Correlates of sedentary behaviour among individuals at risk of developing type 2 diabetes mellitus in a low resource setting

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AFRCHA004

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Abstract

Background: There is evidence regarding the adverse effects of prolonged sedentary behaviour (SB) on health outcomes, including the association with non-communicable diseases (NCDs) such as type 2 diabetesmellitus (T2DM). However, there is a scarcity of information regarding the correlates of SB among individuals at risk of developing T2DM in low-income settings such as in South Africa (SA). Therefore, we aimed to identify the prevalence and correlates of SB among adults at riskof developing T2DM in low-income communities in Cape Town, South Africa. **Methods:** This was secondary analysis of cross-sectional data from the South African Diabetes Prevention Programme (SADPP). The study population consisted of 698 participants from 16 lower socio-economic communities in Cape Town, recruited between August 2017 and March 2018.

Participants classified at high-risk completed questionnaires on socio-demographic, behavioural and psychological factors, neighbourhood living conditions and medical history. Self-reported SB was measured using the Global Physical Activity Questionnaire (GPAQ) and a separate questionnaire that recorded minutes of screen time (ST) during a typical working and non-working day. Blood samples were collected forthe determination of fasting glucose, glycated haemoglobin, and lipids**.** A Kruskal-Wallis or one-way ANOVA was conducted depending on the distribution of the numerical variable. A chi-squared or Fisher's exact test was conducted depending on the expected frequencies of the cells. Robust regression was used to investigate the association between the exposure and outcome variable. Statistical significance was set at $p<0.05$. **Results:** Among the 698 participants, the median time (minutes/day) spent in SB and ST was 180.0 and 137.1 minutes/day, respectively. When grouped by SB or ST, most of the participants (66.0% and 77.9%) were classified as having low levels (<4h/day) of SB and ST, respectively. After adjusting for age and gender, SB was associated with type of housing, lower safety, and walking infrastructure scores, excellent self-reported sleep quality and having at least one barrier to physical activity (PA). **Conclusion:** SB was correlated to factors related to socioeconomic status (SES), as well as barriers to PA and self-reported sleep quality. As such interventions to decrease SB should focus on environmental factors.

Keywords: Sedentary behaviour, type 2 diabetes mellitus, correlates, at-risk, low-resourced communities.

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Part A: Research protocol

1. Background and Rationale

It is well known that moderate-to-vigorous physical activity (MVPA) is associated with a reduced risk for conditions such as cardiovascular disease, type 2 diabetes mellitus (T2DM), obesity and some cancers (1). In contrast, those who do not meet the physical activity (PA) guidelines have an increased risk of developing these conditions and premature mortality (1, 2). Due to the ever changing economic, industrial, and social developments, rapid technological advancements, widespread urbanization, as well as changes to traditional food and transport systems, global surveillance experts have revealed a behavioural shift from more active lifestyles to industrialized and sedentary lifestyles (1). This decrease in PA and the resultant increase in sedentary behaviours (SB) over time is referred to as the "physical activity transition" (1). The PA transition can be seen in sub-Saharan Africa (SSA) which is currently undergoing a shift in habitual, occupational and transport related physical activities from high energy expenditure activities (e.g., active transport and manual labour) to low energy expenditure activities or sedentary behaviours (e.g., motorized transport or desk work) (1, 3). The shifting PA patterns to a more sedentary lifestyle in combination with changes in dietary patterns may be important contributors to the increasing burden of non-communicable diseases (NCDs) seen in SSA (4).

SB is defined as behaviours that involve sitting and/or reclining positions and low levels of energy expenditure (≤1.5 metabolic equivalents [METS]) during waking hours (5). SB can be thought of as being part of the energy expenditure spectrum before light intensity physical activity (LPA) (1.6 – 2.9 METS), moderate physical activity (MPA) (3.0 – 5.9 METS) and vigorous physical activity

(VPA) (≥6.0 METS). The World Health Organization (WHO) PA recommendations state that adults should engage in at least 150 minutes of moderate intensity aerobic PA per week or 75 minutes of vigorous intensity aerobic PA per week, or a combination of MVPA per week (6). In order to meet the WHO PA guidelines, one only has to spend about 2% of waking time in MVPA, while the remaining 98% of waking day is spent in SB and LPA behaviours (7). This introduces the concept whereby, even though potential health gains are attributed to participating in MVPA, there is potential for these gains to be counteracted if the remainder of the day is spent in SB (8). It is important to note that SB is not the same as physical inactivity, which is defined as not meeting the WHO PA recommendations (7).

SB and physical inactivity are two distinct constructs and SB is an ever-present occurrence. As such, opportunities to engage in it will continue to increase due to the rapid growth in communication, transport, and workplace technologies (8). SB generally involves "sitting time" and, similar to PA, there are different domains in which these can take place i.e., leisure time SB (e.g. watching television), transport SB (e.g. driving in your car or taking public transport), or occupational SB (e.g. sitting behind a desk at work) (8). It is important to note that sitting is a natural behaviour, however, the problem arises when individuals engage in extended periods (>8h/day) of uninterrupted sitting (9); a behaviour shown to have adverse effects on cardio-metabolic health (9).

There is a plethora of information regarding the adverse effects of SB on health outcomes. The evidence tends to indicate that SB (measured subjectively and/or objectively) is adversely associated with a range of cardiometabolic biomarkers, including fasting plasma glucose, triglycerides, high-density lipoprotein cholesterol [HDL-C] and waist circumference [WC], as well as the metabolic syndrome among adults (5, 10, 11). A systematic review conducted by Powell et al., (2018) included 46 papers with a combined sample size of 70,576 adults from North America, South America, Europe and Asia and explored the association between

objectively measured sedentary time and cardiometabolic health. They found that sedentary time was positively associated with fasting glucose, fasting insulin, triglycerides, HDL-C and WC. Furthermore, the risk of all-cause mortality was higher if adults accumulated more than six to eight hours of sedentary time per day (12). Similarly, findings from a recent meta-analysis showed that between seven and eight hours per day of sitting time (self-reported) significantly increased the hazard- ratio for mortality (7, 13).

High levels of SB have also been shown to be associated with an increased risk of T2DM (12, 13). The prevalence of T2DM is on the rise globally (14). While in Sub-Saharan Africa (SSA), T2DM currently contributes the smallest proportion to the global population of people with T2DM, it has the highest projected rate of increase over the next 25 years (15). The prevalence of T2DM in South Africa (SA) is the largest contributor to the T2DM burden in SSA (15). The International Diabetes Federation (IDF) estimated a 12.7% prevalence of diabetes in SA adults in 2019, which is a 137% increase on the 2017 estimate of 5.4% (15). Type 2 diabetes is the second leading cause of mortality in the general SA population and first among women (STATS SA, 2016). Although there are several well-known risk factors for developing T2DM, which include genetic, environmental and lifestyle factors such as unhealthy diet, and physical inactivity, SB should also be considered as an important risk factor in developing T2DM (14).As such, it is important to understand the correlates of SB among adults who are at risk of developing T2DM as it may be helpful in developing interventions and policies to reduce SB, thereby reducing the progression to T2DM in high-risk individuals.

Currently there is a scarcity of information regarding the correlates of SB among individuals at risk of developing T2DM in SA. Most studies that examined factors that are associated with SB have generally been conducted in high-income countries (16) and they focused on individual-level correlates. According to these studies, individual-level correlates associated with SB

include older age, female gender, lower education, full-time employment status, a higher body mass index (BMI), a higher income or socio-economic status (SES), smoking and the presence of depressive symptoms (16, 17, 18). Studies in high-income countries also show that environmental factors associated with SB include lack of proximity of green space, lack of neighbourhood walkability, unsafe environment, and bad weather conditions (16,17,18, 19). In a study examining the correlates of SB in six low-and-middle-income countries (China, Ghana, India, Mexico, Russia and SA), it was found that, in the overall sample, in addition to the above mentioned individual correlates, a greater number of chronic conditions, poor self-reported health, higher disability levels and worse health status in terms of pain/discomfort, affect (i.e. feelings of sadness, depression, worry and/or anxiety), sleep disturbances, low energy levels, and cognition were also significantly associated with high SB (19). In the African setting, it was found that the non-modifiable individual level correlates of SB were similar to those of studies conducted in high-income countries (20, 21, 22, 23, 24, 25, 26, 27, 28). Environmental factors such as residing in an urban/peri-urban area, a lower walkability index, further proximity to destinations, less access to services, poor traffic safety and poor safety from crime were correlated with higher amounts of SB (24).

In addition to the negative effect that SB has on health outcomes and the fact that it is a risk factor for developing T2DM, there is also a difference in occupational, social, and cultural factors, methods of transportation and environmental factors in SA compared to high-income countries (29). As such, it is important to understand the correlates of this behaviour as this data can inform the design of interventions aimed at minimizing SB in our setting and ultimatelyreduce cases of T2DM.

2. Aims and Objectives:

2.1. Aim

The aims of this study are to determine the prevalence of SB and identify the variables associated with SB among adults at risk of developing T2DM in low-income communities in CapeTown, South Africa.

2.2. Objectives

i. To determine the level of self-reported sedentary time and screen time (ST) of adults athigh-risk of developing T2DM.
ii. To evaluate the association between SB and various exposure variables.

3. Methodology

3.1. Study design, setting and population

This is a cross-sectional study, utilizing existing data from the South African Diabetes Prevention Programme (SADPP) study. The SADPP study is a cluster randomized control trial, aimed at developing and evaluating a culturally relevant model for T2DM prevention in SA (30). The study population includes participants who were recruited between August 2017 and March 2018, aged between 25–65 years, who are at high-risk of developing T2DM (basedon the African Diabetes Risk Score (ADRS)(31)) and are from the 16 low-socioeconomic communities (formal and informal townships) in Cape Town. These 16 communities comprised of mainly black African and mixed-ancestry communities in the Western Cape. They consist of formal residential areas as well as informal settlements and/or townships and were selected based on their sociodemographic characteristics (low resource area) and high diabetes risk (32). The average household monthly income for residents in these communities is ~3500 ZAR (230.94 USD). In addition, high unemployment rates are reported (21.6%), with Black African (31.0%), followed by the mixed ancestry population (23.5%) being the most affected (33).

The SADPP sample size was calculated, assuming a cumulative incident T2DM rate of 13.6%at 2–3 years, with an expected relative risk to be 0.51. Further, an intra-cluster correlation coefficient (ICC) was assumed for fasting glucose of 0.02 (34). The sample size calculation was based on the above at a significance level of 5% with a type II error risk of 20% and with an estimated 36-month loss to follow-up of 20–25%. As such, 702 participants were deemed at high risk of T2DM based on the ADRS. Of these participants, four were excluded due to missing outcome data, with 698 participants included in the study.

3.2 Sampling method

There were two approaches to sampling. Participants were initially selected using a random sampling technique where aerial maps of the included townships (obtained from the municipality of Cape Town) were used to randomly select households (30).

Fieldworkers would then visit these households to identify and screen potentially eligible participants (30). This method was unsuccessful in the first four areas, with less than a 10% response rate. Subsequently, the self-selection approach was used. In the self- selection approach, the study was advertised through local councillors' offices, churches, schools, as well as flyers, being distributed door-to-door (or dropped in post-boxes) in the community. Potentially interested participants could then attend pre-determined venues in their community for community-based diabetes risk screening.

3.3. Data collection methods and research procedures

3.3.1 Screening and overview of study methods

Screening for diabetes risk followed a two-stage approach. Firstly, community-based risk screening was carried out using a questionnaire (general information i.e., age, gender, race, address, contact information) and anthropometric and blood pressure (BP) measurements. These measures were then used to estimate the risk of developing T2DM using the ADRS, which has been validated in

black (35) and mixed-ancestry (36) South Africans. Those identified as being at high-risk of developing T2DM were invited to complete clinic-based risk status assessment. During the clinic-based risk status assessment, validated questionnaires were administered and completed by all the participants. In addition, standard anthropometric and BP measures were conducted. Finally, fasting (10-12 hours) blood samples were drawn, where after an oral glucose tolerance test (OGTT) was completed. Participants were excluded if they were younger than 25 or older than 65, if they were bedridden, pregnant, or breastfeeding, in receipt of cancer or tuberculosis treatment within the past three months and those with known diabetes.

3.3.2. Anthropometry and BP

Three BP measurements were taken at two-minute intervals using an Omron BP monitor after the participant had been seated for five minutes. The average of the three BP measurements was used in the analysis. Participants with increased BP levels (systolic blood pressure (SBP) ≥ 140 and/or diastolic blood pressure (DBP) ≥ 90 mmHg) were classified as hypertensive. These individuals were referred to a nearby public health facility for further management. For anthropometric measures, participants were asked to wear minimal light-weight clothing and no shoes. Weight was measured on a digital scale (SECA, Hamburg, Germany) and recorded to the nearest 0.1 kg. Height was measured using a stadiometer (SECA, Hamburg, Germany). BMI was calculated by the weight (in kg) divided by the height (in meters squared). BMI was categorized as underweight (≤18.5 $kg.m^2$), normal weight (18.5- 24.9 $kg.m^2$), overweight (25.0- 29.9 $kg.m^2$) and obese (≥30 $kg.m^2$). Waist circumference measurement was taken at the level mid-way between the upper border of the hip bone and the lower border of the lowest rib (37).

3.3.2 Fasting blood samples and OGTT

After a 10-hour overnight fast, blood samples were drawn for the determination of glucose and lipid profile (total cholesterol, HDL-cholesterol, and triglycerides). Then, a standard OGTT was

completed during which 75 g of anhydrous glucose in 250 ml of water was ingested, and a blood sample was taken 120 minutes later for the determination of glucose concentrations (38).

3.3.3 Biochemical analysis

All biochemical analysis was conducted by an ISO-accredited pathology laboratory (Pathcare Laboratories).-Plasma glucose concentrations were determined using the enzymatic hexokinase method (Cobas 6000, Roche Diagnostics). Hba1c was measured using high- performance liquid chromatography (Biorad Variant Turbo, biorad, South Africa).

3.3.3.1 Serum lipids

Serum lipids were measured using a Roche Modular auto analyser and enzymatic colorimetric assays. Low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula (39) as: LDL-c = Total cholesterol – HDL-cholesterol -TG ÷ 5.

3.3.4 Questionnaires

3.3.4.1 Sociodemographic measures

Questionnaires were used to capture sociodemographic information such as age, sex, level of education, occupation, household income and marital status. Level of education was categorized into six categories, i.e., never went to school, grade 1-7, grade 8-10, less than grade 12 plus a further education training (FET) certificate/diploma, grade 12, tertiary diploma/degree. Occupation was categorized as unemployed, employed (i.e., self-employed/part-time employed), full-time homemaker, pensioner, on disability grant, or student. The household income continuous variable was categorized by tertiles into low income (0-3200 ZAR [0-174 USD]), middle income (3201-6400 ZAR [175-349 USD]) and high income (>6400 ZAR [≥350 USD]).Marital status was categorized into living alone (single, widowed, separated) or cohabiting(married or living as married).

3.3.4.2 Physical activity and SB measures

PA was characterised using GPAQ. Participants were classified as physically active if they met the WHO PA guidelines of 150 minutes of moderate intensity aerobic PA per week or 75 minutes of vigorous intensity aerobic PA per week, or a combination of MVPA per week. Participants not meeting the WHO PA guidelines were defined as being insufficiently active (40). PA domains were characterised by the GPAQ as work-related PA, travel-related PA and leisure-related PA (40).

SB was also captured using the GPAQ and was characterized as the amount of time (minutes per day) an individual spends sitting or reclining on a usual day (excluding sleep). This may include time sitting at a desk, visiting friends, reading, or sitting down to watch television and could be during working hours and/or during leisure time. Monitoring SB by self-report remains the most practical and widely used means for most national surveillance systems and research studies (41) and allows capturing of contextual information, often missed by device-assessed SB such as domain (i.e. occupational, transportation, leisure-time) and type (i.e. watching TV, sitting and playing the piano) of SB. Previous works have described various measures of SB and their properties and found that, in the majority of cases, self-reported measures of SB tend to largely underestimate SB compared to device-based measures of SB, and that composite questionnaires appear to perform better than single-item questionnaires such as that measured in the GPAQ. (41). Screen time (ST) was assessed with a separate question and was used as an additional estimate of SB. Participants were asked "How much time do you spend in front of a screen (watching television/DVDs, on the computer) during a typical working day (at home and at work) and non-working day (at home only)?", respectively.

Barriers to PA were assessed using a 11-item scale (42). Participants identified each item as either not a barrier (coded 1) or very much a barrier (coded 2). Only those items identified as being very much a barrier would be considered a barrier for PA in this study.

3.3.4.3 Lifestyle behaviours

Lifestyle behaviours such as tobacco use (yes or no) and alcohol use (yes or no) were measured using the WHO STEPS instrument (40) as well as sleep time and sleep quality (disrupted or not disrupted). Tobacco use was assessed with the question “Do you currently smoke any tobacco products, such as cigarettes, cigars or pipes?”. Alcohol use was assessed withthe question “Have you ever consumed a drink that contain alcohol such as beer, wine, spirits or sorghum beer?”. Sleep time was assessed with the question “How many hours do you usually sleep a night?” And sleep quality was assessed with the question “do you usually have disrupted sleep?”. Participants who answered “yes” to the sleep quality question were noted as having poor sleep quality.

