, including lifestyle (Velten et al., 2014) and work factors (Kopp et al., 2008); thus, an increasing number of workplace interventions addressing mental health have been published. A systematic review by Chu et al. (2014) examined the impact of workplace physical activity interventions on mental health outcomes and included 17 studies revealed that while there was moderate evidence supporting the effectiveness of physical activity programmes in alleviating symptoms of depression and strong evidence for yoga interventions in reducing anxiety, the evidence for stress relief was inconclusive. The majority of interventions within this review were RCTs (76%) and non-RCTs (24%), with the majority conducted in white-collar professions (88%) and limited application in blue-collar professions (12%, only 2 studies). Although a number of positive findings were revealed, 76% of the intervention studies had a follow-up of less than 7 months, and out of these studies, 62% (1 study in blue-collar jobs) had a follow-up of 3 months or less. The review highlights the potential of these interventions to enhance mental health in workplace settings, though the variability in outcomes and short follow-up duration suggests the need for more high-quality interventions. Appendix C1.F presents an overview of workplace interventions targeting blue-collar occupations identified in Chu et al. (2014) review.

A systematic review that included 4 intervention studies evaluated the effectiveness of organisational-level mental health interventions on mental health outcomes and overall mental well-being within the construction industry (Greiner et al., 2022). The findings revealed no significant effects on general mental health outcomes. The review encompassed various study designs, including RCTs (1 study), non-RCT (1 study), and before-and-after studies (2 studies), which targeted different organisational levels, such as supervisors and employees. This lack of positive results may be partly due to the primary focus of the interventions, which did not explicitly aim to enhance mental health outcomes. Consequently, the scope of mental health metrics assessed was limited, often integrated within broader health evaluations rather than focusing specifically on mental health. Additionally, the quality of the studies was suboptimal, with limitations including a small number of studies and short follow-up periods, which reduced the reliability of the conclusions. Appendix C1.G presents an overview of workplace interventions targeting blue-collar occupations identified in Greiner et al. (2022) systematic review.

The systematic reviews by Chu et al. (2014) and Greiner et al. (2022) collectively underscore the complex and nuanced impact of workplace interventions on mental health outcomes. Chu et al. (2014) demonstrate moderate support for the effectiveness of physical activity, particularly yoga, in reducing symptoms of depression and anxiety, yet the inconclusiveness regarding stress relief and the predominance of short follow-up durations indicate a need for more robust research. On the other hand, Greiner et al. (2022) review of organisational-level interventions in the construction industry highlights a significant gap in the focus and quality of existing studies, with no notable improvements in general mental health outcomes. The overarching conclusion from these reviews is the critical need for well-designed, long-term interventions that specifically target mental health improvements and include a diverse range of occupations.

1.4.2 The concept of workplace health promotion programs and mitigating unhealthy lifestyle behaviour; conclusion

Work and NCDs are two key areas of public health that can have significant overlaps. NCDs not only impact an individual's health but can greatly impact their ability to work or the quality of their work. Certain aspects of work, in addition to lifestyle factors, can contribute to the development of NCDs. Therefore, workplace health promotion programs have been implemented to address these aspects. Although there have been improvements in weight management and promising results in diet, these programs exhibit great variability in terms of interventions, population and outcomes. Additionally, the vast majority of workplace health promotion programs in these four domains (physical activity, weight, diet, smoking, and mental health) were conducted within white-collar professions, and thus, a notable disparity can be seen in the application of these interventions in blue-collar jobs. Therefore, further high-quality studies are needed in general, even more in blue-collar professions, specifically construction workers.

1.5 Summary and PhD rationale

Employee health and well-being is an important concern for employers, from a duty of care perspective, and due to the potential effects on productivity (presenteeism, sickness absence, NCD-related disability) and staff retention (Robroek et al., 2011; van Duijvenbode et al., 2009; Proper, 2006; Alavinia, Molenaar and Burdorf, 2009; Williden, Schofield and Duncan, 2012; Chaker et al., 2015). Many aspects of health and well-being are affected by unhealthy lifestyle behaviours, including physical inactivity, sedentary behaviour, poor diet, alcohol, smoking, and psychological factors such as stress. Understanding the prevalence of these factors, as well as the factors that might drive these – for example, long working hours contribute to physical inactivity (Hu, Chen and Cheng, 2016; Baek et al., 2023) and unhealthy diet (Escoto et al., 2012) - is a necessary first step towards developing effective interventions. Although a number of observational studies describing the lifestyle behaviour of employees are available within the literature, they often focus on an individual behavioural risk factor, “single outcome”, such as sedentary behaviour

(Prince et al., 2019; Clemes, O'Connell and Edwardson, 2014), or diet (Clohessy, Walasek and Meyer, 2019; Walker and Flannery, 2020) and these are often focused on employees in office-based settings. Studies describing multiple lifestyle behaviours of employees are scarcer, particularly for non-office-based workplaces, such as the construction industry.

In addition, the majority of studies addressing the working populations are in the form of interventions with inconclusive, moderate, or limited effects of lifestyle behaviours such as sedentary behaviour (Shrestha et al., 2018), increasing physical activity (Malik, Blake and Suggs, 2014; Buckingham et al., 2019; Prieske et al., 2019), diet (Geaney et al., 2013; Peñalvo et al., 2021), smoking (Fishwick et al., 2013), and mental health and well-being (Greiner et al., 2022; Wagner et al., 2016; Graveling et al., 2008); with majority of published workplace interventions primarily targeting affluent jobs (e.g. office, educational, and healthcare jobs), which may be due to the ease of access, and with limited application in blue-collar based jobs; specifically construction workers. Within this limited application within the construction industry, Hulls et al. (2022) concluded in their systematic review addressing workplace interventions and improving employees' health and well-being in male-dominated industries, which included workplace intervention directed towards construction workers, that these interventions had none to limited positive effects. According to them, these none to limited positive effects may be attributed to a variety of factors; however, the short follow-up period (6-12 months) limits the assessment of the intervention's sustainability and long-term effect, and In most studies, there was an absence of information on intervention design, context and process and with only quantitative analysis of the results; therefore they were unable to determine if failures in the effectiveness had been due to ineffective implementation or the result of erroneous theory underlying intervention development.

To conclude, observational-based studies that describe lifestyle behaviour and other associated factors in different working professions are essential in providing insight and are a bridge to better understanding these workers (Office and construction-based workers). Observational research is invaluable in shedding light on and providing critical information that aids in pinpointing specific factors requiring intervention, potentially enhancing the efficacy of health promotion programs within the workplace or outside it. As highlighted by Groeneveld et al. (2010), the success of interventions aimed at promoting lifestyle changes is significantly influenced by the characteristics and disease risk factors of the participants, whether these interventions occur in the workplace or elsewhere. Consequently, this PhD project is dedicated to exploring the lifestyle behaviours and other associated factors, including mental health and well-being, of both office and construction workers to help guide and inform future interventions.

1.5.1 Thesis aims and outline

1.5.1.1 Pre COVID-19 aim

The original overall aim of this thesis was to develop and test the feasibility of a workplace-based intervention to improve the health of construction workers, who are an underserved group for such interventions. The target population was workers at Multiplex – a large multinational construction company that was awarded the contract for a £300 million development of the University of Glasgow campus from

2017 to 2023. During peak construction times, it was anticipated that there would be several hundred Multiplex workers on the University campus at any one time, providing the ideal opportunity to develop and test a workplace-based intervention to improve construction worker health. To address this overall aim, the original study plan for the thesis included five objectives:

i) A systematic review to identify previously undertaken workplace-based health interventions (physical activity, diet, weight, and smoking) in construction workers targeting improvement in physical activity, diet, weight, and smoking to see what has been previously done and the degree of its effectiveness.

ii) A cross-sectional study quantifying demographic, physical and mental health risk factors, and lifestyle-related health behaviours amongst construction workers (workers at Multiplex and their subcontractors) to identify health behaviours to target for intervention.

iii) In-depth qualitative interviews with a subsample from the prior cross-sectional study participants to explore their perspectives of their own lifestyle behaviour choices, the potential barriers and facilitators towards improving their current lifestyle choices, and what are the available workplace health promotion programs provided by their organisation and their opinion regarding them.

iv) Co-design a workplace-based health-behaviour change intervention to improve physical and/or mental health tailored to the needs of Multiplex workers.

v) Test the feasibility of the co-designed workplace-based intervention.

1.5.1.2 Post COVID-19 aim

COVID-19 had a considerable impact on this project. Construction at the University was stopped for several months, and priorities of Multiplex management shifted away from the study. This led to incomplete recruitment of participants in the cross-sectional and qualitative study (objective ii: 43 out of a target of 200 participants recruited, and objective iii: 14 out of a target of 30 recruited over a 12-month recruitment period) and meant that further development of a workplace health intervention (objectives iv and v from pre-COVID-19 aim) was not possible. It was, therefore, necessary to pivot to enable the thesis to be completed. To retain the central theme of understanding workplace health to inform intervention development, a final section was added using a large dataset describing demographic, social, physical and mental health, and behavioural risk factors, as well as organisational structural factors, and absenteeism and presenteeism in a large UK-based public sector organisation. These data were used to understand which factors were most strongly associated with employee health, absenteeism, and presenteeism in the organisation to help inform future interventions. Thus, the final thesis undertook preliminary work to help inform future workplace-based interventions in two different employment settings, with the primary emphasis on construction settings. The specific objectives of the chapters in the final thesis were, therefore, as follows:

i) A cross-sectional secondary data analysis of a large data set of employees from a public sector organisation (Office workers) to look at demographic, social, organisational, health and behavioural factors and whether they are associated with employee absenteeism and presenteeism to help inform potential targets for future interventions to improve health (Chapter 2).

ii) A systematic review to identify and synthesise previously undertaken workplace-based health interventions (physical activity, diet, weight, and smoking) in construction workers targeting improvement in physical activity, diet, weight, and smoking to see what has been previously done and the degree of its effectiveness. (Chapter 3).

iii) A cross-sectional study quantifying demographic, physical and mental health risk factors, and lifestyle-related health behaviours amongst construction workers (workers at Multiplex and their subcontractors) to help guide future interventions by highlighting which health behaviours to target for interventions (Chapter 4).

iv) A qualitative study with the aim to further build up on findings from the prior cross-sectional study (Objective iii) explaining the lifestyle choices of people working in the construction industry and the potential barriers and facilitators towards improving their current lifestyle choices, and in addition, what are the available workplace health promotion programs provided by their organisation and their opinion regarding them. (Chapter 5).

Chapter 2 The Workwell study: a look into the lifestyle behaviour and other associated factors in office-based workers.

2.1 Introduction

Non-communicable diseases (NCDs), such as cardiovascular diseases, cancer, and diabetes, are among the major health challenges and are the leading cause of mortality worldwide (World Health Organisation, 2014). NCDs, caused by modifiable unhealthy lifestyle factors like sedentary behaviour, physical inactivity, poor diet, excessive alcohol intake, and smoking, are additionally primary drivers of presenteeism and absenteeism, affecting productivity (Hunter and Reddy, 2013).

Office workers' profession is characterised by long periods of sitting time, typically lasting more than 30 minutes (Thorp et al., 2012), and are professions that require mental effort instead of physical effort. Sedentary behaviours at office-based workplaces are a risk factor for NCDs (Nunes et al., 2016), overweight and obesity, and musculoskeletal disorders (Gerr et al., 2002).

Being overweight and obese are, in addition, major risks for office workers. Church et al. (2011) reported that a 100-calorie per decrease in energy expenditure was responsible for about 80% of the average increase in body weight in the working population from the 1960s to 2010. Similar to sedentary behaviours, overweight and obesity are continuously growing challenges worldwide and are major risk factors for hypertension, dyslipidemia (Hennekens and Andreotti, 2013), NCDs, and mortality globally (Banjare and Bhalerao, 2016).

Office workers are prone to stress attributed to high workloads and time pressure (Bolliger et al., 2022). Stress is recognised as a major and modifiable risk factor linked to cardiovascular disease (Hjemdahl, Rosengren and Steptoe (Eds), 2011). External stressors have been identified by research to cause a harmful reaction in a large number of people, which includes work factors such as work demands (Steptoe and Kivimäki, 2012). Employees with highly demanding jobs that they may not be able to control may undergo job strain, and if sustained for long periods of time, elevates the risk of stress-related diseases such as coronary artery disease (Karasek and Theorell, 1990). In addition, Kivimäki et al. (2006) reported that an average of 50% elevated risk of coronary heart disease is observed in employees who are exposed to workplace stress compared to those who are not.

Office-based jobs are one of the most crowded jobs; according to the Official census and labour market statistics, in the UK, more than 50% of workers work in an office-based occupation and thus have an impact on national and organisational income. However, there is a lack of studies within the literature addressing lifestyle behaviour holistically and factors associated with it, such as mental, personal, workplace environment, and home environment, as the majority of published studies address a single or multi-behaviour factor such as smoking (Howard, 2004), sedentary behaviour (Clemes, O'Connell and Edwardson, 2014), Physical activity (Biernat, Tomaszewski and Milde, 2010) and stress (Thorsteinsson, Brown and Richards, 2014). In addition, the bulk of the literature associated with office-based workers tends to be in the form of an intervention study rather than an observational one (Peñalvo et al., 2021). This scarcity of observational studies may have left a gap in the literature in providing a better understanding of the importance of lifestyle and other factors associated with office-based workers, such as mental health. Therefore, the aim of this study was to look at the lifestyle behaviour, mental health, and personal and environmental factors in office-based workers and whether it is possible to predict presenteeism and absenteeism from these variables.

2.2 Methods

This was a cross-sectional study based on data obtained from the Workwell group on office-based workers. Workwell is a UK science-led business that produces next-generation cloud-based diagnostic solutions. Their programme enables organisations to adapt to the increased pressures by analysing employees' lifestyle behaviour and relating it to health risks and workforce productivity, thus helping improve productivity and corporate resilience within organisations.

The recruitment process commenced when the Workwell group shared the recruitment email with the applicant organisation, which was then disseminated to employees. The process for registering a new participant and commencing the assessment unfolds in three key stages: registration (which includes completing a consent form), set-up, and the actual assessment. The registration process was designed to be automated, allowing prospective participants to either initiate the registration independently by visiting www.workwelltoday.net and selecting the "register here" option or to engage directly with the Workwell group via www.workwelltoday.net to begin their recruitment process collaboratively. Upon completing the registration stage, participants are prompted to enter their company's name and start the assessment.

2.2.1 Assessment

The assessment form focused on acquiring information on sociodemographic characteristics and occupation, lifestyle, medical, psychological, and COVID-19 impact on a personal level, employment, and lifestyle.

2.2.1.1 Sociodemographic characteristics and local area

Gender, age, ethnicity, marital status, childcare and responsibilities, education, employment status, job type, and annual salary were self-reported. Education was classified into five categories: higher education degree and professional/vocational equivalents, “A” levels, vocational level 3 and equivalents, GCSE/O level grade A*-C or vocational level 2 and equivalents, qualifications at level 1 and below, and no qualifications. Employment status was classified into seven categories: full-time, part-time, consultant, trainee/apprentice, casual work, unemployed, and furloughed. Job type was grouped under 12 classifications: Information technology (IT), production, research, development, administration, sales marketing, professional services, client support, product, delivery, human resources, engineering, laboratory staff, and others. Annual salary was grouped according to the following: <£15,000, £16,000–£29,000, £30,000-£39,000, £40,000–£49,000, £50,000–£59,000, £60,000–£84,000, £85,000–£99,000, >£100,000.

For the local area, participants were asked to rate the following amenities and services where they live: parks and open spaces, public transport, schools and local services, places to socialise such as pubs and clubs, noise and pollution, medical services, and the safety of the local area on a Likert scale of 7, where 7 was good. Refer to Appendix C2.A Section 1 for further details.

2.2.1.2 Workplace assessment

Participants were asked to rate the following questions on workplace environment on a scale of 7, where 7 represents good: workplace environment warmth, lighting, noise and amenities; tools and equipment (e.g., the level of IT equipment, vehicle, tools); a safe and healthy environment to work in; time spent at work; training and support; flexible working arrangements. Furthermore, participants were asked if, at times, working from home, how they rate the working environment compared with the office, and means of travel to work and how long the journey takes.

In regard to work experience, participants were asked the following statements regarding work experience and were asked to rate them from 1 to 7, where 1 represents strongly disagree, and 7 strongly agree: working with members of this organisation, my unique skills and talents are valued and utilised; my working day life is generally stimulating and rewarding; my manager believes that I can handle demanding tasks; my work is physically very demanding; my manager allows me to do my job my way; I never seem to have enough time to get everything done at work; I feel I know where I stand with my manager and how satisfied my manager is with me; I often have to work longer than my contracted hours; I often feel bullied, harassed or discriminated against; people in this organisation sometimes reject others for being different; childcare often causes problems. In addition, participants who had shift work were asked to rate the impact it may have on the quality of life out of 7, where 1 represents major disruption. Refer to Appendix C2.A Section 2 for further details.

2.2.1.3 Anthropometric and other measurements

Participants were asked to fill in their height, weight, and waist circumference (WC, cm), with WC cut-off points as per Lean, Han and Morrison (1995) (males: <94, 94-101, ≥102, and females: <80, 80-87, ≥88) and body mass index (BMI, kg/m^2) score was generated from these data. In addition, participants were asked to input their blood pressure (BP, mmHg), cholesterol, and blood glucose levels if available. BP values were classified as per the American Heart Association redefined guidelines for BP: normal (SBP <120 and DBP <80), elevated (SBP 120-129 and DBP <80), hypertension stage 1 (SBP 130-139 or DBP 80-89), and hypertension stage 2 (SBP ≥140 or DBP ≥90) (Whelton et al., 2018). Mean arterial pressure (MAP, mmHg) was generated from BP values (MAP = DBP + 1/3(SBP – DBP) (DeMers and Wachs, 2023), and classified as normal (<99.01,), and hypertensive (>99.00) (Kandil et al., 2023).

2.2.1.4 Medical data

Medical data were self-reported and obtained for both the participants and their families. Participants were asked if they or a family member had the following subjective illnesses (illnesses without a formal medical diagnosis): stress, depression or anxiety, back pain, neck, shoulder or arm pain, leg pain, and headache and/or eye strain. Similarly, participants were also asked if they or a family member had the following objective illnesses (illnesses with a formal medical diagnosis): infectious diseases, such as flu, heart disease, breathing or lung problems, skin problems, cancer, hearing problems, arthritis, dementia, type 1 diabetes, type 2 diabetes, COVID-19, and others. Refer to Appendix C2.A Section 3.

2.2.1.5 Lifestyle behaviours

2.2.1.5.1 Smoking and alcohol consumption

For smoking, participants were asked whether they had ever smoked. If yes, how often? As for alcohol consumption, participants were asked how often they drink less than 14 units of alcohol per week.

2.2.1.5.2 Diet

The Workwell group gathered dietary information using self-developed questions, focusing on participants' eating habits, including regular meal consumption, calorie control, and portion control. Queries also covered the weekly frequency of consuming processed foods (such as sausages, pate, cakes, pastries, biscuits, chips, and crisps), fatty foods (such as fatty cuts of pork, beef or lamb, butter, dairy foods, and fried foods), sweet foods or drinks, adherence to a five-a-day fruit and vegetable intake, and daily salt consumption exceeding one teaspoon, including hidden salt. Further details can be seen in Appendix C2.A Section 5.

2.2.1.5.3 Physical activity

Physical activity measurement was acquired through the International Physical Activity Questionnaire (IPAQ) (Booth, 2000), a convenient tool with acceptable reliability and validity for large population cross-sectional studies, as per Craig et al. (2003). However, Roman-Viñas et al. (2010) noted a weak positive correlation between the IPAQ and objectively measured physical activity (r=0.29), even with good reliability (coefficient=82). The IPAQ assesses physical activity during work, leisure, and transportation, converting responses to MET.minutes/week, which was based on Jetté, Sidney and Blümchen (1990) study. A score of 450 MET.min/week or higher categorises a participant as physically active as moderate physical activity starts at 3 MET as per HASKELL et al. (2007), thus reaching the physical activity threshold of 150 minutes of moderate physical activity per week set by the NHS and the American Heart Association (3 MET.min x 150 = 450 MET.min/week).

2.2.1.6 Mental health

2.2.1.6.1 Hospital Anxiety and Depression Scale (HADS)

Anxiety and depression were measured using the HADS (Stern, 2014), a tool that showed good reliability (mean Cronbach's α of 0.83 and 0.82 for HADS anxiety and depression, respectively), sensitivity and specificity (0.80) in assessing anxiety and depression in the general population, as per Bjelland et al. (2002). Participants were asked 14 questions (7 for each), with a sum score of 21. Scores were classified as normal (≤7), borderline abnormal (8-10), and abnormal (11-21) (Zigmond and Snaith, 1983). A HADS score was generated, combining both anxiety and depression scores and was inverted, indicating higher scores as better outcomes.

2.2.1.6.2 Workforce well-being

Well-being was assessed using a self-constructed questionnaire by the Workwell group. The score was generated from the sum of the following statements (out of 7): I normally have lots of energy and drive, I am usually happy and glad to be alive, I cope well with life's problems, I do not let day-to-day problems get me down, I normally feel lethargic and lack motivation, I often feel down and wonder what the point of life is, I struggle with life's pressures, I feel isolated and rejected. A maximum score of 56 could be generated, where the higher the score, the better the outcome (negative statements scores were inverted). Appendix C2.A Section 6.

2.2.1.7 Sickness absence and presenteeism days

Sickness absence and presenteeism days were obtained subjectively by answering the following questions: In the last 12 months, how many days of absence from work have you had? And over the past 12 months, how many days did you work when you were sick?

2.2.1.8 COVID impact

2.2.1.8.1 Personal level

Participants were asked whether COVID-19 had an impact on them on a personal level via answering questions related to energy levels, happiness, coping, and sleep on a Likert scale of 5, where 5 represents the least impact. Refer to Appendix C2.A Section 7 for further details.

2.2.1.8.2 COVID-19 Impact on work status

Participants were asked to choose the following answer if COVID-19 had an impact on their job: I remain employed in the same role, I remain in the same role but working from home, I remain employed but with a significant change in role, furloughed, lost employment; how long and when did it end.

2.2.1.8.3 COVID-19 Impact on daily life

Participants were asked whether COVID-19 impacted their daily lives in regards to the daily commute, work efficiency, financial status, exercise, diet and weight, social contact, relations with the manager, company communication, technology access, and childcare provision. Refer to Appendix C2.A Section 7 for further details.

2.2.2 Statistical analysis

Data from this study are presented as numbers and percentages, mean ± the standard deviation (SD) for normally distributed data, and mean ± SD in addition to the median and interquartile range (IQR) for non-normally distributed data, if applicable; and are displayed as "mean ± SD (median (IQR))" for in-text and "mean ± SD; median (IQR)" for tables. To determine the distribution of data, both visual inspection and a normality test (Anderson-darling) were used, as per the recommendations of Ghasemi and Zahediasl (2012), to ensure that the assumptions about the data's distribution were accurate and reliable.

For statistical tests, when dealing with continuous variables, statistical tests were selected based on their assumptions, as outlined in Table C2.1. If the assumptions of normality and homogeneity of variance were met, the two-sample t-test was used to compare the means between the two independent groups - males and females (Kim and Park, 2019). However, if these assumptions were violated, Welch's t-test and the non-parametric Mann-Witney test were implemented. The choice of these alternate tests allows us to avoid the potential bias that might arise from violations of the assumptions of the standard t-test. In addition, the Chi-square test was used to examine the relationship between categorical variables. This test was applied to compare categorical variables between males and females for each categorical data. The p-value was set at <0.05, and to ensure the consistency, accuracy and reproducibility of the analyses, all data analysis was performed using Minitab software (version 19.2020.2.0) for MacOS.

Table C2.1: Statistical test selection based on assumption for continuous variables

Outcome	Data distribution	Continuous data	Homogeneity of variance	Random sampled	Statistical test
BP (SBP & DBP)	Normal	✓	X	✓	Welch's t-test
MAP	Normal	✓	X	✓	Welch's t-test
Height	Normal	✓	✓	✓	2-sample t-test
Weight	Normal	✓	✓	✓	2-sample t-test
BMI	Normal	✓	X	✓	Welch's t-test
WC	Normal	✓	X	✓	Welch's t-test
PA	Non-normal	✓	X	✓	Mann-Witney test
HADS - Anxiety and depression	Normal	✓	X	✓	Welch's t-test
Well-being	Normal	✓	✓	✓	2-sample t-test
Sickness absence days/year	Non-normal	✓	X	✓	Mann-Witney test
Presenteeism days/year	Non-normal	✓	✓	✓	Mann-Witney test

Stepwise regression analysis was employed to generate predictor variables for sickness absence and presenteeism for the total population. However, due to Minitab's limitations in addressing heteroscedasticity, RStudio (Version 2024.04.2+764 for MacOS) was utilised. The process involved the following steps:

- Only significant variables from a univariate correlation with sickness absence and presenteeism were considered.
- This was then fitted in the multivariable stepwise regression analysis.
- Models were generated, removing variables with multicollinearity based on a variance inflation factor (VIF) threshold of 5, if detected, ensuring only variables with acceptable VIF levels were retained (Kutner, Nachtsheim and Neter, 2004; James et al., 2013).
- A final predictor model was created after removing collinear variables.
- **Refer to Appendix C2.B for step-by-step details.**

For clarity, a positive direction was noted when a higher score indicated a lesser impact or better outcome (e.g., higher physical activity scores indicate a positive direction). Conversely, a negative direction was assigned when a higher score indicated a worse outcome.

2.3 Results

2846 participants completed the online assessment, who were predominantly White British and with a mean age of 42.2 ± 12.3. The majority of the participants were married (49.2%, N=1400), or single (22.7%, N=645), and with a higher educational degree or equivalent (74.4%, N=2117), followed by "A" level degree or vocational level 3 and equivalent (15.4%, N=438). In addition, participants were predominantly full-time employed (85.0%, N=2420), and 12.4% (N=352) were part-time employed. The majority of participants occupied administration jobs, followed by other unspecified jobs, and then research development (28.8% N=819, 18.7% N=532, and 14.2% n=405, respectively). The annual salary of the majority of the participants was between £30,000 and £39,000 (39.3%, N=1118), followed by £16,000 to £29,000 (24.7%, N=703). Data on all participants can be seen in Table C2.2.

Out of 2846, 1171 (41.1%) were males, 1637 (57.5%) were females, 28 (1.0%) preferred not to disclose their gender, and 10 (0.4%) were other. The mean age of male and female participants was 43.6 ± 12.8 and 41.2 ± 11.7, with males being significantly older. Male and female participants were predominantly white British and with a significant association in marital status, with the majority of both genders being married (male 54.3%, n=636 and female 45.8%, n=749). 78.9% (n=924) of male participants had a higher education and professional/degree, compared to 71.2% (n=1166) of females. Furthermore, a statistically significant association was observed between males and females in employment status, where 92.1% (n=1078) of males were full-time employed compared to 79.9% (n=1308) of full-time employed females, whereas only 4.1% (n=48) males were part-time employed compared to 18.4% (n=302) of females. A statistically significant association was also observed in job type, where 19.0% (n=222) of males worked in research development, followed by engineering (17.6%, n=206), while 38.1% (n=623) of females occupied administration jobs, followed by other unspecified jobs (20.6%, n=337). A similar significant association between males and females was also noted in the annual salary, where the majority of males (34.4%, n=403) and females (42.8%, n=701) earned between £30,000 and £39,000 annually; however, where they differ was that 18.5% (n=217) of males earn between £16,000 and £29,000 compared to 29.1% (n=476) of females, and in contrast, 18.3% (n=214) and 13.9% (n=163) of males earn between £40,000 to £49,000 and £50,000 to £59,000 annually compared to 13.3% (n=217) and 6.7% (n=110) of females; a similar pattern can also be observed in upper-income brackets (Table C2.2). Data on others and those who prefer not to disclose their gender can be seen in Appendix C2.C and C2.D.

Table C2. 2: Sociodemographic data

Sociodemographic category	All (N=2846)	Male (n=1171)	Female (n=1637)	P-value
Age	**42.2 ± 12.3**	**43.6 ± 12.8**	**41.2 ± 11.7**	**0.000**
Ethnicity				
White Welsh/English/Scottish/North. Irish/British	80.1% (N=2280)	82.8% (n=970)	78.4% (n=1283)	
Irish	1.0% (N =29)	0.9% (n=10)	1.2% (n=19)	
Gypsy or Irish traveller	0.1% (N =3)	0.1% (n=1)	0.1% (n=2)	
Any other white	10.7% (N=305)	9.8% (n=115)	11.4% (n=187)	
Mixed white and black Caribbean	0.2% (N=6)	0.3% (n=4)	0.1% (n=2)	
Mixed white and black African	0.1% (N=3)	0.1% (n=1)	0.1% (n=2)	
Mixed White and Asian	0.6% (N=16)	0.5% (n=6)	0.6% (n=10)	
Any other mixed background	1.2% (N=35)	0.7% (n=8)	1.6% (n=27)	
Asian Indian	1.6% (N=46)	1.4% (n=16)	1.8% (n=30)	
Asian Pakistani	0.6% (N=17)	0.6% (n=7)	0.6% (n=10)	
Asian Bangladeshi	0.2% (N=7)	0.1% (n=1)	0.3% (n=5)	
Asian Chinese	0.5% (N=13)	0.4% (n=5)	0.5% (n=8)	
Any other Asian	0.6% (N=18)	0.7% (n=8)	0.5% (n=9)	
Black African	0.9% (N=26)	0.9% (n=10)	1.0% (n=16)	

Continue table C2.2

Black Caribbean	0.4% (N=10)	0.3% (n=4)	0.4% (n=6)	
Any other Black	0.0% (N=1)	0.0% (n=0)	0.1% (n=1)	
Arab	0.1% (N=4)	0.2% (n=2)	0.1% (n=2)	
Any other ethnic group	0.9% (N=27)	0.3% (n=3)	1.1% (n=18)	
Marital stratus				**0.000**
Single	22.7% (N=645)	21.9% (n=257)	23.0% (n=376)	
Married	49.2% (N=1400)	54.3% (n=636)	45.8% (n=749)	
Living with a partner	22.1% (N=630)	18.7% (n=219)	24.6% (n=402)	
Separated	2.0% (N=56)	1.5% (n=18)	2.2% (n=36)	
Divorced	3.4% (N=97)	3.1% (n=36)	3.7% (n=61)	
Widowed	0.6% (N=18)	0.4% (n=5)	0.8% (n=13)	
Education				**0.000**
Higher education/professional/vocational equivalents	74.4% (N=2117)	78.9% (n=924)	71.2% (n=1166)	
"A" level, vocational level 3 and equivalents	15.4% (N=438)	14.4% (n=169)	16.0% (n=262)	
GCSE/O lvl grade A*- Vocational lvl 2 and equivalents	9.4% (N=267)	6.1% (n=72)	11.7% (n=191)	
Qualifications at level 1 and below	0.5% (N=13)	0.4% (n=5)	0.5% (n=8)	
No qualifications	0.4% (N=11)	0.1% (n=1)	0.6% (n=10)	
Employment status				**0.000**
Employed full-time	85.0% (n=2420)	92.1% (n=1078)	79.9% (n=1308)	
Employed part-time	12.4% (n=352)	4.1% (n=48)	18.4% (n=302)	
Consultant	1.1% (n=32)	2.0% (n=23)	0.5% (n=8)	
Trainee/ Apprentice	1.3% (n=37)	1.6% (n=19)	1.0% (n=17)	
Casual work	0.2% (n=5)	0.3% (n=3)	0.1% (n=2)	
Unemployed	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	
Furloughed	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	
Job type				**0.000**
IT	6.7% (n=192)	11.8% (n=138)	2.9% (n=48)	
Production	0.2% (n=6)	0.3% (n=4)	0.1% (n=2)	
Research development	14.2% (n=405)	19.0% (n=222)	10.9% (n=178)	
Administration	28.8% (n=819)	15.9% (n=186)	38.1% (n=623)	
Sales marketing	0.8% (n=22)	0.6% (n=7)	0.9% (n=15)	
Professional services	12.4% (n=353)	10.8% (n=126)	13.7% (n=225)	
Client support	0.7% (n=20)	0.7% (n=8)	0.7% (n=12)	
Product delivery	1.8% (n=50)	1.9% (n=22)	1.7% (n=28)	
Human resources	3.1% (n=87)	1.1% (n=13)	4.5% (n=73)	
Engineering	8.7% (n=249)	17.6% (n=206)	2.3% (n=38)	
Laboratory staff	3.9% (n=111)	4.5% (n=53)	3.5% (n=58)	
Other	18.7% (n=532)	15.9% (n=186)	20.6% (n=337)	
Annual salary (£)				**0.000**
<15K	2.2% (n=63)	1.9% (n=22)	2.4% (n=40)	
16K - 29K	24.7% (n=703)	18.5% (n=217)	29.1% (n=476)	
30K - 39K	39.3% (n=1118)	34.4% (n=403)	42.8% (n=701)	
40K - 49K	15.4% (n=438)	18.3% (n=214)	13.3% (n=217)	
50K - 59K	9.7% (n=276)	13.9% (n=163)	6.7% (n=110)	
60K - 84K	6.1% (n=174)	9.0% (n=105)	4.0% (n=66)	
85K - 99K	1.5% (n=43)	2.0% (n=23)	1.2% (n=20)	
>100K	1.1% (n=31)	2.0% (n=24)	0.4% (n=7)	

Data are presented as mean ± SD and percentages where applicable.

2.3.1 Anthropometrics

The mean systolic BP for the total sample was 124.9 ± 13.3, with males having a significantly higher systolic BP (126.9 ± 11.2) than females (123.1 ± 14.7), with a similar significance also being observed in Diastolic BP. The majority of the population (60%) were classified within hypertensive categories (Stage 1, 47.6% and Stage 2, 12.4%), with a significant association observed, as males were more likely to be categorised under the higher blood pressure categories. (Table C2.3). Similarly, males had a significantly higher MAP compared to females (96.0 ± 8.4 and 92.3 ± 11.1, respectively), with a mean of 94.1 ± 10.1 for the total population, and a borderline significance association was noted where males were more likely to be in the hypertensive categories. (Table C2.3)

The mean weight for the total population was 76.5 ± 17.0, with males significantly heavier than females (83.5 ± 15.4 and 71.3 ± 16.2, respectively). No statistical significance was noted in the mean BMI scores between males and females; however, a statistically significant association was observed in BMI categories as males were more likely to be overweight compared to females (41.6%, n=458 versus 32.0%, n=466, respectively). In contrast, females were more likely to be obese compared to males (16.3%, n=237 versus 10.5%, n=116, respectively), and with the majority of the total sample, males and females, within normal BMI ranges (48.2% N=1247, 46.5% n=511, and 49.6% n=721, respectively). The mean WC for males and females was 85.4 ± 13.7 and 78.6 ± 16.0, respectively. (Table C2.3)

Table C2. 3: Anthropometric data

Anthropometric category	All (N)	Male (n)	Female (n)	P-value
Systolic BP (mmHg)	**124.9 ± 13.3 (N=460)**	**126.9 ± 11.2 (n=216)**	**123.1 ± 14.7 (n=239)**	**0.002**
Diastolic BP (mmHg)	**78.7 ± 9.8 (N=460)**	**80.6 ± 8.5 (n=216)**	**76.9 ± 10.6 (n=239)**	**0.000**
Normal	26.1% (N=120)	15.7% (n=34)	35.6% (n=85)	
Elevated	13.9% (N=64)	14.8% (n=32)	13.0% (n=31)	
Hypertension stage 1	47.6% (N=219)	56.0% (n=121)	39.7% (n=95)	
Hypertension stage 2	12.4% (N=57)	13.4% (n=29)	11.7% (n=28)	
BP classification				0.000
Mean arterial pressure (mmHg)	**94.1 ± 10.1 (N=460)**	**96.0 ± 8.4 (n=216)**	**92.3 ± 11.1 (n=239)**	**0.000**
Normal	72.2% (N=332)	68.1% (n=147)	76.2% (n=182)	
Hypertensive	27.8% (N=128)	31.9% (n=69)	23.8% (n=57)	
MAP classification				0.054
Height (CM)	**171.0 ± 10.5 (N=2792)**	**178.8 ± 7.4 (n=1152)**	**165.4 ± 7.0 (n=1605)**	**0.000**
Weight (KG)	**76.5 ± 17.0 (N=2594)**	**83.5 ± 15.4 (n=1102)**	**71.3 ± 16.2 (n=1461)**	**0.000**
BMI Score	**26.1 ± 5.3 (N=2585)**	**26.1 ± 4.7 (n=1100)**	**26.1 ± 5.8 (n=1455)**	**0.960**
Normal	48.2% (N=1247)	46.5% (n=511)	49.6% (n=721)	
Underweight	1.8% (N=47)	1.4% (n=15)	2.1% (n=31)	
Overweight	36.1% (N=934)	41.6% (n=458)	32.0% (n=466)	
Obese	13.8% (N=357)	10.5% (n=116)	16.3% (n=237)	
BM classification				0.000
Waist circumference (CM)	**82.3 ± 15.3 (N=1657)**	**85.4 ± 13.7 (n=898)**	**78.6 ± 16.0 (n=737)**	**0.000**
Normal (Male <94, Female <80)	NA	81.6% (n=733)	54.1% (n=399)	
Increased (Male 94 - 101, Female 80 - 87)	NA	10.5% (n=94)	22.8% (n=168)	
Substantially increased (Male ≥ 102, female ≥88)	NA	7.9% (n=71)	23.1% (n=170)	
Waist circumference classification	NA			0.000

Data are presented as mean ± SD and percentages where applicable.

2.3.2 Lifestyle behaviours, well-being, and mental health.

2.3.2.1 Smoking and alcohol

8.1% of the participants were smokers, 8.6% of males, and 7.6% of females, with no statistically significant association (Table C2.4). In regard to alcohol consumption (Table C2.4), 51.5% of the total sample consume less than 14 units of alcohol per week, with males significantly less likely to consume 14 units of alcohol per week compared to females (45.6% n=534 and 56.0% n=916, respectively).

