Metabolic syndrome and the risk of depression across the epidemiological transition.

Viwe Dikoko
SKLVIW002

Dissertation submitted in partial fulfilment of the requirements for
MSc in Epidemiology and Biostatistics

In the
School of Public Health and Family Medicine

Supervisor: Prof Lara Dugas
Co-supervisor: Dr Asanda Mtintsilana

University of Cape Town

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

University of Cape Town

Plagiarism Declaration

I, Viwe Dikoko (SKLVIW002) hereby declare that the work on which this dissertation is based on is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being or is to be submitted for another degree in this or any other university. I empower the university to reproduce for the purpose of research, either the whole or any portion of the contents, in any manner whatsoever.

Signature: Signed by candidate

Date: 11/06/2025

Acknowledgements

I would like to sincerely thank my supervisor, Prof. Lara Dugas, for her guidance and support. Her insights and encouragement have been invaluable throughout this journey. Your reviews and feedback greatly contributed to the quality and depth of my work. A big thank you to my co-supervisor, Dr Asanda Mtintsilana for the consistent feedback and check-ins, which helped keep me on track and refine my work. Your attention to detail and thoughtful suggestions made a significant difference.

I am also grateful to the Candice Choo-Kang and Dr Larske Soepnel for their guidance and support with data-related aspects of this research. Their assistance in helping me understand what data was available, facilitating access, and always being available to answer my questions was invaluable.

Lastly, I want to express my deepest appreciation to my family and friends for their unwavering support over the past three years of doing this degree. Your encouragement and patience have meant the world.

Thank you all!

Abstract

Background: Depression and metabolic syndrome (MetS) are rising public health concerns globally. While existing evidence suggests that MetS and its components may increase the risk for depression, much of the research has not been conducted on African origin populations. This study examines the association between MetS and the risk for depression in a cohort of African-origin in Ghana, South Africa, Jamaica, Seychelles, and the United States (US), focusing on gender and regional disparities.

Methods: This secondary data analysis utilized data from 446 participants in the METS and METS-Microbiome study, which followed African-origin adults from five countries between 2010 and 2019. MetS was defined as 3 or more of the following: elevated blood pressure, low HDL, elevated triglycerides, or high glucose. Depression was measured using the Center for Epidemiological Studies Depression (CESD) scale, with a score of ≥16 indicating depressive symptoms. Logistic regression analyses examined the relationship between MetS and risk for depression, stratified by gender, while controlling for demographic and behavioural factors.

Results: The prevalence of MetS was 12% in Ghana (N=23), 17% in SA (N=9), 29% in Jamaica (N=26), 27% in Seychelles (N=33), and 39% in the US (N=36). The prevalence of depression was 15% in Ghana (N=29), 25% in SA (N=13), 18% in Jamaica (N=16), 9% in Seychelles (N=11) and 33% in the US (N=30). No significant overall association between MetS and depression was found. However, in men, individual MetS components showed weak associations at $p < 0.1$. High blood pressure (OR = 3.46, $p<0.1$) and low HDL (OR = 3.45, $p<0.1$) were associated with higher odds of depression, while obesity appeared protective (OR = 0.20, $p<0.1$). Women showed higher rates of obesity, abdominal adiposity, and depression, particularly in Jamaica, Seychelles, and the US. Age inversely correlated with depression in both genders, with older individuals reporting fewer symptoms. Regionally, living in Ghana, Seychelles, and Jamaica was linked to lower odds of depression compared to the US.

Conclusions: This study underscores significant gender and geographic differences between the risk for depression and MetS. Overall, obese women had a greater risk for depression, while men presenting with depression had elevated blood pressure, low HDL (High-Density Lipoprotein). Similarly, geographic differences further emphasize the role of local sociocultural and environmental factors. These findings highlight the need for tailored public health interventions addressing the distinct health risks and behavioural profiles of men and women across diverse settings, with a focus on mitigating the dual burden of metabolic and psychological health challenges.

List of Abbreviations

MetS: Metabolic Syndrome

CES-D: Center for Epidemiologic Studies Depression Scale

HDL: High-Density Lipoprotein

TG: Triglycerides

BMI: Body Mass Index

BP: Blood Pressure

US: United States

OR: Odds Ratio

SA: South Africa

HDI : Human Development Index

WC: Waist Circumference

TG: Triglycerides

HDL: High Density Lipoproteincholesterol

SBP: Systolic Blood Pressure

DBP: Diastolic Blood Pressure

Table of Contents

List of Tables and Figures

Part A: Protocol

1. Research Question

Research Question: Does the relationship between metabolic syndrome and risk of depression differ in African-origin adults spanning the epidemiologic transition?

Aims and Objectives: The study aims to measure metabolic syndrome and risk of depression in 1000 African-origin adults from five countries spanning the epidemiologic transition.

Rationale: To date, much of the research exploring the relationship between metabolic syndrome and depression has been conducted on primarily European populations, with little investigations among African-origin populations or African regions. This is a major gap in the literature, given that both the risk for metabolic syndrome and depression among African-origin populations has been increasing over the years, due to shifts in diet, work, environmental factors and more. Additionally, the pace at which different nations encounter modifications in lifestyle patterns is contingent upon their respective stages within the epidemiological transition. Comprehending the nuances of the epidemiological transition illuminates the evolution of food and disease environments in the countries included in our study, and how the evolutions moderate the relationship between metabolic syndrome and risk of depression. Given the existing limitations in current literature, this study will significantly add to the existing body of literature in a multi-country study of African-origin adults and health outcomes.

Hypothesis: We hypothesize that metabolic syndrome is positively associated with risk of depression in 5 African-origin populations, irrespective of country of origin.

2. Background & Literature Review

Globally, an estimated 5% of adults suffer from depression and more than 280 million people in the world have depression (WHO, 2023). Metabolic syndrome (MetS) is a cluster of several cardiometabolic (CM) risk factors, including central obesity, hyperglycaemia, elevated blood pressure, hypertriglyceridemia, and low HDL cholesterol (Grundy et al., 2005). The cut-points for each risk factor are: (i) a waist circumference above 94 cm for men and 80 cm for women (ii) low HDL is below 40 mg/dL in men and 50 mg/dL in women (iii) Elevated blood pressure occurs when systolic blood pressure is above 135 mmHg or the diastolic blood pressure is above 85 mmHg (iv) impaired fasting glucose greater than 100 mg/dL (5.6 mmol/L) and (v) Elevated Triglycerides (TG) greater ≥150 mg/dL.

Depression and MetS are significant contributors to the global burden of disease, and they often co-occur, creating a complex web of physical and mental health challenges. The presence of depression is associated with an increased likelihood of developing MetS, and conversely, MetS is linked to a heightened risk of depression. The coexistence of these conditions is known to result in poorer clinical outcomes and diminished quality of life (Jani & Cavanagh et al., 2014). Observational studies (Jani et al., 2014; Huang et al., 2022; Gelaye et al., 2019; Qiao, Ding & Li, 2022; Luppiono et al., 2010) have consistently shown that depression and MetS are both precursors of type 2 diabetes and CVD, which have a

bidirectional link to each other. However, the temporal direction of this association remains unclear (Pan & Keum, 2012). Diabetes and obesity intersect with chronic depression more frequently in low-income populations because of the strong relationship between depression and poverty and the stresses linked to poor access to health care (Singh, Pella & Mechivora, 2007; Mendenhall et al., 2017).

The connection between depression and Metabolic Syndrome (MetS) is driven by overlapping biological mechanisms, including chronic inflammation, oxidative stress, and disruption of the hypothalamic-pituitary-adrenal (HPA) axis (Nouwen et al., 2010; Mendenhall et al., 2017). Depression is linked to increased levels of pro-inflammatory cytokines, such as interleukin-6 and tumor necrosis factor-alpha, which contribute to atherosclerosis and insulin resistance (Nouwen et al., 2010). Additionally, HPA axis dysfunction can cause excess cortisol production, promoting abdominal obesity, insulin resistance, and abnormal lipid profiles.

Multiple risk factors contribute to the coexistence of depression and MetS. These include genetic predispositions, lifestyle patterns such as physical inactivity, poor dietary habits, and smoking, as well as socioeconomic conditions and psychological stressors(Marizziti et al., 2014; Al-Khatib et al., 2022). Furthermore, some antidepressant medications, known for their potential side effects, may induce weight gain and disrupt metabolic processes, intensifying the relationship between these conditions.

Given that metabolic syndrome and depression have a bidirectional relationship, in this study we will be focusing on how metabolic syndrome increases the risk of depression among people of African-origin. The relationship between MetS and the risk of depression in this population group is largely under-recognised and unclear although there is the growing literature on sub-Saharan Africa or African Americans. For example, Gurka & Vishnu et al. (2016) find that in African American women but not men, higher depressive symptoms were associated with higher MetS severity. Similarly, Cooper (2013) found that in African American women, depressive symptoms promoted premature CVD risk. In contrast to data from the United States, Gelaye et al. (2019) and Brinkmann et al. (2020) both found no significant association between depressive disorders and cardiometabolic diseases in sub-Saharan African adults.

Epidemiologic transition

The concept of epidemiologic transition refers to shifts in population trends influenced by changes in mortality rates, fertility patterns, life expectancy, and primary causes of death. (Zuckerman, Harper, Barrett & Armelagos, 2014). Several studies (e.g., Singh, Pella & Mechivora, 2007; Tokunaga et al., 2012; Gaziano, 2010) report a rise in depression rates during the epidemiologic transition, driven by factors such as urbanization, social displacement, and shifts in lifestyle behaviors. This period of transition is also marked by an increase in metabolic syndrome prevalence, often intertwined with depressive disorders in complex ways.