3.3.4.4 Psychological measures

Chronic stress was assessed in terms of long term (>12 months) events which have been shown to be associated with psychological stress (43). Events included, personal serious ongoing health problems or serious ongoing health problems in a close relative or friend, ongoing difficulties related to employment, ongoing financial strain, or ongoing difficulties in a close relationship (43). Events were assessed on a scale from not very stressful (coded 1) to very stressful (coded 3) (43). Only events identified as very stressful were considered stressful events and participants who experienced at least one stressful event over a period of12 months were coded as 1 compared with those experiencing no stressful event (coded as 0)(43).

Anxiety symptoms were assessed using a self-reported 7-item general anxiety disorder (GAD) questionnaire (44). Participants were asked to respond to statements about how often they have experienced anxiety related to certain events. Items were scored on a 4-point scale ranging from not at all (coded 0) to nearly every day (coded 3). High scores reflect high levels of anxiety (44). The presence and severity of depression was assessed by the self-report patient health questionnaire (PHQ-9) (45). For this questionnaire, respondents rated the extent to which asymptom has been present, over the past 2 weeks, from not at all (coded 0) to nearly

everyday (coded 3). Higher scores reflect more severe depressive symptoms (44, 45). Support networks were assessed using a ENRICHD social support inventory (ESSI) 5-item scale to assess individuals' perceived level of social support (46). A total score of less than 18 is required to classify an individual as having low perceived social support (LPSS) (46).

3.3.4.5 Medical history

Medical history included self-reported family (mother, father, brother and/or sister) history of T2DM. Participants answered the question "has your biological mother, father, sister and/or brother ever been diagnosed with diabetes?". If participants answered yes to any one of the family members, they were considered as having a positive family history of diabetes.

3.3.4.6 Neighbourhood indicators

Neighbourhood indicators were assessed using the Neighbourhood Environmental Walkability Scale for Africa (NEWS-A). NEWS-A gauged perceived neighbourhood environmental attributes in seven domains: stores and facilities, access to services and places, roads and walking paths, places for walking/cycling/playing, surroundings, safety from crime and traffic and personal safety. All domains were rated by using Likert-type response options ranging from 1 (strongly disagree) to 4 (strongly agree). Responses for the domains of the NEWS-A will be computed as the mean of the items of each domain, with responses coded (or reverse coded) such that higher values indicate higher walkability of the neighbourhood (47).

3.4. Types of variables in proposed study

3.4.1 Outcome variables to be included in the analysis

Variable name	Scale	Categories
Sedentary behaviour	Numerical – continuous Categorical – ordinal	Mean (SD)/median (IQR) <4h, 4-7h, ≥8h/day
Screen time (working and Non-working day)	Numerical – continuous	Mean (SD)/median (IQR)

3.4.2 Individual-level variables to be included in the analysis

Variable name	Scale	Categories
Age (years)	Numerical – continuous	Mean (SD)/median (IQR)
Sex	Categorical – binary	Male or female
Education level	Categorical – ordinal	No school, grade 1-7, grade 8-10, <grade 12 + FET/certificate/diploma, grade 12, Tertiary/diploma/degree
Occupation	Categorical – nominal	Unemployed, employed (i.e., self-employed/part-time employed), full-time homemaker, pensioner, on Disability grant, student
Household income	Categorical – ordinal	Low income, middle income, High income
Waist circumference	Numerical – continuous	Mean (SD)/median (IQR)
Body Mass Index (BMI)	Numerical – continuous	Mean (SD)/median (IQR)
	Categorical – ordinal	Underweight, normal-Weight, overweight, obese
Blood pressure	Numerical – continuous Categorical – binary	Mean (SD)/median (IQR) Hypertension – yes or no
Fasting glucose	Numerical – continuous	Mean (SD)/median (IQR)
HBA1c	Numerical – continuous	Mean (SD)/median (IQR)
Total cholesterol	Numerical – continuous	Mean (SD)/median (IQR)
HDL-cholesterol	Numerical – continuous	Mean (SD)/median (IQR)
LDL-cholesterol	Numerical – continuous	Mean (SD)/median (IQR)
Triglycerides	Numerical – continuous	Mean (SD)/median (IQR)
Family history of diabetes	Categorical – binary	Yes/no

3.4.3 Interpersonal-level variables to be included in the analysis

Variable name	Scale	Categories
Marital status	Categorical – Binary	Living alone or cohabiting
Support networks – 7 questions	Categorical – ordinal Numerical – continuous	None of the time, a little of the time, some of the time, most of the time, all of the time Mean (SD)/Median(IQR)

3.4.4 Behavioural variables to be included in the analysis

Variable name	Scale	Categories
Tobacco use	Categorical – binary	Yes, no
Alcohol use	Categorical – binary	Yes, no
Sleep time	Numerical – continuous	Mean (SD)/median (IQR)
Sleep quality	Numerical – discrete Categorical – binary Categorical – ordinal	Mean (SD)/median (IQR) Disrupted sleep – yes/no Excellent, very good, good, Fair, poor
Physical activity	Numerical – continuous Categorical – binary	Mean (SD)/median (IQR) Physically active/insufficiently active

3.4.5 Psychological variables to be included in the analysis

Variable name	Scale	Categories
Stress – 5 questions	Categorical – ordinal	Not very stressful, moderately stressful, very Stressful
Anxiety – 7 statements	Categorical – ordinal	Not at all, several days, more than half the days, Nearly everyday
Life satisfaction	Numerical – continuous	Mean (SD)/median (IQR)

Barriers to physical activity – 11 statements	Categorical – ordinal	Not a barrier, somewhat a Barrier, very much a barrier

3.4.6 Environmental-level variables to be included in the analysis

Variable name	Scale	Categories
Stores and facilities – 26 locations	Categorical – ordinal Numerical - discrete	Do not know, 1-5min, 6-10min, 11-20min, 21-30min, >30min Mean (SD)
Access to services and places – 7 statements	Categorical – ordinal Numerical - discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly agree Mean (SD)
Roads and walking paths – 5 statements	Categorical – ordinal Numerical - discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly Agree
		Mean (SD)
Places for walking/cycling /playing – 13 statements	Categorical – ordinal Numerical – discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly agree Mean (SD)
Surroundings – 8 statements	Categorical – ordinal Numerical – discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly agree Mean (SD)

Safety from crime and/or traffic – 5 statements	Categorical – ordinal Numerical - discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly agree Mean (SD)
Personal safety – 4 statements	Categorical – ordinal Numerical - discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly agree Mean (SD)
Stranger danger – 4 statements	Categorical – ordinal Numerical - discrete	Strongly disagree, somewhat disagree, somewhat agree, strongly agree Mean (SD)

3.5 Data analysis

All data were analysed using Rstudio version 1.4. Continuous variables were summarised using mean ± standard deviation (SD) or median (25^{th} – 75^{th} percentile) based on data distribution. Categorical variables were summarised using count and proportions. Multivariable linear regression and ordinal (multinomial) logistic regression were used to investigate the association between the exposures and outcome variables i.e., SB and screen time. Statistical significance was set at $p<0.05$.

4. Ethical considerations

The parent study has been approved by the Research Ethics Committee of the South African Medical Research Council, Cape Town (EC018-7/2015) and will be carried out according to the ethical guidelines and principles of the Declaration of Helsinki, 2013. Ethical approval for the

proposed study will be obtained by the University of Cape Town Human Research Ethics Committee (UCT-HREC).

4.1. Informed consent

Informed consent was obtained for the participants during the parent study on two occasions: firstly, at community-based screening and then again at the clinic for participants who were identified at high-risk of developing T2DM. This study will use the consented data and will therefore not require further consent from the participants.

4.2. Privacy and confidentiality

Participants were issued a unique identifier code which will be used in all documents and bar-coded containers for biological specimens. Participant folders are kept in locked cabinets to restrict access and electronic data is stored on a password protected central database which only the principal investigator and study coordinator will have access to. The proposed study will use the unique identifier codes for all analyses.

4.3. Data safety

All the data were collected and managed on a web-based research data management system (Bryant Research Systems). Data collected from the field were automatically transferred via a secured internet connection to the central database, which was maintained on an on-going basis. This allowed for quality control to be implemented as data was being collected, which, inturn, improved the accuracy of the information collected. Biological samples were collected andstored in bar-coded containers, which facilitated the incorporation of laboratory results onto the main database.

4.4. Risks and benefits

There are no risks or direct benefits for the proposed study, but the knowledge of the correlates of sedentary behaviour will give us insight regarding the amount of SB people are engaging in and

the factors associated with engaging in these behaviours. This knowledge may be used to inform interventions to reduce SB and ultimately decrease the risk of individuals developing T2DM. In the parent study, risks included answering personal questions regarding participants' health, a medical examination and collection of blood for laboratory analysis (for those at high-risk) which can cause bleeding, bruising, discomfort and in rare cases an infection may occur at the site of the needle stick. Rarely, light-headedness or fainting may occur. Benefits of participating in the parent study included screening of participants for risk of developing diabetes; participants received copies of blood tests and BP measurements and were referred to a clinic for treatment if abnormalities were found.

4.5. Feasibility

The feasibility of the proposed study is high, as I will be using existing data from the SADPP study, so limited resources will be required.

4.6. Conflict of interest

There are no conflicts of interest.

4.7. Budget required

There will be no additional budget required to conduct this study.

4.8. Timeline

Activity	Time (months)				
	Nov21-Mar22	Dec21-Mar22	Mar-Apr22	May-Jun22	Jul-Aug22
Protocol submission To ethics					
Merge and clean Data					
Data analysis					

Thesis and Manuscript write-up					
Finalize thesis and Submit for marking					

4.9. Impact of the study

Knowledge of the correlates of sedentary behaviour may be used to inform interventions to reduce SB and ultimately to reduce the risk of developing T2DM in high-risk adults in low socioeconomic communities in Cape Town, South Africa.

5. References

1. Katzmarzyk PT, Mason C. The physical activity transition. J Phys Act Health. 2009;6(3):269–80.

2. Hamilton MT, Hamilton DG, Zderic TW. Exercise physiology versus inactivity physiology: anessential concept for understanding lipoprotein lipase regulation. Exerc Sport Sci Rev. 2004;32(4):161.

3. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord J Int Assoc Study Obes. 2004 Nov;28 Suppl 3:S2-9.

4. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risksin 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Vol. 393, The Lancet. 2019. p. 1958–72.

5. Powell C, Herring MP, Dowd KP, Donnelly AE, Carson BP. The cross-sectional associations between objectively measured sedentary time and cardiometabolic health markers in adults – a systematic review with meta-analysis component. Obes Rev. 2018;19(3):381–95.

6. Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British Journal of Sports Medicine, 54(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

7. van der Ploeg HP, Hillsdon M. Is sedentary behaviour just physical inactivity by anothername? Int J Behav Nutr Phys Act. 2017 Oct 23;14(1):142.

8. Hamilton MT, Healy GN, Dunstan DW, Zderic TW, Owen N. Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior.Curr Cardiovasc Risk Rep. 2008;2(4):292–8.

9. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population healthscience of sedentary behavior. Exerc Sport Sci Rev. 2010 Jul;38(3):105–13

10. Honda T, Chen S, Kishimoto H, Narazaki K, Kumagai S. Identifying associations between sedentary time and cardio-metabolic risk factors in working adults using objective and subjective measures: a cross-sectional analysis. BMC Public Health. 2014 Dec 19;14(1):1307.

11. Lemes IR, Sui X, Fernandes RA, Blair SN, Turi-Lynch BC, Codogno JS, et al. Association of sedentary behavior and metabolic syndrome. Public Health. 2019 Feb 1;167:96–102.

12. Patterson R, McNamara E, Tainio M, de Sá TH, Smith AD, Sharp SJ, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2diabetes: a systematic review and dose response meta-analysis. Eur J Epidemiol. 2018;33(9):811–29.

13. Ekelund U, Tarp J, Steene-Johannessen J, Hansen BH, Jefferis B, Fagerland MW, et al. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. BMJ. 2019 Aug 21;366:l4570.
14. van der Berg JD, Stehouwer CDA, Bosma H, van der Velde JHPM, Willems PJB, SavelbergHHCM, et al. Associations of total amount and patterns of sedentary behaviour with type 2 diabetes and the metabolic syndrome: The Maastricht Study. Diabetologia. 2016 Apr 1;59(4):709–18.
15. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF DiabetesAtlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022 Jan 1;183:109119.
16. Prince SA, Reed JL, McFetridge C, Tremblay MS, Reid RD. Correlates of sedentarybehaviour in adults: a systematic review. Obes Rev. 2017;18(8):915–35.
17. O'Donoghue G, Perchoux C, Mensah K, Lakerveld J, van der Ploeg H, Bernaards C, et al. Asystematic review of correlates of sedentary behaviour in adults aged 18-65 years: A socio- ecological approach. BMC Public Health. 2016 Feb 17;16.
18. Rhodes RE, Mark RS, Temmel CP. Adult sedentary behavior: a systematic review. Am JPrev Med. 2012 Mar;42(3):e3-28.
19. Koyanagi A, Stubbs B, Vancampfort D. Correlates of sedentary behavior in the generalpopulation: A cross-sectional study using nationally representative data from six low- and middle-income countries. PloS One. 2018;13(8):e0202222.
20. Prioreschi A, Brage S, Westgate K, Norris SA, Micklesfield LK. Cardiorespiratory fitnesslevels and associations with physical activity and body composition in young South Africanadults from Soweto. BMC Public Health. 2017 Apr 5;17(1):301.
21. Pengpid S, Peltzer K. High Sedentary Behavior Is Associated with Depression amongRural South Africans. Int J Environ Res Public Health. 2019 Jan;16(8):1413.
22. Pengpid S, Peltzer K. Sedentary Behaviour and 12 Sleep Problem Indicators amongMiddle-Aged and Elderly Adults in South Africa. Int J Environ Res Public Health. 2019 Jan;16(8):1422.
23. Hamer M, Bruwer EJ, de Ridder JH, Swanepoel M, Kengne AP, Cockeran M, et al. Theassociation between seven-day objectively measured habitual physical activity and 24 h ambulatory blood pressure: the SABPA study. J Hum Hypertens. 2017 Jun;31(6):409–14.
24. Oyeyemi AL, Kolo SM, Rufai AA, Oyeyemi AY, Omotara BA, Sallis JF. Associations of Neighborhood Walkability with Sedentary Time in Nigerian Older Adults. Int J Environ ResPublic Health. 2019 Jun;16(11):1879.
25. Kirunda BE, Wamani H, Fadnes LT, Van den Broeck J, Tylleskär T. Objectively AssessedPhysical Activity and Associated Factors Among Adults in Peri-Urban and Rural Eastern Uganda: A Population-based Study. J Phys Act Health. 2016 Nov;13(11):1243–54.
26. Vancampfort D, Stubbs B, Sallis JF, Nabanoba J, Basangwa D, Oyeyemi AL, et al. Associations of the built environment with physical activity and sedentary time in Ugandan outpatients with mental health problems. J Phys Act Health. 2019;16:8–8.
27. Musaiger AO, Al-Khalifa F, Al-Mannai M. Obesity, unhealthy dietary habits and sedentary behaviors among university students in Sudan: growing risks for chronic diseases in a poor country. Environ Health Prev Med. 2016 Jul;21(4):224–30.

28. Capingana DP, Magalhães P, Silva AB, Gonçalves MA, Baldo MP, Rodrigues SL, et al. Prevalence of cardiovascular risk factors and socioeconomic level among public-sector workers in Angola. BMC Public Health. 2013 Aug 7;13(1):732.
29. Atkinson K, Lowe S, Moore S. Human development, occupational structure and physicalinactivity among 47 low and middle income countries. Prev Med Rep. 2016 Jun 1;3:40–5.
30. Hill J, Lavigne Delville C, Auorousseau AM, Jonathan D, Peer N, Oldenburg B, et al. Development of a Tool to Increase Physical Activity among People at Risk for Diabetes in Low-Resourced Communities in Cape Town. Int J Environ Res Public Health. 2020 Jan;17(3):865.
31. Mayige M. Derivation and Validation of a Simple Risk Score for Undiagnosed Diabetesfor Tanzania and Other African Populations. :248.
32. Peer N, Steyn K, Lombard C, Lambert EV, Vythilingum B, Levitt NS. Rising Diabetes Prevalence among Urban-Dwelling Black South Africans. PLOS ONE. 2012 Sep 4;7(9):e43336.
33. Statistics South Africa. Quarterly Labour Force Survey, Quarter 4: 2020, Statistical Release P0211; Stats SA: Pretoria, South Africa, 2021. Available online: http://www.statssa.gov.za/publications/P0211/P02114thQuarter2020.pdf (accessed on 22 July 2023).
34. Parker DR, Evangelou E, Eaton CB. Intraclass correlation coefficients for cluster randomized trials in primary care: The cholesterol education and research trial (CEART). Contemp Clin Trials. 2005 Apr 1;26(2):260–7.
35. Peer N, Steyn K, Lombard C, Lambert EV, Vythilingum B, Levitt NS. Rising Diabetes Prevalence among Urban-Dwelling Black South Africans. PLOS ONE. 2012 Sep 4;7(9):e43336.
36. Erasmus RT, Soita DJ, Hassan MS, Blanco-Blanco E, Vergotine Z, Kengne AP, et al. High prevalence of diabetes mellitus and metabolic syndrome in a South African coloured population: Baseline data of a study in Bellville, Cape Town. S Afr Med J. 2012;102(11):841–4.
37. Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome—a new world-wide definition. AConsensus Statement from the International Diabetes Federation. Diabet Med. 2006;23(5):469–80.
38. WHO_NCD_NCS_99.2.pdf [Internet]. [cited 2023 Feb 11]. Available from: https://apps.who.int/iris/bitstream/handle/10665/66040/WHO_NCD_NCS_99.2.pdf?sequence=1&isAllowed=y
39. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972 Jun;18(6):499–502.
40. Riley L, Guthold R, Cowan M, Savin S, Bhatti L, Armstrong T, et al. The World Health Organization STEPwise Approach to Noncommunicable Disease Risk-Factor Surveillance: Methods, Challenges, and Opportunities. Am J Public Health. 2016 Jan;106(1):74–8.