2.3.2.2 Diet

The majority of participants (83.3% N=2371) always eat regular meals, and similarly, 86.6% (n=1014) of males and 81.0% (n=1326) of females (p=0.001) (Table C2.4). 36.0%

(n=422) of male participants never controlled their calories, while 37.1% (n=608) of females did (p=0.002) (Table C2.4). In addition, more than half of the participants (53.5% N=1523) eat fatty food at least 1 to 2 times per week, which was also the case for males (51.8% n=606) and females (54.8% n=897) (p=0.010) (Table C2.4). In regard to fruit and vegetables, 41.6% (N=1183) of participants eat their five portions of fruit and vegetables between 3 to 5 times per week, with a similar pattern in males (41.7% n=488) and females (41.8 n=684) (p=0.001). All data on diet can be seen in Table C2.4.

2.3.2.3 Physical activity

The mean MET.min per week for participants was 1240.8 ± 922.1 (1080.0(1200.0)), with males significantly higher than females (p=0.001). However, 21.1% (N=531) of total participants, 20.1% (n=212) of males, and 21.8% of females perfumed less than 450 MET.min per week (Table C2.4).

2.3.2.4 Mental health

2.3.2.4.1 The Hospital Anxiety and Depression Scale (HADS):

The mean HADS anxiety score for all participants was 8.4 ± 4.8 (N=2846), with males (7.7 ± 4.5, n=1171) significantly lower than females (8.8 ± 4.9, n=1637) (p=0.000). However, 26.0% (n=304) of males and 35.6% (n=582) of females (p=0.000) were classified as abnormal. For the HASD depression score, the mean score for the sample was 6.8 ± 3.6, with no significant difference between males and females, with 12.6% (n=148) of males and 14.5% (n=238) of females classified as abnormal. Females were significantly more likely to report signs of anxiety or depression compared to males (0.000 and 0.034). (Table C2.4)

2.3.2.4.2 Workforce well-being

The mean score for participants was 38.5 ± 9.5, with a significantly higher well-being score observed in males (39.2 ± 9.4) compared to females (38.2 ± 9.4). (Table C2.4)

2.3.2.5 Sickness absence and presenteeism days

The mean sickness absence days per year for this sample was 5.1 ± 14.7 (0.0 (4.0)), with males (4.0 ± 11.4 (0.0 (3.0))) being significantly lower than females (5.8 ± 16.6; (1.0 (4.0))). Similarly, males were, in addition, significantly lower in presenteeism days compared to females (p=0.000), with average presenteeism days of 4.3 ± 18.9 (0.0 (3.0)) for the total sample. (Table C2.4)

Table C2. 4: lifestyle categories, mental health, sickness absence and presenteeism

Lifestyle category and factors	All (N)	Male (n)	Female (n)	P-value
Smoking	8.1% (N=230)	8.6% (n=101)	7.6% (n=125)	0.230
Alcohol				0.000
I drink less than 14 units of alcohol per week.				
Never	12.8% (N=363)	13.0% (n=152)	12.4% (n=203)	
Occasionally	15.4% (N=438)	18.1% (n=212)	13.3% (n=218)	
Sometimes	20.3% (N=578)	23.3% (n=273)	18.3% (n=300)	
Always	51.5% (N=1467)	45.6% (n=534)	56.0% (n=916)	
I do not drink alcohol	0.0% (N=0)	0.0% (n=0)	0.0% (n=0)	
Diet				
I eat regular meals				0.001
Never	0.5% (N=15)	0.4% (n=5)	0.5% (n=9)	
Occasionally	3.9% (N=110)	2.9% (n=34)	4.6% (n=76)	
Sometimes	12.3% (N=350)	10.1% (n=118)	13.8% (n=226)	
Always	83.3% (N=2371)	86.6% (n=1014)	81.0% (n=1326)	
I control the calories I eat				0.002
Never	33.8% (N=962)	36.0% (n=422)	31.9% (n=523)	
Occasionally	21.6% (N=616)	23.4% (n=274)	20.6% (n=337)	
Sometimes	34.2% (N=974)	30.3% (n=355)	37.1% (n=608)	
Always	10.3% (N=294)	10.2% (n=120)	10.3% (n=169)	
I control the amount I eat				0.082
Never	14.5% (N=413)	15.9% (n=186)	13.4% (n=220)	
Occasionally	21.2% (N=603)	21.9% (n=257)	20.8% (n=340)	
Sometimes	38.8% (N=1103)	36.3% (n=425)	40.6% (n=665)	
Always	25.5% (N=727)	25.9% (n=303)	25.2% (n=412)	

Continue table C2.4

I eat processed foods such as sausages, pate, cakes, pastries, biscuits, chips, and crisps				0.299
No times	4.1% (N=116)	4.3% (n=50)	4.0% (n=65)	
1-2 times	44.2% (N=1258)	42.4% (n=496)	45.7% (n=748)	
3-5 times	35.8% (N=1019)	36.4% (n=426)	35.2% (n=577)	
6 or more times	15.9% (N=453)	17.0% (n=199)	15.1% (n=247)	
I eat fatty foods such as fatty cuts of pork, beef or lamb, butter, dairy foods, fried foods				0.010
No times	10.6% (N=303)	9.3% (n=109)	11.8% (n=193)	
1-2 times	53.5% (N=1523)	51.8% (n=606)	54.8% (n=897)	
3-5 times	26.2% (N=746)	29.0% (n=340)	24.3% (n=397)	
6 or more times	9.6% (N=274)	9.9% (n=116)	9.2% (n=150)	
I drink or eat sweet food such as sugary drinks and cereals, creamy yoghurts, and ice cream				0.359
No times	19.6% (N=559)	19.5% (n=228)	19.7 % (n=323)	
1-2 times	49.9% (N=1420)	50.3% (n=589)	49.7% (n=813)	
3-5 times	22.1% (N=630)	22.9% (n=268)	21.6% (n=353)	
6 or more times	8.3% (N=237)	7.3% (n=86)	9.0% (n=148)	
I eat five portions of fruit and vegetables a day				0.001
No times	5.4% (N=153)	6.7% (n=79)	4.2% (n=69)	
1-2 times	25.0% (N=712)	26.6% (n=311)	24.1% (n=394)	
3-5 times	41.6% (N=1183)	41.7% (n=488)	41.8% (n=684)	
6 or more times	28.0% (N=798)	25.0% (n=293)	29.9% (n=490)	
I have a salt intake of more than one teaspoon per day, including hidden salt (e.g., crisps and frozen meals)				0.190
No times	28.5% (N=812)	26.6% (n=312)	29.9% (n=490)	
1-2 times	52.9% (N=1506)	54.7% (n=641)	51.7% (n=846)	
3-5 times	14.5% (N=412)	14.2% (n=166)	14.7% (n=240)	
6 or more times	4.1% (N=116)	4.4% (n=52)	3.7% (n=61)	
Physical activity	1240.8 ± 922.1; 1080.0(1200.0) (N=2519)	1327.5 ± 984.2; 1140.0(1320.0) (n=1056)	1178.7 ± 871.0; 960.0(1140.0) (n=1429)	0.001
< 450 MET.min/week	21.1% (N=531)	20.1% (n=212)	21.8% (n=312)	
Mental health (HADS)				
HADS anxiety score	8.4 ± 4.8 (N=2846)	7.7 ± 4.5 (n=1171)	8.8 ± 4.9 (n=1637)	0.000
0 to 7; Normal	49.1% (N=1396)	55.3% (n=647)	44.8% (n=734)	
8 to 10; Borderline abnormal	19.1% (N=544)	18.8% (n=220)	19.6% % (n=321)	
11 to 21; Abnormal	31.8% (N=906)	26.0% (n=304)	35.6% % (n=582)	
HADS anxiety classification				0.000
HADS depression score	6.8 ± 3.6 (N=2846)	6.7 ± 3.5 (N=1171)	6.9 ± 3.6 (n=1637)	0.115
0 to 7; Normal	62.5% (N=1778)	65.6% (n=768)	60.8% % (n=995)	
8 to 10; Borderline abnormal	23.6% (N=673)	21.8% (n=255)	24.7% (n=404)	
11 to 21; Abnormal	13.9% (N=359)	12.6% (n=148)	14.5% (n=238)	
HADS depression classification				0.034
Workforce Well-being	38.5 ± 9.5 (N=2846)	39.2 ± 9.4 (n=1171)	38.2 ± 9.4 (n=1637)	0.004
Sickness absence days/year	5.1 ± 14.7; 0.0(4.0) (N=2846)	4.0 ± 11.4; 0.0(3.0) (n=1171)	5.8 ± 16.6; 1.0(4.0) (n=1637)	0.000
Presenteeism days/year	4.3 ± 18.9; 0.0(3.0) (N=2846)	3.6 ± 18.2; 0.0(2.0) (n=1171)	4.5 ± 18.4; 0.0(4.0) (n=1637)	0.000

Data are presented as mean ± SD and percentages and mean ± SD with median and (IQR) where applicable.

2.3.3 Predictors of sickness absence and presenteeism

2.3.3.1 Predictors of sickness absence

Sickness absence in the total sample was strongly influenced by several key factors, including the presence of subjective illnesses (Coef = 3.985), stress, depression, or anxiety (Coef = 2.653), and other unspecified illnesses (Coef = 4.359), where these conditions were associated with greater sickness absence due to the negative direction of the variables. Additionally, workplace factors such as shorter working hours (Coef = 0.033) and longer tenure with the same employer (Coef = 0.422) were positively linked to increased sickness absence. Furthermore, lifestyle factors such as lower physical activity (Coef = -0.024) and smoking (Coef = -0.113) significantly predicted higher sickness absence, suggesting that lower levels of physical activity and smoking contributed to greater absenteeism. (Table C2.5)

Table C2. 5: Predictors of sickness absence days; Total sample

Term	Term direction	Coef	Robust SE Coef	T-Value	P-Value	VIF
Subjective illness presence	Negative	3.985	1.012	3.937	0.000	3.285
Stress, depression, or anxiety	Negative	2.653	1.022	2.595	0.009	1.887
Infected with Covid-19	Negative	7.406	1.570	4.716	0.000	1.016
Other unmentioned illnesses	Negative	4.359	1.082	4.027	0.000	1.035
Working hours	Positive	0.033	0.008	4.232	0.000	1.100
Time spent with current employer	Positive	0.422	0.162	2.603	0.009	1.095
COVID-19 Impact on work efficiency	Positive	-0.644	0.257	-2.502	0.012	1.050
Physical activity level	Positive	-0.024	0.012	-2.074	0.038	1.033
Headache and/or eye strain	Negative	-3.777	1.076	-3.512	0.000	2.234
Smoking	Positive	-0.113	0.047	-2.423	0.015	1.027
Accident or illness (not work)	Positive	-0.123	0.027	-4.573	0.000	1.109

Term direction is not related to the Coef but rather the outcome. With higher scores, a positive direction reflects a better outcome, while a negative direction indicates a worse outcome.

2.3.3.3 Predictors of presenteeism days

In the total sample, presenteeism days were significantly associated with both psychological and physical ailments, specifically stress, depression, or anxiety (Coef = 6.786) and neck, shoulder or arm pain (Coef = 5.502). Workplace factors also played a critical role, with longer working hours (Coef = -0.038), reduced workplace pressure (Coef = 0.115), and decreased leadership support (Coef = -0.042) emerging as significant predictors of presenteeism. (Table C2.6)

Table C2. 6: Predictors of presenteeism days; Total sample

Term	Term direction	Coef	Robust SE Coef	T-Value	P-Value	VIF
Stress, depression, or anxiety	Negative	6.786	1.367	4.964	0.000	1.193
Neck, shoulder or arm pain	Negative	5.502	2.509	2.193	0.028	1.129
Arthritis (Family members)	Negative	0.752	0.378	1.991	0.047	1.041
Working hours	Positive	-0.038	0.012	-3.104	0.002	1.080
Workplace pressures	Positive	0.115	0.053	2.178	0.030	1.767
Workplace leadership support	Positive	-0.042	0.020	-2.092	0.037	1.323
Accident or illness (not work)	Positive	-0.081	0.036	-2.265	0.024	1.107

Term direction is not related to the Coef but rather the outcome. With higher scores, a positive direction reflects a better outcome, while a negative direction indicates a worse outcome.

2.4 Discussion

The aim of this study was to look at the lifestyle behaviour and other associated factors, including mental health, of office workers and whether it is possible to predict sickness absence and presenteeism. The majority of the participants were British, married, with a higher educational degree or equivalent, and occupied administration jobs. A significant difference between males and females was observed in age, employment status, job type, and annual salary. In addition, the majority of participants' BP values, males and females, were classified under hypertensive values and were within the normal BMI range. Regarding lifestyle, well-being, and mental health, the larger part of the population were non-smokers, consumed less than 14 units of alcohol per week, ate regular meals, and consumed fatty foods 1 to 2 times per week, with physical activity levels equating to more than 450 MET.min per week, and about 42% of participants, males and females consume five portions of fruit 3 to 5 times per week. Furthermore, the mean HADS score for anxiety for the total population was 8.4 ± 4.8, with a significant difference between males and females, with a similar significance observed in the well-being score. The mean sickness absence days per year was 5.1 ± 14.7 (0.0 (4.0)), with female participants significantly more absent than male participants, which was, in addition, the case for presenteeism. Sickness absence was linked to the presence of subjective illnesses, including stress, depression or anxiety, reduced physical activity, and smoking. Similarly, presenteeism was associated with stress, depression, or anxiety, as well as adverse workplace factors, such as extended working hours and reduced leadership support.

The mean systolic BP of this cohort (total population 124.9 ± 13.3, males 126.9 ± 11.2, and 123.1 ± 14.7) were in the range of elevated BP, with the majority of participants, males and females, falling under hypertension values (60.0%, 69.4% and 51.4%), and males were more likely to be classified under hypertensive values. A similarly high percentage, “the majority” of office workers (53.2%), were classified under hypertensive values as per Ofori and Obosi (2019), with the male gender as a predictor of hypertension. Nonetheless, several studies have identified that individuals with high elevated BP are at an increased risk of developing hypertension (Apostolides et al., 1982; Weissfeld and Kuller, 1985). Leitschuh et al. (1991) and Vasan et al. (2001) further confirmed this and reported that individuals with elevated BP increase the risk of developing hypertension twofold, with Vasan et al. (2001) adding that 37.3% of individuals with elevated BP below the age of 65 progress to hypertension. Furthermore, Sipahi et al. (2006) reported that even with acceptable BP (average of 127/76 mmHg), the increase in Systolic BP remains a significant factor in the development of coronary heart disease.

In the Scottish population, 37% were overweight, and 29% were obese (Minister for Public Health, Women's Health and Sport, 2020; The Scottish Health Survey, 2019); however, in our cohort, 36.1% were overweight, and 13.8% were obese. Being classified as overweight increases all cardiovascular disease risk factors, such as hypertension, left-ventricular hypertrophy, dyslipidaemia, and hyperuricemia (Kannel, D'Agostino and Cobb, 1996). Zhou et al. (2002) revealed that individuals with a BMI score of ≥ 28 had more than four times the risk of developing hypertension, more than 2.5 times of developing high fasting blood glucose levels, more than 2.3 times in the prevalence of low high-density lipoprotein cholesterol, and more than 1.8 times in the prevalence of high serum total cholesterol. In addition, in the Framingham Heart Study, Hubert et al. (1983) noted that weight is related to the rate of cardiovascular disease development.

Smoking behaviour within this cohort of office-based workers (8.1% of the participants, 8.6% of males, and 7.6% of females) was lower than those reported by the UK Office for National Statistics in 2021 (13.3% of the UK population, 15.1% of men, and 11.5% of females) and the 2021 Scottish Health Survey (11% of the Scottish population, 12% of men, and 11% of females) (UK Office for national statistics, 2022; The Scottish Health Survey, 2022), and in addition, was lower than what was reported by de Castro et al., (2010) in their sample of white-collar workers (10%). In addition, according to the Scottish Health Survey Dashboard and Health Survey for England 2019, 60% of the Scottish population and 57% of the English population consume less than 14 units of alcohol per week, slightly higher than what this cohort of office workers consume (51.5%) (The Scottish health survey, 2020; Health Survey for England, 2020).

In this cohort of office workers, only 21% (similar percentage in males and females) had a physical activity level lower than 450 MET.min/week. According to this, the majority of office workers were sufficiently physically active as they were meeting the American Heart Association guidelines for physical activity of a minimum of 150 minutes of moderate physical activity per week (3 MET.min x 150 min) (HASKELL et al., 2007). This was also observed in Clemes, O'Connell and Edwardson's (2014) study, where they analysed objectively measured physical activity in a cohort of office workers and concluded that time spent in moderate to vigorous physical activity was, on average, 32 minutes per day on working days and 28 minutes on non-working days, which translates to more than 150 min of moderate physical activity per week. Although the IPAQ, the questionnaire used to measure physical activity, has acceptable reliability and validity, several studies questioned its accuracy in detecting physical activity levels. Dahl-Petersen et al. (2013) and Sebastião et al. (2012) questioned the validity of the IPAQ in measuring different levels of physical activity, with the latter reporting overestimation in physical activity in both males and females. Boon et al. (2010) reported that the IPAQ tended to overestimate physical activity levels by 165% compared to ActiGraph data (accelerometer data). Therefore, more studies are needed to objectively measure physical activity in office-based jobs and take into account their bouts' duration rather than relying on the time spent in a specific activity.

Although the majority of office workers were within the normal range of anxiety (49.1% of the total sample, 55.3% of males and 44.8% of females) and depression (62.5% of the total sample, 65.6 of males and 60.8% of females), the mean scores for this population, males and females remain high in comparison (anxiety; 8.4 ± 4.8, 7.7 ± 4.5, 8.8 ± 4.9, depression; 6.8 ± 3.6, 6.7 ± 3.5, 6.9 ± 3.6, respectively). Hinz and Brähler (2011) reported a lower mean in both males and females in anxiety (4.4 ± 3.3, and 5.0 ± 3.6) and depression (4.8 ± 4.0, 4.7 ± 3.9). Similarly, Hannah, Batty and Benzeval (2013) reported lower anxiety and depression means for their sample (7.6 ± 3.9 and 4.3 ± 3.1) and in males and females (anxiety; 6.9 ± 3.8, 8.1 ± 4.0, and depression; 4.2 ± 3.1, 4.4 ± 3.1). Due to the scarcity of studies addressing depression and anxiety using the HADS questionnaire in office workers as well as the general population, further studies are needed to provide insight and valid comparison points for future studies addressing depression and anxiety.

Stress, depression or anxiety have been identified as significant predictors of both sickness absence and presenteeism in the workplace. In the UK, stress is the leading cause of work absence, and in addition, one out of six Americans reported they were extremely stressed (Griffin and Clarke, 2011), underscoring the pervasive nature of this issue. Furthermore, stress has been recognised as one of the top ten leading causes of work-related diseases, according to the National Institute for Occupational Safety and Health (Sauter, Murphy and Hurrell, 1990). These findings highlight the critical need for effective stress management strategies in occupational health programmes to mitigate the negative consequences on both individual health and organisational productivity.

The assessment of diet relied on self-constructed questions that incorporated different food types within a number of questions, thus making it difficult to quantify and assess. Similarly, the assessment of well-being in this project relied on the sum of other variables rather than using a valid and reliable measurement tool that is heavily incorporated within the literature. This may not have been ideal and may not have provided a good representation of this cohort of office workers' well-being, as there is a lack of cut-off points (thresholds) that help classify well-being and thus provide a better understanding of well-being scores.

The study aimed to understand the lifestyle behaviour and other factors, including mental health, of office-based workers. A strength of this project was the large number of recruited office workers with a wide range of job types. In addition, the wide range of acquired data, including occupational, psychological, medical, and lifestyle data, helped provide insight as well as a good understanding of office workers' lives holistically. However, two main drawbacks were associated with this study. The first drawback was the reliance on self-reported data, as participants provided all the data by answering the assessment forms without help or guidance from the assessment team. This may have led to a lack of understanding of some questions, thus answering the questions inconsistently, and may have resulted in overestimation due to social desirability bias (HEBERT et al., 1995). The second drawback was the integration of self-constructed questionnaires by the Workwell group. A number of critical limitations are associated with self-constructed questionnaires, primarily the lack of reliability and validity, bias, and lack of comparability. The reliability and validity concerns stem from the absence of rigorous validation processes that guarantee the assessment tool's consistency, repeatability, and precision in measuring the intended constructs. This includes testing and re-testing for consistency (reliability) (Urbina and Monks, 2023) and establishing a proper relationship between the questionnaire's content and the construct intended to measure (validity), which refers to the assessment tool's themes, wording, and formatting (Beckman, Cook and Mandrekar, 2005). Bias is another significant issue, as the researcher's personal opinions, beliefs, and perspectives may influence the wording and structure of the questions, potentially influencing respondents' answers. Furthermore, the lack of comparability with standardised assessment tools prevalent in the literature hampers the ability to compare findings against other studies or to generalise the results beyond the specific study.

2.5 Conclusion

The aim of this study was to look at the lifestyle behaviour and associated factors, including mental health, of office workers and whether it is possible to predict sickness, absence and presenteeism. A number of health concerns were observed within this cohort of office workers, including the majority of the population being classified under the Stage 1 hypertension category and a large number classified as overweight. Mental health issues were apparent, as 50.9% and 37.5% of the population reported signs of anxiety and depression, respectively, with stress, depression or anxiety emerging as key predictors of sickness absence and presenteeism days. Despite these concerns, physical activity levels were in line with the NHS's recommendations, with an average of 1240.8 MET.min/week.

Chapter 3 Workplace health promotion programme for construction workers: a systematic review

3.1 Introduction

Unhealthy lifestyle factors such as lack of physical activity, poor nutrition, smoking, poor sleep and living with obesity are major risk factors for chronic illnesses (Reilly et al., 2003; World Health Organization, 2003). In construction workers, the prevalence of both overweight and obesity is higher when compared to the general population (Viester et al., 2018; Proper and Hildebrandt, 2010; Arndt et al., 1996). This may result in negative effects on their work, such as lower productivity as well as more sick leave (Viester et al., 2018; Alavinia et al., 2009). In addition, workplace factors, including high job demands, work-related stress, shift work, and prolonged working hours, can have a substantial impact on employees' overall health, well-being, and health-related behaviours (Schroer, Haupt and Pieper, 2014). From an organisational perspective, the health status of employees is closely linked to their productivity levels, with poor health leading to a decline in productivity due to increased absenteeism, lost workdays, and sick leave, thereby affecting organisational profitability (Cancelliere et al., 2011). Consequently, workplace health promotion programmes have been widely adopted as a strategic approach to alleviate the growing burden of illnesses.

The goals of workplace health promotion programs are to prevent, eliminate, and minimise health risks, promote, improve, or maintain work-related outcomes, as well as make the work environment a safer place by changing work and techniques (Naumanen, 2006). Workplace health promotion and primary prevention programs can be applied in many ways, such as targeting an individual's behaviour (Anderson et al., 2009) or targeting the workplace environment (McEachan et al., 2011; Makrides et al., 2008).

Workplace health promotion and primary prevention programs are becoming increasingly prevalent. However, their overall impact remains unclear (Anderson et al., 2009; Burn et al., 2019). In addition, the majority of workplace health promotion and primary prevention programs target office-based workers and other affluent professions, with a minimal application of these interventions within the construction industry. This systematic review aims to identify, synthesise and report current evidence on the effectiveness of workplace health promotion and prevention programs in improving the lifestyle behaviour and weight of construction workers.

3.2 Methods

3.2.1 Protocol and Registration

This systematic review was registered with PROSPERO, the International Prospective Register of Systematic Reviews (registration number CRD42022325902; access link https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022325902). In addition, this systematic review was reported using PRISMA, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement for reporting systematic reviews and meta-analyses (Moher et al., 2015) (Appendix C3.A).

3.2.2 Eligibility criteria

Table C3.1 presents the PICO framework for this systematic review, along with terms used in each PICO domain.

Table C3.1: PICO framework and terms used

Population: Construction workers **Terms:** Construction, Construction worker, Industrial worker, Blue-collar worker, Builders, Laborer, Labourer, Worker, Engineer, Inspector, Surveyor, Manager, Director, Estimator, Carpenter, Joiner, Plasterer, Roofer, Glazier, Painter, Electrician, Plumber, Pipe Fitter, Mason Concrete, Elevator Mechanic, Crane Operator, Crane driver, Equipment Operator, Building industry.
Intervention: workplace interventions delivered during working hours and within the workplace **Terms:** Occupational health, Occupational intervention, Workplace intervention, Workplace health, Worksite intervention, Worksite health, Health promotion, Health program.
Comparator: Any intervention
Outcome (primary): Physical activity (such as meeting guidelines and increasing weekly duration), exercise (exercise-specific outcomes, such as Vo2max), dietary intake, weight, and smoking **Terms:** Physical activity, Exercise, Diet, Nutrition, Smoking, Smoking reduction, Smoking cessation, Weight, Body weight, BMI. **Additional outcomes, if reported in the included studies:** cardiovascular diseases and diabetes biomarkers, mental health, sleep and quality of life, and work-related outcomes (presenteeism, absenteeism, and productivity).

To be eligible for inclusion in this review, studies had to be workplace interventions targeted at construction company employees (18 years and above). This systematic review targeted the term workplace intervention and, thus, refers to any intervention delivered during working hours and within the workplace and/or performed within it. This may include, for example, exercise interventions during breaks or diet counselling programs with take-home messages delivered to improve diet. The types of interventions that were considered eligible had to be lifestyle, physical activity, exercise, diet, smoking, counselling, and education, all of which had to have an association with the improvement of physical activity, exercise, diet, weight, and smoking habits. Moreover, studies had to include a quantitative analysis of the intervention's effectiveness on physical activity, exercise, diet, weight, and smoking regardless of the time point measured. Inclusion in this systematic review required studies to be written or available in English and published. Grey literature, such as abstracts, dissertations, and conference summaries, were not considered for inclusion. Exclusion criteria encompassed studies that targeted interventions for joint or musculoskeletal injuries, pain, stiffness, and soreness. Studies that incorporated interventions that did not directly address physical activity, diet, weight, and smoking habits, or those that were not workplace-based, were also excluded. In addition, studies that did not incorporate construction workers or did not conduct a sub-analysis for this demographic were not considered.

3.2.3 Search Strategy

Studies were identified using electronic searches of online databases published up to August 08, 2020. The following four databases were used: EMBASE, MEDLINE, CENTRAL and Web of Science. The main concepts of the search were: 1) Construction workers, 2) Workplace intervention or Workplace health promotion, 2) Physical activity, diet, and smoking (lifestyle behaviours), and 4) body weight. The search strategy's aim was to identify all relevant studies; thus, specific keywords, thesaurus, and medical subject headings (MeSH) were used for each concept. The search was limited to include only human studies published in English or available in English that were eligible for inclusion and had no limit on the publication period. Refer to Table C3.2 for search strategy results and search strategy.

The included references were imported to the Mendeley reference manager. Subsequently, these were uploaded to the Covidence web service, a web-based tool designed to facilitate the systematic review screening process. Following the removal of duplicates, two independent reviewers (the primary H.A. and secondary reviewer A.A.) reviewed article titles and abstracts for eligibility according to the eligibility criteria using the Covidence web service. Each title and abstract were assessed independently by the two reviewers, and if they did not agree, a third reviewer was consulted (M.A.). Similarly, eligible articles underwent full-text retrieval and were reviewed by the two independent reviewers and, if still eligible, data extraction. The main author was contacted for any missing data or information.

Table C3.2: Search strategy results and search strategy

Search results for each database until August 08, 2020 (Total: 20044 records) **Embase:** 6806 records - **refer to Appendix C3.B for Search strategy** **Medline:** 4374 records - **refer to Appendix C3.B for Search strategy** **CENTRAL:** 5058 records - **refer to Appendix C3.B for Search strategy** **Web of Science:** 3806 records
Search strategy, Web of Science: ALL=(construction OR "construction worker$" OR "Industrial worker$" OR "blue-collar worker$" OR blue collar worker$ OR Builders OR Laborer$ OR Labourer$ OR worker$ OR Engineer$ OR Inspector$ OR Surveyor$ OR Manager$ OR Director$ OR Estimator$ OR carpenter$ OR Joiner$ OR Plasterer$ OR Roofer$ OR Glazier$ OR painter$ OR electrician$ OR Plumber$ OR Pipe Fitter$ OR Mason$ OR concrete$ OR Elevator Mechanic$ OR Crane Operator$ OR Crane driver$ OR Equipment Operator$ OR "Building industry") **And** ALL=("occupational health" OR "work$place intervention" OR "work$place health" OR "work$site intervention" OR "work$site health" OR "health promotion" OR "health program") **And** ALL=("Physical activity" OR Diet* OR Nutrition* OR Exercise* OR Smoking OR "Smoking cessation" OR "Smoking reduction" OR Obesity OR Overweight OR Weight OR Body$weight)

3.2.4 Data Extraction

Data extraction criteria were developed before commencing the systematic review, and data extraction was performed by the primary reviewer (H.A.). A data extraction table was developed containing 11 elements: 1) First author and study date, 2) Country, 3) Study design, 4) Sample size and setting, 5) Socio-demographic characteristics such as age, sex, ethnicity, and if available markers of income levels or education, 6) Intervention type, 7) Intervention delivery (e.g. leaflets, supervised exercise), 8) Intervention content, 9) Intervention duration, 10) Primary and additional outcomes, and 11) results in relation to the primary outcomes and if reported the additional outcomes. Additionally, intervention components were extracted for each included study using the TIDieR checklist (why, what, who provided, how, where, when and how much, tailoring, modification if occurred).

3.2.5 Quality Assessment

Methodological quality and sources of potential bias were assessed by two independent reviewers (H.A. and A.A.) using the National Heart, Lung, and Blood Institute (NHLBI) quality assessment tool (NHLBI, 2013). If discrepancies were present at any given stage, the third reviewer (M.A.) was consulted to reach a consensus. The NHLBI assessment tool was used to appraise the title, abstract, introduction or background, methods, results and discussion. The NHLBI assessment tool classifies studies into three tiers according to the quality assessment: Good, which is the equivalent of high quality; Fair, which is the equivalent of intermediate quality; and lastly, Poor. 'Good' signifies a study possessing minimal bias risk, rendering its results valid. 'Fair' encompasses studies with a potential for bias, not to an extent that would compromise the validity of the results. Conversely, 'Poor' encompasses studies exhibiting a substantial bias risk, invalidating its results. The classification of studies is determined by the quality assessor's judgment.

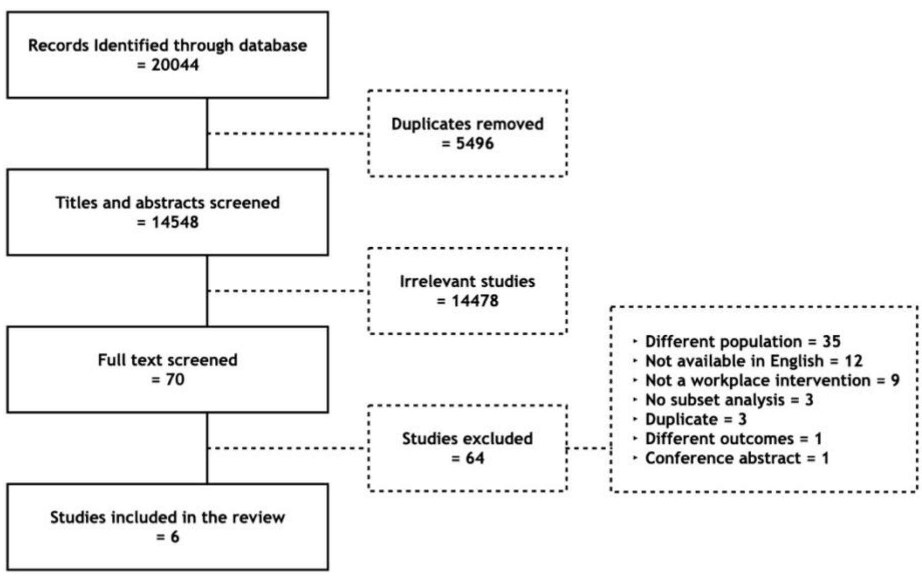
3.2.6 Analysis

A narrative synthesis was done via collecting, summarising and result reporting to identify intervention and their outcomes (Levac, Colquhoun and O'Brien, 2010).

Narrative tables were used for all included studies, and for each type of intervention, related outcomes and results were used to group similar outcomes close to each other and, thus, assess their effectiveness thoroughly, with primary emphasis on significant improvements. As the aim of this review was to identify and synthesise, an evidence synthesis was performed to assess the effectiveness of an intervention based on the quality of the study and the significance/non-significance of the outcome measures (Best evidence synthesis) (Table C3.3) (van Poppel et al., 1997; Bernard, 1997; Groeneveld et al., 2010). Consistency of the result is when at least 75% of the studies had the results in the same direction (van Poppel et al., 1997; Groeneveld et al., 2010).

Table C3.3: Best evidence synthesis criteria

Criteria grade	Criteria condition
Strong evidence	Consistent statistical significance results between two or more good-quality studies
Moderate evidence	Consistent statistical significance results between one good-quality study and one or more fair-quality studies or two or more fair-quality studies
Insufficient evidence	Indicates the identification of a single study or inconsistent results across other studies
No association	Indicates consistent results of no association in two or more studies



Flowchart C3.1: Flow chart of the inclusion process

3.3 Results

3.3.1 Study selection and characteristics of included studies

In total, six studies with five interventions were included in this systematic review (flowchart C3.1). The main reasons for exclusion were not targeting construction workers (different populations, n=35), with other reasons including not having a workplace intervention study (n=9), did not include a subset analysis for construction workers (n=3), or different outcomes of interest (n=1). The included studies were from three countries: the Netherlands (Viester et al., 2018; Hengel et al., 2013; Viester et al., 2015), the United States (Anger et al., 2018; Peters et al., 2018), and Denmark (Gram et al., 2012) (Table C3.4). The majority of the included studies were conducted within one company (Viester et al., 2018; Anger et al., 2018; Gram et al., 2012; Peters et al., 2018; Viester et al., 2015), and only one included multiple worksites (Hengel et al., 2013). The designs of included studies were randomised control trials (Viester et al., 2018; Gram et al., 2012; Viester et al., 2015), cluster randomised control trials (Hengel et al., 2013; Peters et al., 2018), and a pre-and-post pilot study (Anger et al., 2018). The total number of recruited participants from studies included in this systematic review was N=1320; the smallest study size was N=35 (Anger et al., 2018), and the largest study size was N=607 (Peters et al., 2018). All of the included studies had physical activity or exercise as part of the intervention; three studies had dietary components (Anger et al., 2018; Peters et al., 2018; Viester et al., 2018), while only two studies had smoking reduction as part of the intervention (Anger et al., 2018; Peters et al., 2018). All of the included studies had their intervention delivered in the workplace.