Ghana, SA, Jamaica, Seychelles, and the US represent varying levels of social and economic development, as classified by the 2010 UN Human Development Index (HDI) (Barrow &

Lee, 2011). According to the HDI, Ghana is categorized as a low HDI country, South Africa as middle HDI, Jamaica and Seychelles as high HDI, and the United States as a very high HDI country. Countries at different HDI levels face distinct structural challenges—such as nutritional transitions, healthcare access, psychosocial stress, and urbanization—that can influence both the prevalence and co-occurrence of MetS and depression. Lower HDI settings may experience underdiagnosis of metabolic conditions and limited mental health services, while higher HDI contexts often contend with sedentary lifestyles and processed diets (Cifuentes et al., 2008; Manyanga et al., 2017). This study's inclusion of sites across the HDI spectrum provides an opportunity to explore how social and economic development moderates the MetS–depression relationship—an area that remains underexplored in the literature. These differences also reflect that each site is at a distinct phase of the epidemiologic transition, often accompanied by nutrition and health transitions driven by modernization (Mendenhall et al., 2017). Economic growth and urbanization have led to shifts from traditional, plant-based diets to processed, calorie-dense foods and sugary beverages, contributing to the rise in obesity and related non-communicable diseases (NCDs).

Understanding the context of the epidemiologic transition provides insight into how food systems and disease patterns have changed over time in the countries included in this study. It further emphasizes why the prevalences of depression and MetS are growing public health concerns. Additionally, there is a clear gap in existing literature focusing on populations of African origin.

3. Methodology

3.1. Study Design

For this study, we will perform secondary data analysis from participants originally enrolled in the Modelling the Epidemiologic Transition Study (METS) and its ancillary studies METS-Microbiome Baseline (2018-2019) and METS-Microbiome follow-up (2021-2022). The original METS study was a prospective, longitudinal study of weight change among African-origin adults (Luke & Dugas, 2011; Dugas, Lie & Plange-Rhule et al., 2018).

3.2. Study Population & Sampling

The METS study initially recruited 2,500 adults of African origin from five locations—rural Ghana, urban South Africa, urban Jamaica, Seychelles, and suburban United States (Chicago area)—between January 2010 and September 2011. Participants, aged 25-45, underwent baseline assessments of energy expenditure, dietary intake, body composition, and biomarkers related to obesity and diabetes. Over the following 24 months, changes in body weight, composition, and diabetes or cardiovascular disease risk were monitored.

The METS-Microbiome study, conducted between 2018 and 2021, followed approximately 2,000 participants from the original METS cohort, collecting annual biological samples to assess obesity risk, gut microbiota, and stool short-chain fatty acids (SCFAs). Retention rates across all sites exceeded 60%.

These study sites were selected to capture a range of experiences within the 'epidemiologic transition,' with Ghana and the US representing opposite ends of the spectrum. Mean BMI ranged from 24 kg/m² in rural Nkwantakese, Ghana, to 31 kg/m² in suburban Maywood, USA. Each site recruited 500 participants. The in-country locations included Nkwantakese in Ghana (population ~17,000), Khayelitsha in South Africa (population ~500,000), Kingston in Jamaica (population ~651,880), Mahé Island in Seychelles (population ~75,000), and Maywood, Illinois, USA (population ~24,903).

Participants with infectious diseases, including active malaria, HIV, or conditions limiting physical activity, such as severe arthritis or disability, were excluded. Pregnant or lactating women were also not eligible.

Recruitment strategies varied by site. In Nkwantakese, Ghana, a simple random sample from the local census was used. In Seychelles and South Africa, sex- and age-stratified random samples were drawn from national censuses. In Kingston, Jamaica, random district sampling was followed by door-to-door recruitment. Similarly, in Maywood, Illinois, randomized city blocks were used for door-to-door recruitment.

3.3. Procedures and Data Collection

Data collected from the METS-Microbiome study will be used for this proposed study. This data was collected using enrolment and follow-up questionnaires as well as biological samples and measurements.

Enrolment and Follow-up Questionnaires

In the parent study, the enrolment questionnaire collected data on self-reported measures such as physical activity (GPAQ), dietary intake (24-hr Recall), medication & supplement use, smoking status and alcohol consumption, and health history. It also included demographics such as household socioeconomic status, education level, industry of employment and occupation. All participants completed the questionnaire at baseline and during follow-up visit. During the 12-month follow-up, medication use, smoking status and health history were the only questions asked. At the 24-month follow up, all reported self-measures were taken except for the dietary intake (24hr recall).

See Appendix A: Table 1 for summary of the data collected at baseline and follow-up periods.

Biological samples and measurements

The METS study included baseline, 12-month, and 24-month follow-up assessments, all conducted at outpatient clinics within the participating METS communities. Standardized procedures and uniform equipment were used to collect anthropometric measurements, including weight, height, and waist and hip circumferences. Blood pressure was measured in triplicate at two time points during each visit using an automatic digital monitor (model

HEM-747Ic, Omron Healthcare, Bannockburn, IL, USA). Body composition was evaluated through bioelectrical impedance analysis at each examination.

Fasting blood samples were obtained to measure glucose, insulin, lipids, albumin, adipose-related hormones, and adipocytokines. Spot urine samples were collected at baseline to assess urinary albumin and creatinine levels. Additionally, unused whole blood, plasma, serum, and urine samples were preserved at -80°C for future research. Fecal samples were analyzed from all participants to assess gut microbiota and short-chain fatty acids (SCFAs).

See Appendix A: Table 2 for variables that will be used in the proposed study.

3.4. Variable Definitions

Outcome of interest: Depression

Participants were asked to complete the Kessler Psychological Distress Scale 10 item (K10) of the Centre for Epidemiologic Studies Depression (CES-D) Scale at follow-up. Using this scale, the depression outcome was assessed as a sum of scores of the 20 items which ranges from 0 to 30. A score of 16 or above (CES-D score≥ 16) indicates the presence of mild to significant depression.

Exposure of interest: Metabolic syndrome

Metabolic syndrome is defined as the presence of abdominal obesity and two or more of the metabolic syndrome components, according to the Harmonized MetS criteria (Alberti, Eckel & Grundy et el., 2009) and is defined below:

- We defined abdominal obesity as those having a waist circumference of ≥94 cm for men and ≥80 cm for women. The criteria for US is ≥102 cm for men and ≥88 cm for women.
- Low High-density Lipoprotein Cholesterol (HDL-C) is defined to be <1.0 mmol/L (40 mg/dL) in men and <1.3 mmol/L (50 mg/dL) in women.
- Elevated blood pressure is defined as a systolic blood pressure≥135 mmHg or a diastolic blood pressure≥85 mmHg.
- Impaired fasting glucose is defined to be ≥ 5.6 mmol/L (100 mg/dL) or with a previous history of diabetes.
- Elevated Triglycerides (TG) was defined as ≥1.7 mmol/L (150 mg/dL).

Confounders:

Confounders: age, sex, employment status, cardiovascular risks, socioeconomic status, BMI, physical activity, smoking, medication use and alcohol consumption.

4. Data Analysis

The statistical analysis of this study will be conducted using R. The differences in characteristics for (i) all participants (ii) those with MetS at baseline and (iii) those with MetS and depression at the end of the study will be compared using statistical tests. Regression analysis will be used to measure the strength of association between depression and

metabolic syndrome at the different study sites. The covariates of interest include age, sex, site, BMI, smoking, alcohol use, education, employment status and marital status.

5. Ethics

5.1. Use of Secondary Data

There are specific rules that have been set to minimise the risk of any loss of confidentiality throughout study design and conduct. All participants who participated in the original METS study signed informed consent forms and were assigned unique identifier codes at each local research site. Thereafter, all consent forms and questionnaires were scanned and encrypted electronically and stored on a secure database that can only be accessed by the authorised staff. To access the anonymised dataset for our analyses, we will submit an official request to the Data Manager at Loyola University Chicago. Professor Dugas has a dedicated Research Manager at Loyola University Chicago, the coordinating centre for the METS cohort, who oversees all the data management.

We will verify the integrity of the secondary data to ensure that it is accurate and reliable. This includes critically assessing the methodology used in the original data collection and understanding any limitations or biases that may have been present. By doing so, we can make informed decisions about the applicability of the data to our research question and minimize the risk of drawing erroneous conclusions.

We will maintain the confidentiality and security of the secondary data we use. We will also ensure that any reporting of the data is done in a way that maintains confidentiality and does not allow for the re-identification of individuals. We will clearly document our use of secondary data, including how the data were obtained, and any transformations or analyses performed. The original data collectors will be properly cited and acknowledged in any publications or presentations resulting from our research.

5.2. Ethics Clearance

This study protocol was submitted for ethical approval to the Research Ethics Committee of the University of Cape Town. The protocol was approved (HREC: 563/2024). The protocol for the parent METS study was approved by the Institutional Review Board of Loyola University Chicago, IL, USA; the Committee on Human Research Publication and Ethics of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; the Research Ethics Committee of the University of Cape Town, South Africa; the Board for Ethics and Clinical Research of the University of Lausanne, Switzerland; the Ethics Committee of the University of the West Indies, Kingston, Jamaica; and the Health Sciences Institutional Review Board of the University of Wisconsin, Madison, WI, USA. Written informed consent was obtained from all participants.