41. Prince SA, Cardilli L, Reed JL, Saunders TJ, Kite C, Douillette K, et al. A comparison of self-reported and device measured sedentary behaviour in adults: a systematic review and meta-analysis. Int J Behav Nutr Phys Act. 2020 Mar 4;17(1):31.
42. Booth ML, Bauman A, Owen N, Gore CJ. Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. Prev Med. 1997;26(1):131–7.

43. Bromberger JT, Matthews KA. A longitudinal study of the effects of pessimism, traitanxiety, and life stress on depressive symptoms in middle-aged women. Psychol Aging. 1996;11(2):207.

44. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalizedanxiety disorder: the GAD-7. Arch Intern Med. 2006;166(10):1092–7.

45. Poongothai S, Pradeepa R, Ganesan A, Mohan V. Reliability and validity of a modified PHQ-9 item inventory (PHQ-12) as a screening instrument for assessing depression in Asian Indians (CURES-65). J Assoc Physicians India. 2009;57(2):1–6.

46. Berkman LF, Blumenthal J, Burg M, Carney RM, Catellier D, Cowan MJ, et al. Effects oftreating depression and low perceived social support on clinical events after myocardial infarction: the Enhancing Recovery in Coronary Heart Disease Patients (ENRICHD) Randomized Trial. J Am Med Assoc. 2003;289(23):3106–16.

47. Oyeyemi AL, Kolo SM, Rufai AA, Oyeyemi AY, Omotara BA, Sallis JF. Associations of Neighborhood Walkability with Sedentary Time in Nigerian Older Adults. Int J Environ ResPublic Health. 2019 Jun;16(11):1879.

Part B: Manuscript

Correlates of sedentary behaviour among individuals at risk of developing type 2 diabetes mellitus in a low resource setting

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Abstract

Background: There is evidence regarding the adverse effects of prolonged sedentary behaviour (SB) on health outcomes, including the association with non-communicable diseases such as type 2 diabetesmellitus (T2DM). However, there is a scarcity of information regarding the correlates of SB among individuals at risk of developing T2DM in low-income settings such as in South Africa (SA). Therefore, we aimed to identify the prevalence and correlates of SB among adults at riskof developing T2DM in low-income communities in Cape Town, SA. **Methods:** Secondary analysis of cross-sectional data from the South African Diabetes Prevention Programme (SADPP) was conducted for this study. The study population consisted of 698 participants from 16 lower socio-economic communities in Cape Town, recruited between August 2017 and March 2018. Participants classified at high-risk of T2DM completed questionnaires on socio-demographic, behaviouraland psychological factors, neighbourhood living conditions and medical history. Self-reported SB was measured using the Global Physical Activity Questionnaire and a separate questionnaire that recorded minutesof screen time (ST) during a typical working and non-working day. Blood samples were collected for the determination of fasting glucose, glycated haemoglobin, and lipids**.** A Kruskal-Wallis or one-way ANOVA was conducted depending on the distribution of the numerical variable. A chi-squared or Fisher's exact test was conducted depending on the expected frequencies of the cells. Robust regression was used to investigate the association between the exposure and outcome variable. Statistical significance was set at $p<0.05$. **Results:** Among the 698 participants, the median time (minutes/day) spent in SB and in ST was 180.0 and 137.1 minutes/day, respectively. When grouped by SB or ST, most of the participants (66.0% and 77.9%) were classified as having low levels (<4h/day) of SB and ST, respectively. After adjusting for age and gender, SB was associated with type of housing, lower safety, and walking infrastructure scores, excellent self-reported sleep quality and having at least one barrier to physical activity (PA). **Conclusion:** SB was correlated to factors related to socioeconomic status (SES), as well as barriers to PA and self-reported sleep quality. As such interventions to decrease SB should focus on environmental factors.

Keywords: Sedentary behaviour, type 2 diabetes mellitus, correlates, at-risk, low-resourced

communities.

1. Introduction

The prevalence of type 2 diabetes mellitus (T2DM) is on the rise globally (1). Currently, sub-Saharan Africa (SSA) contributes the smallest proportion of people with T2DM globally yet has the highest projected rate of increase over the next 25 years (2). Within SSA, South Africa (SA) has the largest burden of T2DM (2). Indeed, according to the International Diabetes Federation (IDF), 12.7% of SA adults had diabetes in 2019, which is a 137% increase from the 2017 estimateof 5.4% (2). Diabetes is also the second leading cause of mortality in the general SA population and the leading cause of death among women (2).

Due to widespread urbanisation, rapid technological advancements, and changes to dietary patterns and transport systems, experts have noted a behavioural shift from more active lifestyles to sedentary lifestyles. This decrease in physical activity (PA) and resultant increase in sedentary behaviour (SB) is referred to as the "physical activity transition" (3). This PA transitionis evident in SSA, which is currently undergoing a shift in habitual-, occupational- and transport-related high energy expenditure PA (e.g., active transport and manual labour) to low energy expenditure activities or SB (e.g., motorized transport or desk work) (3, 4). SB is defined as behaviours that involve sitting and/or reclining positions and low levels of energy expenditure (≤1.5 metabolic equivalents [METS]) during waking hours (5). SB generally involves "sitting time" and, similar to PA, there are different domains and patterns in which these can occur i.e.,leisure time SB (e.g., watching television), transport SB (e.g., driving in your car or taking public transport), or occupational SB (e.g. sitting behind a desk at work) (6). The shift in pattern from PA to a more sedentary lifestyle in combination with changes in dietary patterns may beimportant contributors to the increasing burden of T2DM seen in SSA (7).

It is important to note that sitting is a natural behaviour, however, the problem arises when individuals engage in extended periods (>8h/day) of uninterrupted sitting (6); a behaviour shown

to have adverse effects on cardio-metabolic health and mortality (6). There is a plethoraof information regarding the adverse effects of SB on health outcomes. SB (measured subjectively and/or objectively) was found to be positively associated with abnormal glucose metabolism and metabolic syndrome (8, 9). Furthermore, a detrimental, dose-response relationship was observed between SB and fasting insulin, waist circumference (WC), systolic blood pressure (SBP), fasting plasma glucose (FPG), triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) (9). All-cause mortality risk was also shown to increase if adults accumulated more than six to eight hours of sedentary time per day(10, 11).

Currently there is a scarcity of information regarding the correlates of SB among individuals at risk of developing T2DM in SA. Most studies that examined factors associated with SB have generally been conducted in adults from high-income countries (HIC) (12). According to these studies, individual-level correlates associated with SB include older age, female gender, lower education, full-time employment status, a higher body mass index (BMI), a higher income or socio-economic status (SES), smoking and the presence of depressive symptoms (12, 13 14). Additionally, these studies show that environmental factors associated with SB include lack of proximity of green space, lack of neighbourhood walkability, an unsafe environment and bad weather conditions (12, 13, 14, 15). In addition to the above-mentioned individual correlates, a greater number of chronic conditions, poor self-reported health, higher disability levels and worse health status in terms of pain/discomfort, affect (i.e., Feelings of sadness, depression, worry and/or anxiety), sleep disturbances, low energy levels, and cognition were also significantly associated with high SB (15). Environmental factors such as residing in an urban/peri-urban area, a further proximity to destinations, less access to services, poor traffic safety and poor safety from crime were correlated with higher SB (16).

Previous studies investigating the correlates of SB did not include participants at high-risk of developing T2DM. In addition, there is also a difference in occupational, social, and cultural

factors, methods of transportation and environmental factors among adults in low-resource settings compared to studies conducted in HIC (17). Given the negative effect that SB has on NCDs such as T2DM, it is important to understand the correlates of SB, as this data can inform the design of interventions aimed at minimizing SB in this low-resource setting and ultimately reduce cases of T2DM. Accordingly, the aims of this study were to determine the prevalence of SB and identify the variables associated with SB among adults at risk of developing T2DM in a low-resource setting in SA.

2. Methodology:

2.1 Study design, setting and participant selection:

This cross-sectional study is a secondary analysis of the South African Diabetes Prevention Programme (SADPP), which is a structured lifestyle intervention programme aimed at developing and evaluating a culturally relevant model for T2DM prevention in SA (18). The SA-DPP uses an open-labelled cluster randomized control design, conducted across 16 resource- poor communities in Cape Town, SA. These 16 communities comprised of mainly black African and mixed-ancestry communities in the Western Cape. They consist of formal residential areas as well as informal settlements and/or townships and were selected based their sociodemographic characteristics (low resource area) and high diabetes risk (19). The average household monthly income for residents in these communities is ~3500 ZAR (230.94 USD). In addition, high unemployment rates are reported (21.6%), with Black African (31.0%), followed by the mixed ancestry population (23.5%) being the most affected (21). The data were collected between August 2017 and March2018. The study population included participants aged between 25 and 65 years, who were at high-risk of developing T2DM based on the African Diabetes Risk Score (ADRS). The ADRS is a screening tool comprising non-laboratory-based variables such as age, WC, and blood pressure (BP) (21, 22). Participants were excluded if they were younger than 25 or older than 65 years, bedridden, pregnant, breastfeeding, in receipt of cancer

or tuberculosis treatment within the past three months or had been diagnosed with diabetes. Participants with complete SB data were included in our study.

The parent study was approved by the Research Ethics Committee of the South African Medical Research Council, Cape Town (EC018-7/2015) and was carried out according to the ethical guidelines and principles of the Declaration of Helsinki, 2013. Informed consent was obtained for the participants during the parent study on two occasions: firstly, at community-based screening and then again at the clinic for participants who were identified at high-risk of developing T2DM. Ethical approval for this secondary analysis was obtained by the University ofCape Town Human Research Ethics Committee (UCT HREC ref 063/2022).

2.2 Research procedures

The participant screening procedure followed a two-stage approach. For the community-based risk screening, the ADRS was used to identify adults at high-risk for T2DM. Trained fieldworkersadministered a questionnaire, which included general information such as age, gender, self- defined ethnicity, and measured anthropometry and BP. Those identified as at high-risk of T2DM were invited to complete a clinic-based risk status assessment, which included standard anthropometric, BP measures, an oral glucose tolerance test (OGTT) and various questionnaires.

2.2.1 Anthropometry and blood pressure:

The following measurements were taken by trained fieldworkers. Weight was measured to the nearest 0.1 kg using a digital scale (SECA, Hamburg, Germany) with participants in light-weight clothing and no shoes. Height was measured to the nearest 0.1 cm using a stadiometer (SECA, Hamburg, Germany). BMI was calculated as weight (in kg) divided by the height (in meters squared). BMI was categorized as underweight ($\leq$18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese ($\geq$30 kg/m^2), according to World Health Organization

(WHO) criteria (23). WC was measured mid-way between the upper border of the hip bone and the lower border of the lowest rib (23).

After at least five-minutes of seated rest, three BP measurements were taken at two-minute intervals using an Omron BP monitor (model M6, Omron Healthcare, Bannockburn, IL, USA). The average of the last two BP measurements was used in the analysis. Participants with elevated BP levels (SBP ≥ 140 and/or DBP ≥ 90 mmHg) and who were on anti-hypertensivemedication were classified as having hypertension.

2.2.2 Biochemical analysis:

After a 10-hour overnight fast, blood samples were drawn for the determination of glycosylated haemoglobin (hba1c), plasma glucose, and serum lipid profile (total cholesterol [TC], HDL-C, Low-Density Lipoprotein [LDL-C], and TG). A standard OGTT was completed during which 75 g ofanhydrous glucose in 250 ml of water was ingested, and a blood sample taken 120 minutes later (24). Participants with a fasting plasma glucose level ≥ 7.0 mmol/l and/or 2h glucose ≥ 11.1 mmol/l were considered as having screen-detected diabetes and were included in the analyses. All biochemical analysis was conducted by an ISO-accredited pathology laboratory (Pathcare Laboratories, SA). Plasma glucose concentrations were determined using the enzymatic hexokinase method (Cobas 6000, Roche Diagnostics). Hba1c was measured using high-performance liquid chromatography (Biorad Variant Turbo, biorad, SA). Serum lipids were measured using a Roche Modular auto analyser and enzymatic colorimetric assays. LDL-C wascalculated using the Friedewald formula (24).

***2.3** Questionnaires*

2.3.1 Sociodemographic measures:

Questionnaires were used to capture sociodemographic information such as age, sex, level of education, occupation, household income and marital status. Level of education was categorized into five categories i.e., grade 1-7 or less, grade 8-10, less than grade 12 plus furthereducation

training (FET) certificate/diploma, grade 12 and tertiary diploma/degree. Occupation was categorized as employed (employed, self-employed, part-time employed), unemployed (unemployed, student, homemaker) and pensioner/grant holder (pensioner, disability grant, other grants). Household income was categorized as low income (0-3200 ZAR [0-174 USD]), middle income (3201-6400 ZAR [175-349 USD]) and high income (>6400 ZAR [≥350 USD]). Marital status was categorized as not cohabitating(single, widowed, separated) or cohabiting (married or living as married).

2.3.2 Lifestyle behaviours:

Sedentary behaviour measures, tobacco and alcohol use, sleep time and sleep quality:

SB was captured using the Global Physical Activity Questionnaire (GPAQ) and reflects the amount of time (minutes per day) an individual spent sitting or reclining on a usual day (excluding time sleeping). This may include time sitting at a desk, visiting friends, reading, or sitting down to watch television and could be during working hours and/or during leisure time. SB was categorized into low SB (<240 min/day), moderate SB (240– 479 min/day) and high SB (≥480 min/day) based on the findings of a meta-analysis (11). Screen time was assessed with a separate question and was used as an additional estimate of SB. Participants were asked "How much time do you spend in front of a screen (watching television/DVDs, on the computer) during a typical working day (at home and at work) and non-working day (at home only)?", respectively.

Tobacco and alcohol use were measured using the WHO stepwise approach to chronic disease risk factor surveillance (WHO STEPS) instrument (25). Tobacco use was assessed with the question, "Do you currently smoke any tobacco products, such as cigarettes, cigars or pipes?" (yes or no). Alcohol use was assessed with the question, "Have you ever consumed a drink that contains alcohol such as beer, wine, spirits or sorghum beer?" (yes or no).

Sleep time and sleep quality (disrupted or not disrupted) were measured using the WHO STEPS instrument (25). Sleep time was assessed with the question, “How many hours do you usually sleep a night?” And sleep quality was assessed with the question, “do you usually have disrupted sleep?”. Participants who answered yes to the sleep quality question were classifiedas having poor sleep quality.

PA was characterized using the GPAQ (25). Participants were classified as physically active if the WHO PA guidelines of 150 minutes of moderate intensity aerobic PA per week or 75 minutes ofvigorous intensity aerobic PA per week, or a combination of MVPA per week were met. Participants not meeting the WHO PA guidelines were classified as being insufficiently active (25).

2.3.3 Psychological measures:

Chronic stress was assessed in terms of long term (>12 months) events including, personal serious ongoing health problems or serious ongoing health problems in a close relative or friend, ongoing difficulties related to employment, ongoing financial strain, or ongoing difficulties in a close relationship (26). Events were assessed on a scale from not very stressful(coded 1) to very stressful (coded 3) (26). Only events identified by the participants as very stressful were considered as a stressful event (26).

Anxiety symptoms were assessed using a self-reported 7-item general anxiety disorder (GAD-7) questionnaire (27). Participants were asked to respond to statements about how often they have experienced anxiety related to certain events. Items were scored on a 4-point scale ranging from not at all (coded 0) to nearly every day (coded 3). Cut points of 5, 10, and 15 wereinterpreted as mild, moderate, and severe levels of anxiety on the GAD-7 (27).

The presence and severity of depression was assessed by the self-report patient health questionnaire (PHQ-9) (28). For this questionnaire, respondents rated the extent to which a symptom has been present over the past 2 weeks from not at all (coded 0) to nearly every day

(coded 3). The PHQ-9 score was divided into the following categories: minimal (0-4), mild (5-9), moderate (10-19) and severe (20-27) (27, 28).

Support networks were assessed using an enhancing recovery in coronary heart disease (ENRICHD) social support inventory (ESSI) 5-item scale to assess the individuals' perceived levelof social support (30). A total score of less than 18 is required to classify an individual as havinglow perceived social support (LPSS) (29, 30).

Barriers to PA were assessed using a 11-item scale (26). Participants identified each item as either not a barrier (coded 1), somewhat a barrier (coded 2) or very much a barrier (coded 3). Participants who identified an item as being very much a barrier were considered to have a barrier to PA.

2.3.4 Medical history:

Medical history included self-reported family history of T2DM. Participants answered the question "has your biological mother, father, sister and/or brother ever been diagnosed with diabetes?". If participants answered yes to any one of the family members, they were considered as having a positive family history of diabetes.

2.3.5 Neighbourhood indicators:

Neighbourhood indicators were assessed using the Neighbourhood Environmental Walkability Scale for Africa (NEWS-A) (31). NEWS-A gauged perceived neighbourhood environmental attributes in seven domains: stores and facilities, access to services and places, roads and walking paths, places for walking/cycling/playing, surroundings, safety from crime and traffic and personal safety. All domains were rated by using Likert-type response options ranging from1 (strongly disagree) to 4 (strongly agree). Responses for the domains of the NEWS-A were computed as the mean of the items of each domain, with responses coded such that higher values indicate higher walkability of the neighbourhood (31).