Table C3. 4 Characteristics of included studies and summary of their findings

Author	Quality	Country	Study type	Population	Intervention	Duration	Time points measured	Outcome measures	Results
Anger et al. (2018)	Fair	United States	Pre and post Pilot	Construction crew (N=35)	Healthier behaviours and lifestyle training	14-weeks	Pre and post	Injury, Pain, Job satisfaction, Occupational stress, Well-being, Nutrition, Alcohol, Smoking, Caffeine, Exercise, Sleep, Safety behaviour, Family-supportive supervisory behaviours, Team cohesion, Diet and exercise social support, Basic reaction, Basal metabolic index, Weight, Grip strength, BP	A significant reduction in sugary drinks and sugary snack consumption. Social support for a healthy diet and sabotage by family increased significantly. Exercising 30 minutes/day and muscle strengthening or toning increased significantly, and all except one of the other exercise measures improved but not significantly. Sleep duration increased significantly, but snoring frequency increased significantly. Systolic BP decreased significantly; no other significant changes in biomarkers
Gram et al. 2012	Good	Denmark	RCT	Construction workers (N=67), Intervention n=35 Control n=32	Individually tailored exercise intervention	12-weeks	Pre and post	VO2max, Maximal voluntary contraction, BMI, Fat percentage, BP, Blood lipid profile	Significant increase in VO2max in the intervention group, with VO2max/kg body weight significantly increased in the intervention group. No significant changes were found in isometric maximal muscle strength, BMI, fat percentage, BP, and blood lipid profile
Hengel et al. (2013)	Fair	Netherlands	Cluster RCT	Construction worksite (N=293), Intervention n=171 Control n=122	Physical and mental prevention program	6-months	Pre, 3, 6, and 12 months	Work-ability, Physical and mental health status, Musculoskeletal symptoms, Sick leave	No overall intervention effect on workability and no significant effects on either physical or mental health status. A non-significant intervention effect in the intervention group was noted, with fewer sick leaves and fewer reported musculoskeletal disorders
Peters et al. (2018)	Fair	United States	Cluster RCT	Construction workers (N=607), Intervention n=324 Control n=283	Soft tissue injury prevention program and health education	6-months	Pre, 5 weeks, 6 months	Musculoskeletal pain and injury, Dietary behaviours, Physical activity, Smoking status, Ergonomic practices, Work limitations, Job's physical demands	In the intervention group and after adjusting for covariates, a 42% reduction in the risk of having new pain or injury, a significant increase in time spent in recreational physical activity, a significant positive influence in healthier diet behaviours with a non-significant improvement in having a more balanced diet, and a slight significant improvement in ergonomic practices were observed
Viester et al. (2015)	Good	Netherlands	RCT	Construction workers (N=314), Intervention n=162 Control n=152	Tailored lifestyle coaching programme	6-months	Pre, 6, and 12 months	Musculoskeletal symptoms, Physical functioning, Work-related measures	The intervention did not result in statistically significant effects on musculoskeletal symptoms, physical functioning, work-related vitality, work performance, workability, and sickness absence; however, the odds ratios were in favour of the intervention group for back and lower extremity symptoms
Viester et al. (2018)	Good	Netherlands	RCT	Construction workers (N=314), Intervention n=162 Control n=152	Tailored lifestyle coaching programme	6-months	Pre, 6, and 12 months	Body weight, BMI, WC, BP, Blood cholesterol, Physical activity, Dietary intake	At 6 months, there was a significant intervention effect on body weight and WC, meeting the public health guideline of vigorous physical activity, and sugar-sweetened beverage intake was found after 6 months. However, no significant intervention effects were found on diastolic or systolic BP or total cholesterol levels

Table C3.5. Quality assessment tool (The National Heart, Lung, and Blood Institute (NHLBI) quality assessment tool)

Quality assessment tool	Anger 2018 (Fair)	Gram 2012 (Good)	Hengel 2013 (Fair)	Peters 2018 (Fair)	Viester 2015 (Good)	Viester 2018 (Good)
Quality assessment of controlled intervention studies						
Was the study described as randomised, a randomised trial, a randomised clinical trial, or an RCT?	NA	Yes	Yes	Yes	Yes	Yes
Was the method of randomisation adequate?	NA	Yes	Yes	Yes	Yes	Yes
Was the treatment allocation concealed?	NA	Yes	No	Yes	Yes	Yes
Were study participants and providers blinded to treatment group assignment?	NA	No	No	No	No	No
Were the people assessing the outcomes blinded to the participants' group assignments?	NA	NR	No	No	Yes	Yes
Were the groups similar at baseline on important characteristics that could affect outcomes (e.g., demographics, risk factors, co-morbid conditions)?	NA	Yes	Yes	Yes	Yes	Yes
Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment?	NA	Yes	No	No	Yes	Yes
Was the differential drop-out rate (between treatment groups) at the endpoint 15 percentage points or lower?	NA	Yes	Yes	Yes	Yes	Yes
Was there high adherence to the intervention protocols for each treatment group?	NA	Yes	NR	NR	NR	NR
Were other interventions avoided or similar in the groups (e.g., similar background treatments)?	NA	Yes	Yes	Yes	Yes	Yes
Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?	NA	Yes	Yes	Yes	Yes	Yes
Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?	NA	Yes	Yes	Yes	Yes	Yes
Were outcomes reported or subgroups analysed prespecified (i.e., identified before analyses were conducted)?	NA	Yes	Yes	Yes	Yes	Yes
Were all randomised participants analysed in the group to which they were originally assigned, i.e., did they use an intention-to-treat analysis?	NA	NR	Yes	NR	NR	NR
Quality assessment tool for Pre-Post studies with no control group						
Was the study question or objective clearly stated?	Yes	NA	NA	NA	NA	NA
Were eligibility/selection criteria for the study population prespecified and clearly described?	No	NA	NA	NA	NA	NA
Were the participants in the study representative of those who would be eligible for the test/service/intervention in the general or clinical population of interest?"	Yes	NA	NA	NA	NA	NA
Were all eligible participants that met the prespecified entry criteria enrolled?	Yes	NA	NA	NA	NA	NA
Was the sample size sufficiently large to provide confidence in the findings?	No	NA	NA	NA	NA	NA
Was the test/service/intervention clearly described and delivered consistently across the study population?"	Yes	NA	NA	NA	NA	NA
Were the outcome measures prespecified, clearly defined, valid, reliable, and assessed consistently across all study participants?"	Yes	NA	NA	NA	NA	NA
Were the people assessing the outcomes blinded to the participants' exposures/interventions?	No	NA	NA	NA	NA	NA
Was the loss to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?"	NR	NA	NA	NA	NA	NA
Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided p values for the pre-to-post changes?"	Yes	NA	NA	NA	NA	NA
Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e., did they use an interrupted time-series design)?"	No	NA	NA	NA	NA	NA
If the intervention was conducted at a group level (e.g., a whole hospital, a community, etc.) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?"	NR	NA	NA	NA	NA	NA

NA = Not Applicable and NR = Not Reported

3.3.2 Risk of bias (quality assessment)

50% of the included studies were of fair quality (Anger et al., 2018; Hengel et al., 2013; Peters et al., 2018), while the rest were of good quality (Gram et al., 2012; Viester et al., 2018, 2015). All RCT studies were adequately randomised; however, RCTs classified as good had both the intervention provider and participant blinded and with an intervention drop rate of 20% or less (Gram et al., 2012; Viester et al., 2015, 2018). Further details on quality assessment can be seen in Table C3.5.

3.3.2 Interventions components in accordance with the TIDieR checklist

Interventions were diverse in the included studies, with all interventions delivered in the workplace and applied during working hours, such as exercise programs or education and counselling programs with take-home messages.

Anger et al. (2018) pre-and-post intervention aimed to assess the impact of a 14-week Total Worker Health intervention program designed specifically for construction workers. The intervention was administered by recruited supervisors who were trained by the research team to integrate the intervention at the worksite. The intervention consisted of two components: (i) a computer-based training module for supervisors, augmented by a self-monitoring app, aimed at enhancing the frequency and quality of their interactions with employees and reinforcing safe work practices and healthy lifestyles, and (ii) the 'Get Healthier' scripted lifestyle training cards, which focused on various health-related topics discussed in small groups of supervisors and employees, with take-home sheets to reaffirm the discussed topics. To gauge the effectiveness of the program, surveys were conducted pre-and post-intervention. Prior to the intervention, supervisors completed a 90-minute training session on team building and behaviour reinforcement and then started a two-week goal-based tracking period to record job and family-related interactions with their employees using the HabiTrack application on an iPod touch provided by the researchers or downloaded to their own devices if they preferred. In the third week, supervisors underwent a 30-minute computer-based training, the first component (i), designed in accordance with behavioural education principles aimed at fostering sustainable and efficacious interaction levels with employees, regarding both work and home activities. The implementation proceeded as follows: increasing interaction frequency (weeks 3-4), reinforcing safety behaviours (weeks 5-8), and reinforcing well-being behaviours (weeks 9-14). The second component (ii), the 'Get Healthier' cards, involved weekly group meetings that lasted 30 minutes each for a period of 12 weeks. Here, a nominated leader, either a supervisor or employee, facilitated discussions on lifestyle topics within the group, followed by take-home sheets.

Gram et al. (2012) randomised control trial aimed to assess if an individually tailored exercise intervention would increase aerobic capacity, maximal oxygen consumption (VO2max), and muscle strength of construction workers. The intervention comprised personalised training programs lasting for 12 weeks, with each session spanning an hour a week, divided into three 20-minute slots versus a control group that received only a one-hour lecture on general health promotion. These sessions were monitored by skilled instructors at or near the workplace during work hours. The training programs consisted of aerobic and strength exercises tailored to the estimated VO2max and the maximal muscle strength of the neck, shoulder, abdomen, back, hip, and knee. The tailoring of these exercises was informed by a comprehensive health check-up conducted prior to the 12-week program to assess VO2max, isometric muscle strength, BMI, body fat percentage, blood pressure, and blood lipid profile. The participants were promptly notified of their results. The results of these individual tests were compared to reference values from the Danish working population, and only the training elements corresponding to test values exceeding 80% of the reference values were incorporated into the individual training instruction. Every training session featured a ten-minute warm-up and aerobic capacity exercises, followed by an additional ten minutes of personalised exercises. The intensity of muscle strength training was set at 60% of one repetition maximum, while the aerobic capacity training required at least 70% of VO2max. Aerobic capacity exercises were bicycling and rowing, while the strength training exercises were selected from the following exercises: shrugs, lateral raises, and rows for the neck and shoulder; bird dog, back extensions, crunches, planks, and oblique crunches for the abdomen and back; and step-ups, static lunges, and hip abductions for the hip and knee. Each participant was given a training diary to record their individual exercise protocol after each session. To evaluate the effectiveness of the intervention, measurements were recorded both before and after its implementation.

Hengel et al. (2013) cluster randomised controlled trial sought to assess the efficacy of a worksite prevention program specifically intended for construction workers, with the objective of enhancing their workability along with their mental and physical health statuses. This was a six-month prevention program that consisted of both a physical and mental component versus a control group that received no intervention. (i) The physical component was supervised by a physical therapist and constituted two individualised training sessions, each extending for a duration of 30 minutes. During the first session at the worksite, the therapist devised three individually targeted recommendations for attenuating the workload based on a brief questionnaire and an observational period of 15 minutes at the worksite. Moreover, the physical therapist introduced a rest-break tool, highlighting the critical role of flexible rest breaks in mitigating fatigue. Workers were instructed to complete this tool on a weekly basis and discuss it with their supervisor. During the second training session at the worksite four months after the first, the therapist engaged in a discussion regarding the workers' experiences and evaluated the effectiveness of earlier advice. (ii) The mental component was delivered by an empowerment trainer and consisted of two interactive empowerment training sessions lasting one hour at the worksite. The goal of these training sessions was to improve the influence of construction workers at the worksite in terms of assuming responsibility for their own health, engaging in discussions with colleagues about personal behavioural accountability, and enhancing communication with the supervisor. In the first training session, workers compiled a list of topics they wished to address during the intervention period, leading to the creation of a signed action plan. During the follow-up meeting four months later, the workers and empowerment trainer discussed the action plan, and the results achieved. To gauge the effectiveness of the intervention, data were collected at baseline, 3, 6, and 12 months follow-up.

Peters et al. (2018) cluster randomised control trial of 10 worksites aimed to assess the effectiveness of “All the Right Moves” (ARM), an integrated Total Worker Health program designed to improve work conditions and workers’ health behaviours through an ergonomics program combined with a worksite-based health promotion programme. The ARM intervention was designed to be integrated into the companies' existing safety and health practices on-site and was delivered by the research team and trained safety managers versus a control group that received no intervention. The ARM program contained two main components: (i) A soft tissue injury prevention program aimed at enhancing ergonomic practices and musculoskeletal health at the worksite, and (ii) Health Week, providing individual workers with health coaching opportunities to improve health behaviours and ergonomic practices. One week prior to the intervention, each worksite underwent a pre-intervention inspection. This facilitated foreman training and one-on-one training for safety managers, equipping them to identify potential soft tissue hazards and ergonomic practices. To evaluate the intervention's efficacy, workers were asked to complete on-site surveys in three distinct phases: at the baseline, following the completion of the soft tissue injury prevention program (follow-up 1), and six months post Health Week (follow-up 2).

The soft tissue injury prevention program (i) was implemented six weeks before Health Week and targeted organisational practices and physical job demands by creating a system to control worksite hazards. The control system was based on worksite inspections and feedback, task pre-planning, and supervisor and worker training. Each week, the research team and safety managers compiled an inspection report, providing crucial feedback to the foreman and the crew. For task pre-planning, a checklist was used to identify potential soft tissue injury hazards from manual material handling tasks, and to apply ergonomic solutions. Supervisor training was initiated at the start of the intervention, involving mandatory weekly foreman training that included safety managers. The training curriculum covered the intervention program activities, injury hazards, and ergonomic solutions identified during the initial worksite inspection. Similarly, workers underwent training through an “Ergonomic Toolbox Talk” at the start of the intervention, which delivered key messages from the supervisor training.

The second component (ii), Health Week, was a health promotion intervention targeting psychological factors and individual health-related behaviour. It provided health education through toolbox talks, including one-on-one discussions, and linking workers with relevant resources to enhance their health behaviours. Toolbox talks took place daily during Health Week and during workers’ breaks, covering topics such as health coaching benefits, soft tissue injury prevention, smoking cessation, and energy balance. These sessions were facilitated by toolbox cards and scripts developed by the research team and a health promotion consultant.

Viester et al. (2018) and Viester et al. (2015) randomised controlled trial aimed to (i) evaluate the effectiveness of an individually tailored intervention for improvement in lifestyle behaviour, health indicators, and prevention and reduction of overweight among construction workers, and (ii) assess the effect a worksite health promotion intervention on musculoskeletal symptoms, physical functioning, workability, work-related vitality, work performance, and sickness absence, respectively. This was a six-month tailored intervention program that was implemented face-to-face at the worksite during working hours and via telephone by health professionals trained specifically for this study (personal health coaches) versus a control group that only received usual care. The six-month tailored intervention program was divided into five sessions: two weeks face-to-face at the worksite, followed by sessions at one, two, three, and four months, respectively, conducted via telephone calls. Tailoring of the intervention was based on the participant's weight status (BMI and waist circumference (WC)), physical activity level, and stage of change during the initial face-to-face baseline measurement session. The intervention commenced two weeks after the baseline measurement session, where participants received personalised feedback on their baseline measurements and current lifestyle behaviour, were provided with training instructions, and were supported in self-monitoring of behaviour, goal setting, and evaluation. Additionally, participants received personal energy plan forms to record their goals and action plans that could be used during the follow-up health coaching sessions, and the 'VIP in Construction' toolbox, which included an overview of the company's health-promoting facilities, a waist circumference measuring tape, a pedometer, a BMI calculator, a calorie guide, recipes, and knowledge tests. To assess intervention effectiveness, outcomes were measured at baseline, 6 and 12-month follow-ups.

3.3.3 Intervention effectiveness

3.3.3.1 Physical activity and Exercise related outcomes

Four Studies reported at least one physical activity or exercise-related outcome. For physical activity, moderate evidence was noted (one of fair quality and one of good quality), as two intervention studies revealed that workplace interventions contributed to the improvement of physical activity. The study conducted by Peters et al. (2018) (Fair) revealed a significant increase in recreational physical activity, while Viester et al. (2018) (Good) observed a significant increase in meeting public health guidelines for vigorous physical activity.

Similarly, for exercise-related outcomes, two intervention studies reported improvement in exercise-related outcomes and thus, moderate evidence was noted (one fair and one good quality). Anger et al. (2018) (Fair) reported that daily exercise for a duration of 30 minutes was linked with a significant increase in muscle strength or muscle tone, while Gram et al. (2012) (good) noted a significant increase in the maximum rate of oxygen consumption (Vo2 max) among the participants.

3.3.3.2 Diet-related outcomes

Three research studies examined the effects of interventions on dietary outcomes. Moderate evidence was noted that interventions could reduce the consumption of sugar-sweetened beverages (one good and one fair quality study). Viester et al. (2018) (Good) showed that the intervention group significantly decreased their intake by one glass per week after six months, whereas the control group demonstrated an increase in consumption, and similarly, Anger et al. (2018) (fair) reported a significant reduction in sugary drinks consumption.

In addition, other insufficient evidence included a significant reduction in the consumption of sugary snacks per Anger et al. (2018). Moreover, Peters et al. (2018) detected a significant positive influence on healthier dietary behaviours, with a near-significant improvement in maintaining a balanced diet.

3.3.3.3 Weight-related outcomes

Three studies assessed at least one weight-related outcome (Viester et al., 2018; Anger et al., 2018; Gram et al., 2012), and two of these did not demonstrate any significant improvement (Anger et al., 2018; Gram et al., 2012); thereby yielding insufficient evidence concerning weight-related outcomes. However, Viester et al. (2018) (Good) intervention did exhibit a significant effect on body weight and WC after six months. The intervention group demonstrated a decrease in WC at both the 6 and 12-month follow-ups. At the 12-month follow-up, analyses within groups revealed that the intervention group had a reduced WC, while the control group had an increase in body weight and BMI compared to their baseline values and remained significant. However, the between-group analyses for body weight, BMI, and WC were not statistically significant.

3.3.3.4 Smoking-related outcomes

Insufficient evidence of intervention effects on smoking was noted, as only two studies incorporated smoking as an intervention component, and neither demonstrated a statistically significant effect (Anger et al., 2018; Peters et al., 2018). Peters et al. (2018) (Fair) reported only marginal change in smoking behaviour and tobacco consumption, with a cessation rate of only two individuals. Conversely, the study by Anger et al. (2018) (Fair) indicated a significant, unfavourable increase in the usage of non-cigarette tobacco products.

3.3.3.5 Other outcomes of interests

Other outcomes of interest included cardiovascular biomarkers, work-related outcomes, sleep and mental health. Three studies (Viester et al., 2018; Anger et al., 2018; Gram et al., 2012) considered cardiovascular biomarkers within their respective outcome variables. However, there was a lack of significant intervention effects and thus, insufficient evidence was noted. This was indicated by the fact that two out of the three studies did not report any intervention effect on cardiovascular biomarkers. Specifically, the intervention implemented by Gram et al. (2012) (Good) failed to present any significant intervention effect on the fat percentage, blood pressure (BP), high-density lipoprotein (HDL), low-density lipoprotein (LDL) cholesterol, and triglyceride levels. Similarly, Viester et al. (2018) (Good) intervention did not observe any significant change in diastolic or systolic BP and total cholesterol levels. On the contrary, only the intervention employed in the study by Anger et al. (2018) (Fair) reported a significant reduction in systolic BP; however, no other biomarker changes were observed.

A total of four research studies (Anger et al., 2018; Hengel et al., 2013; Peters et al., 2018; Viester et al., 2015) assessed at least one work-related outcome, and despite this, the interventions had no significant effect. However, Hengel et al. (2013) (Fair) reported a non-significant reduction in the prevalence of long-term sick leaves in their intervention group. Regardless, the overall observations yielded insufficient evidence of intervention effect.

Insufficient evidence was recorded for sleep, and no association was noted for mental health outcomes. In the intervention study conducted by Anger et al. (2018) (Fair), a significant increase in sleep duration was observed; however, the snoring frequency experienced a significant increase, and no significant changes were observed in the other six sleep-related measures. Correspondingly, the study by

Hengel et al. (2013) (Fair) evaluated mental health-related outcomes, and it did not elicit any discernible effects from the intervention.

3.3.4 Summary

Although the results may have presented limited improvements in physical activity, exercise, and reduction of sugar-sweetened beverage consumption within our synthesis, these findings should be interpreted with caution due to the heterogeneity between included studies in terms of interventions, and in addition, there was a lack of information about the full content provided in the health education (Gram et al., 2012; Peters et al., 2018), scripted lifestyle training cards (Anger et al., 2018) and toolbox talks (Viester et al., 2015, 2018). Therefore, the results may be limited and should not be taken as conclusive evidence of effectiveness.

3.4 Discussion

The aim of this systematic review was to identify, synthesise and report current evidence on the effectiveness of workplace health promotion and primary prevention programs in improving the lifestyle behaviour of construction workers (physical activity, diet, and smoking) and weight. An abundant number of workplace interventions were found in the literature; however, only a small number of them addressed construction workers through the workplace, and as a consequence, a relatively small number of interventions were included in this review. This systematic review included six intervention studies, with quality ranging between good and fair. The interventions in this review often included the outcomes of interest and other outcomes that were not the focus of this review and, in addition, included a variety of intervention types. The intervention types included within this systematic review contained individually tailored exercise interventions, lifestyle training programs, health education programs, and lifestyle coaching programs.

In general, the studies included in the systematic review demonstrated limited evidence of effectiveness on overall outcomes of interest. However, despite these limited effects, a number of studies noted moderate evidence for improving physical activity-related outcomes, moderate evidence for improving exercise-related outcomes, and moderate evidence for the reduction of sugary sweetened beverages. In addition, other positive intervention effects were demonstrated in the included studies, including a significant sugary snack consumption reduction, a significant positive influence on healthier diet behaviours, an improvement in the consumption of a more balanced diet, a significant effect on body weight and WC, a very slight improvement in smoking cessation, a significant decrease in systolic BP, a lower prevalence of long term sick leave, and a significant increase in sleep duration.

The inconsistency across the results of the included studies may have been the reason a lack of evidence was noted on the majority of the outcomes of interest. Several factors may have been the reason for these inconsistencies: measurement methods, intervention type and strategy, intervention delivery, targeted lifestyle behaviour, and participants' compliance with the intervention. In addition, the detailed content and information delivered in the health education, health training, as well as coaching programs were mostly not mentioned. These reasons show how different the included studies are in terms of intervention and outcomes, even though some studies are measuring the same outcomes, e.g., physical activity.

3.4.1 Comparable studies in the context of workplace intervention and lifestyle intervention

Previous studies on workplace interventions have noted that multi-component interventions, interventions that incorporate the organisation as part of the intervention, demonstrated the best effectiveness (Sorensen, Stoddard and Macario, 1998; Holdsworth, Haslam and Raymond, 2000; Hunt et al., 2000). This was evident in the included studies that contained a diet component, as these studies only promoted healthy eating via education and health coaching with no organisational involvement (organisational modifications). The lack of application within the canteen menu and food choices alternatives, whether through the canteen or vending machines, may have resulted in this lack of intervention effects on diet. Conversely, multi-component workplace interventions incorporating staff in the intervention delivery reported a significant positive impact on diet (Beresford et al., 2001; Maes et al., 2012).

The lack of effectiveness in weight-related outcomes may be due to the type and goal of interventions included in this systematic review. Power et al. (2014) reported in their systematic review and meta-analysis of workplace interventions, which focused on interventions targeting weight management, that studies that targeted both physical activity and diet produced the largest difference in weight reduction (-3.95 kg). Similarly, Anderson et al. (2009) reported in an earlier systematic review, which targeted employees overweight and obesity via worksite nutrition and physical activity interventions, strong consistent evidence, however, with modest effects on weight (-1.3 kg). Furthermore, Verweij et al. (2011) reported moderate quality of evidence in their meta-analysis of studies that combined both physical activity and diet interventions, which elicited a -0.34 kg/m^2 decrease in BMI, a -1.19 kg body weight reduction, and -1.12% body fat percentage, and in addition, noted that a greater reduction in body weight was observed in studies with combine physical activity and diet interventions that added an environmental component. Similarly, Mulchandani et al. (2019) reported in their systematic review and meta-analysis that multi-component workplace interventions that included both physical activity and diet components elicited a significant reduction in BMI, body weight, and waist circumference (-0.42 kg/m^2, -2.61 kg, and -1.92 cm, respectively).

Insufficient evidence on smoking was noted in this review. This may be mainly due to the included studies' intervention goals, as they did not include smoking as a primary outcome; consequently, no smoking-focused intervention was specifically included among the interventions, as it was part of the broader intervention. Cahill and Lancaster (2014) reported in an intervention review, which targeted smoking cessation, that studies that include smoking as part of a comprehensive intervention program have failed to show any significant decrease in the overall prevalence of smoking. They further added that trials that contain group behavioural counselling, pharmacological intervention, multiple interventions targeting mainly smoking cessation, and incentive-based interventions all demonstrated positive evidence of such workplace-based interventions. In contrast, intervention studies containing social support, self-help, and relapse prevention did not elicit significant intervention effects on smoking when delivered through the workplace (Cahill and Lancaster, 2014).

The effectiveness of interventions targeting lifestyle behaviours and weight, whether at the workplace or outside it, depends largely on the enrolled participants' characteristics and whether they have an elevated disease risk factor (Groeneveld et al., 2010). The studies included in this systematic review did not provide any details regarding the context, design and development process of the interventions. Therefore, it is possible that the results would have been different if the studies had been implemented in a population with a higher risk of disease due to factors such as being overweight or obese, lack of physical activity, or sedentary behaviour. Groeneveld et al. (2010) reported that interventions that included participants with no cardiovascular disease risk factors elicited a lack of intervention effect on the majority of outcome measures, while in contrast, interventions that included participants with elevated cardiovascular disease risk factors yielded strong evidence on weight-related outcomes.

3.4.2 Study strength

A strength of this systematic review is that it specifically focused on workplace intervention targeting construction workers and delivered through the workplace, as it included any intervention study and targeted different lifestyle behaviours as well as a wide range of outcome measures. The review also covered studies from different countries. In addition, the systematic review covered the main databases MEDLINE, EMBASE, Web of Science, and Cochrane Central Register of Controlled Trials (CENTRAL). This review may have helped highlight the scarcity of workplace health promotion programs for construction workers and the construction industry as a whole, and thus, may help urge researchers, organisations, as well as policymakers to shift their attention to this neglected population.

3.4.3 Study limitation

Although this systematic review targeted different lifestyle behaviours, as well as a wide range of outcome measures, the heterogeneity of the included studies in terms of intervention components and outcomes of interest did not allow for a meta-analysis. This systematic review aimed to collect and synthesise the effectiveness of workplace interventions in construction workers, which meant that any intervention type, even pilot studies, was open for inclusion. In addition, 50% of the included studies were of fair quality. This systematic review only included workplace intervention studies, which may have led to this small pool of studies; thus, a more comprehensive review that includes both workplace interventions and other types of interventions targeted at construction workers may yield different results.

3.5 Conclusion

This systematic review aimed to identify and evaluate the effectiveness of workplace health promotion and primary prevention programmes on lifestyle behaviours (physical activity, diet, smoking) and weight in construction workers. This review provided moderate evidence of the effectiveness of interventions on physical activity-related outcomes, exercise-related outcomes, and the reduction of sugar-sweetened beverage consumption. While other positive effects of the interventions were observed, the evidence supporting these outcomes was deemed insufficient. The review exclusively included workplace intervention studies, which may have contributed to the limited number of studies identified. Consequently, a more comprehensive review incorporating both workplace and other types of interventions targeting construction workers may yield different results.

Chapter 4 The Glasgow-Multiplex Lifestyle Collaboration (Part 1): a quantitative investigation of lifestyle, diet, and health in construction workers

4.1 Introduction

Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide (Townsend et al., 2022). In 2017, 17.8 million deaths were caused by CVD, according to the Global Burden of Disease (GBD) study (Roth et al., 2018), and increased in 2019 to 17.9 million deaths according to the World Health Organization (2022b). In addition, CVD was reported to have a prominent role in driving individuals to early retirement (Kouwenhoven-Pasmooij et al., 2016). Therefore, the World Health Organisation introduced in 2012 the 25x25 global action plan, a road map to reduce premature mortality caused by non-communicable diseases (NCDs) by 25% by the year 2025 (World Health Organization, 2012). This action plan focuses on improving policies and health services to combat the main NCDs, CVD, cancer, chronic respiratory diseases and diabetes. The development of CVD and other NCDs are directly associated with unhealthy lifestyle factors, including unhealthy diet, lack of physical activity, sedentary lifestyle, smoking, and overweight or obesity (Ritz, 2007; Gupta et al., 2008; Reilly et al., 2003; World Health Organization, 2003; Mancia et al., 1990).

In construction workers, several studies have reported a high prevalence of CVD risk factors associated with unhealthy lifestyle behaviours, such as unhealthy diet and smoking (Prabhakaran et al., 2005; Arndt et al., 2005; Groeneveld et al., 2008). Furthermore, Arndt et al. (2005) reported that CVDs are one of the major leading causes of disability in construction workers. This was further confirmed by Brenner and Ahern (2000) in their study, where CVDs were responsible for one-third of the condition resulting in permanent disability, thus, leading to early retirement. To combat this, workplace health promotion programs have been implemented to improve employees' overall health and longevity. Despite this, there is a scarcity of health promotion programs within the construction industry, with most of them addressing white-collar workers, with an inconclusive degree of effectiveness (Malik, Blake and Suggs, 2014; Anderson et al., 2009; Ni Mhurchu, Aston and Jebb, 2010; Maes et al., 2012).

This lack of significant effects of workplace intervention programmes may be attributed to the lack of understanding of employees' current health status. Furthermore, the increasing number of chronic diseases, work-related diseases and injuries are due to a lack of health awareness perceived by both the organisation and employees (Hakro and Jinshan, 2019). Therefore, it seems more sensible to consider employees' health prior to any intervention. Understanding the current health status of employees may be a strong determinant of the effectiveness of a workplace intervention programme. Therefore, this study aims to understand construction workers' current lifestyle behaviour and mental health to help guide future workplace interventions tailored to their needs.

4.2 Methods

4.2.1 Study Design and Population

A cross-sectional study where 43 construction workers (aged 18 to 65) were recruited from the University of Glasgow expansion site. Participants were recruited from

Multiplex, the main contractor on the site, and their subcontractors. Hybrid workers are workers who have desk-based jobs (off-site) and site-based assignments such as project supervision (on-site based jobs); on-site workers (OnSite) are those who work on-site having manual labour jobs or are machine operators. Recruitment started from October 2019 to February 2020 and was terminated due to the COVID-19 pandemic. Recruitment commenced after meeting with Multiplex and their subcontractors and explaining the idea and aim of this project. Following this, the research team dispatched an email to Multiplex, the primary contractor, outlining the objectives and purpose of the project. The intention was for this information to be relayed to the subcontractors and, ultimately, the workers on the ground. Workers who expressed an interest were then invited to convene on-site with the primary researcher for a more detailed explanation of the project's aims. This meeting also served to reaffirm their interest and commitment to the project. Prior to any measurement, all recruited participants provided written informed consent prior to any study procedure. This study was approved by the University of the Ethical Committee (Application Number 200180142).

Participants underwent two main steps as part of this study. Both steps were administered by the primary researcher on-site. The first step included taking anthropometric measurements, measuring blood pressure (BP), heart rate (HR), handgrip strength, and objectively measured physical activity levels via wrist-worn accelerometers. In the second step, participants answered a questionnaire involving questions about sociodemographic parameters, diet and alcohol, smoking, sleep patterns, and mental health (The Full questionnaire can be seen in Appendix C4.A).

4.2.2 Assessment

4.2.2.1 Anthropometric Measurement

Participants' height and weight were measured using a SECA stadiometer and weight measuring device, respectively. Height was determined with the participants barefoot and standing with their heels and feet together, rounded to the nearest 0.1 centimetre. Weight was taken with participants in light clothing and, similarly, rounded to the nearest 0.1 kilogram. The Body Mass Index (BMI, kg/m^2) was then driven from these numbers. The waist circumference (WC, cm) was measured in accordance with The National Heart, Lung, and Blood Institute protocol, with cut-off points as per Lean, Han and Morrison (1995) (males: <94, 94-101, ≥102). The measurement was taken at the midpoint between the last rib and the top of the iliac crest using a measuring tape, with the participant completely exhaled and shirtless. To ensure accuracy and reduce potential errors, the measurement was repeated three times, from which an average was subsequently derived. The assessor was a Master of Science graduate in Sports and Exercise Science and Medicine, with specialised training in various adiposity measurement techniques, including WC.

4.2.2.2 Blood pressure (BP) and Heart rate (HR)

Blood pressure (BP, mmHg) and resting heart rate (HR, beat/min) were measured using a digital monitor (Vital-track). Prior to taking the measurements, participants were asked to rest for five minutes to ensure their bodies were in a relaxed state. Following this rest period, three separate readings were taken, each separated by a three-minute rest interval. An average was then calculated from these readings to ensure accuracy. Classification of BP values was based on American Heart Association redefined guidelines (Normal, <120/80; Elevated, 120-129 systolic and <80 diastolic;

Hypertension stage 1, 130-139 systolic or 80-89 diastolic; Hypertension stage 2, >140 systolic or >90 diastolic) (Whelton et al., 2018). The Mean arterial pressure (MAP, mmHg) was generated from BP values (MAP = Diastolic BP + 1/3 (Systolic BP – Diastolic BP) (DeMers and Wachs, 2023).

4.2.2.3 Questionnaire

4.2.2.3.1 Socio-demographic parameters

Participants answered a series of questions related to Socio-demographic parameters, which involved ethnicity, education, annual income, job title and category, accommodation type and the number of occupants in this accommodation.

4.2.2.3.2 Smoking and Alcohol Dependency

Traditional smoking, vaping, and e-cigarettes were included in the smoking questions. Participants were categorised as current, non-, or former smokers, and a separate question assessed their exposure to second-hand smoke.

Alcohol was assessed using the Alcohol Use Disorders Identification Test (AUDIT), a screening tool that assesses various facets of alcohol consumption, including dependency symptoms, frequency, and volume of drinking, as well as instances of harmful alcohol use to ensure a comprehensive assessment and aid in the identification of individuals with potential alcohol-related disorders, and was scored according to it (Babor et al., 2001). Scores of 8-15 necessitate advice on minimising hazardous alcohol consumption, 16-19 elicit the need for counselling and monitoring, and 20+ indicate potential alcohol dependency. According to Dybek et al. (2006), the AUDIT is a reliable and valid instrument for screening individuals who exhibit alcohol use disorders or are displaying behaviours associated with at-risk drinking. Concurring on this, Habtamu and Madoro (2022) reported that the AUDIT demonstrated excellent internal consistency (Cronbach's α coefficient of 0.9), high sensitivity (0.92 for females and 0.91 for males) and specificity (0.87 for females and 0.84 for males).

4.2.2.3.3 Diet

The diet questionnaire was based on the two-page food frequency list for use as a Dietary Targets Monitor to calculate the consumption of the key foods (Lean et al., 2003). The questionnaire, as per Lean et al. (2003), presents a succinct and easily manageable dietary assessment tool with the capacity to oversee changes in dietary intake towards the national dietary goals for a range of essential foods and nutrients. This involved asking how often participants consume foods (per day/week/month) such as breakfast cereal, fresh fruit, cooked green vegetables (fresh or frozen), cooked root vegetables (fresh or frozen), raw vegetables or salad (including tomatoes), chips, potatoes, pasta, rice, meat, meat products, poultry, white fish, oil-rich fish, cheese, beans or pulses, sweets, chocolate ice cream, crisps, savoury snacks, fruit juice, soft/fizzy drinks, cakes, scones, sweet pies or pastries biscuits.

Responses for all food elements (portions) except for fish were grouped from '6+' per day to 6 times per day, '4–5' times per day to 4.5 times per day, '2–3' times per day to 2.5 times per day, '1' times per day remained the same. Fish was grouped from '5-6' times per week to 5.5 times per week, '2-4' per week to 3 times per week, and '1' time per week remained the same (Lean et al., 2003). Each portion was then multiplied by its corresponding mass, according to Table C4.1.

Fruit and vegetable consumption was collapsed into three categories: 0-199g/day, 200-399g/day, and above 399g/day, with a daily goal of 400g/day (Lean et al., 2003). Starchy foods were set to an arbitrary cut-off of six items per day per Lean et al. (2003). Fish consumption per week was collapsed into three categories: 0-239g/week, 239-359g/week and above 359g/week, with a goal of two times per week (240g/week) (Lean et al., 2003). Meat intake was collapsed into two categories: above or below 70g/day, the limit set by the NHS for meat consumption that should not be exceeded (NHS, 2021). Sweets and snacks were reported as mean consumption per day and were not collapsed into categories.

Table C4. 1: Standardised food in grams

Food type	Standard gram
Fruit and vegetables (Lean et al., 2003)	80g
Meat (Lean et al., 2003)	140g
Meat products (Lean et al., 2003)	40g
Poultry (NHS, 2017)	90g
Fish (Lean et al., 2003)	120g
Biscuits (Lean et al., 2003)	18g
Cakes, scones and sweet pies and pastries (Lean et al., 2003)	65g
Sweets, chocolates (Lean et al., 2003)	65g
Crisps/savoury snacks (Lean et al., 2003)	118g

4.2.2.3.4 Sleep pattern

Sleep was assessed using The Pittsburgh Sleep Quality Index (PSQI) to evaluate adult sleep patterns and quality, assessing seven key elements: sleep duration, sleep latency, subjective sleep quality, habitual sleep efficiency, sleep disturbances, sleeping medications, and daytime dysfunction over the last month (Buysse et al., 1989). A score exceeding 5 indicates serious difficulties in at least two or moderate difficulties in three or more sleep areas. The PSQI, as per Backhaus et al. (2002), has proven to be a reliable measure for sleep disturbances, showing high consistency (correlation coefficient score for test-retest = 0.87) and validity (sensitivity = 0.98 and specificity = 0.84 for scores above 5).

4.2.2.3.5 Mental Health and Well-being

Mental health was measured using the Warwick-Edinburgh mental well-being scale and Patient Health Questionnaire-9 (PHQ-9). The Warwick-Edinburgh Mental Well-being Scale (WEMWBS) is a 14-item that captures well-being, including psychological functioning, cognitive, evaluative dimensions and affective-emotional aspects, with a good validity alongside a robust test-retest reliability, as indicated by a Cronbach's α score of 0.91 and a one-week test-retest score of 0.83 (Tennant et al., 2007). Cut-off points used were according to Ng Fat et al. (2017), where scores from 14-42 indicate low mental well-being, 43-60 indicate medium mental well-being, and 61-70 indicate high mental well-being.

The PHQ-9 is a self-completed questionnaire used for screening, diagnosing, measuring, and monitoring depression severity (Kroenke, Spitzer and Williams, 2001). PHQ-9 scores interpret depression severity as 1-4 (minimal), 5-9 (mild), 10-14 (moderate), 15-19 (moderately severe), and above 20 (severe). According to Molebatsi, Motlhatlhedi and Wambua (2020), the PHQ-9 displays efficacy in the detection and assessment of depression severity in primary care environments, as it demonstrated a good sensitivity of 0.72 and specificity of 0.76, alongside a good internal consistency, as indicated by a Cronbach's α score of 0.79.

4.2.2.3.6 Physical activity levels (PA)

Physical activity levels were measured using GENEActiv, a lightweight, waterproof, wrist-worn accelerometer that measures different physical activity levels as well as adjusts for sleep time. Each participant was fitted with the accelerometer on their non-dominant hand and was instructed to keep it on continuously for an entire week, with the accelerometer recording at 100Hz.

Physical activity analysis was based on the method of ESLIGER et al. (2011). Accelerometer data were extracted using the GENEactiv PC software to raw.csv files, which contain unfiltered time, date and acceleration data across the x, y, and z axes, respectively. Acceleration data were recorded in the gravitational units (g) with a positive and negative sign indicating the direction of movement. The raw.csv files were then converted using the GENEactiv PC software, and the acceleration data was converted into a signal magnitude vector (SVMgs – gravity subtract) in 60-second epochs (1 minute) “g.min”.

Cut-off points for different physical activity levels were in accordance with what ESLIGER et al. (2011) deduced in their GENEActiv validation paper. For left worn wrist accelerometer, an acceleration point below 217 indicates sedentary activity, an acceleration point between 217 to 644 indicates light physical activity, an acceleration point between 645 to 1810 indicates moderate physical activity, and an acceleration point above 1810 indicates vigorous physical activity. For the right-hand-worn wrist accelerometer, an acceleration point below 386 indicates sedentary activity, an acceleration point between 386 to 439 indicates light physical activity, an acceleration point between 440 to 2098 indicates moderate physical activity, and an acceleration point above 2098 indicates vigorous physical activity. The data extracted are presented as average time (min/day) spent sleeping, sedentary, and in different physical activity levels (light, moderate, and vigorous) per day, “working day and weekend day”.