Professor Dugas is the PI of the main study, which was approved through Loyola University Chicago (LU209537). The South Africa arm was approved under the following HREC 698_2014.

References

Al-Khatib, Y., Akhtar, M. A., Kanawati, M. A., Mucheke, R., Mahfouz, M., & Al-Nufoury, M. (2022). Depression and Metabolic Syndrome: A Narrative Review. Cureus. https://doi.org/10.7759/cureus.22153.

Barro, R.J., Lee, J.W. (2011). The National Bureau of Economic Research; 2011. A New Data Set of Educational Attainment in the World, 1950-2010. Volume NBER Working Paper No. 15902.

Brinkmann, B., Payne, C.F., Kohler, I., Harling, G., Davies, J., Witham, M., Siedner, M.J., Sie, A., Bountogo, M., Ouermi, L., Coulibaly, B. & Bärnighausen, T. (2020). Depressive symptoms and cardiovascular disease: a population-based study of older adults in rural Burkina Faso. BMJ Open; 10(12):e038199. doi: 10.1136/bmjopen-2020-038199. PMID: 33371016; PMCID: PMC7757460.

Bruce, M. L., Takeuchi, D. T., & Leaf, P. J. (1991). Poverty and psychiatric status: Longitudinal evidence from the New Haven Epidemiologic Catchment Area Study. *Archives of General Psychiatry, 48*(5), 470-474.http://dx.doi.org/10.1001/archpsyc.1991.01810290082015

Cifuentes, M., Sembajwe, G., Tak, S., Gore, R., Kriebel, D., & Punnett, L. (2008). The association of major depressive episodes with income inequality and the human development index. *Social science & medicine*, *67*(4), 529-539.

Cooper, D.C., Trivedi, R.B., Nelson, K.M., Reiber, G.E., Zonderman, A.B., Evans, M.K. & Waldstein, S.R. (2013). Sex Differences in Associations of Depressive Symptoms with Cardiovascular Risk Factors and Metabolic Syndrome among African Americans. Cardiovasc Psychiatry Neurol.; 2013:979185. doi: 10.1155/2013/979185. Epub 2013 Sep 16. PMID: 24151548; PMCID: PMC3787626.

De Wit ,L,. Luppino, F., Van Straten, A., Penninx, B., Zitman, F. & Cuijpers, P. (2010). Depression and obesity: A meta-analysis of community-based studies. Psychiatry Research ;**178**:230–235. doi: 10.1016/j.psychres.2009.04.015.

Dugas, L.R., Lie, L., Plange-Rhule, J. *et al.* (2018). Gut microbiota, short chain fatty acids, and obesity across the epidemiologic transition: the METS-Microbiome study protocol. *BMC Public Health* **18**, 978. https://doi.org/10.1186/s12889-018-5879-6

Gaziano, J.M. (2010). Fifth phase of the epidemiologic transition: the age of obesity and inactivity. *Jama*, *303*(3), pp.275-276.

Gelaye, B., Williams, M.A., Lemma, S., Berhane, Y., Fann, J.R., Vander Stoep, A. & Zhou, X.H. (2019). Major depressive disorder and cardiometabolic disease risk among sub-Saharan

African adults. Diabetes Metab Syndr.; 9(3):183-91. doi: 10.1016/j.dsx.2014.05.003. Epub 2014 Jun 14. PMID: 25470634; PMCID: PMC4265581.

Gurka, M.J., Vishnu, A., Okereke, O.I., Musani, S., Sims, M. & DeBoer, M.D. (2016). Depressive symptoms are associated with worsened severity of the metabolic syndrome in African American women independent of lifestyle factors: A consideration of mechanistic links from the Jackson heart study. Psychoneuroendocrinology.; 68:82-90. doi: 10.1016/j.psyneuen.2016.02.030. Epub 2016 Mar 3. PMID: 26963374; PMCID: PMC5105331.

Grundy, S.M., Cleeman, J.I., Daniels, S.R., et al. (2005). National Heart, Lung, and Blood Institute Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005;112:2735–2752

Huang, Z.T., Luo, Y., Han, L., Wang, K., Yao, S.S., Su, H.X., Chen, S., Cao, G.Y., De Fries, C.M., Chen, Z.S., Xu, H.W., Hu, Y.H. & Xu B. (2022). Patterns of cardiometabolic multimorbidity and the risk of depressive symptoms in a longitudinal cohort of middle-aged and older Chinese. J Affect Disord ;301:1-7. doi: 10.1016/j.jad.2022.01.030.

Jani, B.D., Boachie, C., McCowan, C., Barry, S.J.E., Cavanagh, J. & Mair, F.S. (2017). Relationship of depression screening in metabolic syndrome with vascular events and mortality: findings from a large primary care cohort with 4 years follow-up. Eur Heart J Qual Care Clin Outcomes ;3(1):61-73. doi: 10.1093/ehjqcco/qcw045. PMID: 28927181.

Jani, B.D., Cavanagh, J., Barry, S.J., Der, G., Sattar, N. & Mair, F.S. (2014). Revisiting the J shaped curve, exploring the association between cardiovascular risk factors and concurrent depressive symptoms in patients with metabolic syndrome: Findings from a large cross-sectional study. BMC Cardiovasc Disord.;14:139. doi: 10.1186/1471-2261-14-139. PMID: 25352020; PMCID: PMC4271339.

Kassi, E., Pervanidou, P., Kaltsas, G. et al. (2011). Metabolic syndrome: definitions and controversies. BMC Med 9, 48. https://doi.org/10.1186/1741-7015-9-48

Knight, R., Cedillo, Y., Judd, S., Tison, S., Baker, E. & Moellering, D. (2022). Dietary inflammation score is associated with perceived stress, depression, and cardiometabolic health risk factors among a young adult cohort of women. Clin Nutr ESPEN. ;51:470-477. doi: 10.1016/j.clnesp.2022.06.013. Epub 2022 Jun 27. PMID: 36184244.

Lee, A., Cardel, M. & Donahoo, W.T. (2012) .Social and Environmental Factors Influencing Obesity. South Dartmouth (MA): MDText.com, Inc.; 2000. Available from: https://www.ncbi.nlm.nih.gov/books/NBK278977/

Luke, A., Bovet, P., Forrester, T.E., Lambert, E.V., Plange-Rhule, J., Schoeller, D.A., Dugas, L.R., Durazo-Arvizu, R.A., Shoham, D., Cooper, R.S., Brage, S., Ekelund, U. & Steyn, N.P. (2011). Protocol for the modeling the epidemiologic transition study: a longitudinal observational study of energy balance and change in body weight, diabetes and

cardiovascular disease risk. BMC Public Health.;11:927. doi: 10.1186/1471-2458-11-927. PMID: 22168992; PMCID: PMC3297543.

Luppino, F.S., de Wit, L.M., Bouvy, P.F., Stijnen, T., Cuijpers, P., Penninx, B.W. & Zitman, F.G. (2010). Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry ;**67**:220–229.
doi: 10.1001/archgenpsychiatry.2010.2.

Manyanga, T., Tremblay, M. S., Chaput, J. P., Katzmarzyk, P. T., Fogelholm, M., Hu, G., ... & Broyles, S. T. (2017). Socioeconomic status and dietary patterns in children from around the world: different associations by levels of country human development?. *BMC Public Health*, *17*, 1-11.

Marazziti, D., Rutigliano, G., Baroni, S., Landi, P., & Dell'Osso, L. (2014). Metabolic syndrome and major depression. In CNS Spectrums (Vol. 19, Issue 4, pp. 293–304). Cambridge University Press. https://doi.org/10.1017/S1092852913000667.

Martin, D.J., Ul-Haq, Z., Nicholl, B.I., Cullen, B., Evans, J., Gill, J.M., Roberts, B., Gallacher, J., Mackay, D., McIntosh, A., Hotopf, M., Craddock, N., Deary, I.J., Pell, J.P. & Smith, D.J. (2016). Metabolic syndrome and features of depression and bipolar disorder: population-based, cross-sectional study. Br J Psychiatry ;208(4):343-51. doi: 10.1192/bjp.bp.114.157784. Epub 2016 Jan 21. PMID: 26795427.

Mendenhall, E., Kohrt, B.A,. Norris, S.A., Ndetei, D. & Prabhakaran, D. (2017). Non-communicable disease syndemics: poverty, depression, and diabetes among low-income populations. Lancet. ;389(10072):951-963. doi: 10.1016/S0140-6736(17)30402-6. PMID: 28271846; PMCID: PMC5491333.

McKeown, R.E., (2009). The epidemiologic transition: changing patterns of mortality and population dynamics. *American journal of lifestyle medicine*, *3*(1_suppl), pp.19S-26S.

Nouwen, A., Winkley, K., Twisk, J., Lloyd, C.E., Peyrot, M., Ismail, K. and Pouwer, F., (2010). Type 2 diabetes mellitus as a risk factor for the onset of depression: a systematic review and meta-analysis. *Diabetologia*, *53*(12), pp.2480-2486.

Pan, A., Keum, N., Okereke, O.I., Sun, Q., Kivimaki, M., Rubin, R.R. & Hu, F.B. (2012). Bidirectional association between depression and metabolic syndrome: a systematic review and meta-analysis of epidemiologic studies. Diabetes Care: 35(5):1171-80. doi: 10.2337/dc11-2055. PMID: 22517938; PMCID: PMC3329841.