2.4 Statistical analysis

As this is a secondary analysis, the sample size (n = 697) was based on the parent study (18). All data were analyzed using Rstudio version 1.4. The Shapiro–Wilk test was conducted to assess normality including visual checking of histogram plots. Continuous variables were summarized using mean ± standard deviation (SD) or median (25^{th} – 75^{th} percentile) based on data distribution. Categorical variables were summarized using count and proportions (column proportions with reference to groups of SB). The sociodemographic, behavioural, psychological,and environmental variables were compared across groups of low, moderate, and high SB. Fornumerical variables, a Kruskal-Wallis or one-way ANOVA was conducted depending on the distribution of the numerical variable. For categorical variables, a chi-squared or Fisher's exacttest was conducted depending on the expected frequencies of the cells. As a sensitivity analysis, we used robust regression to explore the association between SB as a continuous variable and each of the sociodemographic, behavioural, psychological, and environmental variables, adjusted for age and sex. Subsequently, all significant variables were included in amultivariable model to explore the independent associations with SB (table 4). Statistical significance was set at $p<0.05$.

3. Results

3.1 Characteristics of participants

Of the participants screened in the community, 702 participants were deemed at high risk of T2DM based on the ADRS. Of these participants, four were excluded due to missing outcome data, with 698 participants included in the study. The sociodemographic, biochemical, clinical and lifestyle factors in the total sample and across groups of SB are described in Table 1. Among the 698 participants included in this secondary analysis, the median time (minutes/day) spent in SB and in front of a screen (screen time) was 180.0 and 137.1 minutes/day, respectively. The

median age of the overall group was 52 years, with the majority being women (81.0%). Most (76.8%) participants were living with obesity, with a group median BMI of 35.6 kg/m^2, while 34.1% of the participants had hypertension. Most of the participants (81.9%) reported meeting PA guidelines (according to WHO), and 53.9% and 25.3% reported consuming alcohol and smoking, respectively.

3.2 Differences in sociodemographic, biochemical, clinical and lifestyle factors acrosssedentary behaviour groups

When grouped by SB or ST, most of the participants (66.0% and 77.9%) were classified as having low levels (<4h/day of SB and ST, respectively). Apart from the housing type, there were no differences among the sociodemographic variables across SB groups. A greater proportion of participants in the high SB group lived in built formal housing/privately owned houses and were less likely to live in a council house or an informal shack/shelter/hostel. While there were no differences in anthropometry measures between SB groups, a smaller proportion of participants in the high SB group were living with obesity compared to participants in the low and moderate SB groups. There were no differences in any of the lifestyle and cardiometabolic risk factors between SB groups, apart from sleep quality and leisure-time MVPA. A significantly greater proportion of participants who engaged in high SB reported to have fair sleep quality compared to those who engaged in moderate SB. Additionally, a greater proportion of participants who engaged in moderate SB, reported to have excellent sleep quality, compared to those who engaged in high SB. Although the median leisure-time MVPA was zero, participants in the low SB group were more likely to participate in MVPA compared to participants in the high SB group.

3.3 Differences in psychological factors across sedentary behaviour groups

Psychological variables for the overall sample and stratified by SB groups are shown in Table 2. Most participants in the high SB group perceived their health status as “fair” (47.6%), compared

to the majority of those in the low and moderate SB groups who reported a "good" health status (41.7% and 42.5%, respectively). A greater proportion of participants in the moderate SB group had at least one perceived barrier to PA (63.2%) compared to those in the low and high SB groups (52.4% and 47.6%, respectively). Participants in the low SB group reported higher life satisfaction scores, compared to participants in the moderate and high SB groups (7, 6 and 6 for low, moderate, and high SB groups, respectively). Levels of depression, anxiety, and chronic stress were not different across SB groups.

3.4 Differences in the perceived neighbourhood environmental attributes across sedentarybehaviour groups

Perceived neighbourhood environmental attributes stratified across SB groups are presented in Table 3. Participants in the low SB group reported that they live further from destinations in their neighbourhood, had better and safer infrastructure for walking and they had better safetyin relation to crime, compared to participants in the moderate and high SB groups. There were no differences across SB groups in access to services and places, street connectivity, aesthetics, and traffic safety domains.

3.5 Association between SB and individual exposure variables

In the sensitivity analysis we showed that the differences in variables between the SB groups persisted when using multivariable analyses. These variables included: type of housing, self-reported sleep quality, PA barrier, walking infrastructure and safety (NEWS-E) and life satisfaction score (supplementary table 1). These variables were then entered into a multivariable regression model to confirm the independent associations with SB (table 4). Typeof housing, sleep quality, having at least one barrier to PA and the walking infrastructure and safety domain of the NEWS-E scale remained significantly associated with SB.

4. Discussion

In this low-resource setting, adults at high risk of developing T2DM self-reported low levels of high SB (≥8h/day), with only 9.0% of participants reportedly sitting for more than 8 hours per day. The main drivers of SB in this cohort related to socioeconomic status, characterized by the type of housing, lower safety, and walking infrastructure, as well as having a barrier to PA and excellent self-reported sleep quality.

Prevalence of sedentary behaviour

In our study, 9.0% of the participants engaged in high SB (≥8h/day), with a median period of 3 hours per day. The levels of high self-reported SB in our study were less than the 18.5% self-reported in high-income countries (HIC's) like those in Europe (32). Even though the participants from these HICs were similar in age, they were not at risk of T2DM and they resided in a higher SES communities. This might be due to the greater proportion of SB within the domains of work and travel in HIC's, which contrasts with the general setting in low-to-middle income countries (LMICs), where higher levels of PA occur within the domains ofwork and travel (37). Similarly, the levels of high self-reported SB were less than a study conducted among a nationally representative sample of South Africans, who were younger than participants in our study and were sampled from the general population, thus not at risk of T2DM (33). The larger sample size, differences in age as well as the two-item questionaries used to measure SB may explain the differences.

Socioeconomic correlates of sedentary behaviour

Socioeconomic status-related factors were the major correlates of SB in our cohort. We found that participants residing in privately owned houses had lower SB compared to participants who resided in council houses or shacks. To our knowledge, there were no studies conducted in LMICs exploring the association between type of residence and SB. Despite vast differences in SES, our study finding is comparable to studies conducted among older adults living in sub-urban cities in HIC's such as Denmark, Iceland as well as in Germany. These studies' findings

were inconsistent, with two studies finding that living in an apartment was associated with more self-reported SB compared to living in a free-standing house (34) or villas (35), while the study conducted in Germany showed no significant association between type of residence and self-reported SB (36). This may either suggest that participants in privately owned houses may have greater space to engage in PA and reduce SB, or it may rather reflect lower SES and access to facilities such as gyms and parks. Indeed, we demonstrated (upon posteriori analyses) that participants residing in privately owned houses were more likely to live in neighbourhoods with better access to services and places with better aesthetics and greater traffic safety and safety from crime than those living in informal settlements (as shown in supplementary Table 2). These environmental attributes have been shown to be negatively associated with self-reported SB in studies conducted in both HIC and LMICs (13, 16). Furthermore, the association remains when using objective measures of SB (37, 38).

Environmental correlates of sedentary behaviour

Although all participants in our study came from low-resourced communities in Cape Town, upon posteriori analysis, we found that fewer participants residing in privately owned houses also self-reported having a perceived barrier to PA (supplementary Table 3), compared to those residing in shacks. Indeed, we also showed that having a perceived barrier to PA was associated with higher levels of SB. Specifically, environmental determinants, accessibility to facilities to exercise and a lack of skills to exercise were all related to more time spent in SB (supplementary Tables 4, 5 and 6, respectively). Environmental determinants such as crime and traffic safety could lead to participants staying indoors and as a result, engaging in more SB rather than being physically active outdoors. In addition, a lack of facilities such as gyms or parks to exercise or a lack of knowledge on how or what exercises to do could be associated with lower PA and higher levels of SB. Consistent to this, we also found that a higher score in the walking infrastructure and safety domain of the NEWS-A was associated with lower levels of SB. Higher scores

indicate greater walkability of the neighbourhood in relation to walking infrastructure such as pavements, footpaths for walking or paths to cycle, zebra crossings, traffic lights/signals/robots, and functioning streetlights in the neighbourhood. This is important in this population as most of the MVPA is accumulated through transport- andoccupational PA, as shown previously in other low resourced settings (39, 40). A similar finding was seen in a study conducted among community-dwelling older adults (60 years and older) inNigeria, however, this relationship only existed among men and during the weekdays only (16). While a study conducted among among 5712 adults from higher and lower socioeconomic status neighbourhoods in 10 countries observed a similar association between walking infrastructure and objectively measured SB (41). These studies support the importance of improving walking infrastructure and safety as a means of decreasing SB. Based on these findings, interventions to increase PA and reduce SB should focus on addressing the environmental determinants such as crime in the neighbourhood. Furthermore, interventions should educate participants on PA as well as improve walking infrastructure and accessibility of gyms or health facilities in the neighbourhood. Participants who self-reported poor and good sleep quality had lower SB compared to participants who self-reported excellent sleep quality. This is in contrast to previous studies which showed that poorer sleep quality, measured objectively, was associated with increased objectively measured SB (42)(43). The reasons for our contradictory findings are not known andwarrant further investigation.

4.1 Strengths and limitations

A strength of our study is the comprehensive assessment of factors associated with SB, including environmental-related correlates of SB, which have been lacking in studies conductedin Africa. Furthermore, we have investigated unique psychological- and SES-related variables and their relationship with SB. However, this only accounted for 7.4% of the variation in SB. Perhaps other factors not captured in the study could account for more variability in SB, and/orthis could

be related to precision of measure of SB. Self-reported measures are inexpensive, easy to administer and do not alter habitual behaviour. However, self-report measures of SB underestimate sedentary time and this tends to increase with the amount of time participants spend sitting (44, 45). Further, single-item measures of SB have been shown to be less reliable compared to other measures of SB (45, 46). Additionally, the self-report nature of the measurement of SB is prone to recall and social desirability bias, which could lead to invalid results. Further we did not account for multiple testing. However, we performed a sensitivity analysis and showed that variables that were different between groups were also associated with SB in multivariable models, highlighting the robustness of the associations. A further limitation of our study was the cross-sectional study design, which limits the identification of any causal relationships and is subject to reverse causality. Finally, the SB variable did not differentiate between domains of SB (i.e. Occupational vs transport vs leisure SB) or patterns ofSB (short-bout versus long-bout SB). Future research should be encouraged to use prospective designs including objective measures of SB and characterize domain- and pattern-specific SB and their correlates.

4.2 Conclusion

In our study including adult participants at high-risk of developing T2DM and with a high prevalence of obesity, we showed that the self-reported prevalence of SB was low and identified type of housing, lower safety and walking infrastructure, having a barrier to PA and self-reported sleep quality as correlates of SB. Based on these findings interventions aimed at reducing SB should focus on barriers to PA – specifically environmental barriers, knowledge and skills.

5. List of abbreviations

(GAD-7) 7-item general anxiety disorder questionnaire
(ADRS) African Diabetes Risk Score
(BP) Blood pressure
(BMI) Body mass
index
(ENRICHD) Enhancing recovery in coronary heart
disease(ESSI) ENRICHD social support inventory
(FET) Further education training
(GPAQ) Global Physical Activity Questionnaire
(hba1c) Glycosylated hemoglobin
(HDL-C) High-density lipoprotein cholesterol
(HIC) High-income countries
(IDF) International Diabetes Federation
(LPSS) Low perceived social support
(LDL-C) Low-density lipoprotein cholesterol
(MVPA) Moderate-to-vigorous physical activity
(NEWS-A) Neighbourhood Environmental Walkability Scale for Africa
(NCDs) Non-communicable diseases
(OGTT) Oral glucose tolerance test
(PHQ-9) Patient health questionnaire
(PA) Physical activity
(SB) Sedentary behaviour
(SES) Socioeconomic
status
(SA) South Africa
(SA-DPP) South African Diabetes Prevention Program
(SSA) Sub-Saharan Africa
(SBP) Systolic blood pressure
(DBP) Diastolic blood
pressure
(TC) Total cholesterol
(TG) Triglycerides
(T2DM) Type 2 diabetes
mellitus
(WC) Waist circumference
(WHO STEPS) World Health Organization stepwise approach to chronic disease risk factor surveillance
(WHO) World Health
Organization
(FPG) Fasting Plasma Glucose
(METS) Metabolic equivalents

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8. Declarations

8.1 Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Health Research Ethics Committee of The University of Cape Town [UCT HRECref 063/2022]. The SA-DPP study was approved by the SAMRC Human Research Ethics Committee [EC018-7/2015].

8.2 Conflicts of Interest:

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

8.3 Author Contributions:

Conceptualization of the SA-DPP study, J.H, JG; Conceptualization of the cross-sectional study, C.A.CG, JH, JG; formal analysis, C.A.; writing—original draft preparation, C.A.; writing—review and editing, J.H.,C.G., H.M., J.G., J.H; supervision, C.G., H.M., J.H., J.G.; SA-DPP project administration, J.H. All authors have read and agreed to the published version of the manuscript.

9. References

1. van der Berg JD, Stehouwer CDA, Bosma H, van der Velde JHPM, Willems PJB, Savelberg HHCM, et al. Associations of total amount and patterns of sedentary behaviour with type 2 diabetes and the metabolic syndrome: The Maastricht Study. Diabetologia. 2016 Apr 1;59(4):709–18.
2. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022 Jan 1;183:109119.
3. Katzmarzyk PT, Mason C. The physical activity transition. J Phys Act Health. 2009;6(3):269–80.
4. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord J Int Assoc Study Obes. 2004 Nov;28 Suppl 3:S2-9.
5. Powell C, Herring MP, Dowd KP, Donnelly AE, Carson BP. The cross-sectional associations between objectively measured sedentary time and cardiometabolic health markers in adults – a systematic review with meta-analysis component. Obes Rev. 2018;19(3):381–95.
6. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exerc Sport Sci Rev. 2010 Jul;38(3):105–13.
7. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Vol. 393, The Lancet. 2019. p. 1958–72.
8. Lemes IR, Sui X, Fernandes RA, Blair SN, Turi-Lynch BC, Codogno JS, et al. Association of sedentary behavior and metabolic syndrome. Public Health. 2019 Feb 1;167:96–102.
9. Powell C, Herring MP, Dowd KP, Donnelly AE, Carson BP. The cross-sectional associations between objectively measured sedentary time and cardiometabolic health markers in adults – a systematic review with meta-analysis component. Obesity Reviews. 2018;19(3):381–95.
10. Ekelund U, Tarp J, Steene-Johannessen J, Hansen BH, Jefferis B, Fagerland MW, et al. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. BMJ. 2019 Aug 21;366:l4570.
11. Patterson R, McNamara E, Tainio M, de Sá TH, Smith AD, Sharp SJ, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. Eur J Epidemiol. 2018;33(9):811–29.
12. Prince SA, Reed JL, McFetridge C, Tremblay MS, Reid RD. Correlates of sedentary behaviour in adults: a systematic review. Obes Rev. 2017;18(8):915–35.
13. O'Donoghue G, Perchoux C, Mensah K, Lakerveld J, van der Ploeg H, Bernaards C, et al. A systematic review of correlates of sedentary behaviour in adults aged 18-65 years: A socio-ecological approach. BMC Public Health. 2016 Feb 17;16.
14. Rhodes RE, Mark RS, Temmel CP. Adult sedentary behavior: a systematic review. Am J Prev Med. 2012 Mar;42(3):e3-28.
15. Koyanagi A, Stubbs B, Vancampfort D. Correlates of sedentary behavior in the general population: A cross-sectional study using nationally representative data from six low- and middle-income countries. PloS One. 2018;13(8):e0202222.
16. Oyeyemi AL, Kolo SM, Rufai AA, Oyeyemi AY, Omotara BA, Sallis JF. Associations of Neighborhood Walkability with Sedentary Time in Nigerian Older Adults. Int J Environ Res Public Health. 2019 Jun;16(11):1879.
17. Atkinson K, Lowe S, Moore S. Human development, occupational structure and physical inactivity among 47 low and middle income countries. Prev Med Rep. 2016 Jun 1;3:40–5.