<u>4.2.2.3.7 Handgrip strength</u>

Handgrip strength was assessed using a hydraulic hand dynamometer (Jamar J00105). Participants were asked to sit and rest the tested arm on the chair’s armrest and then asked to squeeze three times with a minute rest between each squeeze. The test was performed six times, three times for each hand, and then the average was calculated for the left and right hands separately.

4.2.3 Statistical analysis

The findings of this study are represented in a variety of statistical formats, including the use of percentages and mean ± standard deviation (SD) for data that follows a normal distribution, in addition to the mean ± SD in conjunction with median and interquartile range (IQR) for non-normally distributed data, which are presented as "mean ± SD (median (IQR))" for in-text references and "mean ± SD; median (IQR)" for table representations. Data distribution was determined by visual inspection and a normality test (Anderson-darling) as per Ghasemi and Zahediasl (2012). This approach was to ensure the accuracy of the data distribution determination.

The application of statistical tests to continuous variables was conducted with adherence to the underlying assumptions of each test, as outlined in Table C4.2. Depending on the nature of the variables and the specific conditions of the data, different statistical tests were utilised. In general, where assumptions were met, the two-sample t-tests and paired sample t-tests were implemented for comparing data both between and within groups (Kim and Park, 2019). However, in cases where the assumptions for the two-sample t-tests were not met, the following alternative statistical tests were implemented: Welch's t-test and the Mann-Whitney test. For the analysis of categorical data, the Chi-square test was implemented to compare the categorical data between groups.

The significance level, p-value, was set at <0.05. The entirety of the data analysis process was carried out using the SPSS (version 28.0.0.0) for Windows. The overall approach to data representation, distribution determination, and test selection ensures that the findings of the study are presented in a clear, accessible, and scientifically rigorous manner.

Table C4.2: Statistical test selection based on assumption for continuous variables

Outcome	Data distribution	Continuous data	Homogeneity of variance	Random sampled	Statistical test
Systolic BP	Normal	✓	✓	✓	2-sample t-test
Diastolic BP	Normal	✓	✓	✓	2-sample t-test
MAP	Normal	✓	✓	✓	2-sample t-test
HR	Normal	✓	✓	✓	2-sample t-test
Hand grip Rt	Normal	✓	✓	✓	2-sample t-test
Hand grip Lt	Normal	✓	✓	✓	2-sample t-test
Height	Normal	✓	✓	✓	2-sample t-test
Weight	Normal	✓	✓	✓	2-sample t-test
BMI	Normal	✓	✓	✓	2-sample t-test
WC	Normal	✓	✓	✓	2-sample t-test
AUDIT	Normal	✓	✓	✓	2-sample t-test
PSQI	Non-normal	✓	✓	✓	Mann-Witney test
WEMWEBS	Normal	✓	✓	✓	2-sample t-test
PHQ-9	Non-normal	✓	✓	✓	Mann-Witney test
Objectively PA	Normal	✓	✓	✓	2-sample t-test + Paired sample t-test
Fruit and vegetable	Non-normal	✓	✓	✓	Mann-Witney test
Starchy Foods consumption	Normal	✓	✓	✓	2-sample t-test
Meat consumption	Non-normal	✓	✓	✓	Mann-Witney test
Fish consumption	Non-normal	✓	✓	✓	Mann-Witney test
Sweets/Crisps/Savoury Snacks consumption	Non-normal	✓	✓	✓	Mann-Witney test
Objectively measured steep	Normal	✓	✓	✓	2-sample t-test + Paired sample t-test

4.3 Results

A total of 43 male participants completed the first step of the screening, 38 completed the questionnaire, and 28 participants handed back the wrist-worn accelerometer, with the majority wearing it on their left wrist (N=25). The mean age was 35.7 ± 11.4, with the majority of the recruited participants being British, 85.7%. Participants were divided into two groups according to their line of work; Hybrid (N=16) are workers who work both off-site (desk-based) and on-site, whereas the on-site workers (OnSite) (N=27) are those who work exclusively on-site. Table C4.3 describes the sociodemographic status of this cohort of construction workers.

Table C4. 3: Sociodemographic status

Outcome	Total sample	Hybrid	OnSite	P-value
Age (years)	35.7 ± 11.4	35.0 ± 12.5	36.2 ± 10.9	
Ethnic group (N)	35	13	22	0.063
British	85.7% (30)	100.0% (13)	77.3% (17)	
Other European	14.3% (5)	0.0% (0)	22.7% (5)	
Education (N)	34	13	21	0.002
School Leaver	41.2% (14)	15.4% (2)	57.1% (12)	
College Education	20.6% (7)	7.7% (1)	28.6% (6)	
Bachelors	26.5% (9)	53.8% (7)	9.5% (2)	
Masters	8.8% (3)	23.1% (3)	0.0% (0)	
Prefer not to say	2.9% (1)	0.0% (0)	4.8% (1)	
Annual Income (N) (£)	35	13	22	0.024
< 15000	2.9% (1)	0.0% (0)	4.5% (1)	
15001-30000	17.1% (6)	0.0% (0)	27.3% (6)	
> 30000	68.6% (24)	100.0% (13)	50.0% (11)	
Prefer not to say	11.4% (4)	0.0% (0)	18.2% (4)	
Accommodation (N)	35	13	22	0.009
Own room/House-share	5.7% (2)	7.7% (1)	4.5% (1)	
Rented flat/house	34.3% (12)	0.0% (0)	54.5% (12)	
Own flat/house	57.1% (20)	84.6% (11)	40.9% (9)	
Other	2.9% (1)	7.7% (1)	0.0% (0)	
Who Do you live with (N)	35	13	22	0.880
Partner	42.9% (15)	46.2% (6)	40.9% (9)	
Parents	14.3% (5)	15.4% (2)	13.6% (3)	
Alone	2.9% (1)	0.0% (0)	4.5% (1)	
Partner and children	40.0% (14)	38.5% (5)	40.9% (9)	

4.3.1 Heart rate, blood pressure, mean arterial pressure, and anthropometric measurements

Tables C4.4 and C4.5 present the HR, BP, MAP, and anthropometric measurements of our sample of construction workers. The average HR for the total sample was 66.3 ± 10.9 beat/min, with Hybrid significantly lower than OnSite (58.5 ± 9.4 and 70.9 ± 9.0 beat/min, respectively). The average systolic BP and diastolic BP for the total sample were 128.3 ± 7.4 mmHg and 78.4 ± 7.5 mmHg, with a borderline significant difference (p=0.054) only observed in diastolic BP with Hybrid lower than OnSite (75.6 ± 6.4 mmHg and 80.1 ± 7.7 mmHg). In addition, the majority of Hybrid and OnSite had either an elevated BP (50.0% and 51.9%) or Stage 1 High BP (31.3% and 29.6%); however, no significant association was noted in the BP categories. MAP for the total sample was recorded at 95.1 ± 6.7 mmHg, with a borderline significant difference (p=0.075) with Hybrid lower than OnSite (92.7 ± 4.6 mmHg and 96.5 ± 7.4 mmHg), and with the majority within the normal MAP.

Table C4. 4: Heart rate, blood pressure, mean arterial pressure, and grip strength

Category	Total sample	Hybrid	OnSite	P-value
N	43	16	27	
Resting Heart rate (beat/minute)	66.3 ± 10.9	58.5 ± 9.4	70.9 ± 9.0	<.001
Systolic BP (mmHg)	128.3 ± 7.4	126.9 ± 6.6	129.2 ± 7.8	0.349
Diastolic BP (mmHg)	78.4 ± 7.5	75.6 ± 6.4	80.1 ± 7.7	0.054
Normal BP (N)	7.0% (3)	12.5% (2)	3.7% (1)	
Elevated BP (N)	51.7% (22)	50.0% (8)	51.9% (14)	
Hypertension stage 1 (N)	30.2% (13)	31.3% (5)	29.6% (8)	
Hypertension stage 2 (N)	11.6% (5)	6.3% (1)	14.8% (4)	
BP categories				0.623
Mean arterial pressure (MAP) (mmHg)	95.1 ± 6.7	92.7 ± 4.6	96.5 ± 7.4	0.075
Normal MAP (70 - 100 mmHg) (N)	79.1% (34)	93.8% (15)	70.4% (19)	
MAP > 100 mmHg (N)	20.9% (9)	6.3% (1)	29.6% (8)	
Right-hand grip Strength	50.4 ± 8.6	48.0 ± 6.5	51.9 ± 9.4	0.145
Left-hand grip Strength	50.5 ± 8.5	48.7± 8.0	51.6 ± 8.7	0.288

The recorded mean BMI for the total sample was 26.7 ± 4.4; no significant difference (26.2 ± 3.9 for Hybrid and 27.0 ± 4.8 for OnSite) or association was noted between the groups, with most of them having either a normal BMI (56.3% and 48.1%) or being overweight (37.5% and 29.6%). The recorded mean WC for the total sample was 95.9 ± 11.7; no significant difference between the two groups was noted (Hybrid = 94.3 ± 11.3 cm and OnSite = 96.8 ± 12.1), and no association was observed. Tables C4.5.

Table C4. 5: Anthropometric measurements

Category	Total sample	Hybrid	OnSite	P-value
N	43	16	27	
Hight (cm)	178.3 ± 6.6	180.4 ± 6.4	177.1 ± 6.5	0.113
Weight (Kg)	85.1 ± 16.1	85.3 ± 14.9	85.0 ± 17.1	0.964
BMI	26.7 ± 4.4	26.2 ± 3.9	27.0 ± 4.8	0.540
Normal BMI (N)	51.2% (22)	56.3% (9)	48.1% (13)	
Overweight (N)	32.6% (14)	37.5% (6)	29.6% (8)	
Obese 1 (N)	7.0% (3)	0.0 (0)	11.1% (3)	
Obese 2 (N)	9.3% (4)	6.3% (1)	11.1% (3)	
Obese 3 (N)	0.0% (0)	0.0% (0)	0.0% (0)	
BMI categories				0.502
Waist Circumference (WC) (cm)	95.9 ± 11.7	94.3 ± 11.3	96.8 ± 12.1	0.496
Normal WC < 94 cm (N)	46.5% (20)	50.0% (8)	44.4% (12)	
Increased WC 94 - 101 cm (N)	34.9% (15)	43.8% (7)	29.6% (8)	
Substantially increased WC ≥ 102 cm (N)	18.6% (8)	6.3% (1)	25.9% (7)	
WC categories				0.255

4.3.2 Smoking and Alcohol Dependency

The smoking prevalence for the total sample was 20.0%, with Hybrid having 15.4% of smokers and OnSite having a higher prevalence of 22.7%, with no significant association between the groups. Similarly, the use of vapes and e-cigarettes was 5.9% of the total sample, and only OnSite (9.5%) used them (Table C4.6); no significant association was noted. The mean score of the Alcohol Use Disorder Identification Test was 8.6 ± 6.6, with the majority (53.1%) reporting no hazardous alcohol use, and 40.6% required simple advice for alcohol use; no significant difference was recorded between Hybrid and OnSite (9.2 ± 4.3 and 8.2 ± 7.9) or association (Table C4.6).

Table C4. 6: Smoking and Alcohol (The Alcohol Use Disorder Identification Test)

Smoking	Total sample	Hybrid	OnSite	P-value
N	35	13	22	0.826
No (N)	74.3% (26)	76.9% (10)	72.7% (16)	
Yes (N)	20.0% (7)	15.4% (2)	22.7% (5)	
Not anymore (N)	5.7% (2)	7.7% (1)	4.5% (1)	
Vapes or e-cigarettes	**Total sample**	**Hybrid**	**OnSite**	**P value**
N	34	13	21	0.251
No (N)	94.1% (32)	100.0% (13)	90.5% (19)	
Yes (N)	5.9% (2)	0.0% (0)	9.5% (2)	
Alcohol	**Total sample**	**Hybrid**	**OnSite**	**P value**
N	32	13	19	
Mean score	8.6 ± 6.6	9.2 ± 4.3	8.2 ± 7.9	0.700
Scores Below "8" (N)	53.1% (17)	38.5% (5)	63.2% (12)	
Scores from "8 -15" (N)	40.6% (13)	53.8% (7)	31.6% (6)	
Scores from "16-19" (N)	3.1% (1)	7.7% (1)	0.0% (0)	
Sores from "20" and above (N)	3.1% (1)	0.0% (0)	5.3% (1)	

4.3.3 Diet

4.3.3.1 Fruit, vegetables, and starchy foods

The average "mean ± SD (median (IQR))" daily fruit and vegetable intake (gram/day) was 436.0 ± 304.2 (342.4 (516.8)) for the total population; no significant difference was noted between the groups. In addition, participants who consume 400 grams/day or more account for 45.5% of the total sample, 38.5% of Hybrid and 50.0% of OnSite (Table C4. 7); no significant association was observed. The average daily intake (portion/day) of starchy foods for the total sample was 3.7 ± 1.2, with no significant difference between Hybrid and OnSite, and with only 8.8% who consume 6 or more portions of starchy foods and are all from OnSite (14.3%). (Table C4.7).

4.3.3.2 Meat and fish consumption

The average daily grams (gram/day) of meat consumed was 315.5 ± 286.4 (230.7 (259.3)); no significant difference was found between the two groups (Hybrid = 305.5 ± 313.6 (250.7(283.6)) and OnSite = 321.9 ± 275.5 (221.4(350.7))). However, 93.9% of the total sample consumed more than 70 grams/day (table C4.7). The average weekly intake (gram/week) of fish was 442.2 ± 768.1 (175.2(340.6)); no significant difference was found between Hybrid and OnSite. Despite this, 53.1% reported consuming less than 240 grams/week of fish (Table C4.7).

Table C4. 7: Diet

Fruit and Vegetable	**Total sample**	**Hybrid**	**OnSite**	**P-value**
N	33	13	20	
Fruit and vegetables consumption gram/day	436.0 ± 304.2; 342.4 (516.8)	430.9 ± 351.1; 342.4(487.5)	439.3 ± 279.2; 357.0 (543.7)	0.897
Participant who consumes 0-199 grams/day (N)	24.2% (8)	15.4% (2)	30.0% (6)	
Participant who consumes 200-399 gram/day (N)	30.3% (10)	46.2% (6)	20.0% (4)	
Participant who consumes ≥ 400 gram/day (N)	45.5% (15)	38.5% (5)	50.0% (10)	
Fruit and vegetable categories				0.256
Starchy foods				
N	34	13	21	
Starchy foods consumption portion/day	3.7 ± 1.2	3.4 ± 1.0	4.0 ± 1.3	0.171
Participants who consume < 6 portion/day (N)	91.2% (31)	100% (13)	85.7% (18)	
Participants who consume ≥ 6 portion/day (N)	8.8% (3)	0.0% (0)	14.3% (3)	
Starchy categories				0.154
Meat/day				
N	33	13	20	
Meat consumption gram/day	315.5 ± 286.4; 230.7 (259.3)	305.5 ± 313.6; 250.7(283.6)	321.9 ± 275.5; 221.4(350.7)	0.781
Participant who consumes ≤ 70 gram/day (N)	6.1% (2)	15.4% (2)	0.0% (0)	
Participant who consumes > 70 gram/day (N)	93.9% (31)	84.6% (11)	100% (20)	
Meat categories				N/A
Fish/week				
N	32	13	19	
Fish consumption gram/week	442.2 ± 768.1; 175.2(340.6)	202.7 ± 143.9; 175.2(124.8)	606.0 ± 965.6; 175.2(651.0)	0.846
Participant who consumes 0-239 gram/week (N)	53.1% (17)	53.8% (7)	52.6% (10)	
Participant who consumes 240-359 gram/week (N)	21.9% (7)	30.8% (4)	15.8% (3)	
Participant who consumes ≥ 360 gram/week (N)	25.0% (8)	15.4% (2)	31.6% (6)	
Fish categories				0.449
Sweets/Crisps/Savoury Snacks/day				
N	33	13	20	
Sweets/Crisps/Savoury Snacks consumption gram/day	223.2 ± 181.4; 164.4(162.3)	219.9 ± 167.7; 164.4(196.2)	225.4 ± 193.9; 174.8(154.5)	0.811

4.3.4 Sleep and mental health

The mean PSQI score was 4.2 ± 2.2 (4.0(2.0)) for the total population, with 91.4% ± 8.7 (93.3% (12.5)) sleep efficiency; no significant difference between the groups (Table C4.8). For objectively measured sleep, participants slept significantly less during weekdays compared to weekends for the total sample, with an average of objectively measured time spent sleeping (min/day) of 355.0 ± 40.7 and 415.5 ± 59.9, respectively. Similarly, a significant within-group difference was found where both Hybrid and OnSite slept significantly less during weekdays compared to weekends as per the average objectively measured time spent sleeping (Table C4.8).

Table C4. 8: Sleep

PSQI	**Total sample**	**Hybrid**	**OnSite**	**P-value**
N	**31**	**13**	**18**	
Mean score	4.2 ± 2.2; 4.0(2.0)	4.1 ± 2.4; 3.0(2.5)	4.2 ± 2.1; 4.0(2.3)	0.689
Scores of "5" or greater (N)	29.0% (9)	30.8% (4)	27.8% (5)	
Sleep efficiency	91.4% ± 8.7; 93.3%(12.5)	90.3% ± 9.1; 93.3%(7.8)	92.2% ± 8.6; 93.5%(12.9)	
Objectively measured sleep via GENEActiv (min/day)	**Total sample**	**Hybrid**	**OnSite**	**P value**
N	**28**	**9**	**19**	
Average time spent sleeping – Working day	355.0 ± 40.7	368.4 ± 36.9	348.7 ± 41.8	0.237
Average time spent sleeping – Weekend day	415.5 ± 59.9	438.1 ± 55.3	404.8 ± 60.3	0.174
P value	<.001	0.017	<.001	

The mean score of WEMWBS for the total population was 51.8 ± 8.6 for the total population; no significant differences were noted between the two groups. The majority of Hybrid and OnSite were categorised under medium mental well-being, 92.3% and 63.6% (table C4.9). As for the PHQ-9 (Table C4.9), the mean score for the total sample was 2.3 ± 2.6 (2.0(4.0)) with a mean score of 2.5 ± 1.9 (2.0(3.0)) and 2.3 ± 3.0 (1.0(2.5)) for Hybrid and OnSite, respectively, by which 69.2% of Hybrid and 50.0% of OnSite reported minimal signs of depression.

Table C4. 9: Mental Health: Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) and Mental Health: Patient health questionnaire (PHQ-9)

WEMWBS	Total sample	Hybrid	OnSite	P-value
N	35	13	22	
Mean Score	51.8 ± 8.6	51.2 ± 5.0	52.1 ± 10.3	0.780
Low mental wellbeing (14–42) (N)	14.3% (5)	7.7% (1)	18.2% (4)	
Medium mental wellbeing (43-60) (N)	74.3% (26)	92.3% (12)	63.6% (14)	
High mental wellbeing (61–70) (N)	11.4% (4)	0.0% (0)	18.2% (4)	
PHQ-9	**Total sample**	**Hybrid**	**OnSite**	**P value**
N	35	13	22	
Mean Score	2.3 ± 2.6; 2.0(4.0)	2.5 ± 1.9; 2.0(3.0)	2.3 ± 3.0; 1.0(2.5)	0.375
No sign depression (Score of 0) (N)	25.7% (9)	15.4% (2)	31.8% (7)	
Minimal depression (Scores from 1-4)	57.1% (20)	69.2% (9)	50.0% (11)	
Mild depression (Scores from 5-9)	14.3% (5)	15.4% (2)	13.6% (3)	
Moderate depression (Scores from 10-14)	2.9% (1)	0.0% (0)	4.5% (1)	
Moderately severe depression (Scores from 15-19)	0.0% (0)	0.0% (0)	0.0% (0)	
Severe depression (Scores from 20-27)	0.0% (0)	0.0% (0)	0.0% (0)	

4.3.5 Physical Activity Levels

Participants in the total population spent significantly higher minutes on average in moderate and vigorous physical activity (min/day) on a working day (253.1 ± 97.5 and 39.8 ± 28.8) than on a weekend day (183.3 ± 54.2 and 15.4 ± 17.2) (Table C4.10). Similarly, the average engagement (min/day) in moderate and vigorous physical activity was significantly higher ($p < .001$) during working hours (7 am to 6 pm) (194.8 ± 92.4 and 30.5 ± 25.5) than during leisure time (58.2 ± 15.6 and 9.3 ± 8.3) (Table C4.11). These findings suggest a substantial reduction in physical activity levels during non-working periods in moderate and vigorous physical activities.

For Hybrid, the average time spent in moderate and vigorous physical activity was 173.2 ± 71.9 and 38.3 ± 23.3 min/day on a working day, and 180.2 ± 55.5 and 23.1 ± 21.7 min/day on a weekend day, with a significantly higher engagement observed only in vigorous physical activity on a working day (Table C4.10). However, Hybrid participants spent significantly more time in moderate and vigorous physical activity during working hours (115.3 ± 57.0 and 26.4 ± 15.9 min/day) than during leisure time (57.9 ± 19.9 and 11.9 ± 12.5 min/day) (Table C4.11).

Table C4. 10: Average minutes per day spent in different physical activity (PA) Categories (Sedentary, light, moderate, vigorous) on a working day and a weekend day

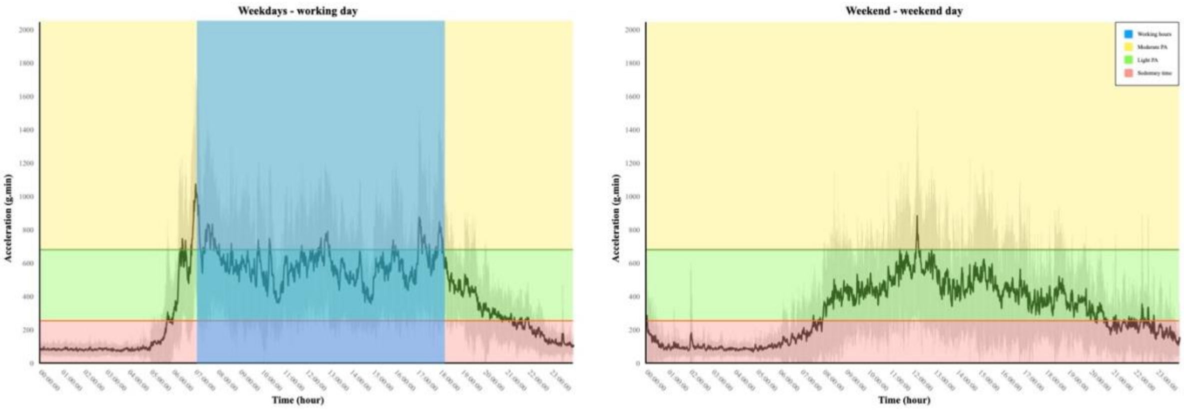
PA category	Sample	Weekdays	Weekends	P-value
Acceleration	Total sample	397.6 ± 82.0	297.5 ± 64.0	**<.001**
	Hybrid	330.8 ± 32.5	303.1 ± 56.8	**0.229**
	OnSite	429.3 ± 79.5	294.8 ± 68.5	**<.001**
	P-value	**<.001**	**0.755**	
Minutes spent sedentary	Total sample	467.4 ± 132.7	512.9 ± 131.8	**0.087**
	Hybrid	611.4 ± 96.5	532.8 ± 157.2	**0.059**
	OnSite	399.2 ± 83.6	503.6 ± 121.6	**<.001**
	P-value	**<.001**	**0.593**	
Minutes spent in light PA	Total sample	323.8 ± 122.5	312.9 ± 131.6	**0.411**
	Hybrid	248.6 ± 142.6	265.9 ± 163.3	**0.414**
	OnSite	359.4 ± 96.5	335.2 ± 111.7	**0.149**
	P-value	**0.022**	**0.199**	
Minutes spent in moderate PA	Total sample	253.1 ± 97.5	183.3 ± 54.2	**0.001**
	Hybrid	173.2 ± 71.9	180.2 ± 55.5	**0.773**
	OnSite	290.9 ± 85.2	184.7 ± 55.1	**<.001**
	P-value	**0.001**	**0.84**	
Minutes spent in vigorous PA	Total sample	39.8 ± 28.8	15.4 ± 17.2	**<.001**
	Hybrid	38.3 ± 23.3	23.1 ± 21.7	**0.001**
	OnSite	40.5 ± 31.7	11.7 ± 13.8	**<.001**
	P-value	**0.853**	**0.102**	

For OnSite, a significantly higher time on average was spent in moderate and vigorous physical activity during a working day (290.9 ± 85.2 min/day and 40.5 ± 31.7 min/day) compared to a weekend day (184.7 ± 55.1 min/day and 11.7 ± 13.8 min/day) (Table C4.10). Similarly, a significantly higher engagement was observed in time spent in moderate and vigorous physical activity during working hours (232.5 ± 81.9 min/day and 32.5 ± 29.2 min/day) than in leisure time (58.4 ± 13.8 min/day and 8.1 ± 5.2 min/day) (Table C4.11).

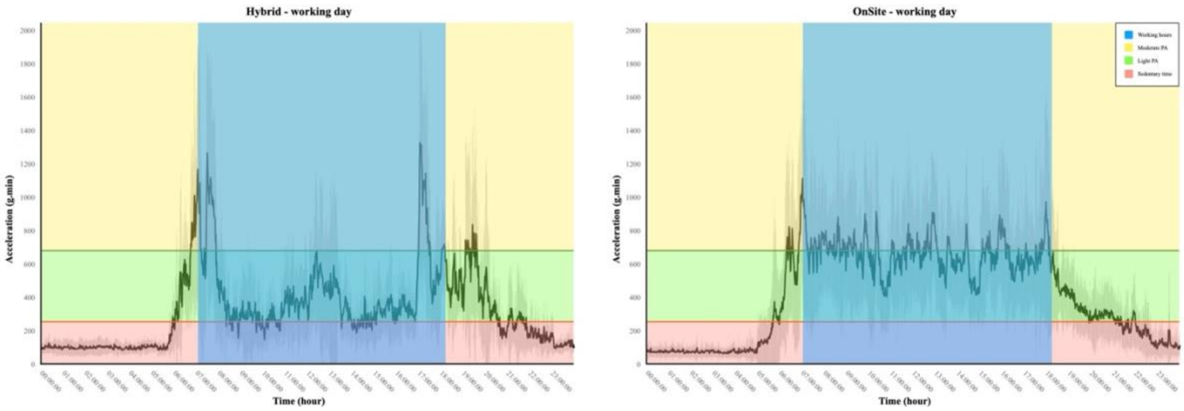
Table C4. 11: Weekdays – Average minutes per day spent in different physical activity (PA) Categories (Sedentary, light, moderate, vigorous) during working hours (7:00 to 17:59) and leisure time on a working day

PA category	Sample	07:00 - 17:59	Leisure time	P-value
Acceleration	Total sample	584.0 ± 172.4	240.2 ± 43.2	**<.001**
	Hybrid	431.3 ± 66.3	247.1 ± 50.6	**<.001**
	OnSite	656.3 ± 159.5	236.9 ± 40.3	**<.001**
	P-value	**<.001**	**0.568**	
Minutes spent sedentary	Total sample	219.2 ± 111.6	248.1 ± 47.4	**0.17**
	Hybrid	348.1 ± 62.4	263.3 ± 51.8	**0.003**
	OnSite	158.2 ± 68.5	241.0 ± 44.9	**<.001**
	P-value	**<.001**	**0.253**	
Minutes spent in light PA	Total sample	207.9 ± 81.2	115.9 ± 51.7	**<.001**
	Hybrid	159.3 ± 89.2	89.3 ± 61.3	**0.006**
	OnSite	230.9 ± 68.0	128.5 ± 42.6	**<.001**
	P-value	**0.026**	**0.059**	
Minutes spent in moderate PA	Total sample	194.8 ± 92.4	58.2 ± 15.6	**<.001**
	Hybrid	115.3 ± 57.0	57.9 ± 19.9	**0.006**
	OnSite	232.5 ± 81.9	58.4 ± 13.8	**<.001**
	P-value	**<.001**	**0.954**	
Minutes spent in vigorous PA	Total sample	30.5 ± 25.5	9.3 ± 8.3	**<.001**
	Hybrid	26.4 ± 15.9	11.9 ± 12.5	**0.031**
	OnSite	32.5 ± 29.2	8.1 ± 5.2	**0.001**
	P-value	**0.564**	**0.393**	

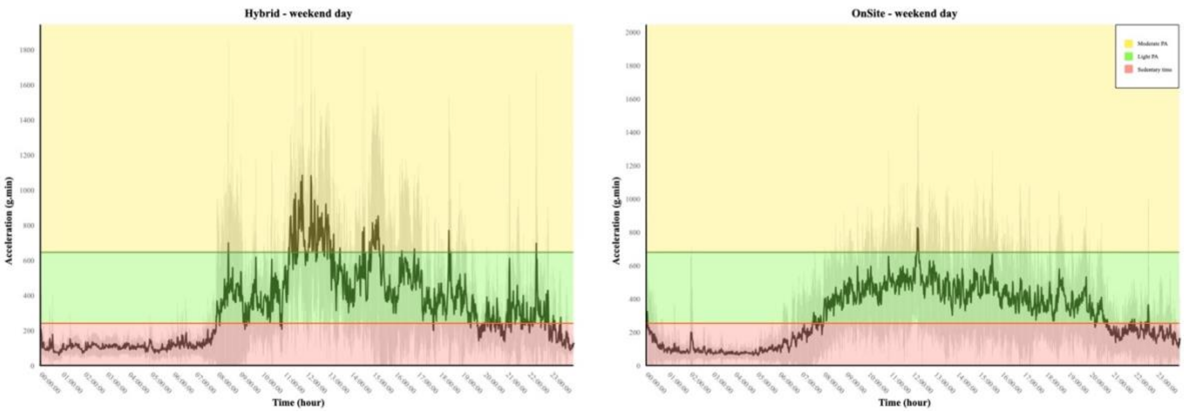
For between-group differences, Hybrid spent significantly more time being sedentary on average compared to OnSite, whereas OnSite engaged in significantly more moderate physical activity during a working day (Table C4.10). Similarly, during working hours, Hybrid exhibited significantly greater sedentary time, while OnSite spent significantly more time in moderate physical activity (Table C4.11). An average hour-by-hour physical activity summary can be seen in graphs C4.1, C4.2, and C4.3.



Graph C4. 1: An average hour-by-hour summary of PA levels during weekdays “a working day” (left), and weekends “weekend day” (right) ± SD (shadow) for the total sample. For a working day, working hours (7:00 to 17:59) are highlighted in blue



Graph C4. 2: An average hour-by-hour summary of PA levels for Hybrid and OnSite during a working day ± SD (shadow). Working hours from 7:00 to 17:59 are highlighted in blue



Graph C4. 3: An average hour-by-hour summary of PA levels for Hybrid and OnSite during a weekend day ± SD (shadow)

4.4 Discussion

The aim of this study was to understand the lifestyle behaviour and mental health of construction workers to help guide future interventions; this included gathering the following data: sociodemographics parameters, anthropometrics, measuring BP, HR, handgrip strength and objectively measured physical activity levels, diet and alcohol, smoking, sleep patterns and mental health. In general, 43 participants participated in this study and were predominantly British. The average HR was within the normal limit for the total sample and OnSite and was slightly lower in Hybrid. Similarly, MAP and the average diastolic BP were within the normal limit for the total sample and with elevated systolic BP, with the majority having an elevated or hypertension stage 1. The BMI for the total sample was within the overweight category; however, WC was within normal ranges. The prevalence of smoking and the use of vapes and e-cigarettes was higher among OnSite; furthermore, the majority of the population reported no hazardous alcohol use. 45% of the total population reported consuming more than 400 grams/day of fruit and vegetables, with slightly higher consumption in OnSite. In addition, 93.9% of the total population consumed more than 70 grams/day of meat, whereas 53.1% reported consuming less than 240 grams/week of fish. A significant difference was noted in objectively measured average sleep time during working days (weekdays) and weekends for the total population and within each group. On average, OnSite participants spend more time in moderate and vigorous physical activity levels during a working day (weekdays) and working hours compared to weekends and outside working hours (leisure time), whereas Hybrid, with the exception of time spent in vigorous physical activity, spend more time in moderate and light PA during weekends than on weekdays.

The general Scottish population exhibited a smoking prevalence of 14.8% (UK Office for National Statistics, 2022), with 37% classified as overweight and 29% as obese (Minister for Public Health Women's Health and Sport, 2020; The Scottish Health Survey, 2019), and 31% of men meeting the criteria for hypertension (Systolic BP of 140mmHg or higher, or Diastolic BP of 90mmHg or higher) (The Scottish Health Survey, 2019). However, in comparison to our sample, the prevalence of smoking, overweight, obesity, and hypertension was observed at 20.0%, 32.6%, 16.3%, and 11.6%, respectively. Although these figures are generally lower than those reported for the Scottish population—except for smoking—there remains significant scope for improvement. This suggests that construction workers may benefit from a targeted health promotion programme aimed at improving lifestyle behaviours.

The mean systolic and diastolic BP in our population (128.3 ± 7.4 and 78.4 ± 7.5, respectively) was lower than what was reported by Stocks et al. (2010) (132.9 ± 14.4 and 79.8 ± 10.5, respectively) cohort of construction workers. The number of participants classified as hypertensive (Stages 1 and 2) in this study was 41.8%. A similarly high percentage was reported by Umar et al. (2020) in their cohort of construction workers, where 43.3% were within hypertensive values. In addition, the number of participants with elevated BP was 51.7%. Vasan et al. (2001) reported that people classified with normal or high normal BP (120-129/80-84mmHg) frequently progress to hypertension within four years, and in addition, about 37.3% of individuals below the age of 65 with high normal BP progress to hypertension.

The data in this study showed that 32.6% and 16.3% of recruited participants were either overweight or obese, and 53.5% had a WC of ≥ 94cm. These findings are lower than what Thabit et al. (2013) reported in their cohort of construction workers (48.3% overweight, 21.8% obese, and 60.3% with WC >94). Being overweight worsens all CVD risk profiles, which include hypertension, insulin resistance, dyslipidaemia, left-ventricular hypertrophy, and hyperuricemia (Kannel, D'Agostino and Cobb, 1996). According to Opio et al. (2020), in their meta-analysis of 23 prospective cohort studies with a total of 4492723 participants, in metabolically healthy groups, cardiovascular disease risk was increased with overweight (relative risk of 1.34; 95% CI, 1.23-1.46) and obesity (relative risk of 1.58; 95% CI, 1.34-1.85). In addition, several studies suggest that central obesity is a stronger risk factor for the future development of cardiovascular disease than overall obesity (McDermott, 2007; Lean, Han and Morrison, 1995; Pouliot et al., 1994). Siren, Eriksson and Vanhanen (2012) reported that men with a WC of ≥ 94cm have an increased risk of developing CVD with a sensitivity of 84.4% (95% CI, 76.4%-90.0%).

Average fruit, vegetables, and fish consumption in this sample of construction workers were in line with the recommendation of the NHS of 5 portions (400g/day) of fruit and vegetables per day and two portions of fish (240g/week) per week. However, the average fruit, vegetable, and fish consumption seems oddly high (436.0 ± 304.2 (342.4 (516.8) g/day) and 442.2 ± 768.1 (175.2(340.6) g/week) when compared to Barton et al. (2018) (267g/day for Scotland and 298g/day for England) and Diet and Healthy Weight Monitoring Report (2020) (3.3 portions = 264g/day) for fruit and vegetable intake and Stewart et al. (2021) (In the UK: 21.6 g/day; equating to 151.2 g/week) for fish consumption. This may be due to the small sample size, the lack of understanding of the questionnaire, or social desirability bias (HEBERT et al., 1995). Similarly, in our sample, the average total meat (red meat, processed meat, and poultry) consumption (315.5 ± 286.4 (230.7 (259.3) g/day) exceeded the NHS recommendation of 70g/day, and in addition, higher than what was reported by Stewart et al. (2021) (86.3 g/day in the UK), and Barton et al. (2018) (62.0 g/day for Scotland, and 59.4 g/day for England). Nonetheless, Zhong et al. (2020) suggest that a slight increase in cardiovascular disease incidents was significantly associated with a higher intake of unprocessed red meat, processed meat, or poultry. Iqbal et al. (2021) further added that a higher risk of major cardiovascular disease incidents and mortality was associated with a higher intake of processed meat.

The results of our questionnaire showed that the mean score of WEMWBS was 51.8 ± 8.6, which was similar to what Ng Fat et al. (2017) reported in their study on establishing national norms for mental well-being from the Health Survey for England (51.7 ± 8.7). Although the mean was slightly higher, 14.3% and 74.3% of our sample still remain classified as having low and medium well-being. In addition, the mean score for the PHQ-9 was 2.3 ± 2.6 (2.0 (4.0)), which was lower than the 2.7 ± 3.5 reported by Kocalevent, Hinz and Brähler (2013); however, 57.1% and 14.3% of our population were classified with signs of minimal depression and moderate depression. Several studies have linked depression to the increased risk of coronary artery disease in healthy individuals by 1.5 times (Pratt et al., 1996; Brown et al., 2011; Ariyo et al., 2000). According to Surtees et al. (2008), patients with depression who had no prior history of cardiovascular disease had a 2.7 higher mortality rate from ischemic heart disease over the span of 8.5 years.

In our sample of construction workers, physical activity levels were significantly higher than the NHS and the American Heart Association recommendation of 150 minutes per week of moderate physical activity. Similar high physical activity levels in construction workers (231 minutes during working hours and 130 minutes during leisure time) were reported by Arias et al. (2015). In addition, the average grip strength for both right and left hands reported in this study (50.4 ± 8.6 and 50.5 ± 8.5Kg) was higher than 49kg and 47 kg reported by Günther et al. (2008) and was slightly lower; nonetheless, within normal grip strength as per Dodds et al. (2014) normative grip strength meta-analysis from twelve British studies (Median 51 kg). According to Lawman et al. (2016), higher grip strength may be associated with better cardiovascular health. This was also reported by Beyer et al. (2018) that higher grip strength might improve cardiac structure and function, thus reducing the risk of cardiovascular disease incidence.