Qiao, Y., Ding, Y., Li, G., Lu, Y., Li, S. & Ke, C. (2022). Role of depression in the development of cardiometabolic multimorbidity: Findings from the UK Biobank study. J Affect Disord. ;319:260-266. doi: 10.1016/j.jad.2022.09.084. Epub 2022 Sep 23. PMID: 36162655.

Singh, R.B., Pella, D., Mechirova, V., et al. (2007). Prevalence of obesity, physical inactivity and undernutrition, a triple burden of diseases during transition in a developing economy. The Five City Study Group. Acta Cardiol ; 62: 119-27.

Tokunaga, M., Takahashi, T., B Singh, R., Rupini, D., Toda, E., Nakamura, T., Mori, H., L Marks, B. and W Wilson, D., (2012). Diet, nutrients and noncommunicable diseases. *The Open Nutraceuticals Journal*, *5*(1).

Van der Feltz-Cornelis, C.M., Nuyen, J., Stoop, C., Chan, J., Jacobson, A.M., Katon, W., Snoek, F. and Sartorius, N., (2010). Effect of interventions for major depressive disorder and significant depressive symptoms in patients with diabetes mellitus: a systematic review and meta-analysis. *General hospital psychiatry*, *32*(4), pp.380-395.

Zuckerman, M., Harper, K., Barrett, R. and Armelagos, G., (2014). The evolution of disease: anthropological perspectives on epidemiologic transitions. *Global health action*, *7*(1), p.23303.

World Health Organization. (2023). Depressive disorder (depression). Available [online]: https://www.who.int/news-room/fact-sheets/detail/depression [Accessed: December 2023]

Part B: Literature Review

1. Introduction and Background

Globally, an estimated 25% of adults have metabolic syndrome, while 5% of adults suffer from depression (IDF, 2015, WHO, 2023). Metabolic syndrome (MetS) is a cluster of several cardiometabolic (CM) risk factors, including central obesity, hyperglycemia, elevated blood pressure, hypertriglyceridemia, and low HDL cholesterol (Alberti, Eckel & Grundy et al., 2009).

Both depression and MetS are significant contributors to the global burden of disease, and they often co-occur, creating a complex web of adverse physical/clinical and mental health outcomes including poor quality of life. There is a bidirectional association between depression and metabolic syndrome (MetS), whereby the presence of depression is linked to a heightened risk of developing MetS, and conversely, MetS is associated with an elevated risk of experiencing depression (Jani & Cavanagh et al., 2014). However, the temporal nature of this relationship remains unclear (Pan & Keum, 2012). Some studies have shown that type 2 diabetes and obesity intersect with chronic depression more frequently in low-income populations due to the strong relationship between depression and poverty, including stresses linked to poor access to health care (Singh, Pella & Mechivora, 2007; Mendenhall et al., 2017).

The connection between depression and metabolic syndrome (MetS) is driven by overlapping biological mechanisms (Nouwen et al., 2010; Mendenhall et al., 2017). Key contributors to this link include chronic inflammation, oxidative stress, and dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis. Depression is linked to increased levels of pro-inflammatory cytokines, such as interleukin-6 and tumor necrosis factor-alpha, which facilitate the development of atherosclerosis and insulin resistance (IR) (Marazziti et al., 2023). Additionally, disturbances in HPA axis function can result in excessive cortisol production, promoting abdominal obesity, IR, and dyslipidemia (Al-Khadib et al., 2022). Several shared risk factors underlie the coexistence of depression and MetS. These include genetic predispositions, lifestyle behaviors such as physical inactivity, unhealthy dietary patterns, and smoking. Socioeconomic factors and psychosocial stressors further compound the relationship between these conditions (Pan et al., 2010; Marazziti et al., 2014; Marazziti et al., 2023). Additionally, certain medications used in the treatment of depression, such as some antidepressants, may be associated with weight gain and metabolic disturbances, further complicating the relationship (Vaccarino, McClure & Johnson et al., 2008).

Given that MetS and depression have a bidirectional relationship, in this study will explore the relationship between MetS and the risk of depression among people of African-origin. This is particularly timely, given that the little is known of this relationship among this population, although there is the growing literature on sub-Saharan Africa or African Americans. For example, Gurka & Vishnu et al. (2016) showed that higher depressive symptoms in African American women but not men were associated with higher MetS severity. Similarly, Cooper (2013) found that depressive symptoms increased premature CVD risk in African American women. Gelaye et al. (2019) and Brinkmann et al. (2020) both found no significant association between depressive disorders and cardiometabolic diseases in sub-Saharan African adults.

Understanding the country-level context for the populations affected by depression and metabolic syndrome is paramount, because it provides insights into how socioeconomic factors, environment, lifestyle norms and culture play a role in the prevalence of disease (Noubiap et al., 2022).The METS study sites (Ghana, SA, Jamaica, Seychelles, and the US) represent a range of social and economic

development as defined by the United Nation (UN) Human Development Index (HDI) 2010: Ghana is defined as a low HDI country, followed by SA, as middle HDI country, then Jamaica and Seychelles which are both high HDI countries and lastly the US which is classified as a very high HDI country (Barrow & Lee, 2011). This implies that each of the study sites are at different stages of epidemiologic transition. The epidemiologic transition describes changing patterns of population distributions in terms of mortality, fertility, life expectancy rates, and leading causes of death (Zuckerman, Harper, Barrett & Armelagos, 2014).

2. Aims and Objectives

The aim of the literature review was to identify literature on the prevalence of depression and metabolic syndrome in Ghana, South Africa, Jamaica, Seychelles and United States. It gives an overview of the determinants of depressions and metabolic syndrome, and how the pathways of these diseases overlap. The literature is synthesized to identify knowledge gaps in existing research to motivate the need to look at the relationship between depression and metabolic syndrome for people of Africa-origin in the epidemiological transition.

3. Literature Search Strategy

The search for literature relating to the study was conducted through PubMed and Google Scholar. All study designs were included and priority was given to studies conducted in the study sites (Ghana, South Africa, Jamaica, Seychelles and United States). All available observational studies (cross-sectional, cohort and case-control), systematic reviews and reports/policy documents that reported the prevalence of MetS in people of African-origin or the study countries were eligible. Studies and reports on the disease pathways of MetS and depression were also eligible even if they were not specifically conducted on people of African-origin or the study countries. The search was restricted to documents written in English language. There were no limitations on the target groups in terms of age and sex. Publications on maternal depression (prenatal and post-partum) or depression with HIV were excluded. The articles chosen were published between January 2005 and October 2024.

The search terms used were conceptually guided and informed by both an initial scoping review of the literature and preexisting knowledge of the subject matter. The search terms included variations of the following keywords with the use of different Boolean operators:

“depression”, “depressive disorder”, “major depressive disorder”, “metabolic syndrome”, “insulin resistance”, “cardiovascular disease risk”, “cardiovascular disease”, “African-origin”, “Ghana”, “South Africa”, “Jamaica”, “Seychelles”, “United States”, “epidemiologic transition”.

4. Definition of depression and metabolic syndrome

4.1. Depression

Major depressive disorder is categorized as a depressed mood or a loss of interest or pleasure in daily activities for more than two weeks (Kumar et al., 2012; WHO, 2023). Additionally, five of the nine specific symptoms must be present nearly every day, which include depressed mood or irritability, decreased interest in most activities, significant change in weight and appetite, change in sleep, psychomotor agitation or retardation, fatigue, feelings of worthlessness, diminished concentration, and suicidal thoughts (Kumar et al., 2012). Depression has a recurrent pattern as patients go through periods of symptomatic episodes and periods of recovery (Greden, 2001). In the absence of treatment intervention, depression episodes accelerate and increase in severity.

Several self-report symptom scales can be used to measure depression in epidemiological studies including the Centre for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977), Patient Health Questionnaire (PHQ-9) (Martin, Rief, Klaiberg et al., 2006), Mental Health Interview (MHI-5) (Have et al., 2024), Major Depression Inventory (Bech et al., 2001). The original 20-item CES-D scale was designed to measure current level of depression symptoms, with emphasis on the affective component, depressed mood. It includes six components: depressed mood; feelings of guilt and worthlessness; feelings of helplessness and hopelessness; psychomotor retardation; loss of appetite; and sleep disturbance. The scale is a self-report measure of depression symptoms and is not intended be a clinical diagnostic tool. Respondents indicate how often within the last week they experienced the symptoms, responding: “rarely or none of the time” (0); “some or little of the time” (1); “occasionally or a moderate amount of time” (2); and “most or all of the time” (3). The scores for the 20 items are added, resulting in a range of possible total scores from 0 to 60.

Shorter versions of the CES-D 20 item scale have subsequently been developed, including the Andresen’s 10-item version (CES-D 10), generated through item-total correlations with the original 20-item CES-D. The depression outcome was assessed as a sum of scores of the 10 items which ranges from 0 to 30. In Andresen’s original study, a cut-off score of 10 on the CES-D-10 was identified as optimal to identify individuals at risk of depression. Studies focusing on the diagnostic validity and reliability of the CES-10 scale in different countries suggest a cut-off between 8 and 16 (Baron, Davies & Lund, 2017). For example, the recommended cut-off in the US is 16. In South Africa, the most balanced sensitivity for Xhosa, Zulu and Afrikaans speaking populations was 12 (Baron, Davies & Lund, 2017). For this study, a total score of 16 or higher was used as the cut-off point to indicate elevated depressive symptomatology, consistent with established thresholds in the literature.