18. Hill J, Lavigne Delville C, Auorousseau AM, Jonathan D, Peer N, Oldenburg B, et al. Development of a Tool to Increase Physical Activity among People at Risk for Diabetes in Low-Resourced Communities in Cape Town. Int J Environ Res Public Health. 2020 Jan;17(3):865.
19. Peer N, Steyn K, Lombard C, Lambert EV, Vythilingum B, Levitt NS. Rising Diabetes Prevalence among Urban-Dwelling Black South Africans. PLOS ONE. 2012 Sep 4;7(9):e43336.
20. Statistics South Africa. Quarterly Labour Force Survey, Quarter 4: 2020, Statistical Release P0211; Stats SA: Pretoria, South Africa, 2021. Available online: http://www.statssa.gov.za/publications/P0211/P02114thQuarter2020.pdf (accessed on 22 July 2023).
21. Mayige M. Derivation and Validation of a Simple Risk Score for Undiagnosed Diabetes for Tanzania and Other African Populations. :248.
22. WHO Consultation on Obesity (1999: Geneva S, Organization WH. Obesity : preventing and managing the global epidemic : report of a WHO consultation [Internet]. World Health Organization; 2000 [cited 2023 Feb 4]. Available from: https://apps.who.int/iris/handle/10665/42330
23. Nishida C, Ko GT, Kumanyika S. Body fat distribution and noncommunicable diseases in populations: overview of the 2008 WHO Expert Consultation on Waist Circumference and Waist–Hip Ratio. Eur J Clin Nutr. 2010 Jan;64(1):2–5.
24. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972 Jun;18(6):499–502.
25. Organization WH. WHO STEPS instrument (core and expanded). WHO STEPwise Approach Noncommunicable Dis Risk Factor Surveill Geneva World Health Organ. 2010;
26. Booth ML, Bauman A, Owen N, Gore CJ. Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. Prev Med. 1997;26(1):131–7.
27. Bromberger JT, Matthews KA. A longitudinal study of the effects of pessimism, trait anxiety, and life stress on depressive symptoms in middle-aged women. Psychol Aging. 1996;11(2):207.
28. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med. 2006;166(10):1092–7.
29. Poongothai S, Pradeepa R, Ganesan A, Mohan V. Reliability and validity of a modified PHQ-9 item inventory (PHQ-12) as a screening instrument for assessing depression in Asian Indians (CURES-65). J Assoc Physicians India. 2009;57(2):1–6.
30. Berkman LF, Blumenthal J, Burg M, Carney RM, Catellier D, Cowan MJ, et al. Effects of treating depression and low perceived social support on clinical events after myocardial infarction: the Enhancing Recovery in Coronary Heart Disease Patients (ENRICHD) Randomized Trial. J Am Med Assoc. 2003;289(23):3106–16.
31. Oyeyemi AL, Kasoma SS, Onywera VO, Assah F, Adedoyin RA, Conway TL, et al. NEWS for Africa: adaptation and reliability of a built environment questionnaire for physical activity in seven African countries. Int J Behav Nutr Phys Act. 2016 Mar 8;13(1):33.
32. Loyen A, Ploeg HP van der, Bauman A, Brug J, Lakerveld J. European Sitting Championship: Prevalence and Correlates of Self-Reported Sitting Time in the 28 European Union Member States. PLOS ONE. 2016 Mar 2;11(3):e0149320.
33. Phaswana -Mafuya Nancy, Peltzer K, Pengpid S. Prevalence and correlates of sedentary behaviour among a national sample of 15-98 years old individuals in South Africa. Afr J Phys Act Health Sci AJPHES. 2018 Sep;24(3):286–98.

34. Saidj M, Jørgensen T, Jacobsen RK, Linneberg A, Aadahl M. The influence of housing characteristics on leisure-time sitting. A prospective cohort study in Danish adults. Prev Med. 2015 Dec 1;81:58–62.
35. van der Berg JD, Bosma H, Caserotti P, Eiriksdottir G, Arnardottir NY, Martin KR, et al. Midlife Determinants Associated with Sedentary Behavior in Old Age. Med Sci Sports Exerc. 2014 Jul;46(7):1359–65.
36. Wallmann-Sperlich B, Bucksch J, Hansen S, Schantz P, Froboese I. Sitting time in Germany: an analysis of socio-demographic and environmental correlates. BMC Public Health. 2013 Mar 6;13(1):196.

1.

37. Arins GCB, Santos CE da S dos, Giehl MWC, Benedetti TRB, Oliveira C de, D'Orsi E, et al. Neighborhood environmental characteristics and sedentary behavior in later life: the EpiFloripa Study. Revista Brasileira de Atividade Física & Saúde. 2018 Aug 14;23:1–7.

1.

38. Owen N, Sugiyama T, Koohsari MJ, De Bourdeaudhuij I, Hadgraft N, Oyeyemi A, et al. Associations of neighborhood environmental attributes with adults' objectively-assessed sedentary time: IPEN adult multi-country study. Preventive Medicine. 2018 Oct 1;115:126–33.

39. Dugas LR, Bovet P, Forrester TE, Lambert EV, Plange-Rhule J, Durazo-Arvizu RA, et al. Comparisons of intensity-duration patterns of physical activity in the US, Jamaica and 3 African countries. BMC Public Health. 2014 Aug 27;14(1):882.
40. Gradidge PJL, Crowther NJ, Chirwa ED, Norris SA, Micklesfield LK. Patterns, levels and correlates of self-reported physical activity in urban black Soweto women. BMC Public Health. 2014 Sep 8;14(1):934.
41. Owen N, Sugiyama T, Koohsari MJ, De Bourdeaudhuij I, Hadgraft N, Oyeyemi A, et al. Associations of neighborhood environmental attributes with adults' objectively-assessed sedentary time: IPEN adult multi-country study. Preventive Medicine. 2018 Oct 1;115:126–33.
42. Creasy SA, Crane TE, Garcia DO, Thomson CA, Kohler LN, Wertheim BC, et al. Higher amounts of sedentary time are associated with short sleep duration and poor sleep quality in postmenopausal women. Sleep. 2019 Jul 8;42(7):zsz093.
43. Park H, Suh B. Association between sleep quality and physical activity according to gender and shift work. J Sleep Res. 2020;29(6):e12924.

44. Chastin SFM, Culhane B, Dall PM. Comparison of self-reported measure of sitting time (IPAQ) with objective measurement (activPAL). Physiol Meas. 2014 Nov;35(11):2319–28.

45. Prince SA, Cardilli L, Reed JL, Saunders TJ, Kite C, Douillette K, et al. A comparison of self-reported and device measured sedentary behaviour in adults: a systematic review and meta-analysis. Int J Behav Nutr Phys Act. 2020 Mar 4;17(1):31.

46. Owen N, Healy GN, Dempsey PC, Salmon J, Timperio A, Clark BK, Goode AD, Koorts H, Ridgers ND, Hadgraft NT, Lambert G. Sedentary behavior and public health: integrating the evidence and identifying potential solutions. Annual review of public health. 2020 Apr 1;41:265-87.

Table 1 – Sociodemographic, biochemical, clinical and lifestyle factors across categories ofsedentary behaviour

		Sedentary behaviour (min/day)			
	Total	**Low (n=460)**	**Moderate (n=174)**	**High (n=63)**	**P-value**
Sedentary behaviour					
Sedentary Behaviour (min/day) (median, IQR)	180.0 (60.0-240.0)	120.0 (60.0-180.0)	300.0 (240.0-327.5)	630.0 (480.0-840.0)	<0.0001
Screen Time (min/day) (median, IQR)	137.1 (77.1-214.3)	120.0 (60.0-180.0)	201.4 (120.0-282.9)	180.0 (94.3-308.6)	<0.0001
Sociodemographics					
Age (years)	52 (45-59)	53 (46 – 59)	52 (45 - 59)	49 (44 - 56)	0.627
Female (n (%))	564 (81.0)	380 (82.8)	139 (79.9)	45 (71.4)	0.088
Education status (n (%))					
Grade 1-7 and less	173 (25.0)	110 (24.2)	47 (27.0)	16 (25.4)	0.079
Grade 8-10 (high school)	310 (44.8)	213 (46.8)	66 (37.9)	31 (49.2)	
Less than grade 12 + FET/certificate/diploma	100 (14.5)	67 (14.7)	29 (16.7)	4 (6.3)	
Grade 12	83 (12.0)	45 (9.9)	29 (16.7)	9 (14.3)	
Tertiary/diploma/degree	26 (3.8)	20 (4.4)	3 (1.7)	3 (4.8)	
Household income (n (%))					
R0-R3200 (0-174USD)	497 (71.7)	325 (71.3)	130 (74.7)	42 (66.7)	0.357
R3201-R6400 (175USD-349USD)	117 (16.9)	75 (16.4)	31 (17.8)	11 (17.5)	
R6401-R51200 (≥350USD)	79 (11.4)	56 (12.3)	13 (7.5)	10 (15.9)	
Employment status (n (%))					
Employed	239 (34.5)	166 (36.4)	50 (28.7)	23 (36.5)	0.373
Unemployed	295 (42.6)	184 (40.4)	84 (48.3)	27 (42.9)	

Pensioner / grant holder	159 (22.9)	106 (23.2)	40 (23.0)	13 (20.6)	
Marital status (n (%))					
Cohabitating	309 (44.4)	208 (45.3)	73 (42.0)	28 (44.4)	0.749
Type of housing (n (%))					
Built formal unit/privately owned	244 (35.4)	175 (38.6)	42 (24.1)	26 (41.9)	0.009
Council/core house	273 (39.6)	171 (37.7)	79 (45.4)	23 (37.1)	
Informal shack/shelter/hostel/other	173 (25.1)	107 (23.6)	53 (30.5)	13 (21.0)	
Anthropometry					
Height (m)	1.59 (1.55-1.65)	1.60 (1.56-1.64)	1.59 (1.55-1.65)	1.61 (1.57-1.67)	0.211
Weight (kg)	91.2 (79.6-103.9)	90.9 (79.3-103.9)	91.6 (82.8-105.2)	90.7 (77.7-100.3)	0.614
BMI (kg/m^2)	35.6 (30.5-40.6)	35.5 (30.6 – 40.6)	36.2 (30.8 – 41.2)	33.9 (29.7-39.1)	0.501
Waist circumference (cm)	103.0 (95.3-111.1)	102.7 (95.1 – 110.9)	104.4 (96.3 – 113.2)	103.4 (94.3-108.4)	0.653
BMI categories (n (%))					
Normal (18.5-24.9 kg/m^2)	29 (4.2)	17 (3.7)	4 (2.3)	8 (12.7)	0.008
Overweight (25.0-29.9kg/m^2)	132 (19.0)	90 (19.6)	33 (19.1)	9 (14.3)	
Obese (≥30 kg/m^2)	534 (76.8)	352 (76.7)	136 (78.6)	46 (73.0)	
Cardiometabolic risk factors					
Hba1c (%)	5.8 (5.6 – 6.1)	5.8 (5.6 – 6.1)	5.9 (5.6 – 6.2)	5.8 (5.5 – 6.0)	0.612

Hba1c (mmol/mol)	40 (38-43)	40 (38-43)	41 (38-44)	40 (37-42)	0.642
Fasting plasma glucose (mmol/l)	5.0 (4.6 – 5.6)	5.0 (4.6 – 5.6)	5.0 (4.6 – 5.5)	5.0 (4.7 – 5.5)	0.934
Two hour glucose (mmol/l)	6.0 (5.0-7.4)	6.0 (5.0 – 7.4)	6.1 (5.0 – 7.6)	5.9 (4.9 – 7.0)	0.278
Systolic blood pressure (mmhg)	124.5 (113.5-137)	125.0 (114.0 – 137.0)	123.5 (113.0 – 139.0)	123.5 (111.2 – 134.0)	0.365
Diastolic blood pressure (mmhg)	83.0 (77.0-91.5)	83.0 (77.0 – 90.9)	84.0 (77.5 - 92.5)	81.5 (77.0 - 89.3)	0.669
Hypertensive (≥140/90 mmhg)(n (%))	237 (34.1)	152 (33.2)	68 (39.3)	17 (27.0)	0.159
Total cholesterol (mmol/l)	4.9 (4.3-5.7)	4.9 (4.3 – 5.7)	4.9 (4.1 – 5.9)	4.8 (4.0-5.6)	0.519
HDL-C (mmol/l)	1.2 (1.1-1.4)	1.2 (1.1 - 1.4)	1.2 (1.0 – 1.4)	1.2 (1.1 – 1.4)	0.705
LDL-C (mmol/l)	3.1 (2.5-3.2)	3.1 (2.5 – 3.7)	3 (2.4 – 3.9)	3.1 (2.3-3.6)	0.505
Triglycerides (mmol/l)	1.2 (0.9 – 1.7)	1.3 (0.9 – 1.7)	1.2 (0.9 – 1.8)	1.2 (0.9 – 1.5)	0.621
Family history of diabetes (n (%))	328 (47.3)	218 (47.6)	82 (47.4)	28 (44.4)	0.895
Lifestyle factors					
Alcohol drinker (n (%))	375 (53.9)	250 (54.5)	95 (54.6)	30 (47.6)	0.579
Tobacco smoker (n (%))	176 (25.3)	114 (24.8)	46 (26.4)	16 (25.8)	0.914
Sleep quality (n (%))					
Excellent	129	79 (17.2)	43 (25.0)	7 (11.1)	0.047

	(18.6)				
Good	253 (36.5)	171 (37.3)	58 (33.7)	24 (38.1)	
Fair	168 (24.2)	108 (23.6)	37 (21.5)	23 (36.5)	
Poor	143 (20.6)	100 (21.8)	34 (19.8)	9 (14.3)	
Sleep time (min/day) (n (%))					
<7 hours/day	270 (38.7)	175 (38.0)	64 (36.8)	31 (49.2)	0.903
≥7- <9 hours/day	320 (45.9)	218 (47.4)	79 (45.4)	23 (36.5)	
≥9 hours/day	107 (15.4)	67 (14.6)	31 (17.8)	9 (14.3)	
Disrupted sleep (n (%))	320 (45.9)	212 (46.1)	74 (42.5)	34 (54.0)	0.293
Work MVPA (min/week)	180.0 (0.0-840.0)	180.0 (0.0-850.0)	285.0 (0.0-575.9)	180.0 (60.0-515.0)	0.631
Travel MVPA (min/week)	120.0 (60.0-300.0)	122.5 (60.0-300.0)	130.0 (60.0-300.0)	120.0 (60.0-210.0)	0.481
Leisure MVPA (min/week)	0.0 (0.0-138.8)	0.0 (0.0-150.0)	0.0 (0.0-116.5)	0.0 (0.0-0.0)	0.005
MVPA (min/week)	500.0 (210.0-1350.0)	495.0 (200.0 – 1385.0)	575.0 (240.0 – 1380.0)	360.0 (180.0 – 840.0)	0.895
Physically active (n (%))	571 (81.9)	371 (80.7)	150 (86.2)	50 (79.4)	0.230

Categories of SB: Low: <240 min/day; Moderate: 240– 479 min/day; High: ≥480 min/day
Data presented as median [25^{th}-75^{th} percentile] or n (%). Abbreviations: BMI, body mass index; hba1c, glycated haemoglobin; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein; MVPA, moderate-to-vigorous physical activity

Table 2 – Psychological factors across categories of sedentary behaviour

		Sedentary behaviour			
	Total	**Low (n=460)**	**Moderate (n=174)**	**High (n=63)**	**P-value**
Self-report health (n (%))					
Excellent	91 (13.1)	66 (14.3)	19 (10.9)	6 (9.5)	0.016
Good	291 (41.8)	192 (41.7)	74 (42.5)	25 (39.7)	
Fair	234 (33.6)	153 (33.3)	51 (29.3)	30 (47.6)	
Poor	81 (11.6)	49 (10.7)	30 (17.2)	2 (3.2)	
Depression (n (%))					
Minimal	376 (54.3)	249 (54.6)	90 (52.0)	37 (58.7)	0.322
Mild	217 (31.4)	144 (31.6)	51 (29.5)	22 (34.9)	
Moderate	95 (13.7)	62 (13.6)	30 (17.3)	3 (4.8)	
Severe	4 (0.6)	1 (0.2)	2 (1.2)	1 (1.6)	
Chronic stress (n (%))	350 (50.4)	226 (49.3)	91 (52.6)	33 (52.4)	0.727
Level of anxiety severity (n (%))					
Minimal	429 (61.8)	281 (61.4)	101 (58.4)	47 (74.6)	0.163
Mild	193 (27.8)	129 (28.2)	52 (30.1)	12 (19.0)	
Moderate	49 (7.1)	33 (7.2)	14 (8.1)	2 (3.2)	
Severe	23 (3.3)	15 (3.3)	6 (3.5)	2 (3.2)	
Low social support (n (%))	118 (17.0)	73 (61.9)	35 (29.7)	10 (8.5)	0.427
PA barrier (n (%))	381 (54.7)	241 (52.4)	110 (63.2)	30 (47.6)	0.025
Life satisfaction score	7 (5-10)	7 (5 – 10)	6 (5 – 9)	6 (5 – 8)	0.005
Self-efficacy score	23 (18 – 26)	23 (18 – 26)	22 (18 – 26)	23 (19 – 26.5)	0.902

Categories of SB: Low: <240min/day; Moderate: ≥240min – <480min/day; High: ≥480min/day
Depression categories (28): Minimal = 0-4; mild = 5-9; moderate = 10-19; severe = 20-27
Anxiety categories (27): Minimal = 0-4; mild = 5-9; moderate = 10-14; severe = 15-21
Low SS (29): total scores across the first five items <18
Data is presented as median [25th-75th percentile] or n (%). Abbreviation: PA, physical activity

Table 3 - Perceived neighbourhood environmental attributes across categories of sedentary behaviour

		Sedentary behaviour (min/day)			
Scale	**Overall**	**Low (n= 460)**	**Moderate (n= 174)**	**High (n= 63)**	**P-value**
Proximity to destinations (AU)*	3.19 (0.63)	3.20 (0.63)	3.12 (0.64)	3.33 (0.52)	0.045
Access to services and places (AU)	3.14 (2.86-3.71)	3.14 (2.71-3.71	3.29 (2.86-3.71)	2.29 (3.07-3.57)	0.768
Street connectivity (AU)	3.40 (2.60-3.80)	3.40 (2.60-4.00)	3.40 (2.45-3.80)	3.40 (2.80-3.80)	0.238
Walking infrastructure and safety (AU)	2.85 (2.39-3.31)	3.00 (2.39-3.46)	2.77 (2.31-3.15)	2.62 (2.15-3.15)	0.001
Aesthetics (AU)	2.50 (2.00-3.13)	2.50 (2.00-3.25)	2.50 (1.90-2.97)	2.50 (2.13-3.06)	0.519
Traffic safety (AU)	1.80 (1.40-2.40)	1.80 (1.60-2.60)	1.60 (1.30-2.40)	1.60 (1.40-2.20)	0.097
Safety from crime (AU)	1.25 (1.00-2.00)	1.25 (1.00-2.06)	1.00 (1.00-2.00)	1.00 (1.00-1.63)	0.005

Categories of SB: Low: <240min/day; Moderate: ≥240min – <480min/day; High: ≥480min/day. Data presented as median (25^{th}-75^{th} percentile) and *Proximity to destinations scale presentedas Mean (SD).
Values presented in the table are arbitrary units (AU). Values closer to 1 indicate low/poor walkability while values closer to 4 or 5 (proximity to destinations domain, street connectivity, walk

Table 4 – multivariable robust linear regression models exploring the independent associations between SB and exposure variables

Variable	B-coefficient estimate	95% CI	P-value
	Multiple R-squared: 0.074		
Age	-0.52	-1.66 to 0.63	0.374
Gender			
Male	Ref	Ref	Ref
Female	-13.12	-39.24 to 12.99	0.324
Type of housing			
Built formal unit/privately owned	Ref	Ref	Ref
Council/core house	36.57	15.79 to 57.36	0.001
Informal shack/shelter/hostel/other	27.69	0.91 to 54.48	0.043
Sleep quality			
Excellent	Ref	Ref	Ref
Good	-35.39	-61.34 to -9.44	0.008
Fair	-18.65	-48.57 to 11.28	0.222
Poor	-37.35	-67.20 to -7.49	0.014
PA barrier			
Yes	Ref	Ref	Ref
No	-28.64	-48.28 to -9.00	0.004
Walking infrastructure and safety	-26.52	-39.29 to -13.75	0.034

Life satisfaction score	-2.70	-6.15 to 0.74	0.124

Data is presented as β-coefficients, 95% confidence intervals (CI) and p-values (p).