Our results suggest that construction workers may benefit from health promotion programmes that target smoking cessation, BP, and mental health. However, the small sample size in this study may not have captured the full extent of the problem associated with lifestyle behaviours. Therefore, further studies with a larger sample size are needed to form a better understanding of the lifestyle behaviours and other associated factors, including mental health and well-being of construction workers.

4.5 Conclusion

Different lifestyle risk factors were observed in this cohort of construction workers, which may lead to cardiovascular disease development in the future. This may warrant the development of future health promotion programs targeted toward construction workers. However, further studies with a larger sample size may provide greater insight into the lifestyle behaviours of construction workers.

Chapter 5 The Glasgow-Multiplex Lifestyle Collaboration (Part 2): a qualitative investigation of lifestyle, diet, and health in construction workers

5.1 Introduction

An appropriate methodological framework is essential to ensure that research results are robust (Rust et al., 2017); as such, combining both quantitative and qualitative methodology may help in achieving this. According to Tavakol and Sandars (2014), both quantitative and qualitative studies complement each other by developing new knowledge in addressing a research problem. They further added that quantitative studies provide opportunities to test a theory deductively; however, qualitative studies may aid in explaining these theories (such as behaviours). Therefore, adding a qualitative component could provide additional insights and depth to our project.

Qualitative research is a method of inquiry that is designed to gather an in-depth understanding of human behaviour and the reasons behind such behaviours. It is not primarily focused on hypothesis confirmation, which is more characteristic of quantitative research. In quantitative research, the researcher usually starts with a hypothesis - a proposed explanation for a behaviour, which is then tested with data. The goal is to either confirm or refute the hypothesis. In contrast, qualitative research typically does not start with a hypothesis. Instead, it aims to explore the behaviour in depth and detail, often leading to the generation of new theories or models rather than testing pre-existing ones. As per Josselson (1994), rather than seeking a hypothesis confirmation, qualitative research provides a way by which data can be understood, which in turn provides an explanation instead of linking it to a pre-existing fact. This is achieved by the process of collecting rich, detailed data from which insights and understanding can be derived. Essentially, qualitative research is more exploratory and inductive in nature, focusing on understanding the links (how and why) behind behaviours, thus providing a holistic understanding.

In the previous chapter, quantitative data were collected. However, to further understand the lifestyle behaviours and mental health of construction workers, further investigation is needed, and thus, the aim of this qualitative study was to further build on our previous findings by exploring the lifestyle choices of people working in the construction industry, the potential barriers and facilitators towards improving their current lifestyle choices (diet, sleep, smoking, alcohol, physical activity, and sleep), understanding their mental health and their views of existing workplace health promotion initiatives.

5.2 Research Design and Methods

5.2.1 Participants and setting

We initially intended to recruit a sub-sample of participants from the prior chapter. However, this was not possible due to COVID-19 (no longer work there), and thus, we expanded recruitment to include other participants. To form a holistic understanding, we sought to diversify our sample and include a variety of job titles and work locations. Work location was classified into two categories: 1) hybrid, for participants with desk-related and on-field work, such as site engineers; 2) on-site, for participants exclusively working on-field with no office-related work. However, this was hindered, as recruitment was significantly impacted by COVID-19.

Consequently, intense communication with Multiplex, the primary contractor, became necessary to expedite recruitment. Despite slow responses from Multiplex (August 2020 to August 2021), 14 participants aged 18 and over were successfully recruited after providing consent and were those available on-site at the time, regardless of job type. This study received approval from the University of Glasgow College of Social Sciences Ethics Committee (Application Number: 400190122).

5.2.2 Data collection

Remote interviews were conducted between August 2020 and August 2021 to comply with restrictions due to the COVID-19 pandemic. Interviews were either via a telephone call or a video call (Zoom), as chosen by the participant, and were up to 45 minutes in total. The interviews were conducted by H.A., except for the first one, which was conducted by H.A. with the aid of C.G.. Prior to this, H.A. had acquired training in qualitative interviewing through a course named 'Introduction to Qualitative Interviewing' (details of the course can be seen in appendix C5.A). To focus discussion on the aim of this chapter, a topic guide was developed encompassing seven domains: diet, smoking, alcohol, physical activity, mental health, sleep, and workplace and health. The goal of this topic guide was to help provide a comprehensive understanding of each domain and highlight the factors that could potentially aid or hinder their improvement. The topic guide is provided in Appendix C5.B. After gaining consent, interviews were audio-recorded, and field notes were directly attached to each participant's file immediately after the interview to capture any relevant contextual information. Each participant was allocated a code, and audio recordings were anonymised to maintain their privacy.

5.2.3 Data Analysis

Participants were categorised by job type: "Hybrid" for those with both office-based roles and on-site duties (engineers involved in site supervision) and "OnSite" for those with exclusively on-site roles (manual labourers). A thematic framework analysis, a structured method for organising and interpreting qualitative data, was employed to identify, analyse, and report patterns within the data (Gale et al., 2013). This approach, both rigorous and flexible, facilitates a comprehensive understanding of the data's complexity. The analysis followed an iterative process similar to that described by Naeem et al. (2023), ensuring thoroughness and depth. Before developing inductive themes — those that naturally emerge from the data (Thomas, 2006) — seven deductive themes, pre-determined based on the domains of the topic guide (diet, smoking, alcohol, physical activity, mental health, sleep, and workplace health), were established. The analysis steps are as follows and summarised below in flowchart F5.1:

1. Audio transcription and anonymisation.

In this step, audio recordings were transcribed, anonymised, and quality assured.

2. Transcriptions were read and re-read for familiarisation.

In this step, transcripts were imported into NVivo software, where transcriptions were read and re-read by H.A. to ensure thorough familiarity and a comprehensive understanding of the data.

3. Relevant quotes were assigned keywords (premature codes) to help summarise underlying information.

In this step, H.A. and C.G. independently reviewed three transcripts, highlighting relevant quotes and assigning keywords (premature codes) to organise the data, which were then discussed. Subsequently, H.A. and C.G. collaboratively reviewed two additional transcripts to affirm or revise the keywords, evolving them into final codes.

4. Assigning codes to data to capture the main message within data.

After the previous step's discussion, keywords (premature codes) were evolved into codes to simplify complex text. For example, physical activity performed outside working hours was coded as higher-intensity leisure-time PA, lower-intensity leisure-time PA, and routine and household PA. Codes were then applied by H.A., including the ones already read and coded by H.A. and C.G., to ensure consistency of coding.

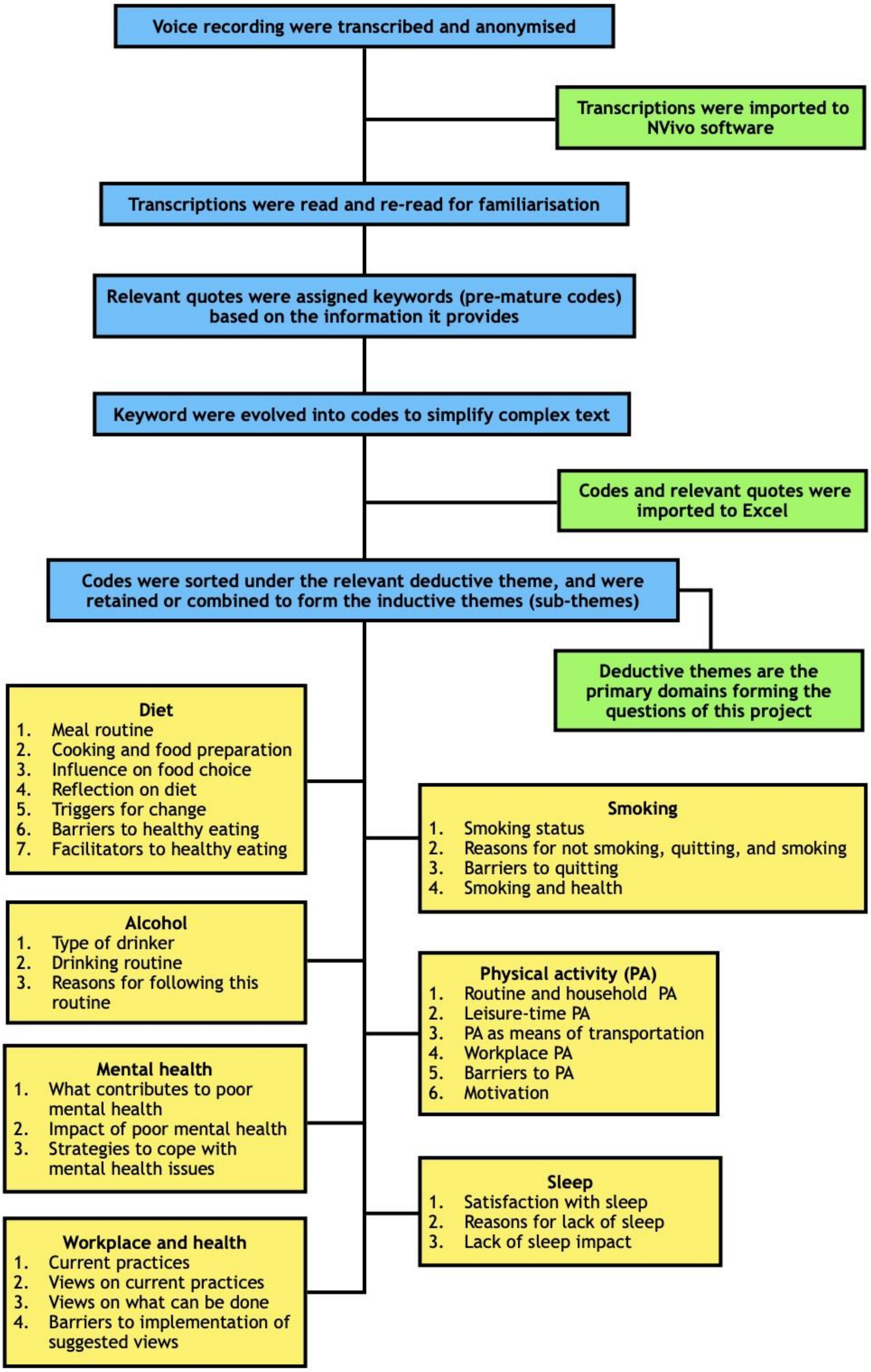
5. Theme development (inductive sub-themes) was achieved by organising codes into more meaningful groups.

In this step, H.A. imported the codes into an Excel spreadsheet, aligning them under the relevant deductive themes. The goal was to categorise the codes into coherent groups, either retaining an individual code as a sub-theme or merging multiple codes into a single sub-theme. This process was conducted meticulously, with each decision made after a detailed consultation with C.G. to ensure accuracy and relevance. For example, within the physical activity theme, routine and household PA was preserved as a separate sub-theme, while higher-intensity and lower-intensity leisure-time PA were combined into a single sub-theme, Leisure time PA (see appendix C5.C for details).

6. Development of a conceptual model that highlights re-occurring factors that negatively affect multiple lifestyle behaviours or domains.

In this step, a conceptual model was developed by identifying recurring factors within the established themes that negatively impact multiple lifestyle behaviours or domains to emphasise these factors and bring them to the forefront.

To ensure the trustworthiness of the analysis, after each step (except steps 1 and 2), work was presented to C.G. for revision and to ensure data were analysed in a proper methodological way. As a result, and guided by our research question, a thematic framework analysis was conducted for each broad theme (deductive theme) by H.A. and C.G., and diet was classified into seven sub-themes (inductive themes): meal routine, cooking and food preparation, influence on food choice, reflection on diet, triggers for change, barriers to healthy eating, and facilitators to healthy eating. Smoking was classified into four sub-themes: smoking status (smoker, ex-smoker, and non-smoker or social smoker), reasons, barriers to quitting, and smoking and health. Alcohol was classified into three sub-themes: type of drinker, in which participants describe the type of drinker they are (e.g., heavy drinker), drinking routine, and reasons for following this routine. Physical activity levels were classified into six sub-themes: routine and household physical activity, leisure-time physical activity, physical activity as means of transportation, workplace physical activity, barriers to physical activity, and motivation. Mental health was classified into three sub-themes: What contributes to poor mental health, the impact of poor mental health, and strategies to cope with mental health issues. Sleep was classified into three sub-themes: satisfaction with sleep, reasons for lack of sleep, and lack of sleep impact. Workplace and health was classified into four sub-themes: current practices (including positive practices, which involve practices that may help improve employees' health, and negative practices, which include practices that do not promote health), views on current practices, views on what can be done, and barriers to implementation of suggested views. (refer to appendix C5.D for Theme description).



Flowchart C5.1: Thematic analysis process to form inductive themes

5.3 Results

Fourteen male participants successfully completed the interview process. These participants were recruited from two sources: the primary contractor Multiplex (N = 3) and those engaged with different subcontractors (N = 11). Seven participants had Hybrid jobs, and seven participants had OnSite jobs.

5.3.1 Thematic analysis

5.3.1.1 Diet

Most participants indicated that they typically consume three meals a day, one of which is usually light. At least one of these meals is home-cooked, according to the majority, and often prepared by their partners or parents: "*The wife usually makes my dinner for me coming in*" **(Onsite-4)**. The partners play a major role in facilitating a healthy diet by introducing healthier alternatives "*My wife generally dictates what's…what we're eating. I'd say we've got fairly similar tastes in what we like. She's certainly introduced a lot more beans and pulses into my diet*" **(Hybrid-2)** and similarly, children influence healthier food choice "*my wife is quite… She tries to be a healthy eater. And especially for…maybe not so much me and her all the time. But we try to do that for the kids*" **(OnSite-6)**.

In contrast to children's influence, instead of cooking, many participants opt for takeaways due to the influence of their work, including the location of their workplaces, which often limits their choices to the available eateries "*What's available in the area. You've only got a few options for take-out shops*" **(OnSite-1),** or their demanding work schedules "It *can be quite a long day sometimes, and if you've not prepared it in the morning, then when you come home at night, and* *you're already tired, and you know that you've only got a couple of hours, I'd rather just order something*" **(Hybrid-3).** This aligned with the identified barriers to healthy eating, which primarily stem from the challenges associated with the preparation, acquisition, and management of nutritious meals amid a busy schedule "*I would say it's a bit harder to obtain, or it's a lot more effort to manage*" **(Hybrid-1)**. Despite these challenges, participants who lead an active lifestyle, such as gym-goers, did not report facing these same issues, and it appeared that being active motivated them to eat healthily "*If I'm going to the gym, I'll try and eat a wee bit healthier, so, I usually have like steak and veg or chicken and veg.*" **(Hybrid-4)**.

Some participants had made efforts to eat more healthily, and this transition was predominantly driven by health reasons "*It's actually changed in the past six weeks because, you see, six weeks ago, I had my work medical, I had high blood pressure*" **(OnSite-4)**. However, overall, participants expressed satisfaction with their diets, with a number displaying a lack of concern regarding whether their eating habits were healthy or unhealthy "*The type of foods I eat, I'm probably fully aware that they're not really the best for me, but I'm also very aware that if I don't eat that, I don't eat anything at all.*" **(Hybrid-1)**.

5.3.1.2 Smoking

Non-smokers credited their abstinence to health consciousness "*I've always lived a healthy lifestyle*" **(Hybrid-6)**, past experiences "*My mum smoked and...well, smokes, and my gran and all of her family smokes. I just don't like it. Never liked the smell of it. I hate the smell of it*" **(Onsite-7)**, and sporting commitments "*I was a keen footballer, so didn't want that to get in the way*" **(Hybrid-2)**. However, health concerns played a key role in motivating smokers to quit *"That was the reason I stopped smoking. I was waking up at like four in the morning every day, every day five, four, three, coughing"* **(OnSite-3)**, along with financial implications serving as an incentive *"It was mostly the cost It was getting too expensive"* **(OnSite-4)**. However, the need for stress relief, mainly due to work, emerged as a prominent reason for continued smoking *"Probably just the stress of work more than anything. It's just a stressful environment. It's just an easy way to have stress relief, isn't it"* **(Hybrid-5)**. Similarly, stress, primarily mainly due to work, "*In March, the reason I went back on smoking was because I lost my other job, so I was a wee bit stressed out. The first thing I went to was a cigarette"* **(OnSite-2)**, coupled with a lack of willpower *"Probably a lot of that is willpower through my part"* **(OnSite-6)**, posed as a barrier to cessation efforts.

In regards to smoking and adverse health, only participants who had never smoked or were ex-smokers talked about smoking and its adverse health effects. Those participants displayed a broad understanding of the negative health implications associated with smoking "*It's not a positive thing for your health. Understand it has, kind of, longer-term health impacts, so it'll take a number of years for those impacts to arise too"* **(Hybrid-2)**.

5.3.1.3 Alcohol

The General consensus highlighted that alcohol consumption was well under control "*It's never been a particular issue I couldn't really control"* **(Hybrid-7)**. Participants typically drink during weekends *"I probably do have a drink probably once a week. On the weekend"* **(OnSite-6)**, on a weekday, if there was no work obligation the following day "*Only drink once a week now. Have a drink, go to the pub on a Wednesday night, not if I've got work"* **(Hybrid-4)**, or only in social settings "*It's more a social thing*" **(Hybrid-2)**. Similarly, the primary reasons for moderating their drinking habits included work "*It'll never been when I've got work or whatever. It'll be if I've got a day off or something*" **(OnSite-6)**, with the addition of family responsibilities "*As a parent I have responsibilities*" **(Hybrid-6)**, and financial considerations "*When I was about twenty-four, twenty-five and decided…looked at the holes in my pocket and wondered where all my money went and decided this isn't for me*" **(Hybrid-1)**.

5.3.1.4 Physical activity

Based on their reported leisure-time physical activity, participants can be classified into two distinct groups: walkers "*The weekends, we go walking, we do walks in parks and stuff in my town, so I do try and do as much as I can anyway*" **(OnSite-1)** and intense exercisers "Monday and Wednesday morning, the gym from five o'clock for an hour; evenings go for a run after work" **(Hybrid-5)**.

Walkers typically report dog walks as their routine and household physical activity *"I would take my dog out for a walk, just a small, half an hour walk, not a long walk, 30 minutes"* **(OnSite-7),** report walking as a means of transportation *"I'm walking to work, and I'm walking back to the van"* **(OnSite-4)** and as a form of physical activity during working hours *"I maybe walking between six and eight miles during a shift at work. I'm carrying equipment. I'm an engineer on-site"* **(OnSite-1)**. However, they frequently report time constraints due to work as the sole barrier to increasing physical activity levels *"I wouldn't mind adding more exercise, but it's* *just because of the amount of time at work; it's just hard to fit in. Having a young child as well, I'd rather than take the time for me; I would rather assign the time to spend with them*" **(OnSite-1)**.

In contrast, the intense exercisers engage in multiple forms of physical activities, including running, sports, gym workouts "*I go to the gym on Monday, Thursday, Wednesday usually, so three times a week … then have football training on a Wednesday and Sunday*" **(Hybrid-3)**, and cycling as a sport and as a means of transportation "*I go to the gym. I'm cycling quite a lot, and then I go to the gym quite a lot, play football quite a lot.*" **(OnSite-7)**. Unlike walkers, intense exercisers described using physical activity as a motivation to improve their fitness levels and sports performance "*I'm quite a competitive person, especially with the rugby and cricket; I enjoy being probably one of the better, more fitter ones there*" **(Hybrid - 5)**, mental health "*You can mentally be a bit more agile … It's also a good way to blow off steam, I suppose, for sometimes pretty stressful days*" **(Hybrid - 3)**, physical appearance "*It's the way it makes me feel healthy, makes me look okay*" **(Hybrid - 5)**, and to help them lose weight "*I was gaining a bit of weight, and I wanted to lose it*" **(OnSite - 7)**. This group did not report any barriers to physical activity engagement, demonstrating a stark contrast to the walking group.

5.3.1.5 Mental health

According to the majority of participants, work and the COVID-19 pandemic were the two main sources of mental health issues. Long working hours, the number of tasks, workloads, and deadlines were linked to stress and anxiety "*I started this job, and I would say probably four out of my five days a week I am very stressed, which* *kind of could be kind of like, kind of being more anxious with stuff, worrying about a lot more stuff than I used to*" **(Hybrid-7)**, and work pressure "*12-hour shifts, and there was pressure put on you to finish things in time*" **(OnSite-7)**.

Work, family, social encounters and sleep have been impacted the most, where participants reported it affecting the way they prioritise tasks at work *"In terms of workload, certainly. It can be challenging to understand what the priorities are and how to be the most effective during the day."* **(Hybrid-2)**, being stern and tired at home *"If you asked my partner, she would probably say yes, it does. For the likes of myself, I don't particularly think it does, but I've heard her saying you're this, you're that, or I might be a wee bit more grouchy or a bit more tired or fatigued or what have you, and that all comes down from obviously the workload"* **(Hybrid-1),** being ill-tempered when talking to others *"It affects like outside work life as well. You know, you're crabbit, you're biting back at people*" **(OnSite-7)**, and difficulty sleeping "*After a 12-hour shift, you're already tired, but there's something playing in your mind like, oh, I should have done this, or I needed to get this done for today, and then when you go to your bed later on at night it's harder to sleep*" (**OnSite-7)**.

Several participants were able to mitigate these impacts through physical activity "*I would cope with it by doing exercise. That's the way I cope, like because it releases my endorphins, like feeling good and such*" **(OnSite-7),** talking to friends or family members "*sharing some of that burden, I suppose, try to be more proactive in that*" **(Hybrid-2)**, video games *"I play a wee bit of video games which is a bit of escapism – shoot a few people on that, which makes you feel a wee bit better"* **(Hybrid-1)**, and smoking "*If I'm feeling a wee bit stressed, depending on the severity of it, I just have a wee cigarette*" **(OnSite-3).**

5.3.1.6 Sleep

The majority of participants expressed satisfaction with the duration of their sleep, with only five exceptions. These individuals attributed their dissatisfaction to work "*My day has been taken up with work, and you know, things that need done, whereas that's kind of my time just to chill out, do what I want, so that's how I feel like I end up staying up till 12 o'clock*" (**Hybrid-7)** and family "*If my wee girl has woke up, or whatever, and then can't get back to sleep*" (**OnSite-2**), which led to feelings of sleepiness "*Most days I feel sleepy; it takes a while to get up*" **(Hybrid-3)** and exhaustion "*The following day, you're waking up tired, and you're constantly thinking…I would say you're…overall, you're exhausted*" **(OnSite-7)**.

5.3.1.7 Workplace and health promotion

In addressing the subject of workplace health promotion, three positive practices were identified: cycling schemes "*You buy a bike off them*" **(OnSite-7)**, sedentary behaviour prevention "*Talks around sedentary lifestyles and trying to promote people getting…stretching their legs*" **(Hybrid-2)**, and mental health initiatives "*In terms of mental health promotion, there are mental first aiders*" **(Hybrid-1).** The single negative practice reported was the presence of unhealthy food options at the workplace, such as burger vans "*The majority of the meal options there would be, kind of, high fatty burgers and chips*" **(Hybrid-2)**.

Although a number of participants reported a number of positive practices, the shared view among participants concerning workplace and health promotion was dissatisfaction and lack of support with the provisions from the organisation *"No is the honest answer to that. If there was more health promotion in terms of that, you wouldn't be working half the hours that you're working; you would have additional support"* **(Hybrid-1),** or a lack of awareness about any existing health promotion programs "*Not that I know of, but they might do*" **(OnSite-2)**. However, a few participants expressed satisfaction with the available health promotion programs; however, they could only identify cycling schemes when asked for specifics.

When discussing potential improvements, a majority suggested the implementation of shorter working hours to promote a better work-life balance "*The likes of Sweden and Denmark and stuff like that where their working week is far less. They promote a more healthy balanced lifestyle*" **(Hybrid-1)**, which they believed to be unfeasible due to industry demands *"Construction industry is driven obviously by cost and timescales and there's no way around having to work the hours that we work; it's just the way the industry"* **(OnSite-1)**. Additional suggestions included spreading awareness of adverse lifestyle behaviours *"I think some guys just do not realise the adverse effects of eating crap and drinking all the time, smoking all the time really has on their health. You maybe know it's not good for you. But if you were able to demonstrate this"* **(Hybrid-5),** and offering healthier food options *"Maybe see that burger van onsite maybe if it was like for healthier eating, if you know what I mean, like for like, obviously, healthier food"* **(Hybrid-4)**.

Table C5.1: Summary of the thematic framework analysis

Theme (Deductive)	Sub-team (Inductive)	Common responses
Diet	Meal Routine	3 meals: breakfast, lunch, dinner
	Cocking and food preparation	1 cooked meal, primarily prepared by parent or partner (dinner)
	Influence on food choice	- Unhealthy diet: Work location, time due to long working hours. - Healthy diet: Active lifestyle and health, children
	Reflection on diet	Content or not concerned with their diet
	Triggers for change	Health
	Barriers to healthy eating	Difficult to prepare, obtain, and manage
	Facilitators to healthy eating	Partner (female) as the primary facilitator of healthy food
Smoking	Smoking status	4 active smokers, 2 ex-smokers, 7 non-smokers, and 1 social smoker
	Reasons for 1) not smoking, 2) quitting, and 3) smoking	1) Health, past experience, and sports. 2) Health concerns, and cost. 3) Stress relief associated with work
	Barriers to quitting	Stress relief associated with work, and willpower
	Smoking and health	Unhealthy, long-term negative effects, cancer, and effects on fitness levels
Alcohol	Type of drinker	Light and well under control
	Drinking routine	Weekends, if there is no work the following day, and socially
	Reasons for following this routine	Work, family responsibilities, and cost
Physical activity	Routine and household PA	Walking the dog, with a couple of participants reporting the duration of these walks
	Leisure time PA	Gym, sports (football, rugby, and cricket) running, and walking
	PA as means of transportation	Walking and cycling
	Workplace PA	Walking
	Barriers to PA	Time constraints due to long working hours
	Motivation PA	Improving fitness level and mental health, appearance, and weight loss
Mental health	What contributes to poor mental health	Work (leads to stress, anxiety, and pressure) and COVID-19
	Impact of poor mental health	Work performance, family and social life, and sleep
	Strategies to cope with mental health issues	PA, talking to someone, playing video games, and smoking
Sleep	Satisfaction with sleep	Only five were not satisfied
	Reasons for lack of sleep	Work and family
	Lack of sleep impact	Feeling sleepy and exhausted
Workplace and health	Current practices	(+) Cycle schemes, sedentary behaviour prevention, mental health support. (-) Unhealthy food options at the workplace
	Views on current practices	Dissatisfaction and lack of organisation support, and not aware of any practices
	Views on what can be done	Shorter working hours, spreading awareness of unhealthy lifestyles, and healthier food options
	Barriers to the implementation of suggested views	Shorter working hours are unfeasible due to the construction industry's demands

5.3.2 Conceptual model

The conceptual model (figure C5.1) was synthesised through a systematic and iterative process of identifying recurrent factors that prominently emerged during our thematic analysis. The model illustrates the negative association between work-related factors (prolonged working hours and job strain) and unhealthy lifestyle choices. These choices, which may be due to direct or indirect responses to the pressures exerted by the work environment, span across several domains, including dietary habits, smoking, physical activity, sleep, and detrimental effects on mental health.

An unhealthy diet, characterised by increased fast food consumption, was observed as a consequence of these work-related factors. This pattern suggests a tendency among individuals to opt for the consumption of unhealthy food options due to the time spent at work. In a similar way, smoking was identified as a coping mechanism for work-induced stress. This adaptive response, while providing temporary relief, seems to significantly hinder attempts to quit, thereby intensifying the adverse health outcomes associated with this habit. As for physical activity, work-related factors such as long work hours and high job demands seem to negatively affect individuals' engagement in and progression of physical activity. Work-related factors, including strain and long working hours, were reported to influence sleep patterns, leading to sleep disruptions. These disruptions result in consequent repercussions on next-day performance. Finally, these work-related factors were identified as significant sources of pressure, stress, and anxiety. As such, they hold potential implications for mental health.

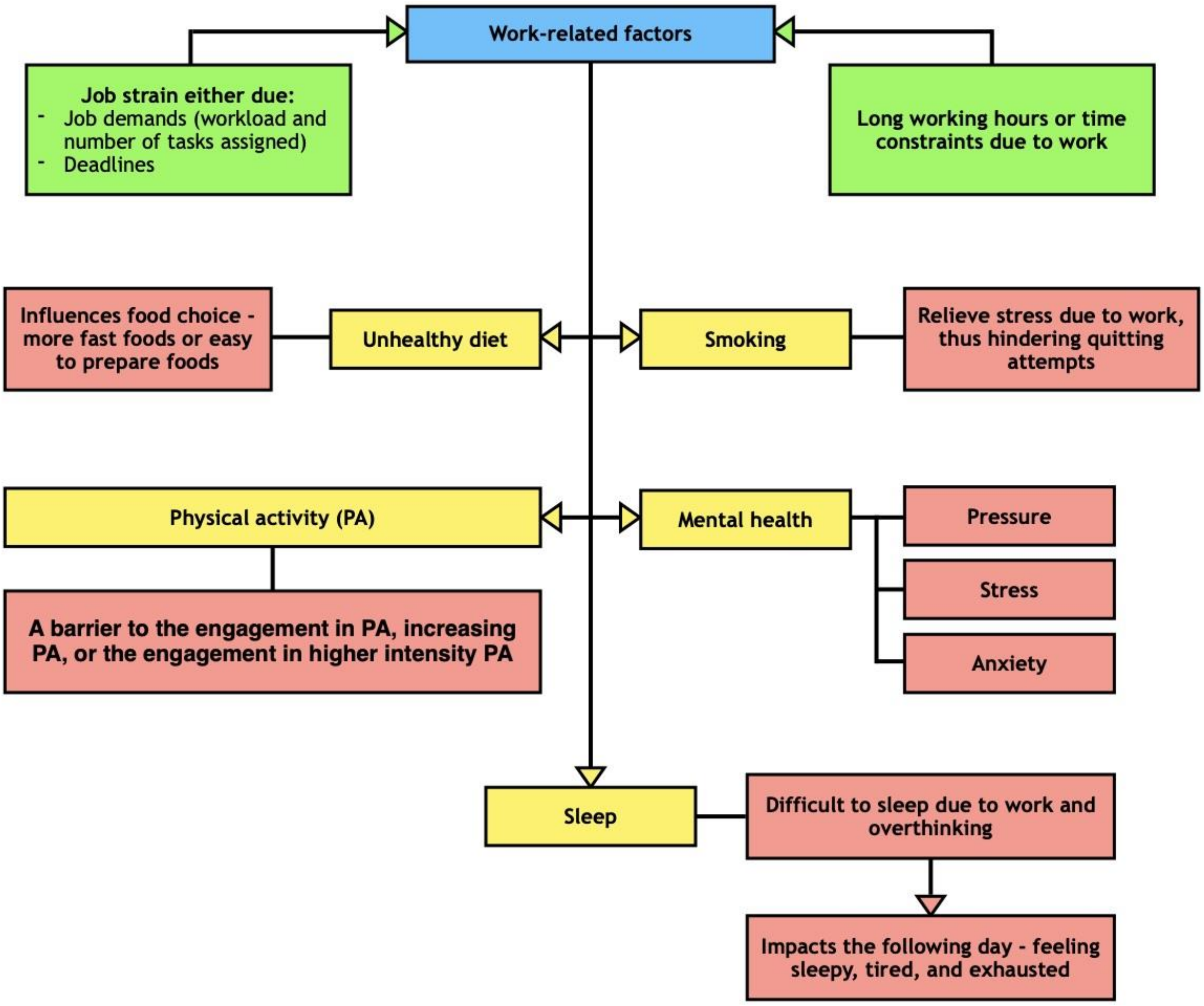


Figure C5.1: The conceptual model highlights re-occurring factors negatively affecting multiple lifestyle behaviours and mental health

5.4 Discussion

This study aimed to build on our previous findings by investigating the lifestyle choices of construction industry workers, focusing on diet, sleep, smoking, alcohol, and physical activity and the potential barriers and facilitators to improving them, and in addition, provide an understanding to their mental health, and explored their views on workplace health practices, evaluating whether these practices promote healthier lifestyles or mitigate the impact of unhealthy behaviours.

The majority of participants reported having three meals a day, with one being a light meal and at least one home-cooked meal, which was usually prepared by partners (wife), with the partners being more of a facilitator for a healthy diet, as they introduce more healthy alternatives. This seems to be aided by the literature, as females are more inclined to eat healthy food alternatives than their male counterparts and, thus, more likely to cook healthy meals as well as introduce healthy options such as beans and pulses. Wardle et al. (2004) noted that females were more likely than males to eat fruit and fibre, avoid fat-enriched foods and limit salt intake, and in addition, were more likely to be on a diet, as they further elaborated this by reporting that 7% of gender differences were in fruit choices, 23% on fibre choices, and 22% on fat choices, and this was mainly attributed to females beliefs in healthy eating habits and greater weight control. This may raise a question that the majority of men may not perceive diet and its implications on the body the same way their female counterparts do.

Only participants who were motivated by any form of intense physical activity were driven to eat healthier foods. In contrast, participants who lacked such motivation often cited difficulty in preparation, obtainment, and management of such healthy foods as barriers to maintaining a nutritious diet. These individuals frequently opted for takeaways, largely due to the demands of their work schedules, which left them with limited time to prepare meals at home. This finding aligns with the work of Escoto et al. (2012), who identified that working more than 40 hours per week was associated with time-related obstacles to healthful eating. However, participants with active lifestyles, such as those who regularly attend the gym, did not experience these barriers to the same extent.

In regard to physical activity, the only barrier reported was time constraints due to work obligations, and this was exclusively mentioned by participants who engaged in less intensive physical activities (walking). However, another possible explanation, which was not reported by our participants but observed in our quantitative study and mentioned within the literature, is that the construction industry is a physically demanding job, as participants engage in a lot of different intensities of physical activity. Arias et al. (2015) reported that construction workers exceed both the American Heart Association and the American College of Sports Medicine's recommendations for the number of minutes spent in physical activity per week, as their bouts of moderate-intensity physical activity during working hours were 231 minutes and 130 minutes outside working hours. However, the majority of participants in our study, who engage in walks as the main physical activity, did not report these intensities during working hours, which raises the question of whether they consider occupational physical activity as a form of physical activity. In addition, time constraints, which may be due to long working hours, may further hinder engaging in higher intensities of physical activities outside working hours, as per Abdel Hadi et al. (2021).

Similarly, other than dog walks, household physical activity was another form of physical activity that participants did not report at all, which may raise the question of whether they considered it a form of physical activity. In total, household physical activity may contribute to a large proportion of an individual's physical activity, thus, making it a valuable source of physical activity. Murphy et al. (2013) reported that when household physical activity was taken into account as a form of physical activity, 42% of their population (46% of males and 40% of females) met the current physical activity recommendations of 150 minutes or more of moderate and vigorous physical activity time per week, as household physical activity contributes to about 35.6% of the time spent in moderate and vigorous physical activity per week.

Stress, anxiety, and pressure were the major mental issues reported by participants when addressing mental health, and this was mainly due to work. Stress has been increasingly linked to work and thus referred to as work-related stress. Common stress sources within the workplace reported within the literature are high demands and workloads (Karasek and Theorell, 1990), time pressure, long working hours, difficult and complex tasks, poor working conditions, and lack of breaks (Michie, 2002), which was, in general, similar to what was reported by our population. Work-related stress can have a significant impact on the organisation in terms of productivity and profit, as well as on the worker in terms of well-being (Bickford, 2005) and disease development (Fransson et al., 2015; Kivimäki et al., 2012). Therefore, organisations need to prioritise this and address it due to the impact it may have on both the organisation and the worker, and in addition, provide workers who are affected by this type of stress a communication line to voice it. Michie (2002) noted that stress management requires the involvement of both workers and the organisation, as the organisation may be the one that creates this form of stress.

When addressing workplace and health, construction industries are a demanding field, which increases the number of tasks and workloads for workers to achieve these results. Participants did agree when asked about ways to implement a better work-life balance, as they deemed it difficult to implement due to these demands imposed on them. However, with this in mind and according to participants, it appeared that the workplace was not a health-promoting environment, with a number of participants adding that the lack of support from the organisation was one of these factors that hindered a better workplace environment. Furthermore, a number of participants even added that they had not heard of any health promotion programs held by the organisation, even when an organisation had, according to reports from participants within the same organisation, which may be attributed to a lack of communication between the two sides. This lack of communication may be added to the lack of support reported by participants; thus, the organisation may be held accountable, and a better communication platform should be in place to provide a better and clearer communication line for both the organisation and worker when it comes to health and well-being.

The developed conceptual model highlighted that work-related factors (long working hours and job strain) were associated with adverse lifestyle choices (diet, smoking, PA, and sleep) and mental health issues. These findings concur with what is currently reported in the literature. Baek et al. (2024) reported that long working hours were linked to undesirable diet quality and patterns, as they noted that individuals working for more than 54 hours/week were more likely to have a low-fruit diet (OR: 1.36; 95% CI: 1.20, 1.55) and an overall poor diet (OR: 1.23; 95% CI: 1.05, 1.43) compared to 35-40 hours/week. Similarly, Ayyagari and Sindelar (2010) reported that job stress was positively associated with smoking among recent smokers and also hindered quitting attempts. Furthermore, a systematic review by Khorrami et al. (2021) concluded that job-related stress was associated with heavier smoking. As for physical activity, a number of studies identified that high levels of work demand, including time pressure and too much work, were correlated with low levels of exercise during leisure time (Abdel Hadi et al., 2021; Häusser and Mojzisch, 2017; Fransson et al., 2012). Similar effects were, in addition, noted in sleep and mental health, as Afonso, Fonseca and Pires (2017) concluded that longer working hours were linked to sleep disruption and poorer mental health via increasing anxiety and depression symptoms.