4.2. Metabolic Syndrome

Metabolic syndrome (MetS) is defined as the presence of three or more cardiometabolic risk factors, which may include central obesity, high blood sugar, elevated blood pressure, increased triglyceride levels, and reduced HDL cholesterol (Alberti, Zimmet, & Shaw, 2005). Diagnosing MetS helps identify those with an elevated likelihood of developing type 2 diabetes (T2D) and cardiovascular disease (CVD) (Huang, 2009; Alberti, Eckel, & Grundy et al., 2009). Individuals exhibiting only a single risk factor, such as hypertension or obesity, face a lower risk of T2D or CVD compared to those meeting the criteria for MetS. For instance, isolated hypertension increases CVD risk, but not to the extent observed in those with multiple cardiometabolic abnormalities. Similarly, isolated obesity raises the likelihood of T2D but poses less risk than a confirmed MetS diagnosis.

The Harmonized MetS criteria (Alberti, Eckel & Grundy et al., 2009) for MetS requires multiple risk factors as mentioned above. Each of the qualifying risk factors has its own diagnostic cut-offs which can also differ for men and women. The standardized cutoff points for each risk factor are listed in Table 1: (i) a waist circumference (WC) above 94 cm for males and 80 cm for females. For the US, the criterion is ≥102cm for males and ≥88cm for females (ii) low HDL is below 40 mg/dL in males and 50 mg/dL in females (iii) Elevated blood pressure occurs when systolic blood pressure is above 135 mmHg or the diastolic blood pressure is above 85 mmHg (iv) impaired fasting glucose greater than 100 mg/dL (5.6 mmol/L) and (v) Elevated Triglycerides (TG) greater ≥150 mg/dL .

Table 1. Clinical Cut-offs of Metabolic Syndrome

Risk Factors	Defining Cut-off
3 or more of the following:	
Elevated Abdominal obesity (Waist circumference)	
Male	≥94 cm
Women	≥80 cm
Elevated Triglycerides	≥ 150 mg/dL or drug use
Reduced HDL cholesterol	
Men	<1.0mmol/L or 40 mg/dL
Women	<1.3mmol/L or 50 mg/dL
Elevated Blood Pressure	≥ 130/85 mm Hg or drug use
Microalbuminuria	>20 µg/min
Albumin: creatinine ratio	≥30 mg/g
Elevated Fasting Glucose	≥ 5.6 mmol/L or 100 mg/dL

Adapted from Alberti et.al., 2009.
T2D-Type 2 Diabetes
HDL- High-Density Lipoprotein

5. Bidirectional association between depression and MetS

A growing body of evidence suggests that both depression and MetS share several pathways, and the prevalence of these diseases often overlaps, raising the need for a comprehensive understanding of their interaction. This is especially important in African-origin individuals, who remain understudied, despite bearing the disproportionate burden of cardiometabolic disorders and are depression risk (Gelaye et al. 2015). Several studies (Gheshlagh, Parizad & Sayehmiri, 2016; (Marazziti et al.,2023;) show a positive association between depression and MetS with obesity being a critical connecting factor. Meta-analyses reveal a bidirectional relationship where depression increases the risk of MetS and vice versa (Moradi et al., 2021; Al-Khatib et al., 2022; Vancampfort et al., 2014), however, heterogeneity in the measurement of both depression and MetS, as well as study designs have been notes in these findings. Current literature can be divided into studies that investigate (i) MetS predicting depression risk (ii) depression predicting MetS risk (iii) mechanisms or pathways of depression and MetS.

In the literature that investigates depression and increasing the risk of MetS; Vancampfort et al. (2014) found that individuals with major depression disorder (MDD) had 1.5 times the odds for MetS compared with general population controls. In addition, 30.5% of depressed individuals had MetS, and other studies support this high comorbidity. Moradi et al. (2021) conducted a meta-analysis of 49 observational studies examining the relationship between depression and metabolic syndrome across different countries, mostly coming from Europe, Asia and the US. Findings showed that individuals with depression had a significantly higher risk of developing MetS compared to non-depressed individuals. The association varied by geography with higher odds reported in Europe (Moradi et al 2021). Cross-sectional studies indicated a stronger link for younger individuals, while cohort studies found age did not explain differences in risk (Heiskanen et al., 2006). Similarly, Pan et al. (2012) and Vancampfort et al.(2014) found no significant differences by age and gender in MetS prevalence among people with depression.

Pan et al. (2012) conducted a systematic review and meta-analysis of epidemiological studies, largely conducted in the US or Europe. Based on the 29 cross-sectional studies, they found that the odds of MetS were 1.42 times higher for people with depression. In 9 cohort studies (included in the systematic review) that looked at the association between baseline MetS and incident depression, individuals with MetS were 1.49 times more likely to develop depression than those who did not have MetS. The association was stronger in men. Four cohort studies that investigated the association between baseline depression and future risk of MetS with follow-up ranging from 6 to 17 years showed that those with depression were 1.52 times more likely to develop MetS and the association was more pronounced in women.

5.1. Pathways of Depression and MetS

The interplay between depression and MetS is mediated through multiple mechanisms that include pathophysiological pathways, genetics and environmental factors. Depression has been positively associated with central obesity, chronic inflammation, and insulin resistance, which are underlying etiological mechanisms for MetS (Marazziti et al.,2023; Al-Khatib et al., 2022). Dysregulation of the HPA axis is a significant factor in both depression and obesity (Al-Khatib et al., 2022). Stress-induced hypercortisolemia (elevated cortisol levels) can impair feedback loops in the brain, leading to prolonged stress responses and increased risk of obesity and depression (Al-Khatib et al., 2022). Both depression and MetS are considered pro-inflammatory states (Marazziti et al.,2023). Inflammatory cytokines, often elevated in obesity, have been implicated in the development of depression, suggesting that inflammation serves as a crucial link between these conditions (Marazziti et al.,2023).

Adipokines (cytokines released from fat tissue, e.g., leptin and adiponectin) play a role in regulating mood and metabolism. Some studies (e.g. Taylor & Macqueen, 2010) suggest that leptin and other adipokines, which are dysregulated in obesity, may influence the risk of developing depression. Dysregulation in neurotransmitter pathways, such as serotonin and dopamine, further ties depression to metabolic imbalances (Belujon & Grace, 2017). Both diseases involve oxidative and nitrosative stress pathways, which can impair cellular functions and exacerbate the symptoms of depression and metabolic syndrome.

Genetic and epigenetic studies (e.g. Ghosh et al.,2010; Afari et al., 2010; Jokela et al., 2012; Lawlor, Harbord & Tybjaerg-Hansen et al., 2011; Samaan, Lee & Gerstein, et al., 2015; van Dijk et al., 2015) have found common variants like the Fat mass and obesity-associated (FTO) gene that modulate both body mass index (BMI) and depression risk. Variants of other genes like T-cell acute lymphoblastic leukemia (TAL1) and brain-derived neurotrophic factor (BDNF) have also been linked to both conditions, underscoring the shared genetic susceptibility. Epigenetic modifications, such as DNA methylation, can influence susceptibility to both metabolic syndrome and depression. For instance, early life stressors can alter gene expression in ways that predispose individuals to these disorders later in life.

Shared environmental factors, such as physical inactivity, chronic stress, and unhealthy eating patterns, can predispose individuals to both depression and MetS (Oladeji & Gureje, 2013; Preiss, Brennan & Clarke, 2013). Adverse childhood experiences also play a significant role in increasing the risk of both depression and obesity (Stunkard, Faith & Allison, 2003). Moreover, low self-esteem associated with obesity can lead to depressive symptoms. Depression and T2D share common metabolic pathways. Depression may exacerbate IR, while T2D increases the risk of developing depressive symptoms, potentially through metabolic dysregulation and chronic stress responses. Results of a meta-analysis by DiMatteo et al. (2000) showed that depressed patients were twice as less likely to adhere to treatment than non-depressed individuals. In addition, some antidepressants may lead to MetS through increasing the risk of abdominal obesity, high blood pressure, and increased triglycerides levels.

6. Statistical modelling approaches used for MetS and Depression

A wide range of statistical models has been applied to investigate the association between MetS and the risk of depression. The dominant approach across epidemiological studies is logistic regression (e.g. Baghdan et al., 2021; Toker et al., 2008, Hooker et al., 2022), which is commonly used to estimate the odds of depressive symptoms given the presence of MetS or its individual components.

In a multisite study of African-origin adults, Baghdan et al. (2021) used logistic regression models adjusted for age, sex, and geographic site to quantify associations between alcohol consumption and cardiometabolic risk, including an analysis of how MetS components relate to behavioral exposures that may also influence depression. Similarly, Toker et al. (2008) applied gender-stratified logistic regression models in a sample of employed adults to assess how depressive symptoms (measured using the PHQ-9 survey) predict MetS and its individual components. Their findings revealed gender-specific associations, emphasizing the need for interaction terms or stratified analysis when modeling these associations.

Hooker et al. (2022) employed multivariable general linear models and logistic regressions in a retrospective medical records study to assess the link between depression severity (using PHQ-9 scores) and estimated cardiovascular risk. Although not focused exclusively on MetS, the inclusion of related cardiometabolic factors such as BMI, blood pressure, and lipid levels provides relevant modeling strategies for studying MetS-depression comorbidity.