Part C: Appendices

1. **Manuscript supplemental material**

Supplementary tables 1 - Robust linear regression for the association between each sociodemographic, biochemical, clinical, lifestyle, psychological and environmental factors, and SB (adjusted for age and sex)

Variable	β-coefficient estimate	95% CI	p-value
Age	-0.71	-1.75 to 0.33	0.179
Gender			
Male	ref	ref	ref
Female	-8.40	-33.88 to 17.07	0.517
Education status			
Grade 1-7 and less	ref	ref	ref
Grade 8-10 (high school)	-16.52	-42.29 to 9.24	0.208
Less than grade 12 + FET/certificate/diploma	-25.04	-69.69 to 19.62	0.271
Grade 12	20.85	-17.90 to 59.60	0.291
Tertiary/diploma/degree	-14.47	-48.53 to 19.58	0.404
Household income			
R0-R3200	ref	ref	ref
R3201-R6400	-8.09	-32.74 to 16.55	0.519
R6401-R51200	-7.95	-38.40 to 22.50	0.608
Employment status			
Employed	ref	ref	ref
Unemployed	18.81	-2.83 to 40.45	0.088
Pensioner / grant holder	15.93	-12.08 to 43.95	0.265
Marital status			
Cohabitating	ref	ref	ref
Not cohabitating	13.395	-5.12 to 31.91	0.156
Type of housing			
Built formal unit/privately owned	ref	ref	ref
Council/core house	34.81	14.23 to 55.40	0.001*
Informal shack/shelter/hostel/other	31.58	4.71 to 58.46	0.021*
Anthropometry			
Height (m)	-0.36	-1.91 to 1.20	0.654
Weight (kg)	0.40	-0.14 to 0.94	0.147
BMI (kg/m^2)	1.16	-0.24 to 2.57	0.105
Waist circumference (cm)	0.53	-0.27 to 1.34	0.193
BMI categories			
Normal	ref	ref	ref
Overweight	-17.00	-88.14 to 54.14	0.639

Obese	7.27	-66.32 to 80.85	0.846
Cardiometabolic risk factors			
Hba1c (%)	6.09	-3.95 to 16.13	0.234
Hba1c (mmol/mol)			
Fasting plasma glucose (mmol/l)	1.62	-4.93 to 8.17	0.627
Two hour glucose (mmol/l)	1.25	-1.67 to 4.18	0.401
Systolic blood pressure (mmHg)	-0.19	-0.72 to 0.34	0.472
Diastolic blood pressure (mmHg)	-0.01	-0.87 to 0.84	0.975
Hypertensive (≥140/90 mmHg)			
No	ref	ref	ref
Yes	6.39	-13.55 to 26.33	0.529
Total cholesterol (mmol/l)	-0.79	-7.87 to 6.30	0.827
HDL-C (mmol/l)	9.30	-16.79 to 35.40	0.484
LDL-C (mmol/l)	-3.54	-11.84 to 4.76	0.403
Triglycerides (mmol/l)	1.71	-3.48 to 6.90	0.519
Family history of diabetes			
Yes	ref	ref	ref
No	0.25	-18.34 to 18.83	0.979
Lifestyle factors			
Alcohol drinker			
Yes	ref	ref	ref
No	3.92	-14.57 to 22.42	0.677
Tobacco smoker			
Yes	ref	ref	ref
No	4.86	-17.10 to 26.83	0.664
Sleep quality			
Excellent	ref	ref	ref
Good	-26.51	-53.15 to 0.13	0.051*
Fair	-7.83	-38.79 to 23.13	0.620
Poor	-17.22	-46.35 to 11.91	0.246
Sleep time (min/day)			
<7 hours/day	ref	ref	ref
≥7- <9 hours/day	-5.89	-26.24 to 14.46	0.570
≥9 hours/day	7.92	-22.19 to 38.04	0.606
Disrupted sleep			
Yes	ref	ref	ref
No	-10.37	-29.41 to 8.68	0.286
Work MVPA (min/week)	0.00	-0.01 to 0.01	0.387
Travel MVPA (min/week)	0.05	-0.02 to 0.02	0.994

Leisure MVPA (min/week)	0.00	-0.02 to 0.03	0.774
MVPA (min/week)	0.00	-0.01 to 0.01	0.552
Physically active			
Yes	ref	ref	ref
No	-22.33	-47.50 to 2.84	0.082
Psychological factors			
Self-report health			
Excellent	ref	ref	ref
Good	11.62	-17.77 to 41.01	0.438
Fair	9.79	-21.49 to 41.08	0.539
Poor	25.85	-12.07 to 63.77	0.181
Depression			
Minimal	ref	Ref	ref
Mild	8.44	-13.97 to 30.85	0.460
Moderate	16.09	-12.10 to 44.28	0.263
Severe	107.10	-210.24 to 424.45	0.508
Chronic stress			
Yes	ref	Ref	ref
No	-9.72	-28.45 to 9.00	0.308
Level of anxiety severity			
Minimal	ref	Ref	ref
Mild	-6.38	-27.33 to 14.57	0.550
Moderate	8.94	-27.90 to 45.78	0.634
severe	44.28	-17.94 to 106.50	0.163
Low social support			
Yes	1.84	-28.38 to 32.06	0.905
No	ref	ref	ref
PA barrier			
Yes	ref	ref	ref
No	-30.73	-49.88 to -11.58	0.002*
Life satisfaction score	-3.55	-6.93 to -0.17	0.040*
Self-efficacy score	-0.16	-1.82 to 1.51	0.854
Perceived neighbourhood environmental attributes			
Proximity to destinations (AU)	-6.82	-21.18 to 7.55	0.352
Access to services and places (AU)	9.62	-4.88 to 24.12	0.193
Street connectivity (AU)	-8.37	-19.42 to 2.67	0.137
Walking infrastructure and safety (AU)	-26.50	-38.98 to -14.01	0.023*
Aesthetics (AU)	-2.25	-13.62 to 9.11	0.697
Traffic safety (AU)	-4.26	-16.70 to 8.19	0.502
Safety from crime (AU)	-5.99	-15.84 to 3.87	0.234

Data is presented as β-coefficients, 95% confidence intervals (CI) and p-values (p).
Abbreviations: BMI, body mass index; HbA1c, glycated haemoglobin; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein; MVPA, moderate-to-vigorous physical activity; PA, physical activity
Depression categories (28): Minimal = 0-4; mild = 5-9; moderate = 10-19; severe = 20-27
Anxiety categories (27): Minimal = 0-4; mild = 5-9; moderate = 10-14; severe = 15-21
low SS (29): total scores across the first five items <18

Supplementary table 2- Perceived neighbourhood environmental attributes overall and across type of housing categories

	overall	private	council	shack	p-value
Proximity to destinations (AU)	3.19 (0.63)	3.16 (0.57)	3.20 (0.67)	3.12(0.57)	0.474
Access to services and places (AU)	3.14 (2.86-3.71)	3.29(2.86-3.71)	3.43(3.00-3.86)	3.14 (2.71-3.57)	<0.001
Street connectivity (AU)	3.40 (2.60-3.80)	3.40 (2.80-3.80)	3.20 (2.20-3.60)	3.40 (3.00-4.00)	<0.001
Walking infrastructure and safety (AU)	2.85 (2.39-3.31)	2.89 (2.46-3.31)	2.92 (2.39-3.31)	2.77 (2.23-3.39)	0.750
Aesthetics (AU)	2.50 (2.00-3.13)	2.75 (2.25-3.25)	2.75 (2.13-3.25)	1.88 (1.38-2.50)	<0.001
Traffic safety (AU)	1.80 (1.40-2.40)	1.80 (1.60-2.65)	1.80 (1.40-2.60)	1.60 (1.40-2.20)	<0.001
Safety from crime (AU)	1.25 (1.00-2.00)	1.50 (1.00-2.50)	1.25 (1.00-2.25)	1.00 (1.00-1.75)	<0.001

Data presented as median (25^{th}-75^{th} percentile) and *Proximity to destinations scale presented as Mean(SD). Values presented in the table are arbitrary units (AU). Values closer to 1 indicate low/poor walkability while values closer to 4 or 5 (proximity to destinations domain, street connectivity, walk

Supplementary table 3- Type of housing categories across PA barrier categories

Type of Housing	**overall**	**PA barrier**		**p-value**
		yes	**no**	
Private	244 (35.4)	120 (49.18%)	124 (50.82%)	0.004
council	273 (39.6)	146 (53.48%)	127 (46.52%)	
shack	173 (25.1)	113 (65.32%)	60 (34.68%)	

Data is presented as median [25^{th}-75^{th} percentile] or n (%).

Supplementary table 4 - Robust linear regression model for the association between environmental determinants and SB

Variable	β-coefficient estimate	95% CI	P-value
Age	-0.50	-1.55 to 0.54	0.342
Female	-9.51	-34.76 to 15.75	0.460
Environmtal issues			
Not a barrier	Ref	ref	Ref
Somewhat a barrier	2.81	-20.73 to 26.35	0.815
Very much a barrier	66.92	37.88 to 95.96	<0.001

Data is presented as β-coefficients, 95% confidence intervals (CI) and p-values (p).

Supplementary table 5- Robust linear regression model for the association between accessibility of facilities and SB

Variable	β-coefficient estimate	95% CI	p-value
age	-0.60	-1.65 to 0.45	0.261
Female	-9.70	-35.32 to 15.91	0.457
Accessibility of facilities			
Not a barrier	ref	ref	ref
Somewhat a barrier	-2.89	-26.46 to 20.68	0.810
Very much a barrier	24.15	0.60 to 48.90	0.053

Data is presented as β-coefficients, 95% confidence intervals (CI) and p-values (p).

Supplementary table 6 - robust linear regression model for the association between lack of skills to do exercise and SB

Variable	β-coefficient estimate	95% CI	p-value
age	-0.61	-1.65 to 0.42	0.245
Female	-6.96	-32.38 to 18.46	0.591
Lack of skills			
Not a barrier	Ref	Ref	Ref

Somewhat a barrier	13.30	-15.36 to 41.96	0.362
Very much a barrier	35.83	0.95 to 72.61	0.054

Data is presented as β-coefficients, 95% confidence intervals (CI) and p-values (p).

2. Ethics approval

2.1 Ethics approval for parent study

9 November 2021

Prof Andre Kengne
Director: Non-Communicable Diseases Research Unit
SAMRC Cape Town

Dear Prof Kengne

Protocol ID: EC018-7/2015
Protocol title: A randomised evaluation of the South African Diabetes Prevention Programme (SA-DPP)
Meeting date: 26 October 2021

Thank you for your progress report and application for the renewal to the Committee, dated 12 October 2021. The Committee noted the progress report and granted ethics approval for the study for another year.

Please note that the approval is valid for 1 year, i.e. from 26 October 2021 to 25 October 2022. Any changes to the research protocol must be submitted as an amendment. Any adverse events must be reported within 48 hours. Any protocol deviations have to be reported.

Wishing you well with your research.

Yours sincerely

Prof Danie du Toit
Chairperson: SAMRC Human Research Ethics Committee

Members present at the meeting: Prof D du Toit (Chairperson), Ms S Behardien, Adv J Early, Dr H Etheredge, Prof A Kengne, Ms M Ledwaba, Prof C Lombard, Dr A Loxton, Mr G Makanda, Dr E Nicol, Dr W Zembe

2.2 Ethics approval for

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room 45 E-52-E-Floor- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

04 February 2022

HREC REF: 063/2022

Prof J Goedecke
Department of Human Biology
Email: Julia.goedecke@uct.ac.za
Student: chad.africa@mrc.ac.za

Dear Prof Goedecke

PROJECT TITLE : THE CORRELATES OF SEDENTARY BEHAVIOR IN INDIVIDUALS AT RISK OF DEVELOPING TYPE 2 DIABETES MELLITUS IN CAPE TOWN, SOUTH AFRICA-MASTERS' CANDIDATE-MR CHAD AFRICA

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, our letter dated 02 February 2022 provides guidance found on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

Approval is granted for one year until the 28 February 2023.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Chad Africa will also be involved in this study.

Please quote the HREC REF 063/2022 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637. Institutional Review Board (IRB) number: IRB00001938 NHREC-registration number: REC-210208-007
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2020), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

3. SADPP screening tool

WOULD YOU LIKE TO KNOW IF YOU ARE AT RISK OF DEVELOPING DIABETES?

The South African Medical Research Council is screening people for diabetes in your area. If you are at risk you may be invited to participate in a study to decrease your risk for diabetes.

We will be screening for diabetes in your area between

20 November 2018

at

Sport Complex, Heideveld

from

9h00 - 14h00

WE HOPE TO SEE YOU THERE.

For more information
please call the

PLACE BARCODE STICKER HERE

4. **SADPP consent form**

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

STUDY TITLE: **The South African Diabetes Prevention Programme (SA-DPP)**
PRINCIPAL INVESTIGATOR: **Andre Pascal Kengne, (M.D., Ph.D., Internist)**
DIRECTOR: **Non-communicable Diseases Research Unit (NCDRU), South African Medical Research Council**

Dear Sir/Madam,

We are scientists from the South African Medical Research Council (MRC). We would like to conduct a study to prevent the development of diabetes in your community.

Purpose and focus of the study

Diabetes is becoming more common than before and we want to try to decrease the risk of people in the community developing the disease. We hope to do this by inviting people at high risk for diabetes, detected after blood testing, to participate in a diabetes prevention programme. The people invited to participate in the study will be educated about the condition and on how to decrease their risk for diabetes. This will be done in 6 group discussions, lasting about 2 hours each. The first 5 sessions will be held every 2 weeks over 2 months and the last session will be 6 months later. Trained community healthcare workers will conduct the group discussions at a time most convenient for members of the group. They will also send text messages over 3 years to people in these groups for support.

Before we can do this, we will need to identify people at high risk for diabetes. We will do this in the following way:

1. Questionnaires: We will first identify people at high risk for diabetes by asking them a few questions about their general and medical history.
2. Blood sampling: People identified as high risk will undergo testing to see whether they have diabetes or are at high risk for diabetes. People with diabetes will be referred and given a referral letter for their nearest clinic or doctor.

Who can take part in the study?

The following steps will be used to identify people who can take part in the intervention study:

1. People between the ages of 25-65 years and not known to have diabetes will be screened to check their risk for diabetes.
2. After screening, people thought to be at high risk for diabetes will be invited to undergo an oral glucose tolerance test where blood samples will be drawn to examine for diabetes.
3. Thereafter, people found to be at high risk for diabetes on blood testing but who did not have diabetes, will be invited to participate in the intervention study to reduce their risk for diabetes.
4. Half the people invited to participate in this study will attend the group sessions while the other half will receive written information about healthy lifestyle and lowering diabetes risk. The allocation into these 2 groups will be done randomly by a statistician on the computer. At the end of the study, people who were not in the discussion group will be invited to also attend these sessions.

Who will have their blood taken?

People who are identified as being at high risk for diabetes on the screening questions will be invited to undergo blood testing.

People who are identified at high risk for diabetes on blood testing and are included in the study will have their blood tested again 1 year and 3 years later.

PLACE BARCODE STICKER HERE

What tests will be done?

The blood tests will include an oral glucose tolerance test to diagnose diabetes and is described below. The other tests include tests to check for high cholesterol (fat) in the blood, for heart and kidney problems and for tobacco use. These tests show if a person is at risk for a heart attack or stroke. We will store any blood that remains for testing later. This blood will be stored in an ultralow temperature freezer at the MRC for up to 20 years. The Research Ethics Committee of the MRC will approve any future tests.

Oral glucose tolerance test

After an overnight 10 hour fast (where you do not eat or drink anything except water after your evening meal, the night before the blood sampling, and miss your breakfast the day of the test), we will place a sterile little tube in a vein in your arm and take 15 mls (3 teaspoons) of blood from this. We will give you a cup of sugar water to drink and then we will take two more blood samples (each 2 teaspoons) over the next two hours. Taking the blood sample may cause a little discomfort at the site but there are no risks for this test, other than those associated with routine blood sampling. All procedures will be supervised and carried out by appropriately trained medical personnel who will use techniques to minimise any risks of infection. This test is used routinely for medical purposes. The blood sample will be used to determine your blood sugar, insulin, cholesterol and other additional factors that may help us learn more about diabetes.