The profound context embedded within this model makes it crucial to understand the dynamics of work-related factors and their pervasive implications on both the physical and mental health of construction workers. The model thus serves as an essential tool in our efforts to comprehend the lifestyle of construction workers and, in addition, the complex interplay between work and lifestyle choices, providing valuable insights that can guide future research and interventions in this field.

This study highlighted different factors that may explain participants' lifestyle choices, their mental health, and whether the workplace helps promote a healthy lifestyle. This was achieved by asking participants about different aspects of their lives, including diet, smoking, alcohol, physical activity, mental health, sleep, and workplace environment and health. The main goal for this was to cover most aspects of participants' lives. However, as interviews were capped to a maximum of 45 minutes, questions or follow-up questions may have been too shallow to accommodate all the other aspects, or questions on other aspects may have been limited due to time spent explaining a single aspect, such as diet. In addition, the recruitment process aimed to diversify the sample by including various job types to offer a comprehensive understanding of lifestyle behaviours, choices, and mental health across different roles within the construction industry. However, due to

COVID-19, the study was stretched in terms of recruitment for more than a year due to communication issues, and thus, it was difficult to achieve. Similarly, we were unable to report sociodemographic characteristics, as we originally planned to only include participants from our prior cross-sectional study (part 1) in this project who had already provided their sociodemographic characteristics; however, due to COVID-19, this was not possible. This drawback became apparent only after communication with Multiplex was lost, preventing us from collecting additional sociodemographic information. Consequently, this resulted in a notable deficiency in our data, hindering our ability to gain a deeper understanding of the participants involved in this research project.

5.5 Conclusion

The aim of this qualitative study was to help provide an explanation of the lifestyle behaviours, mental health aspects, and whether the workplace promotes a healthy lifestyle for construction workers. The finding of this study indicates that participants who eat healthily are either driven by an active lifestyle or have it prepared by their partner. Similarly, participants who had a more active lifestyle were usually driven to improve their fitness level, sports performance, mental health, and physical appearance. In general, participants were not satisfied or had not heard of any health promotion programs at the workplace and tended to be under stress and pressure due to work-related factors such as workloads and long working hours, which were in addition associated with adverse lifestyle choices (unhealthy diet, smoking, lack of engagement in physical activity, and sleep impact) and mental health issues.

Chapter 6 General Discussion

6.1 Project summary and the literature

This PhD project aimed to help inform and direct future interventions, specifically at the workplace, through understanding lifestyle behaviour and other associated factors, such as mental health and well-being of office and construction workers. To achieve this aim, the following were conducted:

i) A cross-sectional secondary data analysis of a large data set of employees from a public sector organisation (Office workers) to determine demographic, social, organisational, health and behavioural factors and whether they were associated with employees' absenteeism and presenteeism (Chapter 2).

ii) A systematic review to identify and synthesise previously undertaken workplace-based health interventions in construction workers to improve physical activity, diet, weight, and smoking to see what has been previously done and the degree of its effectiveness. (Chapter 3).

iii) A cross-sectional study quantifying demographic, physical and mental health risk factors and lifestyle-related health behaviours amongst construction workers (Chapter 4).

iv) A qualitative study to build on previous cross-sectional findings (objective iii) to further understand construction workers' lifestyle choices, facilitators and barriers to improving them, and their views on available workplace health promotion programs (Chapter 5).

Please refer to image C6.1 below for a comprehensive overview of the key findings derived from each chapter of this PhD project.

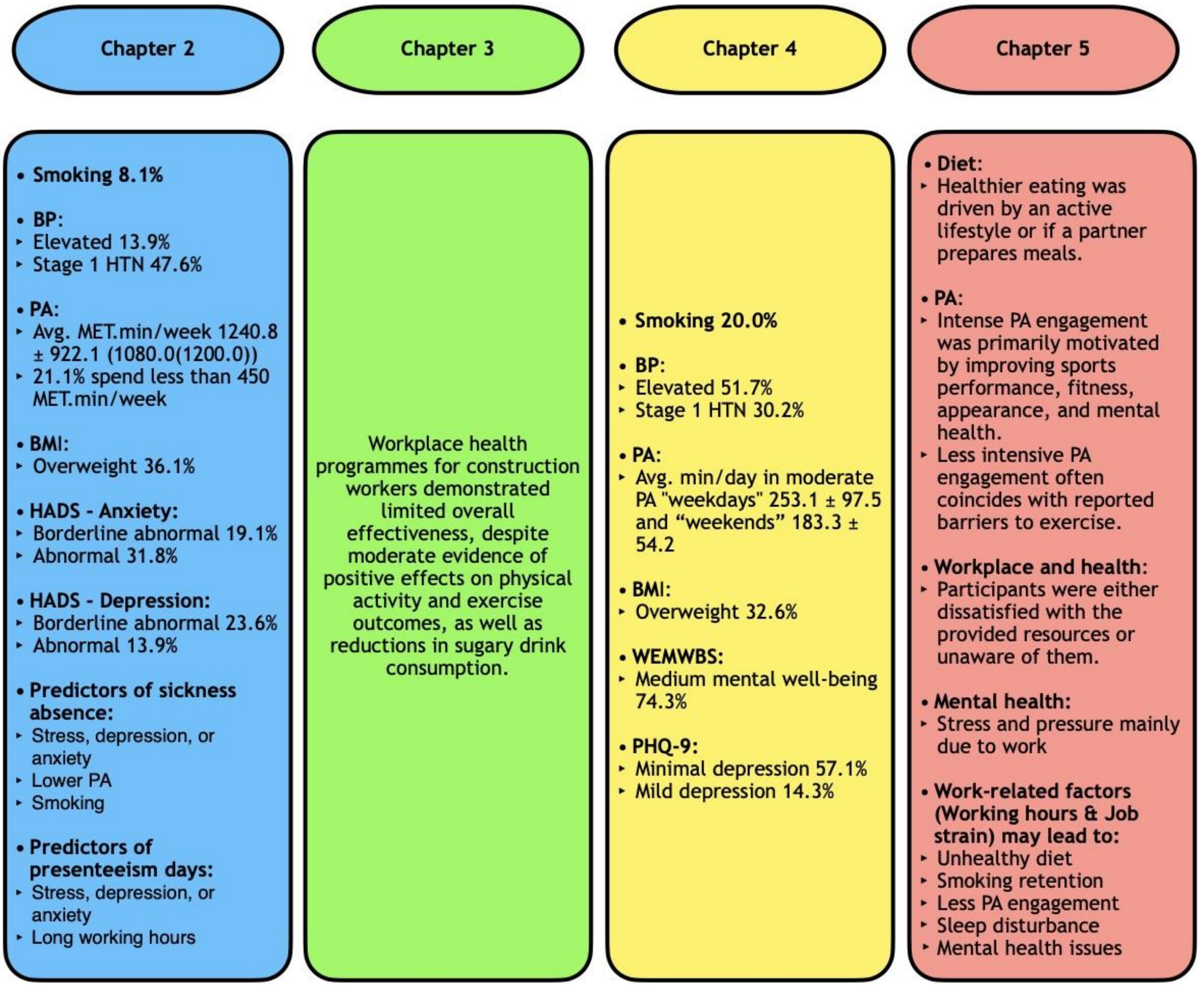


Image C6.1: Summary of key findings from each chapter

Despite moderate evidence in reducing sugary drink consumption, evaluating dietary intake in this project presented significant challenges. In our construction worker cohort, while reported consumption of fruits, vegetables, and fish aligned with NHS guidelines of five portions of fruit and vegetables per day (400g/day) and two portions of fish per week (240g/week), there were indications that these figures along with the other findings might not accurately reflect true intake levels. Possible reasons for this discrepancy include the small sample size and potential misunderstandings of the questionnaire, as they were left with participants with no supervision. Moreover, in our office workers' sample, the absence of a valid and reliable dietary assessment tool compounded the difficulty in accurately measuring diet portions. This issue stemmed from the survey design, which often grouped together foods from disparate categories, such as processed foods and pastries, in a single question. Diet assessment is widely acknowledged as a complex task. According to Nelson (1997), dietary assessment is fraught with errors, with no existing measure perfectly capturing nutrient intake on an individual or national level. Ni Mhurchu, Aston and Jebb (2010) highlighted the risk of reporting bias in self-reported dietary measures, suggesting that knowledge of diet may lead to overreporting. Similarly, Shim, Oh and Kim (2014) asserted that no single method can flawlessly assess dietary intake or exposure. These insights, in addition to the lack of effectiveness of workplace interventions from our systematic review and work emerging as a barrier to a healthy diet in our qualitative chapter, underscore the need for future research with a primary emphasis on diet to capture dietary intake more accurately, and thus aiding future workplace intervention programs, and organisations in improving employees' health.

In our project, the majority of our office-based and construction workers participants align with the physical activity recommendations issued by both the NHS and the American Heart Association, which suggest a minimum of 150 minutes per week of moderate-intensity physical activity, despite the emergence of lower physical activity as a predictor for sickness absence in office workers. This observation is consistent with findings from previous research, as Chau et al. (2012) reported that the majority of office workers, 55%, were sufficiently active by meeting the physical activity guidelines, and Clemes, O'Connell and Edwardson (2014) added that office workers on average spent 32 and 28 minutes in moderate to vigorous physical activity during workdays and non-workdays, respectively, with

Biernat and Piątkowska (2018) reporting that office workers spent on average 428 MET.min/week in vigorous physical activity, 208 MET.min/week in moderate physical activity, and 337 MET.min/week in walking, translating the total to 973 MET.min/week. High physical activity levels were, in addition, reported in construction workers, as Arias et al. (2015) noted that construction workers spent a total of 361 minutes in moderate physical activity per working day (231 minutes during working hours and 130 during leisure time), with Gram et al. (2016) further noting that construction workers had a median of 5036 MET.min/week during working hours and 2842 MET.min/week during leisure time. Even with the findings from our systematic review, which identified moderate evidence of workplace interventions in improving time spent in recreational physical activity and adherence to physical activity guidelines, the evidence from this project, along with numerous studies in the literature, indicates that both office and construction workers generally achieve the recommended levels of weekly physical activity. Therefore, it may be more beneficial to focus intervention efforts on other lifestyle aspects that require more attention and improvement, particularly for construction workers, due to the lower bouts of sedentary behaviour during working hours.

The PhD project revealed a notable disparity in smoking prevalence between construction and office workers, with construction workers exhibiting a higher rate. The disparity in smoking prevalence was also reported by Syamlal et al. (2015), where the prevalence of smoking among construction workers was 30.4% compared to 18.5% among office-based workers. Despite the lower prevalence in office workers, smoking emerged as a significant predictor of sickness absence, underscoring its negative impact on employee health and productivity irrespective of the work environment. However, efforts as per our systematic review to mitigate this, mainly for construction workers, through workplace health promotion programs specifically aimed at reducing smoking have not been successful, which may be explained by the finding from our qualitative study indicating that stress emerging from work-related factors may be a barrier for smoking cessation attempts. This suggests the complexity of addressing smoking behaviour in the workplace and points to the potential need for more tailored or multifaceted approaches to effectively combat smoking and improve health outcomes among workers.

Our project revealed significant mental health challenges among both office and construction workers. Specifically, 50.9% of office workers exhibited signs of anxiety, while 37.5% showed signs of depression. Furthermore, we identified stress, depression, or anxiety as key predictors of both sickness absence and presenteeism in office workers. Among construction workers, 74.3% displayed signs of depression, with 57.1% experiencing minimal depression. These findings align with the high numbers reported by Kang et al. (2016), who observed a 38.3% prevalence of depression among office workers, and Boschman et al. (2013), who found a 37.2% prevalence among construction workers. Our qualitative research pinpointed work-related stress and pressure stemming from factors such as heavy workloads, tight deadlines, long hours, numerous tasks, insufficient organisational support, and the absence of dedicated workplace mental health management programs as primary concerns for mental health in the construction sector. This resonates with existing literature, including Michie (2002), which highlights the role of work overload, extended working hours, time pressure, and challenging tasks in inducing workplace stress. Moreover, our findings corroborate the growing body of research indicating that work-related mental health issues are not only a concern for mental and psychological well-being but also for physical health, as stress and depression have been linked to an increased risk of cardiovascular diseases (Kivimäki et al., 2006; Nicholson, Kuper and Hemingway, 2006), underscoring the urgent need for comprehensive workplace health promotion programs that address both mental and physical health aspects.

6.2 Project impact and strength

Highlighted by the following key factors, this PhD project could contribute to enhancing the overall health and well-being of employees in the workplace:

- The importance of mental health.

This project underscores the widespread mental health issues faced by both office and construction workers, highlighting the urgent need for enhanced mental health support and services in the workplace. By shedding light on these issues, this project could motivate organisations and policymakers to establish and reinforce mental health initiatives, ultimately fostering a healthier work environment.

- Overweight and high blood pressure are prevalent and remain a serious matter.

The prevalence of excess body weight and elevated blood pressure among both office and construction workers points to a pressing health concern. This project draws attention to the importance of understanding and mitigating the risks associated with these conditions, which, even when not classified as obesity or hypertension, significantly contribute to the risk of NCDs. By highlighting these issues, the research project advocates for increased awareness and regular health monitoring by both individuals and organisations. In addition, organisations and policymakers should be encouraged by these findings to implement preventative strategies to combat both issues, as this will not only improve individuals' health but also the organisation's profitability.

- The impact of work on health.

The project, primarily for construction workers, casts a light on the consequential relationship between work and health. It investigated how work-related factors can directly or indirectly alter an individual's lifestyle choices to unhealthy ones (unhealthy diet, smoking, lower physical activity engagement, impact on sleep, and mental health issues). The findings offer valuable insights for the development of health-promoting strategies, policies, and interventions in the workplace, even outside it. Highlighting the impact of work on health can provide organisations and policymakers with a deeper understanding of how job conditions shape health outcomes, guiding the creation of healthier work environments.

- Construction workers may indeed be a neglected population.

Highlighted by our systematic review (chapter 3), the project underscores a significant gap in workplace health promotion efforts, particularly within the construction industry, where interventions targeting lifestyle habits are scarce, and those implemented have demonstrated minimal effectiveness. This highlights construction workers as a potentially neglected demographic in workplace health promotion literature and initiatives. By bringing attention to this oversight, the findings should encourage organisations and policymakers to address this disparity and, in addition, encourage researchers to develop and implement more robust, evidence-based workplace health promotion programs tailored to the needs of construction workers, especially targeting those identified in this project (mental health, weight and blood pressure, and smoking). Emphasising this necessity for targeted health strategies and policies that address challenges faced by construction workers could lead to improved health outcomes and well-being for this workforce.

In summary, this PhD project has provided a rich, multifaceted perspective on health, shedding light on a variety of its aspects. By doing so, it may contribute to the development of a more comprehensive and nuanced understanding of health. In essence, the project may help enhance existing health-related policy-making and may guide future workplace interventions and scientific investigations.

6.3 Project limitations

Although this project may have provided key information on construction and office workers, the heavy reliance on subjective measures, as well as the instance use of self-constructed questions, may have increased the risk of bias; thus, overestimation or underestimation of certain lifestyle behaviours, particularly dietary habits. In addition, our qualitative study may have encompassed a large number of lifestyle behaviours during interviews, with interviews limited to 45 minutes, and as a result, may not have allowed sufficient time to delve deeply into each area of interest. Therefore, future studies are needed to investigate lifestyle behaviours further, especially studies investigating dietary patterns in construction workers as well as office-based workers.

6.4 Recommendations for future studies and interventions

The aim of this project was mainly to look at lifestyle and other factors to help inform future workplace interventions in office and primarily construction workers; however, the prevalence of mental health issues, not only in construction workers but also office-based workers, was alarming, and thus, according to this project, workplace health promotion programs are necessary for tackling four factors: smoking cessation, blood pressure, weight, and mental health, as signs of anxiety, stress, and depression can be observed in both office and construction workers, which were exacerbated by work-related factors such as workload, deadlines, and long working hours.

According to this project, and with a number of studies within the literature that concur, physical activity levels for both samples were within the weekly recommendation of both the NHS and the American Heart Association, and in addition, moderate evidence of the effects of workplace health promotion programs targeting physical activity behaviours was noted. Therefore, workplace health promotion programs targeting improvement in physical activity behaviour may not be a necessity, particularly within the construction industry, and efforts are better directed elsewhere. In addition, future studies targeting diet behaviours are needed, as this project was not able to elicit a reliable assessment of dietary behaviours in both office-based and construction workers.

6.5 Conclusion

The aim of this PhD project was to understand lifestyle behaviour and other associated factors, such as mental health and well-being in construction workers, as well as office-based workers, to help inform future workplace interventions. Based on the findings of this project, mental health issues (exacerbated by work-related factors, particularly in construction workers), high BP, and being overweight were prevalent in both office-based workers and construction workers, whereas smoking, especially for construction workers, where smoking was prevalent. While these health concerns might not be as prevalent as in the wider UK population, especially in relation to overweight, obesity, and hypertension, these findings could enhance the effectiveness of future workplace health promotion programmes aimed at improving the health of both office and construction workers. Such initiatives have the potential to not only create a healthier, more productive workforce but also help decrease the overall prevalence of these risk factors in the broader population.

Chapter 7 PhD and COVID-19 Impact

7.1 COVID-19 Impact

The COVID-19 pandemic has been a profound global crisis, affecting health, economies, and societies on an unprecedented scale. Its impact has been particularly severe in various sectors, leading to halted operations, furloughs, and significant job losses. Additionally, the closure of educational institutions, including schools and universities, was a necessary measure to curb the virus's spread but also brought substantial disruptions.

From the perspective of a PhD student, the pandemic's effects were acutely felt in the context of my research project. My work, which was closely tied to Multiplex, the construction company responsible for the University of Glasgow's expansion, experienced significant delays. The restrictions and challenges posed by COVID-19 directly impacted the company's operations, subsequently hindering the progression and timeline of my PhD project.

7.2 The original aim of this PhD project

The original aim of this PhD project was to understand the health status, lifestyle, physical functioning, and attitudes towards health and lifestyle behaviours among construction workers, with the goal of developing and testing a tailored workplace health promotion programme directed at construction workers. This meant that working with Multiplex was crucial for this project to achieve the intended goal, and thus, Multiplex allocated a staff member to be responsible for communication and accommodating the requirements needed for this project.

To achieve the project aim, a systematic review will first be conducted to investigate what has been previously done regarding workplace health promotion programmes targeting lifestyle behaviours and weight focused on construction workers. This review aims to establish a comprehensive understanding of the existing literature and identify gaps that the current project can address.

Secondly, a cross-sectional study was planned to collect quantitative data on sociodemographic characteristics, anthropometrics, grip strength, and lifestyle factors, including diet, smoking, alcohol consumption, and objectively measured physical activity, alongside mental health and well-being among construction workers. This phase aimed to gather a comprehensive set of data to provide detailed insights into the lifestyle of construction workers and their health-related behaviours.

Thirdly, a qualitative study was planned as an immediate follow-up to the cross-sectional study to further build on the findings from that chapter by providing explanations, barriers, and facilitators related to the current lifestyles of construction workers. This qualitative part was intended to involve interviewing participants from the previous cross-sectional study to help form a comprehensive understanding that included both quantitative and qualitative data for each recruited participant.

Lastly, the collected data will be carefully analysed to develop and test a tailored workplace health promotion programme specifically designed for Multiplex's construction workers.

7.3 COVID-19 Impact on the PhD project

Data collection for the second phase of the study, the cross-sectional study, commenced towards the end of September 2019. This was roughly three months prior to the first reported cases of the COVID-19 pandemic in the UK. However, in early March 2020, the university took preemptive measures against the pandemic by closing its facilities, aiming to reduce the spread by minimising close contact. This decision mirrored actions taken by Multiplex, effectively pausing the recruitment process indefinitely. Consequently, we shifted our focus to the qualitative segment of the project, necessitating a revision of the ethics application to accommodate remote interviews. However, and understandably, during this period of lockdown and uncertainty, communication with Multiplex was lost, and after a period of time, a slow response was achieved. Unfortunately, according to them, tracing down participants from the previous cross-sectional part was deemed difficult and not time-efficient. This feedback prompted us to revise the ethics application for the qualitative phase once more. This amendment expanded our participant criteria to include any construction workers employed by Multiplex rather than limiting our scope exclusively to individuals from the prior phase.

Recruitment and interviews for the qualitative chapter commenced at the end of August 2020, extending over an entire year until August 2021 due to the very slow response from Multiplex. By the end of August 2021, our communication with Multiplex was further compromised when a key staff member involved in our project departed from the company. Given that the pandemic had already placed our prior cross-sectional chapter on hold, we tried to resume recruiting to no avail, as social distancing and slow communication with Multiplex were making it impossible to continue. Consequently, by January 2021, we decided to start data analysis rather than continuing our recruitment process. This meant that under-recruitment was a prevalent issue for both the quantitative and qualitative parts; however, it was deemed necessary due to the time it was taking. Throughout 2020 and 2021, maintaining effective communication with Multiplex became a growing concern. Therefore, by October 2021, we opted to abandon our workplace health promotion program idea and replace it with the Workwell cross-sectional study, a secondary data on office-based workers, after gaining permission in November 2021.

As a couple (my wife), The COVID-19 pandemic profoundly impacted us, both in terms of my academic pursuits and our overall well-being. As an international student from Saudi Arabia, the travel restrictions and global crisis meant that my wife and I could not return to our homeland to be with our family during these challenging times. Instead, we found ourselves isolated in a foreign country, grappling with the enormity of our situation. This isolation took a significant toll on our mental health and livelihood, making it increasingly difficult to stay mentally connected to my studies. Coping with these unprecedented circumstances demanded a great deal of time and resilience as we navigated through the struggles of being far from home and support networks in a time of global uncertainty.

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Appendices

Appendix C1.A: Summary of workplace interventions to improve physical activity within blue-collar jobs included in Malik, Blake and Suggs's (2014) review

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Talvi, Järvisalo and Knuts (1999)	Oil refineries (N=798)	Non-RCT	Tailored 20-week lifestyle promotion (diet and PA)	36	Self-reported "self-constructed"	No significant differences
Campbell et al. (2002)	Manufacturers (N=538)	RCT	Individualised computer-tailored magazines with natural helpers for health education and information in the workplace	18	Self-reported "self-constructed"	Significant increase in average strength and flexibility exercise frequency
Elliot et al. (2004)	Firefighters (N=33)	RCT	One-to-one lifestyle counselling sessions	NR	Self-reported "self-constructed"	A significant increase in exercise practices (3.60 to 4.50) in favour of the intervention group
Heirich et al. (1993)	Manufacturers (N=1880)	RCT	One-to-one counselling with at-risk employees	36	Self-reported "self-constructed"	A significant increase in the number of employees exercising ≥ 3 times/week (44% and 45%)
MacKinnon et al. (2010)	Firefighters (N=599)	RCT	One-to-one motivational interviewing and support	48	Self-reported "self-constructed"	A significant team-based curriculum effect on PA levels that diminished at the annual assessments
Bergström et al. (2008)	4 Manufacturers (N=4894)	Non-RCT	Health and lifestyle questionnaire, followed by feedback to motivate change in lifestyle	42	Self-reported "self-constructed"	A Non-significant increase in regular exercise participation in the intervention group
Cook et al. (2001)	2 Manufacturers (N=253)	Non-RCT	Monthly 30-minute lifestyle workshop for 6 months with healthy food messages at the worksite	12	Self-reported "self-constructed"	A significant intervention increase in PA levels at 12 months vs the control group (+2.8 hr/week vs -2 hr/week)
French et al. (2010)	4 garages (N=832)	RCT	Obesity prevention programme: better PA facility access, low-cost healthy foods, and group programs for PA and nutrition	24	Self-reported "Godin leisure time PA questionnaire"	No intervention-related effects were observed for PA levels
Hedberg, Wikström-Frisén and Janlert (1998)	Drivers (N=102)	Non-RCT	Health promotion: Health assessment with consultant feedback, written behaviour change contract, brochures, family exercise info, and exercise activities	18	Self-reported "self-constructed"	A significant improvement in exercise habits in the Intervention group vs the comparison group at follow-up (2.02 vs.1.87)
Morgan et al. (2011)	Aluminium company (N=110)	RCT	Workplace power program (info session, booklets, group financial incentives for weight loss, online resource access, and pedometer for self-monitoring)	3	Self-reported "Godin Leisure time PA Questionnaire"	A significant intervention effect was observed for self-reported PA (960 vs 600 MET.minutes)
Naito et al. (2008)	10 Factories (N=2929)	Non-RCT	Health promotion programme targeting nutrition, physical activity and smoking	60	Self-reported "self-constructed"	A significant Intervention effect on daily walking times at 5-year follow-up
Stonecipher and Hyner (1993)	Manufacturers (N=246)	Non-RCT	Health screening interventions with results shared in small group sessions during a 1-hour workday meeting	2	Self-reported "self-constructed"	Despite significantly reserving more time for exercise, no significant differences in moderate PA compared to the control group
Yap et al. (2009)	2 Manufacturers (N=73)	Non-RCT	Theory-based tailored emails to increase PA levels for participants in contemplation and preparation stages of change	3	Self-reported "Stanford Brief Activity Survey" and accelerometers	Both groups elicited an increase in steps/day, but a significantly greater increase was noted in the intervention group

* **Green** signifies an intervention study with a significant intervention effect on at least one PA-related outcomes.
* NR = not reported.

Appendix C1.B: Summary of workplace interventions to improve weight within blue-collar jobs included in Anderson et al. (2009)

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Drummond and Kirk (1998)	Police (N=93)	RCT	Diet: Advice to reduce fat and sugar (Group 1) and advice to reduce fat only (Group 2)	6	Blood tests and anthropometric measurements	Group 1 saw a 0.8% drop in body fat without weight loss, while Group 2 experienced a 1.4% decrease in body fat with a 1.2 kg weight loss
Okayama, Chiba and Ueshima (2004)	Chemical factory (N=191)	RCT	Diet and PA: Health professionals conducted an education program focused on lifestyle changes, helping participants plan to improve their diet and activity levels.	6	Blood tests and anthropometric measurements	Both groups exhibited a reduction in weight; however, the intervention group demonstrated a significantly greater decrease
Cook et al. (2001)	2 Manufacturers (N=253)	Non-RCT	Diet and PA: Monthly 30-minute lifestyle workshop for 6 months with healthy food messages at the worksite	12	Anthropometric measurements	No significant change in mean weight, BMI or waist circumference
Elliot et al. (2004)	Firefighters (N=33)	RCT	Diet and PA: One-to-one lifestyle counselling sessions	NR	Anthropometric measurements	Non-significant change in BMI
Gomel et al. (1993)	Ambulance Services (N=431)	RCT	Diet and PA: CVD risk assessment, education, behavioural counselling, and incentives	12	Blood tests and anthropometric measurements	A significant increase in BMI indicated a negative intervention effect
Kornitzer and Rose (1986)	Factories (N=63732)	RCT	Diet and weight: The intervention included advice on dietary intake, smoking cessation, weight reduction, PA, and hypertension treatment	72	Self-reported	After 2 years of follow-up, a 0.7 lb weight decrease was noted, which diminished over time
Furuki et al. (1999)	Automobile manufacturer (N=507)	Non-RCT	Diet and PA: Total Health Promotion Plan and a lifestyle promotion program that included diet and PA	48	Blood tests and anthropometric measurements	Men's intervention group showed a significant decrease in BMI (0.56 kg/m^2) Vs the control group (0.25 kg/m^2), with no significant difference in women's groups
Talvi, Järvisalo and Knuts (1999)	Oil refineries (N=798)	Non-RCT	Diet and PA: Tailored 20-week lifestyle Promotion (diet and PA)	36	Blood tests and anthropometric measurements	Both males in the intervention group, control group, and females in the control significantly increased their BMI by 0.30, 0.46 and 0.87 and a non-significant increase in women's intervention group by 0.12
Peterson et al. (1985)	Unspecified blue-collar workers (N=63)	RCT	Diet and PA: Learn To Be Lean, a weight loss program designed to teach behavioural changes for weight loss and maintenance	8	Anthropometric measurements	Both treatment groups showed a significant decrease in weight at 6 months follow-up by 10.8 Kg for treatment group A and 7.6 Kg for treatment group C
Erfurt, Foote and Heirich (1991)	4 Manufacturers (N=400-600)	RCT	Diet and PA: CVD risk reduction and smoking cessation programme emphasising education via wellness programmes	36	Anthropometric measurements	Significant improvements in weight were noted in 3/4 treatment sites in 8 months follow-up (site "2" -2.4 lb, site "3" -5.0 lb, and site "4" -6.4 lb)
Shimizu et al. (2004)	2 Manufacturers (N=629)	RCT	An interview-based health promotion program included health assessments, measurements, and group education on health behaviours	48	Anthropometric measurements	In the younger group (35>), BMI was significantly lower compared to the reference group (mean -0.3 kg/m^2 vs mean +0.8 kg/m^2)
Thorsteinsson et al. (1994)	Alloy factory (N=155)	Cohort design	Diet: Modifying the kitchen's menu for 200 workers by reducing total calorie intake and increasing fibre and unsaturated fat content in the diet	24	Anthropometric measurements	No significant change occurred in BMI.
BRILEY, MONTGOMERY and BLEWETT (1992)	Police department (N=40)	Before and after	Diet: Integrating a nutrition education component into the police department's wellness program	12	Anthropometric measurements	Significant group trend toward weight loss (Mean of -5 lb)
Hedberg, Wikström-Frisén and Janlert (1998)	Drivers (N=102)	Non-RCT	Diet and PA: Health promotion: Health assessment with consultant feedback, written behaviours change contract, brochures, family exercise info, and exercise activities	18	Anthropometric measurements	No significant change was noted in BMI; however, a slight increase was noted in the intervention group

* **Green** signifies an intervention study with a significant intervention effect on at least one weight-related outcomes.
* NR = not reported.

Appendix C1.C: Summary of workplace interventions to improve weight within blue-collar jobs included in Mulchandani et al. (2019) systematic review and meta-analysis

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Brehm et al. (2011)	8 Manufacturers (N=341)	RCT	Diet and PA: A multicomponent intervention with advisory committees, decision prompts, walking paths, cafeteria/vending changes, and educational materials	12	Anthropometric measurements	No intervention effect was noted, as changes in weight were similar in both groups
Fernandez et al. (2015)	Manufacturing company (N=3799)	RCT	Diet and PA: An educational program on nutrition and PA with newsletters, nutrition promotion, a wellness website, team-based PA competitions, and outdoor walks	60	Anthropometric measurements	In the intervention group, a significant decrease in BMI (-0.54 kg/m²) and the prevalence of overweight and obesity (-3.7%)
French et al. (2010)	4 garages (N=832)	RCT	Diet and PA: Obesity prevention programme: better PA facility access, low-cost healthy foods, and group programs for PA and nutrition	24	Anthropometric measurements	A non-significant decrease in BMI (-0.14 kg/m²) in the intervention group
Kim et al. (2015)	Utility Corporation (N=196)	RCT	Diet and PA: A text message-based intervention tailored to the participant's diet and PA	6	Anthropometric measurements	A non-significant decrease in weight in both groups, with a greater decrease in favour of the intervention group (-1.7 kg)
Limaye et al. (2017)	IT industries (N=265)	RCT	Diet and PA: Lifestyle modification, with weekly reinforcement messages via text and e-mails	12	Anthropometric measurements	A significant decrease in the prevalence of overweight/obesity by 6.0% in the intervention group vs an increase of 6.8% in the control group, with similar significant changes in weight (-1.0 kg vs +0.7 kg) and WC (-1.7 cm vs +0.5 cm)
Morgan et al. (2011)	Aluminium company (N=110)	RCT	Diet and PA: Workplace power program (info session, booklets, group financial incentives for weight loss, online resource access, and pedometer for self-monitoring)	3	Anthropometric measurements	A significant between-group differences in weight, WC, and BMI (mean difference: 4.3 kg, 5.9 cm, 1.4 kg/m², respectively) in favour of the intervention group
Muto and Yamauchi (2001)	Maintenance company (N=352)	RCT	Diet and PA: An educational program encompassing nutrition, PA, stress, and CVD risk factors with practical training and individual counselling	18	Anthropometric measurements	The intervention group significantly reduced weight (-1.0 kg vs +0.5 kg) and BMI (-0.3 kg/m² vs +0.2 kg/m²) compared to the control group
Naito et al. (2008)	10 Factories (N=2929)	Non-RCT	Diet and PA: Health promotion programme targeting nutrition, PA and smoking	60	Anthropometric measurements	No intervention effect was noted, as the mean BMI did not change in either group
Prabhakaran et al. (2009)	Industrial sites (N=6889)	Non-RCT	Diet and PA: A multilevel intervention program included individual and group-based interactions and key environmental changes (a healthier canteen menu, posters, banners, short videos, and a booklist available around the worksite)	48	Anthropometric measurements	The intervention group demonstrated a significant decrease in weight (mean difference: 2.8 kg) and WC (mean difference: 3.5 cm) compared to the control group
Viester et al. (2018)	Construction workers (N=314)	RCT	Diet and PA: Tailored lifestyle coaching programme	12	Anthropometric measurements	An initial statistically significant intervention effect was found on weight, BMI, and WC; however, intervention effects diminished at the endpoint measurement
Wilson et al. (2016)	Railroad maintenance (N=362)	RCT	Diet and PA: A Diabetes Prevention Program to modify individual lifestyles and include peer health coaches for social support and reinforcement, occupational nurses for educational purposes, and environmental changes (such as posters)	12	Anthropometric measurements	The intervention group exhibited a significant effect, maintaining weight and BMI (mean change: -0.1 lb, -0.1 kg/m²), while the control group experienced increases in weight and BMI (mean change: +2.6 lb, +0.3 kg/m²)

* **Green** signifies an intervention study with a significant intervention effect on at least one weight-related outcomes.

Appendix C1.D: Summary of workplace interventions to improve diet within blue-collar jobs included in Peñalvo et al. (2021) systematic review and meta-analysis - Only studies with a subset analysis on diet are presented in the table

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Braeckman et al. (1999)	Unspecified blue-collar (N=770)	RCT	Group nutrition education, personal counselling, risk factor screening with feedback, and a media campaign on cholesterol and heart disease (posters, leaflets, videos, and newsletters)	3	Self-reported "24-hour food record"	Significant improvement in nutrition knowledge and dietary habits
Campbell et al. (2002)	Manufacturers (N=538)	RCT	Individualised computer-tailored magazines with natural helpers for health education and information in the workplace	18	Self-reported "brief 28-item food frequency checklist"	Significant increase in the intervention group in fruit and vegetable consumption by 0.7 daily servings compared to no change in the control group
Cook et al. (2001)	2 Manufacturers (N=253)	Non-RCT	Monthly 30-minute lifestyle workshop for 6 months with healthy food messages at the worksite	12	Self-reported	Compared to the control site, the intervention reduced fat intake, increased vegetable intake, and improved nutrition knowledge
Elliot et al. (2007)	Firefighters (N=599)	RCT	Intervention "1" Education sessions on nutrition, PA, and energy balance, workbooks, baseline results, goal setting, a health and fitness guide, and a team member tracking grid. Intervention "2" individualised motivational interviewing included a health assessment review, goal setting, behaviour change planning, and a health and fitness guide	12	Self-reported "combination of validated questionnaires to Measure daily servings of fruits and vegetables and percentage of total calories from fat"	Both interventions significantly increased the daily serving of fruit and vegetables (intervention "1": from 5.8 servings at baseline to 7.4, and intervention "2": from 5.5 servings at baseline to 6.2)
Fitzgerald et al. (2020)	4 Manufacturers (n=850)	RCT	4 groups: Control, Nutrition Education, Environmental Dietary Modification, and Combined. Nutrition education included detailed nutrition information, individual consultations, and monthly group presentations. Environmental modification included menu modification, increased availability of fruits and vegetables, price discounts on healthy foods, strategic positioning of healthier options, and portion size control	7-9	Self-reported "24-hour dietary recalls"	The combined intervention group significantly reduced total fat, saturated fat, salt, and total sugars consumed on duty and off duty. The environmental intervention also significantly reduced total fat and saturated fat consumed on duty, while the education group only significantly reduced total sugar intake off-duty
French et al. (2010)	4 garages (N=832)	RCT	Obesity prevention programme: better PA facility access, low-cost healthy foods, and group programs for PA and nutrition	24	Self-report "Food Frequency Questionnaire"	A significant intervention effect was noted in average daily energy intake (2363 kcals/day to 1864 kcals/day) and an increase in fruit and vegetable daily serving (by 0.25 serving/day)
Geaney et al. (2016)	Manufacturers (N=850)	RCT	Education Group: Participants received nutrition education, which included group presentations, individual consultations, and detailed nutrition information. Environment Group: environmental dietary modification, which included menu modifications, fruit price discounts, strategic positioning of healthier alternatives, and portion size control. Combined Group: received both interventions	7-9	Self-reported "24-hour dietary recalls"	The combined intervention group had the most significant improvements in diet (reductions in saturated fat intake by 7.0 g/day, salt intake by 1.4 g/day, total fat intake by 14.2 g/day, and total sugar intake by 11.1 g/day), along with an increased nutrition knowledge score of 3.0 points
Guldan et al. (1992)	Steel tube factory (N=480)	Pre & post test	A nutrition education program that included the Chinese dietary guidelines handout	3	Food frequency interview	The education intervention significantly reduced the number of respondents who seldom or never consumed pork liver and blood products (85% to 63%) and dairy products (46% to 31%) while significantly increasing daily consumption of lean meat (30% to 62%), and non-leafy green vegetables (45% to 61%)
Kuehl et al. (2014)	Law enforcement (N=408)	RCT	Team-based worksite health and safety intervention encompassing exercise, nutrition, stress, sleep, weight, injury, and other unhealthy lifestyle behaviours.	6	Self-reported "the National Cancer Institute's fruit and vegetable all-day screener"	The intervention group significantly increased daily servings of fruit (2.07 to 3.05), vegetables (3.53 to 4.40), and combined fruit and vegetables (5.60 to 7.48)

* **Green** signifies an intervention study with a significant intervention effect on at least one diet-related outcomes.