Beyond logistic regression, generalized estimating equations (GEE) and mixed-effects model have been used in longitudinal designs to account for repeated measures and intra-subject correlation over time. For instance, studies like Pan et al. (2012) employed Cox proportional hazards models to estimate the risk of developing depression among individuals with baseline MetS in prospective cohorts, enabling temporal inference.

As the field advances, integrative approaches that combine physiological, behavioral, and psychosocial data within robust statistical frameworks are increasingly recommended for understanding the complex bidirectional links between metabolic and mental health outcomes (Marazziti et al., 2014).

7. Depression and Metabolic Syndrome in African Diaspora

The most recent systematic review and meta-analysis on African populations (at the time of writing this paper) by Bowo-Ngandji et al. (2023) indicated that the prevalence of MetS was 32,4% [95% CI: 30.2–34.7]. The reported prevalence was based on 29 African countries with more than 150 000 participants. This study also observed that the prevalence of MetS was significantly higher in females (36,9%) compared to males (26,7%). In addition, Type 2 Diabetes patients had the highest prevalence of MetS. Country-level prevalence was significantly heterogenous with Algeria having the highest prevalence (43,9%) and Sudan having the lowest (11,5%). The study did find publication bias among papers used to calculate MetS prevalence in African countries. Only the cross-sectional studies and studies with a low risk of bias agreed well with the overall prevalence of MetS.

7.1. Ghana

In Ghana, studies on the prevalence of metabolic syndrome (MetS) and its association with depression are limited but provide some key insights. Amu et al. (2021) using a cross-sectional study with 2456 adults found a prevalence of 25.2% for depression, 53,3% and 9,7% for anxiety and stress, respectively. A study conducted during the COVID-19 pandemic found a prevalence of major depressive disorder (MDD) symptoms at 12.3% among adults (Owusu-Antwi et al., 2021). Among adolescents, depression symptoms were reported at 32.5% in rural settings (Nyundo et al., 2019).

Metabolic syndrome prevalence among adults is estimated at 15-20%, influenced by urbanization and lifestyle changes leading to increased rates of obesity and diabetes (Ofori-Asenso et al., 2020). Gyakobo et al. (2012) shows a growing concern for MetS in rural Ghana using a cross-sectional study, with a prevalence of 35.9%[1]. The main components identified were central obesity, high blood pressure, and low HDL cholesterol, with higher rates observed in females compared to males (Mogre et al., 2014). A study in the Kumasi Metropolis showed an increased prevalence of MetS with age and higher rates among postmenopausal women (Kow Nanse Arthur et al.,2013). The rates ranged from 14.4% to 30.4% depending on the diagnostic criteria used. Central obesity and high blood pressure were significant contributors to MetS, suggesting that menopausal changes influence the syndrome's prevalence. Among individuals with type 2 diabetes, Osei-Yeboah et al. (2017) reported a MetS prevalence ranging from 24% to 69%, with the IDF criteria, and women having higher prevalence than men.

[1] Based on the International Diabetes Federation(IDF criterion). See Appendix for details on the different diagnostic criteria for MetS.

We could not find studies evaluating the association between the risk of depression and MetS covering the Ghanaian population. We could only find the HELIUS[2] study which explored the association of depression and post-traumatic stress with MetS in multi-ethnic cohorts, including Ghanaians in the Netherlands (van Leijden et al., 2018). The findings showed that depression was consistently linked to MetS. This suggests similar patterns may be present among Ghanaians in Ghana.

7.2. South Africa

In SA, depression and metabolic syndrome (MetS) present significant public health challenges, with evidence suggesting high prevalence rates and interconnected risk factors. A recent study by Craig et al. (2022) noted that depression prevalence varied was 25.7%. Similarly, Mungai and Bayat (2019) noted that 26% of South African have depression. The South African Stress and Health (SASH) study indicated that approximately 9.7% of the population experiences major depression at some point in their lifetime, while 4.9% experience it within a 12-month period (Tomlinson, et al., 2009). Depression is more prevalent among women, in particular among those with lower education levels, and individuals experiencing socioeconomic hardship (Onuh et al., 2021; Tomlinson, et al., 2009). Depression prevalence varies across regions and demographic groups. Urban areas, especially informal settlements, show higher rates due to stress factors related to unemployment, crime, and poverty (Craig et al, 2022; Igboeli et al., 2021). MetS prevalence also differs, with studies in farm worker communities revealing rates as high as 46.3% among women, attributed to lifestyle and occupational factors (Kruger & Nell. 2017).

MetS is also widespread in South Africa, particularly among urban and female populations. A study in Cape Town's Black communities reported MetS prevalence of 31.7%, with women showing significantly higher rates (44.9%) compared to men (17.3%) (Gradidge & Crowther, 2017). Urbanization and lifestyle changes associated with the nutrition transition contribute to higher MetS rates in women (Gradidge & Crowther, 2017; Peer et al., 2015). Similarly, studies in rural populations show notable MetS prevalence, often linked to obesity and hypertension(Kruger & Nell, 2017). While research explicitly linking depression with MetS in South Africa is scarce, the existing literature highlights shared risk factors such as obesity, physical inactivity, and socioeconomic stress. For instance, older adults and African women with chronic conditions like hypertension and diabetes often exhibit both depression and MetS (Geldsetzer et al., 2019).

7.3. Jamaica

Existing literature shows that depression disproportionately affects vulnerable groups such as women, the elderly, and lower socioeconomic communities (Brown et al., 2017; Gibson et al., 2013). A systematic review on the social determinants of depression in the Caribbean found that depression frequency, depression severity, and suicidal behaviour were higher among females; persons with lower education, income, and occupation levels; those participating in less religious activity; and those with less social capital and support (Brown et al., 2017).

About 25% of adults in Jamaica are affected by metabolic syndrome, largely driven by dietary habits and low physical activity levels (Ferguson et al., 2011). Data from the 2008 Jamaica Health and Lifestyle survey showed depression rates between 20-30% in persons with chronic illnesses, such as other non-communicable diseases. Additionally, urban populations in Jamaica show a higher

[2] The HELIUS (Healthy Life in an Urban Setting) Study is a multi-enthinc cohort study aiming to unravel the mechanisms underlying the impact of ethnicity on communicable and non-communicable diseases. It looked at people from different ethnic groups living in Amsterdam (van Leijden et al., 2018).

prevalence of CVD risk. While there is limited research explicitly linking depression with MetS in Jamaica, a study looking at the prevalence of MetS in adult psychiatric patients on antipsychotic medications found a prevalence of 28,9% (ref).

7.4. Seychelles

Mental health data in Seychelles indicate that common mental disorders, including depression, are a growing concern. The WHO estimated depression to be 4% in 2015. Depression prevalence is likely underreported due to stigma, with mental health services often under-resourced.

Approximately 30% of adults in Seychelles meet the criteria for metabolic syndrome, with risks heightened by dietary changes and reduced physical activity (Gedeon et al., 2011). MetS prevalence was also higher among older adults, reflecting lifestyle changes due to urbanization and shifts in dietary habits. The prevalence of MetS in Seychelles varies based on the definition used. According to a study examining three major criteria (ATP, IDF, WHO), prevalence is higher for women (25-35%) compared to men (25%) (Kelliny, et al., 2008). Obesity and hypertension were the most commonly observed components. We could not find a study that investigated the association between risk of depression and MetS in the population of Seychelles.

7.5. United States

Metabolic syndrome affects around 34% of the adult population in the U.S., with obesity being a significant contributor (Moore et al., 2017). Recent data from the National Health and Nutrition Examination Survey (NHANES) between 2011 and 2018, reported the prevalence of MetS among US adults to be around 37.3% (Liang et al., 2021). The prevalence is higher in older adults, reaching over 50% in those aged 60 and older. Central obesity and elevated glucose levels were the most common components (Limon et al., 2020). Depression affects about 8.1% of adults in the US, with women nearly twice as likely as men to experience it (Brody et al., 2018). Depression was more common among those with lower socioeconomic status. Adolescents and young adults also had high prevalence rates (NIMH, 2021).

Studies consistently show a significant association between MetS and depression with individuals who have MetS being more likely to experience depressive symptoms (Limon et al., 2020). Again, women were more vulnerable to this association. In 2023, a nationwide cross-sectional study using NHANES data found that the risk of depression increased by 40% in individuals with MetS, with higher risks observed in those with four or five MetS components (Zhang et al., 2023).

7.6. The epidemiological transition effect

The epidemiologic transition refers to shifts in population patterns influenced by changes in mortality, fertility, life expectancy, and major causes of death (Zuckerman, Harper, Barrett & Armelagos, 2014). Research studies (e.g., Singh, Pella & Mechivora, 2007; Tokunaga et al., 2012; Gaziano, 2010) report a rise in depression rates during this transition, driven by urbanization, social dislocation, and lifestyle changes. This period of transition is also marked by an increase in metabolic syndrome prevalence.

The study sites included here are experiencing concurrent nutrition and health transitions alongside the epidemiologic transition, largely due to modernization (Mendenhall et al., 2017). Economic development linked to modernization, such as changes in diet, technological advances, and rural-to-urban migration, has contributed to rising obesity rates through lifestyle changes. Notably, modernization often leads to dietary shifts from traditional, plant-based foods to highly processed, calorie-dense items, fueling the growing prevalence of obesity, type 2 diabetes, and other non-communicable diseases (NCDs).