In addition, we will also do an electrocardiograph (ECG) and a cardiovascular ultrasound to check your heart and blood vessels, a retinal scan to check for damage caused by high blood pressure or high blood glucose, and a lung function test. These tests are non-invasive and don't take long.

We will also ask you to wear two devices, at different times, for a longer period including at home and at work. The one is an ambulatory blood pressure monitor which checks your blood pressure automatically at different times throughout the day for 24 hours. The other device is an accelerometer which checks the amount of physical activity you do over 7 days.

Do I have to take part in the study?

You have no obligation to participate in the study and you may withdraw from the study at any time. There will be no penalty to you if you decide not to participate in the study, or if you want to withdraw from the study later on. Remember: Your participation in this study is completely voluntary.

If you decide to withdraw from the study, you may be asked why you have decided to withdraw for statistical purposes, but giving reasons for withdrawal from the study is also completely voluntary.

What can I expect to gain from participating in this study?

1. You will have access to trained staff who will check your risk for diabetes.
2. If your blood is tested or blood pressure measurements taken, you will receive copies of your blood tests and measurements for your records.
3. You will be referred for appropriate treatment if any abnormalities are found
4. You will contribute to medical research that may provide very useful insights on how to prevent diabetes
5. You will receive at no cost to yourself, an assessment of your risk for diabetes. For people at high risk, you will receive free testing to check if you have diabetes.

What will be the costs of my participation in this study?

1. Transport to and from the research facility/clinic for blood testing will be provided if you are found to have high risk. You will receive a R120-00 for each visit when blood tests are done and questionnaires administered because you will spend between 2-3 hours at the study venue.
2. The voucher will be for R50 for each visit when you attend the group sessions, which will be held in the community, where you learn more on how to prevent diabetes.
3. You will be required to sacrifice your time for completion of questionnaires, group discussion session and medical assessments/ testing. The questionnaire and blood tests, to be done 3 times in total, at yearly intervals, will be about 2-3 hours long. The 6 groups sessions will each be 2 hours long.

What will happen to the data collected during the study?

PLACE BARCODE STICKER HERE

The data collected will be sent to researchers at the South African Medical Research Council and used solely for the purpose of this study.

Who will know that I participated in this study?

Only the research staff and other participants in the study will know that you participated in the study. Your name will not be recorded or revealed to anyone not involved in the study, and your name or other details will not be published in any documents.

Will I be informed about the results of the study?

You will be informed about the study results after publication.

How will I find out about my results?

A member of the research team will contact you directly by telephone and advise you or refer you for further medical assistance if you are diagnosed with diabetes. Your blood results will be sent to you by post as soon as they become available. People with high risk will be informed of their results and invited to continue with the study.

What are my rights while taking part in the study?

Your taking part in this study is your choice and you are free to not take part. All information will be confidential and anonymous. You may also refuse to answer any questions you do not feel comfortable answering and you may stop during the interview andnot continue. Your name will not be linked to the information collected at any time and will not appear in any report or publication.

What are the risks to my health in this study?

Your participation in this study will involve answering questions, and for those at high risk, it will include a medical examination and collection of blood for laboratory analysis.

Blood will be collected by an experienced professional nurse, doctor or appropriately trained staff member. Having your blood drawn can cause bleeding, bruising and in rare cases an infection may occur at the site of the needle stick and may also be uncomfortable. Rarely, light-headedness or fainting may occur.

If you fall ill, suffer any side effects or if you are injured in any study related manner contact the investigator/researcher immediately. The SAMRC, as the sponsor of this study, has taken out the necessary insurance to cover you as a research participant.

This study has been approved by the Research Ethics Committee of the South African Medical Research Council, Cape Town and will be carried out according to the ethical guidelines and principles of the International Declaration of Helsinki, 2013. If you have questions about your rights as someone who took part in the study, you are welcome to contact the Chairperson of the Research Ethics Committee, Prof Danie Du Toit, at the South African Medical Research Council, P.O. Box 19070, Tygerberg. 7505. Contact telephone number: 021 938 0687; email: adri.labuschagne@mrc.ac.za. You will receive a copy of this information sheet and consent form for your own records. If you have any questions or concerns about the research, please feel free to contact Prof.Andre Kengne (021 938 0805) at the South African Medical Research Council, Tygerberg, Cape Town.

Declaration by investigator (or person designated)

I (name) .....declare that I have explained the information in this document to ..... I have encouraged him/her to ask questions and took adequate time to answer them. I am satisfied that he/she adequately understands all aspects of the research, as discussed above.

Signed at..... on (date) .....

Name of investigator ..... Signature of investigator .....

Signed at _____ on (date) _____

PLACE BARCODE STICKER HERE

Name of participant _____ Signature of participant _____

Name of witness _____ Signature of witness _____

5. SADPP questionnaire

Baseline Questionnaires

SECTION 1: GENERAL INFORMATION	*Office use*
STUDY NUMBER:	4
INTERVIEWER'S NAME ……	
AREA/TOWNSHIP ……	
NAME OF PARTICIPANT……	
ADDRESS OF PARTICIPANT……	
TELEPHONE ……	
EMAIL ADRESS……	
How long have you stayed at your current address?……	
……	
2ND CONTACT PERSON'S DETAILS:	
NAME ……	
ADDRESS ……	
TELEPHONE ……	
3RD CONTACT NOT LIVING IN THE SAME HOUSE……	
NAME ……	
ADDRESS ……	
DATE OF INTERVIEW: D D M M Y Y Y Y	16
I TERVIEW START TIME : …… IN ERVIEW COMPLETION TIME : ……	
NDER: Male 1 | Female 2	
GE AT LAST BIRTHDAY …… ……	
TE OF BIRTH: D D M M Y Y Y Y	27
CURRENT MARITAL STATUS:	
Single/Married/Divorced/Separated/Living as married/Widowed?	

SECTION2: SOCIO-DEMOGRAPHIC INFORMATION

Office use

3A. What is the highest level of education that you have achieved?

Never went to school	Grade 1-7 (Primary school)	Grade 8-12 (High

40

3B. Are you currently…

Employed	Unemployed	A full-time homemaker	A pensioner	C

3C. What type of housing do you live in?

Built formal unit/ privately owned	Council / core house	

3D. Does your household have any of the following in working condition:

a)	A radio?		Yes 1	No 2
b)	A television?		Yes 1	No 2
c)	A landline telephone?		Yes 1	No 2
d)	A desktop or laptop computer?		Yes 1	No 2
e)	A refrigerator?		Yes 1	No 2
f)	A vacuum cleaner or floor polisher?		Yes 1	No 2
g)	A microwave oven?		Yes 1	No 2
h)	An electric or gas stove?		Yes 1	No 2
i)	A washing machine?		Yes 1	No 2
j)	Electricity that is connected to the mains?		Yes 1	No 2

Does any member of this household [eats with you] own any of the following in working condition:

a)	A watch?	
b)	A cell phone?	
c)	A bicycle?	
d)	A motorcycle or scooter?	
e)	An animal-drawn cart?	

57

3E What is the COMBINED monthly income for your household?
(Participants can answer only if they feel comfortable doing so, ensure utter confidentiality)

1. No income
2. R1 – R400
3. R401 – R800
4. R801 – R1 600
5. R1 601 – R3 200
6. R3 201 – R6 400
7. R6 401- R12 800
8. R12 801 – R25 600
9. R25 601 – R51 200
10. R51 200 or more

SECTION 3A: SELF-REPORTED MEDICAL HISTORY

Office use

STUDY NUMBER: 4

4A. Would you say your health is poor, average, good, or very good/excellent?

Poor 1	Average 2	Good 3	Very good/excellent 4

4B. Do you personally think that you are underweight, normal weight or overweight?

Underweight 1	Normal weight 2	Overweight 3

In the past year have you noted any changes in your w

No changes 1	Lost some weight 2	Gained some weight

In the past year have you noticed any changes in your waist (midsec

4C. Has a **doctor** or **nurse** or **health worker** at a **clinic** or **hospital told you** that you have or have had any of the following conditions?

1) High blood pressure	Yes 1	
2) Heart attack or angina (chest pains)	Yes 1	
3) Stroke	Yes 1	
4) High blood cholesterol or fats in the blood	Yes 1	
5) Diabetes or blood sugar	Yes 1	
6) Diabetes during pregnancy	Yes 1	
7) Chronic bronchitis, emphysema or CPOD?	Yes 1	
8) Asthma?	Yes 1	
9) Have you ever had Tuberculosis?	Yes 1	
9b) If yes, when was the last time you were told you had TB?		
9c) What type of TB did you have?		
9d) Did you get medical treatment the last time you had TB?		
9e) How long did you take treatment?		
10) Cancer	Yes 1	
10a) If yes, what type of cancer did you have?		

12

4D. During the past 12 months have you been tested/checked for:

1) Hypertension/high blood pressure	Yes 1	No 2
2) Diabetes	Yes 1	No 2

4E	During the past 12 months have you seen a traditional healer/alternative practitioner for any of the conditions mentioned above?	Yes 1	No 2
4F	Are you currently taking any herbal/traditional or alternative medications for any of the conditions mentioned above?	Yes 1	No 2

SECTION 5: FAMILY MEDICAL HISTORY

Office use

STUDY NUMBER: | | | | | 4

6A. Do you have a **close blood relative** (father, mother, brother, sister / son/daughter) who has ever bee diagnosed:
by a doctor or nurse with any of the following conditions? Under each question, if yes, choose which relative

Mother			
1) High blood pressure	Yes 1	N	
3) Heart attack/angina/chest pain when exerting herse	Yes 1	No 2	Don't know 9
4) Stroke	Yes 1	No 2	Don't know 9
5) Cancer	Yes 1	N	
6) Obesity	Yes 1	N	
Father			
1) High blood pressure	Yes 1	N	
2) Diabetes	Yes 1	N	
3) Heart attack/angina/chest pain when exerting himse	Yes 1	N	
4) Stroke	Yes 1	N	
5) Cancer	Yes 1	N	
6) Obesity	Yes 1	N	
Sister			
1) High blood pressure	Yes 1	N	
2) Diabetes	Yes 1	N	
3) Heart attack/angina/chest pain when exerting herse	Yes 1	N	
4) Stroke	Yes 1	N	
5) Cancer	Yes 1	N	
6) Obesity	Yes 1	N	
Brother			

SECTION 6: ALCOHOL USE

Office use

STUDY NUMBER: | | | | | 4

8A Have you ever consumed a drink that contain alcohol such as beer, wine, spirits or sorghum beer? Yes 1 / No 2 | 5

8B Was this within the past 12 months? Yes 1 / No 2

In the past 12 months how frequently have you had at least one drink?

- 5+ days per week
- 1-4 days per week

8E	Have people annoyed	Ye	N
8G	Have you ever felt bad	Ye	N
8H	Have you ever had a drink first thing in the morning to steady	Ye	N

SECTION 7: TOBACCO USE

Office use

9A

10

9B

9C **How old** were you when you first **started** smoking daily? how Years old

Don't remember/not sure = 99

9D

Do you **currently smoke** any tobacco products, such as cigarettes, cigars

16

9E

Do you currently smoke tobacco products **daily**?

24

SECTION 7: TOBACCO USE

Office use

If you do not remember how old you were, do you remember how long ago

daily? 1

9F 2

25

9G On average, how many of the following items do you smoke each day?

How old were you when you first **stopped** smoking daily? Years old

1 Manufact

Don't remember/not sure = 99

9H If you do not remember how old you were, do you remember how long ago you stopped smoking

2 Hand-ro

daily? 3 Pipes 1 WEEKS AGO

In the past, did you ever smoke daily?

30

ASSESSING USE OF SMOKELESS TOBACCO

9I 2

9J Do you **currently use any** smokeless tobacco, such as snuff or chewing t

9K Do you currently use smokeless tobacco **daily**?

34

On average, how many times do you use each of the following items per d

1 Sn

2 S

9L

40

SECTION 8: MOOD AND THE SUPPORT NETWORKS

1. This next section is about your mood and the support networks that you have available. It is important that we understand people's experiences and moods, because these have been shown to be related to diabetes risk. Some of them may seem personal but please try to answer them as accurately as possible.

Over the last 2 weeks, how often have you been bothered by any of the following problems? Please circle the response closest to how you have been feeling.

	Not at all	Several days	More than half the days	Nearly everyday
a. Little interest or pleasure in doing things	0	1	2	3
b. Feeling down, depressed, or hopeless	0	1	2	3
c. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
d. Feeling tired or having little energy	0	1	2	3
e. Poor appetite or overeating	0	1	2	3
f. Feeling bad about yourself—or that you are a failure or have let yourself or your family down	0	1	2	3
g. 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	0	1	2	3
h. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
i. Thought about death more than usual, either your own, someone else's, or death in general	0	1	2	3

From the responses, calculate the total score. If the participant's score is ≥ 4 give them the leaflet on mental health and advise them to consult a health professional.

Many people experience ongoing problems in their everyday lives. Please tell us whether any of the following has been a problem for you.

Yes	No

2. a. Serious ongoing health problem (yourself)

If **No**, go to ques 24

Yes	No

b. If yes, has this been a problem for 12 months or more?

Not very stressful	Moderately stressful	Very stressful

c. Would you say this problem has been...

Yes	No

3. a. Serious ongoing health problem (someone close to you)

If **No**, go to ques 25

Yes	No

b. If yes, has this been a problem for 12 months or more?

Not very stressful	Moderately stressful	Very stressful

c. Would you say this problem has been...

Yes	No

4. a. Ongoing difficulties with your job or ability to work

If **No**, go to ques 26

Yes	No

b. If yes, has this been a problem for 12 months or more?

Not very stressful	Moderately stressful	Very stressful

c. Would you say this problem has been...

Yes	No

5. a. Ongoing financial strain

If **No**, go to ques 27

Yes	No

b. If yes, has this been a problem for 12 months or more?

Not very stressful	Moderately stressful	Very stressful

c. Would you say this problem has been...

Yes	No

6. a. Ongoing difficulties in a relationship with someone close to you

If **No**, go to ques 28

Yes	No

b. If yes, has this been a problem for12 months or more?

Not very stressful	Moderately stressful	Very stressful

c. Would you say this problem has been...

7. This section of the questionnaire is concerned with your relationships with the peoplearound you (e.g. family, friends, etc.). Please circle appropriate number.

At the present time:	**None of the time**	**A little of the time**	**Some of the time**	**Most of the time**	**All the time**
a. Is there someone available who you can rely on to listen to you when you need to talk?	1	2	3	4	5
b. Is there someone available to give you good advice about a problem?	1	2	3	4	5
c. Is there someone who shows you love and affection?	1	2	3	4	5
d. Can you rely on anyone to give you emotional support (talking over problems or helping you make a difficult decision)?	1	2	3	4	5
e. Do you have as much contact as you would like with someone you feel close to, someone who you can confide in and trust?	1	2	3	4	5
f. Do people that are close to you make too many demands on you?	1	2	3	4	5
g. Are the people that are close to you critical of what you do?	1	2	3	4	5

8. Over the last 2 weeks, how often have you been bothered by the following problems? Please circle appropriate number.

	Not at all	**Several days**	**More than half the days**	**Nearly every day**
a. Feeling nervous, anxious or on edge	0	1	2	3
b. Not being able to stop or control worrying	0	1	2	3
c. Worrying too much about different things	0	1	2	3
d. Trouble relaxing	0	1	2	3
e. Being so restless that it is hard to sit still	0	1	2	3
f. Becoming easily annoying or irritable	0	1	2	3
g. Feeling afraid as if something awful might happen	0	1	2	3

9. Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole?

1	2	3	4	5	6	7	8	9	10

10. These questions are about how you feel and how things have been with you during the past 4 weeks. Please give one answer that is the closest to the way you have been feeling for each item. (Please tick one box for each statement).

How much of the time during the past 4 weeks...

How much time during the past 4 weeks:	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a. Did you feel full of life	1	2	3	4	5
b. Have you been very nervous?	1	2	3	4	5
c. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5
d. Have you felt calm and peaceful?	1	2	3	4	5
e. Did you have a lot of energy?	1	2	3	4	5
f. Have you felt downhearted and depressed?	1	2	3	4	5
g. Did you feel worn out?	1	2	3	4	5
h. Have you been happy?	1	2	3	4	5
i. Did you feel tired?	1	2	3	4	5

SECTION 9: PHYSICAL ACTIVITY – MODIFIED STEPS/GPAQ

Office use

STUDY NUMBER: ☐☐☐☐ 4

10 The next questions are about the time you spend doing different types of physical activities. This includes activities you do **at home, at work, travelling from place to place and during your spare time**. You are requested to answer the questions even if you don't consider yourself to be an active person.

Occupation-Related Physical Activity (paid or unpaid work): When answering the following questions, think back over the **past 12 months** and consider (think of) **a usual week**.

10A Does your work involve vigorous activities, (like heavy lifting, digging, or he
for **at least 10 minutes** at a time? ☐

10B In **a usual week**, how many days do you do vigorous activities as part of y ☐☐

10C On **a usual day** on which you do vigorous activities, how much time do you ☐☐
☐☐☐

10D Does your work involve moderate-intensity activities, (like brisk walking or c
for **at least 10 minutes** at a time? ☐ 13

SECTION 8: PHYSICAL ACTIVITY – MODIFIED STEPS/GPAQ

Office use

10E In **a usual week**, how many days do you do moderate-intensity activities as part of your work? ☐

15

10F On **a usual day** on which you do moderate-intensity activities, how much ti
work?