Continue appendix C1.D

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Limaye et al. (2017)	IT industries (N=265)	RCT	Lifestyle modification, with weekly reinforcement messages via text and e-mails	12	Self-reported "self-constructed"	The intervention group elicited a significant increase in fibre-rich foods and a reduced intake of calorie-dense foods, as the proportion of participants consuming ≥8 servings of fibre-rich foods/week increased from 14.3% to 24.1%, and consuming ≤4 servings of calorie-dense foods/week increased from 13.5% to 29.3%
Mache et al. (2015)	Logistics company (N=3095)	QE	A multi-component intervention that included group health education, individualised coaching on PA, nutrition, goal setting, cooking lessons, free fruits and vegetables during education sessions, and on-site exercise	12	Self-reported "FEG questionnaire"	The intervention group elicited a significant daily increase in vegetable (28.6% to 38.7%) and fruit intakes (36.5% to 41.6%), whereas a significant daily reduction in sweets (22.4% to 20.7%) and fast-food intakes (0.3% to 0.0%)
Morgan et al. (2011)	Aluminium company (N=110)	RCT	Workplace power program (info session, booklets, group financial incentives for weight loss, online resource access, and pedometer for self-monitoring)	3	Self-reported "combination of validated questionnaires to measure foot frequency, beverage intake, and alcohol consumption"	Compared to the control, a significant intervention effect was found for reducing cola and soda/soft drink intake (mean difference of 1.2) and for other soda drinks (mean difference of 1.4)
Peters et al. (2018)	Construction workers (N=607)	RCT	Integrated Total Worker Health® program, 'All the Right Moves' (ARM), which included an ergonomics program and Health Week intervention	6	Self-reported "questions adapted from a number of validated questionnaires"	A significant positive influence on healthier dietary behaviours, with a near-significant improvement in maintaining a balanced diet in favour of the intervention group
Prabhakaran et al. (2009)	Industrial sites (6889)	Non-RCT	A multilevel intervention program included individual and group-based interactions and key environmental changes (a healthier canteen menu, posters, banners, short videos, and a booklist available around the worksite)	48	Self-reported "self-constructed"	The intervention group showed a significant increase in daily fruit consumption (37.9% to 44.5%), with a significant reduction in salt consumption (28% to 12.7%)
Rameshbabu, Reddy and Ports (2018)	Janitorial employees (N=54)	RCT	A saturated fat information booklet and a food diary were provided to allow daily self-monitoring of saturated fat, with a worksheet developed to record self-regulation activities	6	Self-reported "MEDFICTS questionnaire"	The intervention group demonstrated a significant reduction in saturated fat intake from a baseline (mean MEDFICTS score of 84.52 to 36.56), marking a 57% reduction compared to 19% in the control group
Sorensen et al. (2005)	26 Manufacturers (N=1740)	RCT	The lifestyle intervention programme included a smoke-free policy, advisory committees, informational displays, small-group discussions (nutrition, PA, and occupational health), health fairs with assessments, healthy food options at events, and smoking cessation support, with facilities and signage promoting PA, and safety consultations with an industrial hygienist	18	Self-reported "questions adapted from a number of validated questionnaires"	A non-statistically significant improvement in fruit, vegetable, and red meat daily consumption in favour of the intervention group
Viester et al. (2018)	Construction workers (N=314)	RCT	Tailored lifestyle coaching programme	12	Self-reported "self-constructed"	A significant intervention reduction in sugar-sweetened beverages intake at 6 months; no long-term significant effects
Wilson et al. (2016)	Railroad maintenance (N=362)	RCT	A Diabetes Prevention Program to modify individual lifestyles and include peer health coaches for social support and reinforcement, occupational nurses for educational purposes, and environmental changes (such as posters)	12	Self-reported "National Cancer Institute's Fat Screener and the Fruit and Vegetable Screener"	The control group showed significant improvements in diet-related outcomes, with a decrease in the percentage of calories from fat and an increase in both fruit and vegetable servings, while the intervention group did not show any significant improvements

* **Green** signifies an intervention study with a significant intervention effect on at least one diet-related outcomes.

Appendix C1.E: Summary of workplace interventions to improve smoking within blue-collar jobs included in Cahill and Lancaster's (2014) review

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Campbell et al. (2002)	Manufacturers (N=538)	RCT	Individualised computer-tailored magazines with natural helpers for health education and information in the workplace	18	Self-reported	No significant differences in smoking cessation. Both groups saw a reduction in smoking rates by 3%
Dawley et al. (1991)	Oil refineries (N=30)	RCT	A smoking control program that included discouragement tactics, cinnamon sticks as cigarette substitutes, and smoking cessation support	5	Self-reported, and urinary cotinine validation	At the end of the follow-up, 5-months, a 43% abstinence rate was recorded in favour of the intervention group
Erfurt, Foote and Heirich (1991)	4 Manufacturers (N=400-600)	RCT	CVD risk reduction and smoking cessation programme emphasising education via wellness programmes	36	Self-reported	The intervention group saw a significant reduction in smoking prevalence (31% to 22%), while the control group saw minimal change
Gomel et al. (1993)	Ambulance Services (N=431)	RCT	CVD risk assessment, education, behavioural counselling, and incentives	12	Self-reported, and validated by serum cotinine	A significant 7% cessation rate was achieved in favour of behavioural counselling and behavioural counselling plus incentive groups
Groeneveld et al. (2011)	Construction workers (N=816)	RCT	Individual counselling using motivational interviewing by a physician or nurse. The intervention included 3 face-to-face and 4 telephone contacts over 6 months on diet, PA, or smoking	12	Self-reported	An initial significant improvement was noted at 6 months (OR 0.3; 95% CI 0.1; 0.7), which diminished at the end follow-up (12 months)
Gunes, Ilgar and Karaoglu (2007)	Textile factory (N=200)	Non-RCT	The intervention group received a 3-week educational program with sessions based on the American Lung Society's "Life without smoking in 7 steps." This included understanding smoking habits, motivation to quit, developing a quitting plan, preparing for the quit day, and quitting	6	Self-reported	The intervention group showed significant improvements in their smoking outcomes, specifically a significant reduction in the pre-contemplation stage (36% to 20%), an increase in the number of workers in the preparation stage (31% to 43%), and an increase in the number of workers who reached the maintenance stage (0% to 6%)
KADOWAKI et al. (2000)	1 Factory (N=542)	RCT	Physician guidance, Co2 monitoring, a cessation agreement, self-help resources, and follow-up for over five months. Smoking Cessation Marathon held in the fourth month	18	Self-reported, and validated by expired Co2 and urine test	The Intervention group significantly improved compared to the control group, specifically in smoking prevalence (62.9% to 56.7%), cigarette consumption (decreased by 30.3%), and cessation rate (12.9% at 5 months), with long-term follow-up showing an overall cessation rate of 8.4%
Kornitzer et al. (1980)	30 factories (N=16230)	RCT	High-risk subjects received individual physician counselling to improve CVD biomarkers, PA, diet and smoking cessation rates, supported advice booklets and posters	24	Self-reported	A significant improvement in favour of the intervention group compared to the control group was observed in smoking cessation (18.7% vs 12.2%) and reduction in daily cigarette consumption (18.8% vs 9.1%)
Noor et al. (2011)	11 unspecified industrial worksites (N=155)	RCT	Viva QS (herbal medication) vs placebo, supplied for 24 weeks, with follow-up at weeks 4, 12, and 24, with counselling provided at follow-up points	6	Expired CO2, saliva cotinine test, and urine cotinine test	Significant intervention group improvement with higher abstinence rates compared to the control group (30.7% vs. 13.9%)
Okechukwu et al. (2009)	Apprentice construction workers (N=624)	RCT	Multi-pronged intervention integrating occupational health concerns, including two 1-hour modules on job hazards and smoking, group-based behavioural counselling, nicotine replacement therapy, quit kits, and environmental cues for smoking cessation	10	Self-reported	An initial significant quit rate in the intervention group compared to the control group (26% vs 16.8) was not maintained at the end of the follow-up (9% vs 7.2%). However, a significant reduction in smoking intensity was observed in the intervention group (OR 3.13; 95% CI: 1.55-6.31)
Sorensen et al. (2002)	Manufacturing worksites (N=9019)	RCT	Health Promotion (control) (smoking cessation and dietary improvements) vs Health Promotion plus Occupational Health and Safety (intervention) (smoking cessation, dietary improvements, and occupational exposure reduction)	24	Self-reported	The study observed a significant improvement in smoking cessation among blue-collar workers in the intervention group, with a quit of 11.8% (OR 2.13), more than double the 5.9% quit rate observed in the control group.
Sorensen et al. (2007)	Construction workers (N=674)	RCT	Tailored telephone-delivered and mailed interventions to promote smoking cessation and increase fruit and vegetable consumption	6	Self-reported	The study demonstrated a significant improvement in the intervention group compared to the control group, specifically in smoking cessation (19% vs. 8%) and cessation from any tobacco use (19% vs. 7%)
Tanaka et al. (2006)	Variety of worksites (N=2307)	Non-RCT	Low-intensity, multi-component program including posters, websites, newsletters, cessation campaigns, advice on smoking areas, and periodic site visits	36	Self-reported	Blue-collar workers' smoking cessation rates were higher in the intervention group than in the control group (11.9% vs 9.4%); however, this difference was not statistically significant

* **Green** signifies an intervention study with a significant intervention effect on at least one smoking-related outcomes.

Appendix C1.F: Summary of workplace interventions to improve mental health within blue-collar jobs included in Chu et al. (2014) review

Author	Population	Design	Intervention	Follow-up (Months)	Measuring tool	Result
Nurminen et al. (2002)	Laundry workers (N=260)	RCT	Worksite exercise program with weekly 60-minute sessions guided by a physiotherapist, along with feedback on physical capacity, exercise prescription, and counselling	15	Modified version of the Nordic questionnaire	At the end of the follow-up period, there was no statistically significant difference between the intervention and control groups' stress levels, as both groups experienced a reduction in reported stress levels
Norris, Carroll and Cochrane (1990)	Police officers (N=77)	Non-RCT	Participants were assigned to aerobic, anaerobic, or a control group. The aerobic training consisted of 3 sessions/week, 45 minutes each of running and stretching, while the anaerobic training consisted of 3 sessions/week of weight training	3	Job Stress Questionnaire (JSQ)	A significant intervention effect was only noted in the aerobic training group, with a reduction in job-related stress (from 1.61 to 1.44)

* **Green** signifies an intervention study with a significant intervention effect on at least one mental health-related outcomes.

Appendix C1.G: Summary of workplace interventions to improve mental health within blue-collar jobs included in Greiner et al. (2022) systematic review

Author	Population	Design	Intervention's Aim	Intervention Summary	Follow-up (Months)	Outcomes Measured	Results
Anger et al. (2018)	Construction workers (N=35)	Pre and post pilot study	To test that Total Worker Health intervention could produce positive impacts on the construction industry	Healthier behaviours and lifestyle training	3	Mental Health (SF12), General Health, Supervisor Support, Worker Interactions	No significant improvement in mental health scores
Elo et al. (2014)	Construction workers (N=145)	Non-RCT	To investigate the effect of a personal growth-oriented leadership intervention among line supervisors on subordinate well-being	A 7.5-day leadership training course spread over 6 months, featuring creativity exercises, role-playing, group discussions, and short lectures, aimed to enhance self-awareness and leadership skills among supervisors	24	Work-related outcomes (via Healthy Organisation Questionnaire and Maslach's Burnout Inventory, and via self-constructed single question)	No significant improvement in emotional exhaustion or stress symptoms
Guimarães et al. (2013)	Construction workers (N=5)	Pre and post study	To evaluate the reorganisation of work tasks for live-line electricians to optimise circadian rhythms and reduce stress	The work schedules were adjusted according to circadian cycles	< 1	Stress (via heart frequency and levels of urinary catecholamines - adrenaline and noradrenaline) and Workload (cognitive tests such as the matchstick arrangement)	Re-organising work schedules based on circadian rhythms significantly reduced both physical and mental stress among live-line electricians
Hengel et al. (2012, 2013)	Construction workers (N=297)	RCT	To evaluate the effectiveness of a worksite prevention program with an emphasis on improving workability, physical health, and mental health	A physical and mental prevention program that included a two-component prevention programme involving physical training sessions and empowerment training	12	Mental Health (SF12), Social Support, Sick Leave, Physical Health	No significant improvement in mental health scores; non-significant decline in sick leave days

* **Green** signifies an intervention study with a significant intervention effect on at least one mental health-related outcomes.

Appendix C2.A: Workwell self-constructed questionnaire

Section 1: Local area							
Please indicate how good these features are in your local area (1=very poor and 7= excellent)							
Parks and open spaces	1	2	3	4	5	6	7
Public transport	1	2	3	4	5	6	7
Schools and local services	1	2	3	4	5	6	7
Places to socialise such as pubs and clubs	1	2	3	4	5	6	7
Noise and pollution	1	2	3	4	5	6	7
Medical services	1	2	3	4	5	6	7
Safety of your local area	1	2	3	4	5	6	7
Section 2: Workplace							
Provides an understanding of your working environment. Using the scale provided please indicate how bad (1) or good (7) each of the following:							
Workplace environment - warmth, lighting, noise & amenities	1	2	3	4	5	6	7
Tools and equipment e.g. Level of IT equipment, vehicle, tools etc	1	2	3	4	5	6	7
Safe and healthy environment	1	2	3	4	5	6	7
Time spent at work	1	2	3	4	5	6	7
Training and support	1	2	3	4	5	6	7
Flexible working arrangements	1	2	3	4	5	6	7
if at times working from home, how do you rate the working environment compared with the office	My home office working conditions are very poor	My home office working conditions are poor	My home office working conditions are adequate	My home office working conditions are good	My home office working conditions are very good		
Travel to work							
How do you travel to work most frequently	Walk	Drive	Cycle	Train/Tram	Bus	Work at home	Work requires much travelling
On average how long does you journey to work take	<10mins	10 - 30 mins	31 - 45mins	46 - 60 mins	> 1 hour		
The below statements considers the nature of your work experience, please indicate the extent to which you disagree (1) or agree (7) with the following statements.							
Working with members of this organisation, my unique skills and talents are valued and utilised.	1	2	3	4	5	6	7
My working day life is generally stimulating and rewarding	1	2	3	4	5	6	7
My manager believes that I can handle demanding tasks	1	2	3	4	5	6	7
My work is physically very demanding	1	2	3	4	5	6	7
My manager allows me to do my job my way	1	2	3	4	5	6	7
I never seem to have enough time to get everything done at work	1	2	3	4	5	6	7
I feel I know where I stand with my manager and how satisfied my manager is with me	1	2	3	4	5	6	7
I often have to work longer than my contracted hours	1	2	3	4	5	6	7
I often feel bullied, harassed, or discriminated against	1	2	3	4	5	6	7
People in this organisation sometimes reject others for being different.	1	2	3	4	5	6	7
Childcare often causes problems	1	2	3	4	5	6	7
Do you do shift work	yes	no					
Shift work affects my quality of life, where 7 = major disruption	1	2	3	4	5	6	7

Section 3: Medical data					
Do you have any of the following (no formal diagnosis)					
Neck, shoulder, or arm pain	Yes	No			
Stress, depression, or anxiety	Yes	No			
Back pain	Yes	No			
Headache and/or eye strain	Yes	No			
Leg pain	Yes	No			
Do you have a formal diagnosis of any of the following					
Heart disease	Yes	No			
Breathing or lung problems	Yes	No			
Infectious disease	Yes	No			
Skin problems	Yes	No			
Cancer	Yes	No			
Hearing problems	Yes	No			
Arthritis	Yes	No			
Dementia	Yes	No			
Diabetes type 1	Yes	No			
Diabetes type 2	Yes	No			
Covid-19 epidemic	Yes	No			
Other	Yes	No			
Section 4: Smoking and Alcohol					
Have you ever smoked?	Yes	No			
How often do you smoke?	Never	Occasionally	Frequently		
I drink less than 14 units of alcohol a week (1 beer pint ~550 ml=3 units, 1 red wine glass ~250 ml=2 units, 1 spirit shot ~25 ml=1 unit	Never	Occasionally	Sometimes	Always	I do not drink alcohol
Section 5: Diet					
I eat regular meals		Never	Occasionally	Sometimes	Always
I control the calories I eat		Never	Occasionally	Sometimes	Always
I control the amount I eat		Never	Occasionally	Sometimes	Always
I eat processed foods such as sausages, pate, cakes, pastries, biscuits, chips, crisps" and the scoring would be "no times", "1-2 times","3-5 times","6 or more times		No times	1-2 times	3-5 times	6 or more times
I eat fatty foods such as fatty cuts of pork beef or lamb, butter, dairy foods, fried foods		No times	1-2 times	3-5 times	6 or more times
I eat sweet food such as sugary drinks and cereals, creamy yogurts, ice cream		No times	1-2 times	3-5 times	6 or more times
I eat 5 portions of fruit / vegetables a day		No times	1-2 times	3-5 times	6 or more times
I have salt intake of more than 1 teaspoon per day including hidden salt (e.g. crisps and frozen meals)		No times	1-2 times	3-5 times	6 or more times

Section 6: Well-being							
Please answer the following on a scale of 7, where 1 is completely disagree and seven is completely agree							
I normally have lots of energy and drive	1	2	3	4	5	6	7
I am usually happy and glad to be alive	1	2	3	4	5	6	7
I cope well with life's problems	1	2	3	4	5	6	7
I do not let day to day problems get me down	1	2	3	4	5	6	7
I normally feel lethargic and lack motivation	1	2	3	4	5	6	7
I often feel down and wonder what the point of life is	1	2	3	4	5	6	7
I struggle with life's pressures	1	2	3	4	5	6	7
I feel isolated and rejected	1	2	3	4	5	6	7

Section 7: COVID-19 impact					
COVID-19 impact on Personal level					
Energy levels	I have a great deal less energy	I have less energy	My energy levels are the same	I have more energy	I have a great deal more energy
Happiness	I feel a great deal less happy than I was	I feel less happy than I was	My happiness levels are unchanged	I feel happier than before	I feel much happier than before
Coping	I find it much harder to cope with life's problems	I find it harder to cope with life's problems	I cope as well as before with life's problems	I cope better with life's problems	I cope much better with life's problems
Sleep	I sleep a great deal less well than I did	I sleep less well than I did	I sleep just as well as I did	My sleeping has improved	My sleeping has improved a great deal
COVID-19 Impact on work status					
COVID-19 effect on employment status	I remain employed in the same role	I remain in the same role but working from home	I remain employed but with significant change in role	furloughed	lost employment
COVID-19 Impact on daily life					
Your daily commute	My commuting is a great deal more stressful	My commuting is more stressful	My commuting stress levels have not changed	My commuting stresses are less than before	My commuting stresses are a great deal less than before
Work efficiency	I feel that I work a great deal less efficiently	I feel that I work less efficiently	My work efficiency has not changed	I feel that I work more efficiently	I feel that I work a great deal more efficiently
Financial status	I am under a great deal more financial pressure	I am under more financial pressure	My financial pressure has not changed	I am under less financial pressure	I am under a great deal less financial pressure
Exercise	I exercise a great deal less than before	I exercise less than before	My exercise habits are unchanged	I exercise more than before	I exercise a great deal more than before
Diet	My diet das deteriorated considerably	My diet deteriorated a little	My diet remained the same	My diet has improved a little	My diet has improved considerably
Weight	Increased more than 1 Stone / 2 Kg	Increased less than 1 Stone / 6Kg	Stayed the same	lost more than 1 Stone / 6 Kg	lost less than 1 Stone / 6Kg
Social Contacts	My social contacts have deteriorated considerably	My social contacts have deteriorated a little	remained the same	My social contacts have improved a little	My social contacts have improved a lot
Manager relations	Relations with my manager have deteriorated considerably	Relations with my manager have deteriorated a little	Relations with my manager have remained the same	Relations with my manager have improved	Relations with my manager have improved considerably
Company communication	Communications within the company have deteriorated considerably	Communications within the company have deteriorated a little	Communications within the company have remained the same	Communication within the company have improved a little	Communication within the company have improved considerably
Technology Access	My access to technology at home is very poor	My access to technology at home is poor	My access to technology at home is reasonable	My access to technology at home is good	My access to technology at home is very good
Childcare	Not applicable	Childcare has been a major problem	Childcare has caused some problems	Childcare provision has been reasonable	Childcare provision has been good	Childcare provision has been very good

Appendix C2.B: A step-by-step description of stepwise regression analysis

This appendix provides a step-by-step explanation of how the predictive models for both sickness absence and presenteeism were generated.

1. Only significant variables from a univariate correlation were considered, and this step was produced using Minitab.

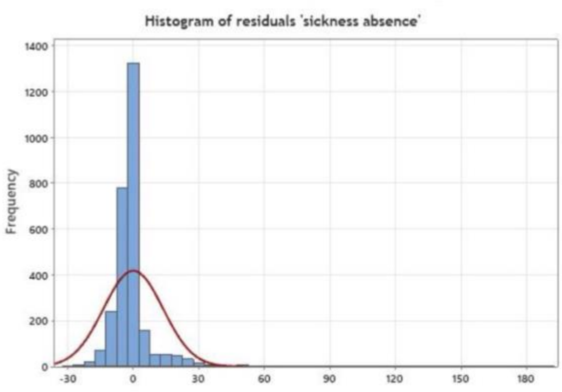
Significant variables of sickness absence obtained from univariate correlation

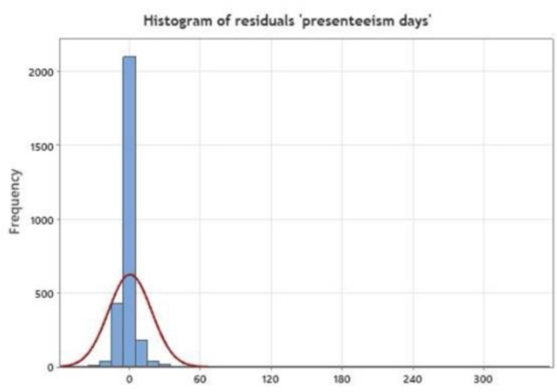
Variable description	Variable	N	Correlation	95% CI	P-Value	Variable description	Variable	N	Correlation	95% CI	P-Value
Subjective illness presence	SIP_1	2847	0.153	(0.117, 0.189)	0.000	Work life balance	EME_4	2848	-0.051	(-0.087, -0.014)	0.007
Mental health_GeneticLinks	ILL_7h	2848	0.117	(0.081, 0.153)	0.000	Bereavement	LE_1b	2848	-0.053	(-0.089, -0.016)	0.005
Stress,Depression or Anxiety	ILL_4b	1768	0.109	(0.062, 0.154)	0.000	Workplace pressures	PEP_1	2848	-0.054	(-0.091, -0.018)	0.004
Disability	EMP_8	2848	0.102	(0.065, 0.138)	0.000	Bullied harrassed	EMS_8	2848	-0.055	(-0.091, -0.018)	0.004
Hearing problems	ILL_4k	1768	0.085	(0.039, 0.131)	0.000	BMI	TBMI_1	2848	-0.056	(-0.093, -0.020)	0.003
Covid-19 epidemic_Obj Illness	ILL_4q	1768	0.08	(0.034, 0.126)	0.001	CoporateEmployerChangeEpidemic	ER_1	2848	-0.056	(-0.092, -0.019)	0.003
Stress-relieving medication	ILL_6d	1119	0.078	(0.020, 0.136)	0.009	Out of control	FIN_4	2848	-0.058	(-0.094, -0.021)	0.002
Breathing or lung problems	ILL_4g	1768	0.077	(0.031, 0.123)	0.001	Break up conflict	LE_2b	2848	-0.059	(-0.096, -0.023)	0.002
Pain killers	ILL_6h	1119	0.075	(0.017, 0.133)	0.012	CopratedEmpChange SinceEpidemic	EE_1	2848	-0.063	(-0.099, -0.026)	0.001
Respiratory_GeneticLinks	ILL_7c	2848	0.066	(0.029, 0.103)	0.000	WorkEfficiency_COVID impact	EMP_14f	2848	-0.065	(-0.101, -0.028)	0.001
Education	EMP_4	2848	0.064	(0.027, 0.101)	0.001	Corporate culture	CCUL_1	2848	-0.065	(-0.102, -0.028)	0.001
Other	ILL_4p	1768	0.063	(0.017, 0.110)	0.008	Salary	EMP_3	2848	-0.067	(-0.103, -0.030)	0.000
Gender	GEN_1	2848	0.062	(0.025, 0.099)	0.001	Activity	ACT_1	2848	-0.07	(-0.106, -0.033)	0.000
Long hours	EMS_7	2848	0.059	(0.022, 0.096)	0.002	Personal impact of epidemic	HST_1	2848	-0.07	(-0.107, -0.033)	0.000
Anti inflammatories	ILL_6g	1119	0.059	(0.001, 0.118)	0.047	Disturbed sleep	M1g	2848	-0.071	(-0.108, -0.035)	0.000
Strokes_GeneticLinks	ILL_7g	2848	0.054	(0.017, 0.090)	0.004	Exercise_COVID impact	EMP_14c	2848	-0.071	(-0.107, -0.034)	0.000
Time with employer	EMP_6	2848	0.044	(0.007, 0.080)	0.019	Regular meals	N4a	2848	-0.078	(-0.114, -0.041)	0.000
Blood pressure_GeneticLinks	ILL_7f	2848	0.041	(0.004, 0.077)	0.029	Headache and/or eye strain	ILL_4d	1768	-0.082	(-0.128, -0.035)	0.001
5 a day	N4h	2848	-0.037	(-0.074, -0.000	0.049	Smoking	SLK_1	2848	-0.083	(-0.120, -0.047)	0.000
Alcohol_Diet	N4j	2848	-0.037	(-0.074, -0.000	0.049	Getting to sleep	M1f	2848	-0.09	(-0.126, -0.053)	0.000
Diet_COVID impact	EMP_14d	2848	-0.041	(-0.078, -0.004	0.028	Mental health (HADS score)	MEN_1	2848	-0.098	(-0.135, -0.062)	0.000
Social contact_COVID impact	EMP_14e	2848	-0.043	(-0.080, -0.006	0.021	Accident illness work related	LE_5b	2848	-0.099	(-0.135, -0.063)	0.000
Financial impact_COVID impact	EMP_14b	2848	-0.043	(-0.080, -0.006	0.022	Waking refreshed	M1o	2848	-0.111	(-0.147, -0.075)	0.000
Time pressure	M1l	2848	-0.045	(-0.081, -0.008	0.017	Disease risk	DIS_1	2848	-0.112	(-0.149, -0.076)	0.000
Personal relationships	M1n	2848	-0.047	(-0.083, -0.010	0.013	Leadership support	CPM_3	2848	-0.121	(-0.157, -0.084)	0.000
Sleep_COVID impact	M1gc	2848	-0.047	(-0.083, -0.010	0.013	Infectious disease,eg flu	ILL_4h	1768	-0.13	(-0.175, -0.084)	0.000
Replace staff within 1 year	EMP_7	2848	-0.049	(-0.085, -0.012	0.010	Accident illness not work	LE_5e	2848	-0.251	(-0.285, -0.216)	0.000
Financial planning	FIN_6	2848	-0.049	(-0.086, -0.012	0.009						

Significant variables of presenteeism days obtained from univariate correlation

Variable description	Variable	N	Correlation	95% CI	P-Value	Variable description	Variable	N	Correlation	95% CI	P-Value
Subjective illness presence	SIP_1	2847	0.215	(0.180, 0.250)	0.000	Training support	EME_5	2848	-0.049	(-0.086, -0.012	0.009
Stress,Depression or Anxiety	ILL_4b	1768	0.181	(0.136, 0.226)	0.000	Manager relations	EMS_6	2848	-0.049	(-0.086, -0.012	0.009
Skin problems	ILL_4i	1768	0.17	(0.124, 0.215)	0.000	Regular meals	N4a	2848	-0.05	(-0.086, -0.013	0.008
Neck, shoulder or arm pain	ILL_4a	1768	0.148	(0.102, 0.193)	0.000	Shared vision	CPC_3	2848	-0.051	(-0.088, -0.014	0.006
Disability	EMP_8	2848	0.135	(0.099, 0.171)	0.000	Workplace	WKP_1	2848	-0.052	(-0.089, -0.016	0.005
Arthritis	ILL_4l	1768	0.129	(0.083, 0.175)	0.000	Long hours	EMS_7	2848	-0.053	(-0.090, -0.017	0.004
Leg pain	ILL_4e	1768	0.117	(0.071, 0.163)	0.000	Job security	EMS_14	2848	-0.053	(-0.089, -0.016	0.005
Pain killers	ILL_6h	1119	0.117	(0.059, 0.175)	0.000	LikelyToMove TO suitable job	ILL_10	2848	-0.053	(-0.090, -0.016	0.005
Mental health_GeneticLinks	ILL_7h	2848	0.106	(0.070, 0.142)	0.000	Personal impact of epidemic	HST_1	2848	-0.058	(-0.094, -0.021	0.002
Stress-relieving medication	ILL_6d	1119	0.099	(0.040, 0.156)	0.001	Warmth & lighting	EME_1	2848	-0.059	(-0.095, -0.022	0.002
Hearing problems	ILL_4k	1768	0.094	(0.048, 0.140)	0.000	Sleep_COVID impact	M1gc	2848	-0.06	(-0.096, -0.023	0.001
Anti inflammatories	ILL_6g	1119	0.092	(0.034, 0.150)	0.002	Personal relationships	M1n	2848	-0.061	(-0.098, -0.025	0.001
Back pain	ILL_4c	1768	0.087	(0.040, 0.133)	0.000	Employee experience	WLB_1	2848	-0.068	(-0.104, -0.031	0.000
Employed same job_COVID	EMJ_1	2848	0.08	(0.044, 0.117)	0.000	Money to meet demands	FIN_5	2848	-0.069	(-0.106, -0.033	0.000
Asthma_GeneticLinks	ILL_7b	2848	0.07	(0.034, 0.107)	0.000	Work rewarding	EMS_1	2848	-0.069	(-0.106, -0.032	0.000
Arthritis_GeneticLinks	ILL_7e	2848	0.064	(0.027, 0.100)	0.001	Work experience	WEX_1	2848	-0.07	(-0.107, -0.034	0.000
Diabetes type 2_GeneticLinks	ILL_7j	2848	0.064	(0.028, 0.101)	0.001	Workplace pressures	PEP_1	2848	-0.07	(-0.106, -0.033	0.000
Respiratory_GeneticLinks	ILL_7c	2848	0.059	(0.022, 0.095)	0.002	Work pressures	EMS_5	2848	-0.071	(-0.108, -0.034	0.000
Headache and/or eye strain	ILL_4d	1768	0.053	(0.006, 0.099)	0.026	Getting to sleep	M1f	2848	-0.076	(-0.113, -0.040	0.000
Noise & pollution (Local)	N7e	2848	0.042	(0.005, 0.078)	0.026	Disturbed sleep	M1g	2848	-0.077	(-0.113, -0.040	0.000
Blood pressure_GeneticLinks	ILL_7f	2848	0.039	(0.002, 0.076)	0.038	Family and dependants	CHI_3c	1652	-0.08	(-0.128, -0.032	0.001
Gender	GEN_1	2848	0.039	(0.002, 0.076)	0.038	Work life balance	EME_4	2848	-0.082	(-0.118, -0.045	0.000
Diabetes type 1_GeneticLinks	ILL_7i	2848	0.037	(0.001, 0.074)	0.046	Bullied harrassed	EMS_8	2848	-0.084	(-0.120, -0.047	0.000
Out of control	FIN_4	2848	-0.038	(-0.075, -0.001)	0.043	Break up conflict	LE_2b	2848	-0.084	(-0.120, -0.047	0.000
Financial planning	FIN_6	2848	-0.039	(-0.075, -0.002)	0.039	Family support	M1d	2848	-0.087	(-0.124, -0.051	0.000
Flexible working	EME_6	2848	-0.039	(-0.075, -0.002)	0.038	Disease risk	DIS_1	2848	-0.11	(-0.146, -0.074	0.000
Internal communication	CPM_10	2848	-0.043	(-0.080, -0.006)	0.022	Time pressure	M1l	2848	-0.112	(-0.148, -0.076	0.000
Fairness	CPC_11	2848	-0.045	(-0.082, -0.009)	0.015	Waking refreshed	M1o	2848	-0.117	(-0.153, -0.080	0.000
CopratedEmpChange SinceEpidemic	EE_1	2848	-0.047	(-0.083, -0.010)	0.012	Mental health (HADS score)	MEN_1	2848	-0.131	(-0.167, -0.095	0.000
Moving home	LE_3b	2848	-0.047	(-0.083, -0.010)	0.013	Accident illness work related	LE_5b	2848	-0.14	(-0.176, -0.104	0.000
Difficult neighbours	LE_7b	2848	-0.047	(-0.083, -0.010)	0.013	Leadership support	CPM_3	2848	-0.155	(-0.190, -0.119	0.000
BMI	TBMI_1	2848	-0.048	(-0.085, -0.012)	0.010	Accident illness not work	LE_5e	2848	-0.167	(-0.202, -0.131	0.000

2. Prior to producing the model, the normality of residuals was checked for both sickness absence and presenteeism days.





3. Due to Minitab's limitations in addressing heteroscedasticity, RStudio software was used. In this step, the 'sandwich' package was integrated into the RStudio script to manage heteroscedasticity. The 'sandwich' package is an essential tool for making valid inferences from regression models in the presence of heteroscedasticity, as it provides robust standard error estimates (White, 1980; Long and Ervin, 2000; Zeileis, 2004).