8. Gaps in existing literature

There is limited research explicitly connecting depression and MetS in people of African-origin. Current research often relies on cross-sectional data, limiting insights into long-term outcomes. There is a lack of longitudinal studies examining the causal relationships between depression and MetS. Most research uses diverse diagnostic criteria, leading to inconsistencies in prevalence estimates. There is a need for further exploration is required to understand the underlying mechanisms driving the gender differences in the MetS-depression relationship. Furthermore, studies evaluating the prevalences of depression or metabolic syndrome are also far in-between.

9. Conclusion

This literature review highlights the growing global burden of depression and MetS, emphasizing their interrelated nature and the shared risk factors that exacerbate their prevalence, particularly among populations of African origin. Despite the high prevalence of both conditions, limited research explicitly examines their intersection in African-origin populations, leaving critical gaps in understanding their bidirectional relationship and underlying mechanisms.

Across the reviewed studies, gender and regional disparities emerge as significant factors influencing the prevalence and association between depression and MetS. Women consistently exhibit higher rates of depression, obesity, and central adiposity, underscoring their vulnerability to the physical and psychological burdens of MetS. In contrast, men are disproportionately affected by elevated blood pressure and lifestyle behaviors such as smoking and alcohol consumption, which contribute to cardiovascular risks. Regional differences also highlight the role of socioeconomic and cultural contexts, with urbanization and dietary transitions driving increases in MetS and depression prevalence in low- and middle-income countries, while high-income countries like the United States maintain the highest overall rates of both conditions.

Key mechanisms linking MetS and depression include chronic inflammation, hypothalamic-pituitary-adrenal axis dysregulation, and shared genetic and environmental factors. These pathways suggest a complex interplay between biological, psychological, and socioeconomic determinants, further complicating prevention and intervention strategies. Moreover, differences in diagnostic criteria and study designs across the literature underscore the need for standardized approaches to better estimate prevalence and elucidate causal relationships.

References

Afari, N., Noonan, C., Goldberg, J., Roy-Byrne, P., Schur, E., Golnari, G. and Buchwald, D., 2010. Depression and obesity: do shared genes explain the relationship?. *Depression and Anxiety*, 27, pp.799–806. doi:10.1002/da.20704.

Alberti, K., Zimmet, P. and Shaw, J., 2005. The metabolic syndrome—a new worldwide definition. *The Lancet*, 366(9491), pp.1059-1062.

Alberti, K., Eckel, R., Grundy, S., Zimmet, P., Cleeman, J., Donato, K., Fruchart, J., James, W., Loria, C., Smith, S. (2009). Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120:1640–1645.

Al-Khatib, Y., Akhtar, M.A., Kanawati, M.A., Mucheke, R., Mahfouz, M., and Al-Nufoury, M., 2022. Depression and Metabolic Syndrome: A Narrative Review. *Cureus*.

Amu, H., Osei, E., Kofie, P., Owusu, R., Bosoka, S.A., Konlan, K.D., Kim, E., Orish, V.N., Maalman, R.S.E., Manu, E., Parbey, P.A., Saah, F.I., Mumuni, H., Appiah, P.K., Komesuor, J., Ayanore, M.A., Amenuvegbe, G.K., Kim, S., Jung, H., Adjuik, M., Tarkang, E.E., Alhassan, R.K., Donkor, E.S., Zottor, F.B., Kweku, M., Amuna, P., Kim, S.Y. and Gyapong, J.O., 2021. Prevalence and predictors of depression, anxiety, and stress among adults in Ghana: A community-based cross-sectional study. *PLoS ONE*, 16(10), p.e0258965.

Andresen, E.M., Malmgren, J.A., Carter, W.B. and Patrick, D.L., 1994. Screening for depression in well older adults: evaluation of. *Preventive Medicine*, 10, pp.77-84.

Atiase, Y., Farni, K., Plange-Rhule, J., Luke, A., Bovet, P., Forrester, T.G., Lambert, V., Levitt, N.S., Kliethermes, S., Cao, G., Durazo-Arvizu, R.A., Cooper, R.S. and Dugas, L.R., 2015. A comparison of indices of glucose metabolism in five black populations: Data from modeling the epidemiologic transition study (METS). *BMC Public Health*, 15(1).

Baron, E.C., Davies, T. and Lund, C., 2017. Validation of the 10-item centre for epidemiological studies depression scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. *BMC Psychiatry*, 17, pp.1-14.

Bech, P., Rasmussen, N. A., Olsen, L. R., Noerholm, V., & Abildgaard, W. (2001). The sensitivity and specificity of the Major Depression Inventory, using the Present State Examination as the index of diagnostic validity. Journal of affective disorders, 66(2-3), 159–164. https://doi.org/10.1016/s0165-0327(00)00309-8

Belujon, P., & Grace, A. A. (2017). Dopamine system dysregulation in major depressive disorders. International Journal of Neuropsychopharmacology, 20(12), 1036-1046.

Craig, A., Rochat, T., Naicker, S. N., Mapanga, W., Mtintsilana, A., Dlamini, S. N., Ware, L. J., Du Toit, J., Draper, C. E., Richter, L., & Norris, S. A. (2022). The prevalence of probable depression and

probable anxiety, and associations with adverse childhood experiences and socio-demographics: A national survey in South Africa. Frontiers in public health, 10, 986531. https://doi.org/10.3389/fpubh.2022.986531

Ferguson, T.S., Tulloch-Reid, M.K., Younger, N.M., Knight-Madden, J., Samms-Vaughan, M., Ashley, D., Van Den Broeck, J. and Wilks, R.J. (2010). Prevalence of the metabolic syndrome and its components in relation to socioeconomic status among Jamaican young adults: A cross-sectional study. *BMC Public Health*, 10(1).

Geldsetzer, P., Vaikath, M., Wagner, R., Rohr, J. K., Montana, L., Gómez-Olivé, F. X., ... & Berkman, L. F. (2019). Depressive symptoms and their relation to age and chronic diseases among middle-aged and older adults in rural South Africa. The Journals of Gerontology: Series A, 74(6), 957-963.

Ghosh, S., Dent, R., Harper, M.E., Gorman, S.A., Stuart, J.S. and McPherson, R., 2010. Gene expression profiling in whole blood identifies distinct biological pathways associated with obesity. *BMC Medical Genomics*, 3, p.56. doi:10.1186/1755-8794-3-56.

Gibson, R.C., Neita, S.M., Abel, W.D., James, K. and Eldemire-Shearer, D., 2013. Sociodemographic Factors Associated with Depressive Symptoms among Elderly Persons from Two Communities in Kingston, Jamaica. *West Indian Medical Journal*, 62(7), pp.615.

Gossell-Williams, M., Martin, J., Neita, S., Gibson, R.C., Abel, W., Sewell, C. and Mcgrowder, D., 2012. Prevalence of the Metabolic Syndrome in Patients Presenting to the University Hospital of the West Indies: A Need to Adopt Proactive Screening and Specific Management Policy. *West Indian Medical Journal*, 61(8), pp.802.

Gelaye, B., Williams, M. A., Lemma, S., Berhane, Y., Fann, J. R., Stoep, A. vander, & Zhou, X. H. A. (2015). Major depressive disorder and cardiometabolic disease risk among sub-Saharan African adults. Diabetes and Metabolic Syndrome: Clinical Research and Reviews, 9(3), 183–191. https://doi.org/10.1016/j.dsx.2014.05.003

Have, M., Van Bon-Martens, M., Schouten, F., Van Dorsselaer, S., Shields-Zeeman, L., Luik, A. (2024). Validity of the five-item mental health inventory for screening current mood and anxiety disorders in the general population. *International Journal of Methods in Psychiatric Research ;33(3):e2030. doi: 10.1002/mpr.2030. PMID: 38956889; PMCID: PMC11219508.

Noubiap, J., Nansseu, J., Lontchi-Yimagou, E., René Nkeck, J., Nyaga, U., Ngouo, A. T., Tounouga, D., Tianyi, F.-L., Foka, A., Ndoadoumgue, A., & Bigna, J. (2022). Geographic distribution of metabolic syndrome and its components in the general adult population: A meta-analysis of global data from 28 million individuals. Diabetes Research and Clinical Practice, 188, 109924. https://doi.org/10.1016/j.diabres.2022.109924

Jokela, M., Elovainio, M., Keltikangas-Järvinen, L. et al., 2012. Body mass index and depressive symptoms: instrumental-variables regression with genetic risk score. *Genes, Brain and Behavior*, 11, pp.942–948. doi:10.1111/j.1601-183X.2012.00846.x.

Kalk, W.J., Joffe, B.I. and Sumner, A.E., 2011. The waist circumference of risk in black South African men is lower than in men of European ancestry. *Metabolic Syndrome and Related Disorders*, 9(6), pp.491-495.

Kow, F., Arthur, N., Adu-Frimpong, M., Osei-Yeboah, J., Mensah, F.O. and Owusu, L., 2013. The prevalence of metabolic syndrome and its predominant components among pre-and postmenopausal Ghanaian women. *BioMed Central Ltd.*

Marazziti, D., Rutigliano, G., Baroni, S., Landi, P. and Dell'Osso, L., 2014. Metabolic syndrome and major depression. *CNS Spectrums*, 19(4), pp.293-304.