Travel-Related Physical Activity: Other than activities that you've already mentioned, I would like to ask you about the way you travel to and from places (to work, to shopping, to market, to church, etc.).

10G Do you walk or use a bicycle (pedal cycle) for **at least 10 minutes** at a time

10H In **a usual week**, how many days do you walk or cycle for at least 10 minut

10I On **a usual day,** how much time do you spend walking or cycling for travel?
1 HOURS:
2 MINUTES:

Non-Work Related and Leisure Time Physical Activity: The next questions ask about activities you do in your leisure or spare time, for recreation or fitness. Do not include the physical activities you do at work or for travel already mentioned.

10J In your leisure or spare time do you do any vigorous activities (like running sports, weightlifting) for **at least 10 minutes** at a time?

10K In **a usual week**, how many days do you do vigorous activities as part of your leisure or spare time?
DAYS:

10L How much time do you spend doing this on **a usual day?**

38

10M In your leisure or spare time, do you do any moderate-intensity activities (lik swimming) for **at least 10 minutes** at a time?

10N In **a usual week**, how many days do you do moderate-intensity activities as or spare time?

42

10O How much time do you spend doing this on **a usual day?**

Sitting / Resting Activity: Now I would like to ask you about the time spe

10P Over the **past 7 days,** how much time did you spend sitting or reclining (lying) on **a usual day (excluding sleeping)?**
1 HOURS:
2 MINUTES:

52

11. The following statements may be barriers to you being more physically active. For each statement, tell me whether it's not a barrier, somewhat of a barrier or very much a barrier?

	Not a barrier	Somewhat a barrier	Very much a barrier

a. Other priorities (family needs/ lack of time/ work)	1	2	3
b. A disability or injury	1	2	3
c. Environmental issues (rainy season/ pollution/ noise)	1	2	3
d. Safety (e.g. narrow roads, poor lighting, traffic, stray dogs)	1	2	3
e. Cost of accessing exercise facilities	1	2	3
f. Accessibility of facilities (distance, opening hours, availability)	1	2	3
g. Lack of skills to do exercise	1	2	3
h. Lack of self confidence	1	2	3
i. Community attitude to exercise	1	2	3
j. Lack of social support (family, friends)	1	2	3
k. I do not feel it is important to do exercise	1	2	3
l. Other_____	1	2	3
m. Other_____	1	2	3
n. Other_____	1	2	3

The following questions ask for your views about your health, how you feel and how well you are able to do your usual activities.

12. In general, would you say your health is:

Excellent	*Very Good*	*Good*	*Fair*	*Poor*

13. a. How much time do you spend in front of a screen (watching television/DVDs, on the computer) during a typical working day? _____Hours

b. How much time do you spend in front of a screen (watching television/DVDs, on the computer) during a typical non- working day? _____ Hours

14. a. How many hours do you usually sleep a night? _____Hours

b. Do you usually have disrupted sleep?

Yes	No

These next questions are about how confident you are about being able to lead a healthy lifestyle.

15. I can manage to carry out physical activity...

	Very uncertain	Rather uncertain	Rather certain	Very certain
a. even during the holidays.	1	2	3	4
b. even if my family discourages me from spending time doing physical activity.	1	2	3	4
c. even when the weather is very hot.	1	2	3	4

d. even during the rainy season.	1	2	3	4
e. even if my community does not have exercise facilities or safe roads for walking	1	2	3	4
f. even if I have health problems	1	2	3	4
g. even if no other people around me are doing exercise or walking	1	2	3	4

Q35 (Click to edit)

12. I can manage to carry out physical activity...

	Very uncertain	Rather uncertain	Rather certain	Very certain
a. I can manage to carry out physical activity even during the holidays.	○	○	○	○
b. I can manage to carry out physical activity even if my family discourages me from spending time doing physical activity.	○	○	○	○
c. I can manage to carry out physical activity even when the weather is very hot.	○	○	○	○
d. I can manage to carry out physical activity even during the rainy season.	○	○	○	○
e. I can manage to carry out physical activity even if my community does not have exercise facilities or safe roads for walking	○	○	○	○
f. I can manage to carry out physical activity even if I have health problems.	○	○	○	○
g. I can manage to carry out physical activity even if no other people around me are doing exercise or walking.	○	○	○	○
	Very uncertain	Rather uncertain	Rather certain	Very certain

B. Stores, facilities, and other things in your neighbourhood

Q36 (Click to edit)

Approximately how long would it take to get from your house to the nearest places or locations listed below if you walked to them? Please select only one for each business or facility.

	1-5 min	6-10 min	11-20 min	20-30 min	30+ min	Don't know
1 Kiosk/small grocery corner store/ (house shop)	○	○	○	○	○	○
2 Supermarket	○	○	○	○	○	○
3 Fruit/vegetable market(food market stalls)	○	○	○	○	○	○
4 Fast food restaurant/ (outlet KFC, McD, Hungry Lion, FISH & CHIPS)	○	○	○	○	○	○
5 Non-fast food restaurant (SPUR, Wimpy, Ocean Basket)	○	○	○	○	○	○
6 Pub or bar (Shebeen)	○	○	○	○	○	○
7 Cinema/theatre	○	○	○	○	○	○
8 Place of worship/faith centre(church, mosque, shrine)	○	○	○	○	○	○
9 Computer/cell phone kiosks (Places for internet or phone calls)	○	○	○	○	○	○
10 Library	○	○	○	○	○	○
11 Schools (primary or others)	○	○	○	○	○	○
12 Your work place or your school (academic institution)	○	○	○	○	○	○
13 Book store(book shop)	○	○	○	○	○	○
14 Health care clinic/hospital	○	○	○	○	○	○
15 Pharmacy/chemist	○	○	○	○	○	○
16 Salon/barber shop(hair dresser)	○	○	○	○	○	○
17 Clothing store(tailoring/fashion/designer shop)	○	○	○	○	○	○
18 Electronics shop	○	○	○	○	○	○
19 Public bus or train stop	○	○	○	○	○	○
20 Taxi or motorbike stop	○	○	○	○	○	○
21 Sports field or court for basketball, soccer, tennis, etc	○	○	○	○	○	○
22 Other outdoor recreation space(park, open space, informal play/recreation area)	○	○	○	○	○	○
	○	○	○	○	○	○

23 Other indoor recreation facilities(recreation center, gymnasium, health or fitness center)						
24 dance or martial arts classes(karate)	○	○	○	○	○	○
25 Tap/well water, pond, river or stream for fresh water (if plumbing is in house, choose "1-5" minutes)	○	○	○	○	○	○
26 Farm (crop planting/animal herding)places for hunting/ collecting firewood.	○	○	○	○	○	○
	1-5 min	6-10 min	11-20 min	20-30 min	30+ min	Don't know

C. Access to services and places

Q37 (Click to edit)

Please select the answer that best applies to you and your neighbourhood. Within easy walking distance means within a 10-15-minute walk from your house.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1 Stores (shops) are within easy walking distance of my house	○	○	○	○
2 There are many places to go, such as food markets and restaurants, within easy walking distance of my house.	○	○	○	○
3 It is easy to walk to a transit/transport stop (bus, taxi, motorbike, tricycle, train) from my house.	○	○	○	○
4 It is easy to walk to an outdoor recreation play space (park, open space, informal play/recreation area) from my house.	○	○	○	○
5 It is easy to walk to an indoor recreation facility (recreation center, gym, health or fitness center) from my house.	○	○	○	○
6 Places to get essential supplies, like water and firewood, are within easy walking distance of my house.	○	○	○	○
7 There are gathering places (community center, king palace, village square, church/worship places etc.) within easy distance of my house.	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree

D. Roads and walking paths in my neighbourhood

Q38 (Click to edit)

Please select the answer that best applies to you and your neighbourhood.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable (few official roads)
1 The distance to walk to the (closest) next street in my neighbourhood is usually short (100 meters or less; the length of a football field or less)	○	○	○	○	○
2 There are many alternative roads (official routes) for getting from place to place in my neighbourhood. (I don't have to go the same way every time.)	○	○	○	○	○
3 There are many unofficial routes (walking/foot paths) connecting places in my area	○	○	○	○	○
4 There are many shortcuts such as foot paths between roads (official routes) in my area.	○	○	○	○	○
5 Some roads (official routes) or walking/foot paths (unofficial routes) in my area are blocked by gates or barriers.	○	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable (few official roads)

E. Places for walking, cycling and playing

Q39 (Click to edit)

Please select the answer that best applies to you and your neighbourhood

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable (few official roads)
1 There are formally provided sidewalks (pedestrian pavements) on most of the roads (official routes) in my neighbourhood	○	○	○	○	○
2 The sidewalks in my neighbourhood are well maintained (paved, even, and not a lot of cracks)	○	○	○	○	○
3 The sidewalks in my neighbourhood are often blocked by merchandise, construction materials, parked cars, gardens/lawns/barricades	○	○	○	○	○
4 Sidewalks are separated from the road (vehicle traffic) in my neighbourhood by parked cars or dedicated parking bays/curbs.	○	○	○	○	○
5 There is a grass/dirt strip that separates the roads from the sidewalks in my neighbourhood.	○	○	○	○	○
6 There are signals or crosswalks/zebra crossings to help walkers cross the busy roads in my neighbourhood	○	○	○	○	○
7 There are curb ramps (decline or smooth grades) that go from sidewalk level to road level at road crossings (intersections/junctions) in my neighborhood to assist the elderly or wheel chair/prams users	○	○	○	○	○
8 There is enough time for people on foot to cross the road at crossing points/junctions with traffic lights, signals or robots	○	○	○	○	○
9 The roads in my neighbourhood are well lit (adequate functioning street lights) at night	○	○	○	○	○
10 There are informal places (walk/foot paths) for people to walk in my neighbourhood	○	○	○	○	○
11 The walk/foot paths in my neighbourhood are generally of good quality (few potholes, ditches, un-evenness, stones, obstructions), so it is not difficult to walk there	○	○	○	○	○
12 In my neighbourhood/area there are busy roads that are dangerous to cross	○	○	○	○	○
13 There are designated or marked places to bicycle, such as separate paths or trails, or shared use paths for cycles and pedestrians in or near my neighbourhood	○	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable (few official roads)

F. Neighbourhood surroundings

Q40 (Click to edit)

Please circle the answer that best applies to you and your neighbourhood.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1 There are trees along the roads/paths in my neighbourhood	○	○	○	○
2 My neighbourhood is clean and free of litter, garbage or stagnant water	○	○	○	○
3 My neighbourhood is free from bad smells and odors	○	○	○	○
4 There are many beautiful natural sights/views in my neighbourhood	○	○	○	○
5 There are attractive buildings/houses in my neighbourhood	○	○	○	○
6 My neighbourhood is generally free of unpleasant noises like highways, factories, trains, bars, music/record studios, nightclubs/discotheques etc	○	○	○	○
7 My neighbourhood is generally free of noticeable pollution and dust, such as from traffic or factories	○	○	○	○
8 There are many pleasant natural sounds in my neighbourhood such as from birds	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree

G. Safety from traffic

Q41 (Click to edit)

Please circle the answer that best applies to you and your neighbourhood.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable (few official roads)
1 There is so much traffic along nearby roads that it is difficult or unpleasant to walk or play in my neighbourhood	○	○	○	○	○
2 The speed of traffic on most nearby roads in my neighbourhood is usually slow	○	○	○	○	○
3 Most drivers exceed the speed limits while driving in my neighbourhood	○	○	○	○	○
4 Walking or playing is dangerous in my neighbourhood because of careless or aggressive driving	○	○	○	○	○
5 It could be dangerous to ride on bicycle in or near my neighbourhood because of speed of traffic	○	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Not applicable (few official roads)

H. Safety from crime

Q42 (Click to edit)

Please circle the answer that best applies to you and your neighbourhood.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1 There is a lot of crime in my neighbourhood	○	○	○	○
2 There is too much crime in my neighbourhood to go outside for walks or play during the day	○	○	○	○
3 There is too much crime in my neighbourhood to go outside for walks or play the night	○	○	○	○
4 There are groups of people or gangs (rascals, hooligans, thugs) in my neighbourhood who make me feel threatened when I go out	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree

Q43 (Click to edit)

Are you are a parent with a child 17 years old or below?

○ Yes

○ No

Q44 (Click to edit)

H.2. If you are a parent with a child 17 years old or below, please answer these questions:

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1 I am worried about letting my child play outside alone or with friends around my house (e.g. yard, driveway, apartment common area), because I am afraid of them being taken or hurt by a stranger	○	○	○	○

2 I am worried about letting my child play or walk alone or with friends in my neighbourhood and local streets because I am afraid of them being taken or hurt by a stranger	○	○	○	○
3 I am worried about letting my child be alone or with friends in a local or nearby park because I am afraid of them being taken or hurt by a stranger	○	○	○	○
4 I am worried about letting my child play or walk in my neighbourhood and local streets because I am afraid of them being injured by a car	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree

I. Additional individual items (Single Items)

Q45 (Click to edit)

Please select the answer that best applies to you and your neighbourhood.

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1 I see and talk to people when I am walking in my neighbourhood	○	○	○	○
2 There are stray dogs or dangerous animals that scare me in my neighbourhood	○	○	○	○
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree

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6. Journal instructions to authors

1. Preparing your manuscript

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- Number every page except the title page, including figures, tables, and references. Cite each figure and table in textin numerical order.
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- References, figures, and tables should be cited in numerical order according to the first mention in the text.
- The total word count consists of Text, References, Tables, and Figures Legends.

Preparing your manuscript

The information below details the section headings that you should include in your manuscript and what information should be within each section.
Please note that your manuscript must include a 'Declarations' section, including all subheadings (please see below for more information).

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The title page should:

- present a title that should be brief, descriptive, and comprehensible. The title includes, if appropriate, the study design.Avoid abbreviations, numbers, formulae, punctuation, and puns.
- list the full names and institutional addresses for all authors
    - if a collaboration group should be listed as an author, please list the Group name. If you would like the namesof the individual members of the Group to be searchable through their individual PubMed records, please include this information in the "Acknowledgements" section following the instructions below
- indicate the corresponding author
- Short title (not to exceed 50 characters, including spaces)
- The total word count of the manuscript (including Text, References, Tables, and Figures Legends)

Abstract

The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract.Reports of randomized controlled trials should follow the CONSORT extension for abstracts. The abstract must include the following separate sections:

- **Background:** the context and purpose of the study
- **Methods:** how the study was performed and statistical tests used
- **Results:** the main findings
- **Conclusions:** brief summary and potential implications
- **Trial registration:** If your article reports the results of a health care intervention on human participants, it must be registered in an appropriate registry, and the registration number and date of registration should be instated in this section. If it was not registered prospectively (before enrollment of the first participant), you should include the words 'retrospectively registered'.

Keywords

Three to ten keywords representing the main content of the article.

Background

The Background section should explain the background to the study, its aims, a summary of the existing literature, and why this study was necessary or its contribution to the field.

Methods

The methods section should include:

- design, and setting of the study
- the characteristics of participants or description of materials
- a clear description of all processes, interventions, and comparisons. Generic drug names should generally be used.When proprietary brands are used in research, include the brand names in parentheses
- the type of statistical analysis used, including a power calculation if appropriate

Results

This should include the findings of the study, including, if appropriate, results of statistical analysis, which must be includedeither in the text or as tables and figures.

Discussion

This section should discuss the implications of the findings in the context of existing research and highlight the limitations oft he study.

Conclusions

This should clearly state the main conclusions and explain the importance and relevance of the study reported.

List of abbreviations

If abbreviations are used in the text, they should be defined at first use, and a list of abbreviations should be provided.

Preparing tables

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- Tables should be numbered and cited in the text in sequence using Arabic numerals (i.e., Table 1, Table 2, *etc*.).
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- TIFF (suitable for images)
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-

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Figures are resized during publication of the final full text and PDF versions, which are detailed below.Figures on the web:

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- width of 85 mm for half page width figure
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- maximum height of 225 mm for figure and legend
- image resolution of approximately 300 dpi (dots per inch) at the final size

Figures should be designed such that all information, including text, is legible at these dimensions. All lines should be widerthan 0.25 pt when constrained to standard figure widths. All fonts must be embedded.

Figure file compression

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Article within a journal supplement

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Book chapter, or an article within a book

Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. International review of cytology. London: Academic; 1980. p. 251-306.

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Complete book, authored

Blenkinsopp A, Paxton P. Symptoms in the pharmacy: a guide to the management of common illness. 3rd ed. Oxford: Blackwell Science; 1998.

Online document

Doe J. Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. 1999. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999.

Online database

Healthwise Knowledgebase. US Pharmacopeia, Rockville. 1998. http://www.healthwise.org. Accessed 21 Sept 1998.

Supplementary material/private homepage

Doe J. Title of supplementary material. 2000. http://www.privatehomepage.com. Accessed 22 Feb 2000.

University site

Doe, J: Title of preprint. http://www.uni-heidelberg.de/mydata.html (1999). Accessed 25 Dec 1999.

FTP site

Doe, J: Trivial HTTP, RFC2169. ftp://ftp.isi.edu/in-notes/rfc2169.txt (1999). Accessed 12 Nov 1999.

Organization site

ISSN International Centre: The ISSN register. http://www.issn.org (2006). Accessed 20 Feb 2007.

Dataset with persistent identifier

Zheng L-Y, Guo X-S, He B, Sun L-J, Peng Y, Dong S-S, et al. Genome data from sweet and grain sorghum (Sorghum bicolor). GigaScience Database. 2011. http://dx.doi.org/10.5524/100012.

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Acknowledgements

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