R script for sickness absence

```r
# Load necessary libraries
if (!require("readxl")) install.packages("readxl")
if (!require("MASS")) install.packages("MASS")
if (!require("broom")) install.packages("broom")
if (!require("officer")) install.packages("officer")
if (!require("flextable")) install.packages("flextable")
if (!require("dplyr")) install.packages("dplyr")
if (!require("sandwich")) install.packages("sandwich")
if (!require("lmtest")) install.packages("lmtest")
if (!require("car")) install.packages("car")

library(readxl)
library(MASS)
library(broom)
library(officer)   # For creating Word documents
library(flextable) # For creating tables in Word documents
library(dplyr)
library(sandwich)
library(lmtest)
library(car)

# File path to your new Excel sheet
file_path <- "/Users/heshamalfeheid/Desktop/R_P/Predictors/11.Ps-original/Predictor of sickness absence-All.xlsx"

# Load the dataset
data <- read_excel(file_path)

# Convert to data frame and handle any necessary data cleaning
data <- as.data.frame(data)

# Stepwise regression (bidirectional)
# Fit the full model
full_model <- lm(`Sickness absense days` ~ ., data = data)

# Stepwise regression using AIC for selection
step_model <- stepAIC(full_model, direction = "both", trace = FALSE)

# Summary of the final model with robust standard errors
robust_se <- coeftest(step_model, vcov = vcovHC(step_model, type = "HC3"))

# Convert the robust summary into a tidy format
results <- tidy(robust_se)

# Filter results to include only variables with p-value < 0.05
results <- results %>%
  filter(p.value < 0.05)

# Ensure no row names contain NA or missing values
rownames(results) <- NULL

# Check for any missing or NA terms
results <- results %>%
  filter(!is.na(term))

# Calculate Variance Inflation Factor (VIF) for the selected variables only
vif_values <- vif(step_model)

# Align the terms in the VIF with the terms in the results
vif_values <- vif_values[names(vif_values) %in% results$term]

# Ensure that `results` and `vif_values` are aligned
results <- results %>%
  mutate(vif = vif_values[match(term, names(vif_values))]) %>%
  select(term, estimate, std.error, statistic, p.value, vif)

# Calculate F-statistic and add to the results
f_statistic <- glance(step_model)$statistic
results <- results %>%
  mutate(f_statistic = f_statistic)

# Rename columns for clarity
colnames(results) <- c("Variable", "Coefficient", "Robust Std. Error", "T-Value", "P-Value", "VIF", "F-Statistic")

# Ensure no row names contain NA or missing values (again for safety)
rownames(results) <- NULL

# Create a flextable for the Word document
ft <- flextable(results)

# Format the table (optional customization)
ft <- set_header_labels(ft,
                  Variable = "Variable",
                  Coefficient = "Coefficient",
                  `Robust Std. Error` = "Robust Std. Error",
                  `T-Value` = "T-Value",
                  `P-Value` = "P-Value",
                  VIF = "VIF",
                  `F-Statistic` = "F-Statistic")

ft <- autofit(ft)

# Save the table as a Word document
output_file <- "/Users/heshamalfeheid/Desktop/important_variables.docx"
doc <- read_docx()
doc <- body_add_flextable(doc, value = ft)
print(doc, target = output_file)

cat("Stepwise regression with robust standard errors completed and results saved to Word document.")
```

R script for presenteeism days

```r
# Load necessary libraries
if (!require("readxl")) install.packages("readxl")
if (!require("MASS")) install.packages("MASS")
if (!require("broom")) install.packages("broom")
if (!require("officer")) install.packages("officer")
if (!require("flextable")) install.packages("flextable")
if (!require("dplyr")) install.packages("dplyr")
if (!require("sandwich")) install.packages("sandwich")
if (!require("lmtest")) install.packages("lmtest")
if (!require("car")) install.packages("car")

library(readxl)
library(MASS)
library(broom)
library(officer)
library(flextable)
library(dplyr)
library(sandwich)
library(lmtest)
library(car)

# File path to your new Excel sheet
file_path <- "/Users/heshamalfeheid/Desktop/R_P/Predictors/12.Pp-original/Predictors of presentism-All.xlsx"

# Load the dataset
data <- read_excel(file_path)

# Convert to data frame and handle any necessary data cleaning
data <- as.data.frame(data)

# Remove rows with any missing values
data <- na.omit(data)

# Stepwise regression (bidirectional)
# Fit the full model
full_model <- lm(`Presenteeism days` ~ ., data = data)

# Stepwise regression using AIC for selection
step_model <- stepAIC(full_model, direction = "both", trace = FALSE)

# Summary of the final model with robust standard errors
robust_se <- coeftest(step_model, vcov = vcovHC(step_model, type = "HC3"))

# Convert the robust summary into a tidy format
results <- tidy(robust_se)

# Filter results to include only variables with p-value < 0.05
results <- results %>%
  filter(p.value < 0.05)

# Ensure no row names contain NA or missing values
rownames(results) <- NULL

# Check for any missing or NA terms
results <- results %>%
  filter(!is.na(term))

# Calculate Variance Inflation Factor (VIF) for the selected variables only
vif_values <- vif(step_model)

# Align the terms in the VIF with the terms in the results
vif_values <- vif_values[names(vif_values) %in% results$term]

# Ensure that `results` and `vif_values` are aligned
results <- results %>%
  mutate(vif = vif_values[match(term, names(vif_values))]) %>%
  select(term, estimate, std.error, statistic, p.value, vif)

# Calculate F-statistic and add to the results
f_statistic <- glance(step_model)$statistic
results <- results %>%
  mutate(f_statistic = f_statistic)

# Rename columns for clarity
colnames(results) <- c("Variable", "Coefficient", "Robust Std. Error", "T-Value", "P-Value", "VIF", "F-Statistic")

# Ensure no row names contain NA or missing values (again for safety)
rownames(results) <- NULL

# Create a flextable for the Word document
ft <- flextable(results)

# Format the table (optional customization)
ft <- set_header_labels(ft,
                  Variable = "Variable",
                  Coefficient = "Coefficient",
                  `Robust Std. Error` = "Robust Std. Error",
                  `T-Value` = "T-Value",
                  `P-Value` = "P-Value",
                  VIF = "VIF",
                  `F-Statistic` = "F-Statistic")

ft <- autofit(ft)

# Save the table as a Word document
output_file <- "/Users/heshamalfeheid/Desktop/important_variables.docx"
doc <- read_docx()
doc <- body_add_flextable(doc, value = ft)
print(doc, target = output_file)

cat("Stepwise regression with robust standard errors completed and results saved to Word document.")
```

4. After ensuring the VIF was below the threshold of 5, Tables C2.5 and C2.6 were generated based on these steps.

Appendix C2.C: Sociodemographic data (other and prefer not to disclose genders)

Sociodemographic category	Other (n=10)	Prefer not to say (n=28)
Age	38.5 ± 15.2	46.7 ± 16.1
Ethnicity		
White Welsh/English/Scottish /North.Irish/British	80.0% (n=10)	67.9% (n=19)
Any other white	10.0% (n=1)	7.1% (n=2)
Asian Bangladeshi	10.0% (n=1)	0.0% (n=0)
Any other Asian	0.0% (n=0)	3.6% (n=1)
Any other ethnic group	0.0% (n=0)	21.4% (n=4)
Marital stratus		
Single	30.0% (n=3)	32.1% (n=9)
Married	40.0% (n=4)	39.3% (n=11)
Living with a partner	20.0% (n=2)	25.0% (n=7)
Separated	10.0% (n=1)	3.6% (n=1)
Education		
Higher education degree and professional/vocational equivalents	60.0% (n=6)	75.0% (n=21)
"A" levels, vocational level 3 and equivalents	20.0% (n=2)	17.9% (n=5)
GCSE/O level grade A* - C, vocational level 2 and equivalents	20.0% (n=2)	7.1% (n=2)
Employment status		
Employed full-time	80.0% (n=8)	92.9% (n=26)
Employed part-time	10.0% (n=8)	3.6% (n=1)
Consultant	0.0% (n=0)	3.6% (n=1)
Trainee/ Apprentice	10.0% (n=8)	0.0% (n=0)
Job type		
IT	20.0% (n=2)	14.3% (n=4)
Research development	20.0% (n=2)	10.7% (n=3)
Administration	30.0% (n=3)	25.0% (n=7)
Professional services	10.0% (n=1)	3.6% (n=1)
Human resources	0.0% (n=0)	3.6% (n=1)
Engineering	0.0% (n=0)	17.9% (n=5)
Other	20.0% (n=2)	25.0% (n=7)
Annual salary (£)		
<15K	10.0% (n=1)	0.0% (n=0)
16K - 29K	20.0% (n=2)	28.6% (n=8)
30K - 39K	40.0% (n=4)	35.7% (n=10)
40K - 49K	20.0% (n=2)	17.9% (n=5)
50K - 59K	0.0% (n=0)	10.7% (n=3)
60K - 84K	10.0% (n=1)	7.1% (n=2)

Data are presented as mean ± SD and percentages where applicable.

Appendix C2.D: Anthropometric, lifestyle categories, mental health, sickness absence and presenteeism (other and prefer not to disclose genders)

Anthropometric category	Other (n)	Prefer not to say (n)
Systolic BP (mmHg)	NA (n=0)	128.0 ± 15.7 (n=5)
Normal	NA (n=0)	20.0% (n=1)
Pre-hypertension	NA (n=0)	40.0% (n=2)
Stage 1 hypertension	NA (n=0)	40.0% (n=2)
Stage 2 hypertension	NA (n=0)	0.0% (n=0)
Diastolic BP (mmHg)	NA (n=0)	76.8 ± 8.7 (n=5)
Normal	NA (n=0)	60.0% (n=3)
Pre-hypertension	NA (n=0)	40.0% (n=2)
Stage 1 hypertension	NA (n=0)	0.0% (n=0)
Stage 2 hypertension	NA (n=0)	0.0% (n=0)
Mean arterial pressure (mmHg)	NA (n=0)	93.9 ± 10.7 (n=5)
Height (CM)	173.8 ± 8.1 (n=10)	176.6 ± 10.2 (n=24)
Weight (KG)	76.5 ± 17.7 (n=9)	76.8 ± 18.1 (n=21)
BMI Score	25.2 ± 4.3 (N=9)	24.9 ± 5.0 (N=21)
Normal	44.4% (n=4)	52.4% (n=11)
Underweight	0.0% (n=0)	4.8% (n=1)
Overweight	44.4% (n=4)	28.6% (n=6)
Obese	11.1% (n=1)	14.3% (n=3)
Waist circumference (CM)	82.5 ± 9.6 (n=7)	84.5 ± 12.1 (n=14)
Normal (Male <94, Female <80)	NA	NA
Increased (Male 94 - 101, Female 80 - 87)	NA	NA
Substantially increased (Male ≥ 102, female ≥88)	NA	NA
Lifestyle category and factors		
Smoking	10.0% (n=1)	10.7% (n=3)
Alcohol		
I drink less than 14 units of alcohol per week.		
Never	30.0% (n=3)	17.9% (n=5)
Occasionally	30.0% (n=3)	17.9% (n=5)
Sometimes	0.0% (n=0)	17.9% (n=5)
Always	40.0% (n=4)	46.4% (n=13)
I do not drink alcohol	0.0% (n=0)	0.0% (n=0)
Diet		
I eat regular meals		
Never	0.0% (n=0)	3.6% (n=1)
Occasionally	0.0% (n=0)	0.0%% (n=0)
Sometimes	10.0% (n=0)	17.9%% (n=5)
Always	90.0% (n=9)	78.6%% (n=22)
I control the calories I eat		
Never	40.0% (n=4)	46.4% (n=13)
Occasionally	20.0% (n=2)	10.7% (n=3)
Sometimes	20.0% (n=2)	32.1% (n=9)
Always	20.0% (n=2)	10.7% (n=3)
I control the amount I eat		
Never	10.0% (n=1)	21.4% (n=6)
Occasionally	10.0% (n=1)	17.9% (n=5)
Sometimes	30.0% (n=3)	35.7% (n=10)
Always	50.0% (n=5)	25.0% (n=7)

Continue appendix C2.D

I eat processed foods such as sausages, pate, cakes, pastries, biscuits, chips, and crisps		
No times	0.0% (n=0)	3.6% (n=1)
1-2 times	30.0% (n=3)	39.3% (n=11)
3-5 times	40.0% (n=4)	42.9% (n=12)
6 or more times	30.0% (n=3)	14.3% (n=4)
I eat fatty foods such as fatty cuts of pork, beef or lamb, butter, dairy foods, fried foods		
No times	0.0% (n=0)	3.6% (n=1)
1-2 times	50.0% (n=5)	53.6% (n=15)
3-5 times	20.0% (n=2)	25.0% (n=7)
6 or more times	30.0% (n=3)	17.9% (n=5)
I drink or eat sweet food, such as sugary drinks and cereals, creamy yoghurts, and ice cream		
No times	10.0% (n=1)	25.0% (n=7)
1-2 times	40.0% (n=4)	50.0% (n=14)
3-5 times	30.0% (n=3)	21.4% (n=6)
6 or more times	20.0% (n=2)	3.6% (n=1)
I eat five portions of fruit and vegetables a day		
No times	20.0% (n=2)	10.7% (n=3)
1-2 times	40.0% (n=4)	10.7% (n=3)
3-5 times	20.0% (n=2)	32.1% (n=9)
6 or more times	20.0% (n=2)	46.4% (n=13)
I have a salt intake of more than one teaspoon per day, including hidden salt (e.g. crisps and frozen meals)		
No times	10.0% (n=1)	32.1% (n=9)
1-2 times	40.0% (n=4)	53.6% (n=15)
3-5 times	30.0% (n=3)	10.7% (n=3)
6 or more times	20.0% (n=2)	3.6% (n=1)
Physical activity (MET/week)	1013.3 ± 971.4; 360.0(1620.0) (n=9)	1212.0 ± 771.7; 960.0(960.0) (n=25)
< 450 MET.min/week	55.6% (n=5)	8.0% (n=2)
Mental health (HADS)		
HADS anxiety score	**11.3 ± 5.5 (n=10)**	**10.6 ± 6.0 (n=28)**
0 to 7; Normal	40.0% (n=4)	39.3% (n=11)
8 to 10; Borderline abnormal	0.0% (n=0)	10.7% (n=3)
11 to 21; Abnormal	60.0% (n=6)	50.0% (n=14)
HADS depression score	**8.5 ± 3.4 (n=10)**	**8.4 ± 4.6 (n=28)**
0 to 7; Normal	30.0% (n=3)	42.9% (n=12)
8 to 10; Borderline abnormal	50.0% (n=5)	32.1% (n=9)
11 to 21; Abnormal	20.0% (n=2)	25.0% (n=7)
Workforce Well-being	28.2 ± 7.9 (n=10)	34.3 ± 11.7
Sickness absence days/year	8.3 ± 7.4; 7.5(14.0) (n=10)	7.1 ± 15.5; 1.0(6.5) (n=28)
Presenteeism days/year	23.3 ± 55.8; 2.0(13.5) (n=10)	10.7 ± 37.7; 0.5(5.0) (n=28)

Data are presented as mean ± SD and percentages and mean ± SD with median and (IQR) where applicable.

Appendix C3.A: PRISMA guidelines

Section and topic	#	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Pg 102, the title
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	N/A
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Pg 103, the final paragraph in the Introduction
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Pg 103, the final paragraph in the Introduction
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Pg 103-105, under Eligibility criteria
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Pg 105, under Search Strategy
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Pg 105, under Search Strategy with table C3.2 (Pg 106) and Appendix C3.B, Pg 255
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pg 105, under Search Strategy, 2nd paragraph
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Pg 106-107, under Data Extraction, and the last sentence of the 2nd paragraph of Search Strategy (Pg 106)
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Pg 103-105, under Eligibility criteria, and table C3.1, Pg 104
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Pg 106-107, under Data Extraction, and the last sentence of the 2nd paragraph of Search Strategy (Pg 106), No assumptions were made
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Pg 107, under Quality Assessment
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Pg 107-108, under Analysis, via narrative tables based on intervention and related outcome
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Pg 107-108, under Analysis for Individual studies with emphasis on significance, and can be seen in Table C3.4 (Pg 110)
	13d	Describe any methods used to synthesise results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Pg 107-108, under Analysis. The primary objective of this systematic review was to first identify and then synthesise the effectiveness of the studies found. Consequently, the "Best Evidence Synthesis" approach was deemed suitable for this review
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Pg 106-107, under data extraction, the TIDieR checklist to report intervention components
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A

Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	As per the NHLBI quality assessment tool, we compared the outcomes mentioned in the methods and the results sections of the published papers
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Pg 107-108 under analysis and table C3.3 (Pg 108). We classified the overall strength of evidence for each outcome as strong, moderate, insufficient or evidence of no association by using an established method that considers study quality "Best evidence synthesis criteria"
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Pg 108, Flowchart C3.1: Flow chart of the inclusion process
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Pg 109, under Study selection and characteristics of included studies
Study characteristics	17	Cite each included study and present its characteristics.	Pg 109, under Study selection and characteristics of included studies, and Table C3.4 (Pg 110)
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Pg 111, Table C3.5, and under Risk of bias (quality assessment) (Pg 112)
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Pg 110, table C3.4 summary results for each study in terms of significance
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Pg 118-122 Under Intervention effectiveness, and table C3.5 (Pg 111)
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Pg 118-122 Under Intervention effectiveness
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Pg 118-122 Under Intervention effectiveness, Pg 112-118, under Interventions components in accordance with the TIDieR checklist, and Pg 122, under Summary
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Pg 111, table C3.5
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Pg 118-122 under Intervention effectiveness
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pg 122-126, Under Discussion
	23b	Discuss any limitations of the evidence included in the review.	Pg 123, last paragraph
	23c	Discuss any limitations of the review processes used.	Pg 127, under Study limitation
	23d	Discuss implications of the results for practice, policy, and future research.	Pg 126, under Study strength
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Pg 103, under Protocol and Registration
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Pg 103, under Protocol and Registration
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix C3. B: Search strategy for Embase, Medline, and CENTRAL

The search engines Embase, Medline, and CENTRAL share a similar input system, which allows for a consistent search strategy across all three platforms. To enhance the search's comprehensiveness and ensure it captures both singular and plural forms, as well as variations between UK and US spellings, truncation and wildcards were employed for each search term relevant to each search engine, and were applied to search the whole text.

Construction **'OR'** Construction work **'OR'** Construction workers **'OR'** Construction worker **'OR'** Industrial Worker **'OR'** Blue-collar **'OR'** Blue collar worker **'OR'** Builders **'OR'** Labourer **'OR'** Worker **'OR'** Engineer **'OR'** Civil Engineer **'OR'** Field Engineer **'OR'** Inspector **'OR'** Construction Engineer **'OR'** Surveyor **'OR'** Manager **'OR'** Director **'OR'** Estimator **'OR'** carpenter **'OR'** Joiner **'OR'** Plasterer **'OR'** Drywall Installer **OR** Tile Installer **OR** Tile Contractor **OR** Roofer **OR** Insulation Specialist **OR** Glazier **OR** painter **'OR'** electrician **'OR'** Plumber **'OR'** Pipe Fitter **'OR'** Mason **'OR'** concrete **'OR'** Brickmason **'OR'** Elevator Mechanic **'OR'** Elevator Installer **'OR'** Crane Operator **'OR'** Crane driver **'OR'** Equipment Operator **'OR'** Signal Worker **'OR'** Building industry

And

Occupational health **'OR'** Workplace **'OR'** Workplace intervention **'OR'** Workplace health **'OR'** Worksite intervention **'OR'** Worksite health **'OR'** Health promotion **'OR'** Health program

And

Physical activity **'OR'** Diet **'OR'** Diet therapy **'OR'** Healthy diet **'OR'** Exercise **'OR'** Muscle exercise **'OR'** Treadmill exercise **'OR'** Aerobic exercise **'OR'** Anaerobic exercise **'OR'** Smoking **'OR'** Smoking cessation program **'OR'** Smoking cessation **'OR'** Smoking reduction **'OR'** Cigarette smoking **'OR'** Obesity **'OR'** Obesity management **'OR'** Overweight **'OR'** Overweight management **'OR'** Weight **'OR'** Weight management **'OR'** Weight reduction **'OR'** Body weight **'OR'** Body weight management **'OR'** Body weight gain **'OR'** Weight gain **'OR'** Body weight control **'OR'** Weight control **'OR'** Body weight change **'OR'** Body weight loss

Appendix C4.A: Chapter 4 questionnaire

Participant #___________
Date:_________________

The Glasgow-Multiplex Lifestyle Collaboration, a cross-sectional study on lifestyle, diet, and health in construction workers

Health & Wellbeing Questionnaire

*All information will be kept confidential

GENERAL INFORMATION

1. **Ethnic Group:**

☐ White British (Scottish, English, Welsh, Northern Irish)
☐ Indian British ☐ Other Asian British ☐ African British
☐ Other Europeans ☐ Asian ☐ African
☐ Latin American ☐ American ☐ Hispanic
☐ Other (please specify)__________

2. **Education (highest qualification)**:

☐ **school leaver/standard grade/GCSE** ☐ **Highers/A levels**
☐ Higher education HND/HNC/NVQ ☐ Bachelor's degree
☐ Master degree / PhD / Postgraduate ☐ Prefer not to say

3. **Annual income (your total household income if living in a family setting or your personal income if living alone or non-family setting)**

☐ No income ☐ < £15,000 ☐ £15,001 - £30,000
☐ > £30,000 ☐ Prefer not to say

4. **What is your job title / job category?**

Job title: ____

Job category/description: ____

☐ On-site based

☐ Office based

5. **What kind of accommodation do you live in?**

☐ own room in flat/house share ☐ rented flat/house

☐ own flat / house (mortgaged or owned outright) ☐ other:______________

6. **Who do live with?** (tick all that apply)

☐ Partner/husband/wife ☐ Children ☐ Parents
☐ Friends/Flatmates/Housemates ☐ Alone ☐ other ________________

7. **Are you the main grocery shopper in your household?**

☐ Yes, always ☐ Yes, sometimes/occasionally ☐ No

8. **Are you the main cook in your household?**

☐ Yes, always ☐ Yes, sometimes/occasionally ☐ No

Baseline Questionnaire

University of Glasgow | Section of Human Nutrition

Participant #___________

Date:_________________

9. Do you smoke?

☐ No, I do not smoke.

☐ Yes, I smoke _________cigarettes per day, _______ days per week

☐ Not anymore, I stopped smoking _______**years and** ____**months ago**

What do/did you mostly smoke (e.g. cigarette, cigars, pipe, etc – give brand if appropriate) ________________________________

10. Do you vape or use e-cigarettes:

☐ No.

☐ Yes.

11. Are you exposed to tobacco smoke?

	Never	Daily	Occasionally	Often
At home, indoors	☐	☐	☐	☐
At work	☐	☐	☐	☐
In the car / van	☐	☐	☐	☐
Other: _________________	☐	☐	☐	☐
Other: _________________	☐	☐	☐	☐

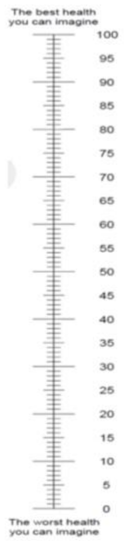
If you reported being exposed to smoke, is it from

☐ you only ☐ one other person only ☐ more than one other person

12. We would like to know how good or bad your health is TODAY

This scale (RIGHT HAND SIDE) is numbered from 0 to 100.

- 100 means the best health you can imagine.
- 0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.



University of Glasgow | Section of Human Nutrition

Participant #___________
Date:_________________

DIET

1. **What kind of bread do you usually eat**

☐ white
☐ brown, granary, wheatmeal
☐ wholemeal
☐ do not eat bread
☐ other kind (please specify)
☐ no usual type
☐ do not know

2. **What do you usually spread on bread?**

☐ butter
☐ hard/block margarine
☐ soft margarine
☐ reduced fat spread
☐ low fat spread
☐ no usual type
☐ do not know
☐ do not spread fat on bread

3. **How much do you usually eat in a day?**

	less than 1	1	2-3	4-5	6 or more
Slices of bread/rolls	☐	☐	☐	☐	☐
Biscuits (including chocolate biscuits)	☐	☐	☐	☐	☐
Cakes, scones, sweet pies and pastries	☐	☐	☐	☐	☐

4. **What kind of milk do you usually use for drinks in tea or coffee and on cereals etc?**

☐ whole milk
☐ semi-skimmed
☐ skimmed
☐ do not drink milk
☐ no usual type
☐ do not know
☐ other kind (please specify) ______________________

5. **Do you usually take sugar in:**

	YES	NO
(a) tea	☐	☐
(b) coffee	☐	☐
DO NOT DRINK TEA/COFFEE	☐	☐

6. **At the table, do you:**

	YES	NO
- generally add salt to food without tasting first	☐	☐
- taste food and then generally add salt	☐	☐
- taste food but only occasionally add salt	☐	☐
- rarely or never add salt at table	☐	☐

7. **Which type of breakfast cereal do you normally eat?**

☐ High fibre (eg All Bran, Branflakes, Shredded Wheat, Muesli, Porridge, Weetabix
☐ other (eg Cornflakes, Rice Krispies, Special K, Sugar Puffs, Honey Snacks
☐ no usual type
☐ do not eat breakfast cereal

Participant #___________
Date:_________________

8. **How often do you eat these foods** *Please add single "tick" per line*

	Per day (times)				**Per week**			**Per month**	
	6+	**4-5**	**2-3**	**1**	**5-6**	**2-4**	**1**	**1-3**	**Less than once**
Breakfast cereal	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fresh fruit	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooked green vegetables (fresh or frozen)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooked root vegetables (fresh or frozen)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Raw vegetables or salad (including tomatoes)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Chips	☐	☐	☐	☐	☐	☐	☐	☐	☐
Potatoes, pasta, rice	☐	☐	☐	☐	☐	☐	☐	☐	☐
Meat	☐	☐	☐	☐	☐	☐	☐	☐	☐
Meat products	☐	☐	☐	☐	☐	☐	☐	☐	☐
Poultry	☐	☐	☐	☐	☐	☐	☐	☐	☐
White fish	☐	☐	☐	☐	☐	☐	☐	☐	☐
Oil rich fish	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cheese	☐	☐	☐	☐	☐	☐	☐	☐	☐
Beans or pulses	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sweets, chocolates	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ice cream	☐	☐	☐	☐	☐	☐	☐	☐	☐
Crisps, savoury snacks	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fruit juice (NOT squash)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft/fizzy drinks	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cakes, scones, sweet pies or pastries	☐	☐	☐	☐	☐	☐	☐	☐	☐
biscuits	☐	☐	☐	☐	☐	☐	☐	☐	☐

9. **In summary:**

(a) how many times do you eat fruit and vegetables or pure fruit juice

☐☐ per day OR ☐☐ per week OR ☐☐ per month

(b) how many times do you eat oil-rich fish

☐☐ per day OR ☐☐ per week OR ☐☐ per month

(c) how many times do you eat sweets, chocolates, cakes, scones, sweet pies, pastries or biscuits

☐☐ per day OR ☐☐ per week OR ☐☐ per month

10. **Do you regularly take any vitamin, mineral or other nutritional supplements?**

☐ **Yes** *(please specify which one and why you take them)*

____

☐ **No** *(please specify why not, if relevant)*

____

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Participant #___________
Date:_________________

ALCOHOL

Please circle the answer that is correct for you.

How often do you have a drink containing alcohol?	Never	Monthly or less	2 to 4 times a month	2 to 3 times per week	4+ times per week
How many drinks containing alcohol do you have on a typical day when you are drinking?	1 or 2	3 or 4	5 or 6	7 to 9	10 or more
How often do you have six or more drinks on one occasion?	Never	Less than monthly	Monthly	2 to 3 times per week	4 or more times per week
How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Less than monthly	Monthly	2 to 3 times per week	4 or more times per week
How often during the last year have you failed to do what was normally expected from you because of drinking?	Never	Less than monthly	Monthly	2 to 3 times per week	4 or more times per week
How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	Never	Less than monthly	Monthly	2 to 3 times per week	4 or more times per week
How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Less than monthly	Monthly	2 to 3 times per week	4 or more times per week
How often during the last year have you been unable to remember what happened the night before because you had been drinking?	Never	Less than monthly	Monthly	2 to 3 times per week	4 or more times per week
Have you or someone else been injured as a result of your drinking?	No		Yes, but not in the last year		Yes, during the last year
Has a relative or friend, or a doctor or other health worker, been concerned about your drinking or suggested you cut down?	No		Yes, but not in the last year		Yes, during the last year

Name____ Date_________

Sleep Quality Assessment (PSQI)

What is PSQI, and what is it measuring?

The Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed? ______________________
2. How long (in minutes) has it taken you to fall asleep each night? ______________________
3. What time have you usually gotten up in the morning? ______________________
4. A. How many hours of actual sleep did you get at night? ______________________
   B. How many hours were you in bed? ______________________

5. During the past month, how often have you had trouble sleeping because you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
A. Cannot get to sleep within 30 minutes				
B. Wake up in the middle of the night or early morning				
C. Have to get up to use the bathroom				
D. Cannot breathe comfortably				
E. Cough or snore loudly				
F. Feel too cold				
G. Feel too hot				
H. Have bad dreams				
I. Have pain				
J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)

Scoring

Component 1	#9 Score	C1 __________
Component 2	#2 Score (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2 __________
Component 3	#4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)	C3 __________
Component 4	(total # of hours asleep) / (total # of hours in bed) x 100 >85%=0, 75%-84%=!, 65%-74%=2, <65%=3	C4 __________
Component 5	# sum of scores 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5 __________
Component 6	#6 Score	C6 __________
Component 7	#7 Score + #8 score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7 __________

Add the seven component scores together __________________ ***Global PSQI*** _______________

A total score of "5" or greater is indicative of poor sleep quality.

If you scored "5" or more it is suggested that you discuss your sleep habits with a healthcare provider

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Participant #___________
Date:_________________

HEALTH and WELLBEING [PHQ-9 + Warwick]

1. **Over the last 2 weeks, how often have you been bothered by any of the following problems?**

(tick one box per row)	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	☐	☐	☐	☐
2. Feeling down, depressed, or hopeless	☐	☐	☐	☐
3. Trouble falling or staying asleep, or sleeping too much	☐	☐	☐	☐
4. Feeling tired or having little energy	☐	☐	☐	☐
5. Poor appetite or overeating	☐	☐	☐	☐
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down	☐	☐	☐	☐
7. Trouble concentrating on things, such as reading the newspaper or watching television	☐	☐	☐	☐
8. Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	☐	☐	☐	☐
9. Thoughts that you would be better off dead or of hurting yourself in some way	☐	☐	☐	☐

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

☐ Not difficult at all ☐ Somewhat difficult ☐ Very difficult ☐ Extremely difficult

2. **Below are some statements about feelings and thoughts.**

Please tick the box that best describes your experience of each over the **last 2 weeks**

(tick one box per row)	**None of the time**	**Rarely**	**Some of the time**	**Often**	**All of the time**
I've been feeling optimistic about the future	☐	☐	☐	☐	☐
I've been feeling useful	☐	☐	☐	☐	☐
I've been feeling relaxed	☐	☐	☐	☐	☐
I've been feeling interested in other people	☐	☐	☐	☐	☐
I've had energy to spare	☐	☐	☐	☐	☐
I've been dealing with problems well	☐	☐	☐	☐	☐
I've been thinking clearly	☐	☐	☐	☐	☐
I've been feeling good about myself	☐	☐	☐	☐	☐

Continue to the next page

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Participant #____________

Date:___________________

(tick one box per row)	None of the time	Rarely	Some of the time	Often	All of the time
I've been feeling close to other people	☐	☐	☐	☐	☐
I've been feeling confident	☐	☐	☐	☐	☐
I've been able to make up my own mind about things	☐	☐	☐	☐	☐
I've been feeling loved	☐	☐	☐	☐	☐
I've been interested in new things	☐	☐	☐	☐	☐
I've been feeling cheerful	☐	☐	☐	☐	☐

Appendix C5.A: Undertaken qualitative study course

DAY COURSES in Social Research
Developing social research skills and techniques

Course:	**Introduction to Qualitative Interviewing**
Date:	Wednesday 25th September 2019
Registration:	9.30am
Location:	02 DK 03
Presenter:	Dr. Sophie Sarre

Programme *Please note that while start and end times for the day are fixed, other timings are provisional*

09:30 Registration

10:00 Introductions and aims for the day

10.15 Anticipating what could go wrong - *flip chart exercise*

10.25 Characteristics of qualitative research: implications for qualitative interviews

10.50 Listening in – *a discussion based around excerpts from interviews*

11.10 Coffee / tea

11.25 The interview process

12.00 Developing an interview guide

12.25 Lunch (not provided)

1:25 Practical exercise Part 1 – preparing an interview guide *(Participants work in groups of 3 to prepare a discussion guide. Each group is given a research scenario. The tutors move around the groups.)*

2:25 Pilot interview (within the small group) and revision of interview guide

2.40 Tea / coffee

2.55 Practical exercise Part 2 - practice interviews *(Participants work in new groups of 3 and take turns to be the interviewer, interviewee and observer. Each interviewer will have a different research scenario.)*

3.55 Feedback from the practical exercise and opportunity to ask questions

4:10 Close

 Introduction to Qualitative Interviewing

UNIVERSITY OF SURREY

Appendix C5.B: Chapter 5 topic guide

Version 1.1 31.10.2019

The Glasgow-Multiplex Lifestyle Collaboration: an investigation of lifestyle, diet, and health in construction workers.

Interviews Topic Guide

This is a draft topic guide, and the final version is likely to change once we have initial data from our current study, which aims to collect preliminary data on socioeconomic stats, health and wellbeing, injuries, diet and alcohol consumption, sleep and physical activity. The data will help form the foundation of these questions. Thus, the questions undertaken will broadly be along these lines.

Introduction

- Aims of the interview– We want to understand the lifestyle choices of people like you who are in the construction industry and what the potential barriers and facilitators are towards improving your current lifestyle choices (diet, physical activity, sleep, and smoking cessation).
- We will ask you about your current lifestyle choices, improvements that you think you could make, and what factors either encourage or deter you from improving your lifestyle.
- Your opinion is important to us, so don't be afraid to speak your mind.

- We will audio-record the discussion and take notes; the recordings will then be transcribed and anonymised and will be kept for 10 years after the study finishes.
- Questions will be in accordance with the following:

- On a typical day, what is your activity routine?
- What type of food do you prefer?
- What are your thoughts about healthy food?
- What do you know about fast food (junk food)?
- What do you know about the health effects associated with smoking?
- What type of physical activities do you usually engage in? And how often?
- Do you exercise regularly?
- What would motivate you to exercise long-term?
- What would deter you from exercising regularly?
- Is there anything you would like to change in order to improve your health?
- Do you think that exercise is important for your health?
- How many hours do you sleep at night?

(Please note that these questions are examples only and may not be the questions used in the interviews; however, the topics discussed will be broadly along these lines).

Summary

At the end of the interview, a summary of what has been said will be given orally, so that if there is anything you wish to add, you may do so.

Appendix C5.C: Themes development process

After exporting codes and relevant quotes from NVivo (end of step 4 and the beginning of step 5) and importing them into Excel, the data (codes) were organised under the corresponding deductive themes. For this example, the focus here will be on the theme of physical activity (PA), as illustrated in Table 1 below. The primary aim of this step was to facilitate a holistic examination of the data, allowing us to identify patterns across all participants rather than analysing each participant in isolation. This approach enabled a more comprehensive assessment of whether the codes aligned with the extracts.

Through this process, we refined the codes into inductive sub-themes (Table 2) by either merging multiple codes or expanding on existing ones. For instance, based on the data, the codes lower-intensity PA, higher-intensity PA, and workout type, which were part of leisure time PA (highlighted in green), were combined to form the inductive sub-theme “leisure-time PA”, while routine and household PA was retained as a separate inductive sub-theme. Additionally, a new inductive sub-theme, transportation PA, emerged as participants engaging in higher-intensity PA often mentioned cycling as a form of transportation, while those involved in lower-intensity PA frequently cited walking as their mode of transport.

Moreover, codes conveying similar concepts were consolidated into a single inductive sub-theme, such as motivation and attitudes towards PA (highlighted in blue) were consolidated into “Motivation PA”. This process of thematic development allowed for a more nuanced understanding of the data, ensuring that the inductive sub-themes accurately reflected the participants’ experiences and perspectives.

Table 1 - Physical activity (Deductive theme)		
Code	OnSite - 7	OnSite - 4
Routine and household PA - leisure time	1- "I would take my dog out for a walk. Just a small, half an hour walk, not a long walk, 30 minutes"	1-"I go on a big walk with the dog. It's about two and a half mile and that takes me up to my 10K". 2- "I take the dog on a big walk at night and that took me up to the 10,000 and 11,000".
Lower-intensity PA - leisure time	1- "I would take my dog out for a walk. Just a small, half an hour walk, not a long walk, 30 minutes"	1- "I try and get time for my 10K steps a day, that's what I aim for". 2- "I go on a big walk with the dog. It's about two and a half mile and that takes me up to my 10K". 2-"1- "I'm walking to work and I'm walking back to the van"
Higher-intensity PA - leisure time	1- "I'm cycling quite a lot, and then I go to the gym quite a lot, play football quite a lot". 2- "Tuesday, Thursday and a Saturday I would go to the gym, ten in the morning, and that's also cycling to the gym". 3- "1- "Go out to work, which would be the cycling, depending on the weather, but it would be mostly cycling, I would cycle to and from work, which is 12 kilometres each way, so it's like 24 kilometres a day cycling, also cycling to the gym".	----------------- None Reported ------------------
Workout type	Cycling, Gym, Football	Dog walks and 10k steps.
Workplace PA	----------------- None Reported ------------------	1- "The walking because I'm in the machine all day, I have to do the walking, do you know what I mean, to level it out"
Barriers to PA	----------------- None Reported ------------------	1- "it would probably be the long hours at work, I've not got time for the gym, I'm out the house for what, 13, 14 hours a day"
Motivation PA	1- "I was gaining…I was always skinny, but I was gaining a bit of weight, and I wanted to lose it, and then once I started cycling, I got the bug for it, and I enjoy it so much, I just enjoy it so much. I want to keep active still for as long as I can".	1- "I do feel a lot healthier. I'm not tired. I just feel more awake"
Attitude to PA	1- "I just enjoy it so much. I want to keep active still for as long as I can".	----------------- None Reported ------------------

Table 2 - Physical activity (Deductive theme)		
Inductive sub-theme	OnSite - 7	OnSite - 4
Routine and household PA	1- "I would take my dog out for a walk. Just a small, half an hour walk, not a long walk, 30 minutes"	1-"I go on a big walk with the dog. It's about two and a half mile and that takes me up to my 10K". 2- "I take the dog on a big walk at night and that took me up to the 10,000 and 11,000".
Type of PA/leisure time PA	1- "I'm cycling quite a lot, and then I go to the gym quite a lot, play football quite a lot". 2- "Tuesday, Thursday and a Saturday I would go to the gym, ten in the morning, and that's also cycling to the gym".	1- "I try and get time for my 10K steps a day, that's what I aim for". 2- "I go on a big walk with the dog. It's about two and a half mile and that takes me up to my 10K"
Type of PA/ transportation PA	1- "Go out to work, which would be the cycling, depending on the weather, but it would be mostly cycling, I would cycle to and from work, which is 12 kilometres each way, so it's like 24 kilometres a day cycling, also cycling to the gym".	1- "I'm walking to work and I'm walking back to the van"
Type of PA/ Workplace PA	----------------- None Reported ------------------	1- "The walking because I'm in the machine all day, I have to do the walking, do you know what I mean, to level it out"
Barriers to PA	----------------- None Reported ------------------	1- "it would probably be the long hours at work, I've not got time for the gym, I'm out the house for what, 13, 14 hours a day"
Motivation PA	1- "I was gaining…I was always skinny, but I was gaining a bit of weight, and I wanted to lose it, and then once I started cycling, I got the bug for it, and I enjoy it so much, I just enjoy it so much. I want to keep active still for as long as I can"	1- "I do feel a lot healthier. I'm not tired. I just feel more awake"

Appendix C5.D: Qualitative study thematic framework description

Theme (Deductive)	Sub-team (Inductive)	Description
Diet	Meal routine	Their meal pattern, associated with the time of eating
	Cooking and food preparation	Who usually does the cooking and food preparation
	Influence of food choice	What makes a participant eat a specific type of food
	Reflection of diet	Participants own thoughts on the way they eat or should eat
	Triggers for change	Reasons participants transitioned to a healthy diet
	Barriers to healthy eating	Things that make it difficult to follow a healthy diet
	Facilitators to healthy eating	Things that help in eating a healthy diet
Smoking	Smoking status	Yes/No/EX or Social smoker
	Reasons - No/EX/Yes	Reasons why they never smoked, quit, or are still smoking
	Barriers to quitting smoking	Barriers that hold a participant back from quitting
	smoking and health	Do participants truly understand the adverse effects of smoking
Alcohol	Type of drinker	How participants describe their drinking consumption
	Drinking routine	Participant's drinking routine across the week
	Reasons for following this routine	Why do they drink this way?
Physical activity	Routine and household physical activity	Any physical activity done routinely (e.g., dog walks) or within the household
	Leisure time physical activity	Activities that take place in the participant's leisure time
	Physical activity as means of transportation	Any physical activity used as means of transportation
	Workplace physical activity	PAs that take place in the workplace (during working hours)
	Barriers to physical activity	Barriers that hold them back from doing physical activity or exercises.
	Motivation PA	What drives them to be physically active
Mental health	What contributes to poor mental health	Things or situations that may lead to mental health issues.
	Impact of poor mental health	The impact of mental health on different life aspects
	Strategies to cope with mental health issues	Strategies that helped improve mental health issues, even if minimal, such as stress
Sleep	Satisfaction with sleep	Participants rate how satisfied they are with their sleep
	Reason for lack of sleep	Reasons why participants do not have enough sleep
	Lack of sleep impact	A description of how lack of sleep impacts the day
Workplace and health	Current practices	Current practices within the workplace, whether they help improve health (positive) or are unhealthy (negative)
	Views on current practices	Participant view on current workplace health promotion programs
	Views on what can be done	Participants view on what can be done to improve health within the workplace.
	Barriers to the implementation of suggested views	Barriers to the implementation of workplace health promotion programs suggested by participants