Marazziti, D., Arone, A., Palermo, S., Annuzzi, E., Cappellato, G., Chiarantini, I., del Prete, L., & Dell'Osso, L. (2023). The Wicked Relationship Between Depression And Metabolic Syndrome. In Clinical Neuropsychiatry (Vol. 20, Issue 2, pp. 100–108). Giovanni Fioriti Editore. https://doi.org/10.36131/cnfioritieditore20230202.

Martin, A., Rief, W., Klaiberg, A., & Braehler, E. (2006). Validity of the brief patient health questionnaire mood scale (PHQ-9) in the general population. General Hospital Psychiatry, 28(1), 71-77. https://doi.org/10.1016/j.genhosppsych.2005.07.003.

Moore, J.X., Chaudhary, N. and Akinyemiju, T. (2017). Metabolic syndrome prevalence by race/ethnicity and sex in the United States, NHANES 1988–2012. Preventive Medicine, 95, pp.75-81.

Mungai, K., & Bayat, A. (2019). An overview of trends in depressive symptoms in South Africa. South African journal of psychology, 49(4), 518-535.

Ofori-Asenso, R., et al. (2020). Metabolic syndrome in Ghana: A systematic review and meta-analysis. BMC Public Health.

O'Neill, S. & O'Driscoll, L. J. O. R. (2015). Metabolic syndrome: A closer look at the growing epidemic and its associated pathologies. Obes. Rev. 16(1), 1–12.

Owusu-Antwi, R., et al. (2021). Prevalence of depression among adults in Ghana during COVID-19. International Journal of Environmental Research and Public Health, 18(13), 7106.

Pan, A., Keum, N., Okereke, O.I., Sun, Q., Kivimaki, M., Rubin, R.R. and Hu, F.B. (2012). Bidirectional association between depression and metabolic syndrome: A systematic review and meta-analysis of epidemiological studies. Diabetes Care, 35(5), pp.1171-1180.

Peer, N., et al. (2015). Urbanization and lifestyle changes as risk factors for metabolic syndrome in South Africa. BMC Endocrine Disorders, 15(1), 23.

Peer, N., Lombard, C., Steyn, K. and Levitt, N. (2015_. High prevalence of metabolic syndrome in the Black population of Cape Town: The Cardiovascular Risk in Black South Africans (CRIBSA) study. European Journal of Preventive Cardiology, 22(8), pp.1036-1042.

Radloff, L.S. (1977). The CES-D Scale: A self-report report depression scale for research in the general population. Applied Psychological Measurement, 1(3), 385-401. http://dx.doi.org/10.1177/014662167700100306.

Stunkard, A.J., Faith, M.S. and Allison, K.C. (2003). Depression and obesity. Biological Psychiatry, 54, pp.330–337. doi:10.1016/s0006-3223(03)00608-5.

Vaccarino, V., McClure, C., Johnson, B.D., Sheps, D.S., Bittner, V., Rutledge, T., Shaw, L.J., Sopko, G., Olson, M.B., Krantz, D.S., Parashar, S., Marroquin, O.C. and Merz, C.N.B.(2008). Depression, the metabolic syndrome, and cardiovascular risk. *Psychosomatic Medicine*, 70(1), pp.40-48.

Van Leijden, M.J., Penninx, B.W.J.H., Agyemang, C., Olff, M., Adriaanse, M.C. and Snijder, M.B., 2018. The association of depression and posttraumatic stress disorder with the metabolic syndrome in a multi-ethnic cohort: the HELIUS study. Social Psychiatry and Psychiatric Epidemiology, 53(9), pp.921-930.

Stansfeld, S. A., et al. (2018). Depression and exposure to violence in adolescents in South Africa. Journal of Adolescent Health, 62(1), 76-82.

Ward, E., et al. (2017). Mental health and violence exposure in Jamaican youth. Rev Panam Salud Publica, 41, e29.

World Health Organization. (2023). Depression. https://www.who.int/news-room/fact-sheets/detail/depression

Part C: Manuscript

The relationship between metabolic syndrome and the risk of depression among African adults spanning the Epidemiologic Transition.

Viwe Dikoko[1], Asanda Mtintsilana[1], Candice Choo-Kang[2], Larske Soepnel[1], Kweku Bedu-Addo[3], Jacob Plange-Rhule[3]†, Pascal Bovet[4], Bharathi Viswanathan[5], Terrence Forrester[6], Estelle Lambert[7], Wolfgang Korte[8], Dale Rae[7], Nandipha Sinyanya[7], Brian Layden[89], Jack Gilbert[10], Gertrude Ecklu-Mensah[10], Cara Joyce[2], Amy Luke[2], Lara Dugas[1]*.

Affiliations:

[1] Division of Epidemiology and Biostatistics, School of Public Health, Faculty of Health Sciences, University of Cape Town, Cape Town, South Africa
[2] Public Health Sciences, Parkinson School of Health Sciences and Public Health, Loyola University Chicago, Maywood, IL, USA
[3] Department of Physiology, School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[4] University Center for Primary Care and Public Health (Unisanté), Lausanne University Hospital, Lausanne, Switzerland
[5] Ministry of Health, Victoria, Republic of Seychelles
[6] Solutions for Developing Countries, University of the West Indies, Mona, Kingston, Jamaica
[7] Health through Physical Activity, Lifestyle and Sport Research Centre (HPALS), Department of Human Biology, Faculty of Health Sciences, University of Cape Town
[8] Diagnostic Hematology and Coagulation Laboratory, University Hospital Basel, Basel, Switzerland
[9] Department of Medicine, University of Illinois at Chicago, Chicago, Illinois, USA
[10] Jesse Brown Veterans Affairs Medical Center, Chicago, Illinois, USA
[11] Department of Pediatrics, Center for Microbiome Innovation, University of California San Diego, La Jolla, CA, USA
[12] School of Health and Medical Sciences, Faculty of Health, Engineering & Sciences, University of Southern Queensland, Australia

Corresponding Author:

*Lara Dugas: lara.dugas@uct.ac.za

Target Journal: The Lancet

Summary

Background: Depression and metabolic syndrome (MetS) are growing global health concerns, but limited research focuses on African-origin populations. This study investigates the association between MetS and depression among individuals in Ghana, South Africa (SA), Jamaica, Seychelles, and the United States (US), emphasizing gender and regional disparities.

Methods: Secondary data of 446 participants from the METS (2008-2010) and METS-Microbiome study (2017-2019), a prospective cohort, were analyzed. MetS was defined as meeting at least three of the following criteria: elevated blood pressure, low HDL(High-Density Lipoprotein), elevated triglycerides, or high glucose. Depression was assessed using the CES-D scale (score ≥16 indicating depressive symptoms). Depression was assessed only at follow-up (2019), while MetS was measured at baseline (2010). Logistic regression examined the MetS-depression relationship, stratified by gender, adjusting for demographic and behavioural factors.

Findings: The prevalence of MetS was 12% in Ghana (N=23), 17% in SA (N=9), 29% in Jamaica (N=26), 27% in Seychelles (N=33), and 39% in the US (N=36). The prevalence of depression was 15% in Ghana (N=29), 25% in SA (N=13), 18% in Jamaica (N=16), 9% in Seychelles (N=11) and 33% in the US (N=30). No significant overall association between MetS and depression was found. However, in men, individual MetS components showed weak associations at $p < 0.1$. High blood pressure (OR = 3.46, $p<0.1$) and low HDL (OR = 3.45, $p<0.1$) were associated with higher odds of depression, while obesity appeared protective (OR = 0.20, $p<0.1$). Women showed higher rates of obesity, abdominal adiposity, and depression, particularly in Jamaica, Seychelles, and the US. Age inversely correlated with depression in both genders, with older individuals reporting fewer symptoms. Regionally, living in Ghana, Seychelles, and Jamaica was linked to lower odds of depression compared to the US.

Interpretation: This study highlights significant gender and regional differences in the MetS-depression relationship. Women face greater vulnerabilities related to obesity and psychological distress, while men are at higher risk due to elevated blood pressure and low HDL. Tailored public health strategies are needed to address these distinct risks and regional disparities, focusing on mitigating the dual burden of metabolic and mental health challenges. Policy strategies should prioritize integrated screening, targeted education, and community-based services—particularly in low-resource settings—to reduce the dual burden of MetS and depression in populations of African origin.

1. Introduction

The global prevalence of Metabolic Syndrome (MetS) is estimated at 29.8%, using the harmonized MetS criteria[1], highlighting its substantial public health burden. With depression affecting approximately 5% of the global population and 6.2% in Low-Middle Income Countries (LMICs), the co-occurrence of MetS and depression presents a growing concern[2,3]. Depression, is a mental health disorder, characterized by several symptoms, including but not limited to persistent sadness, loss of interest in activities, and physical symptoms such as changes in sleep and energy levels[4,5]. Similarly, MetS is a cluster of interconnected cardiometabolic risk factors, including central obesity, high blood pressure, elevated triglycerides, low HDL cholesterol, and impaired fasting glucose[6,7].

The coexistence of depression and MetS creates complex health challenges, with each condition exacerbating the other. Depression can promote metabolic dysregulation through mechanisms such as chronic inflammation, heightened oxidative stress, and disruption of the hypothalamic-pituitary-adrenal (HPA) axis[8]. Conversely, the physical and emotional burden of MetS increases the likelihood of depression[9,10]. Despite growing evidence of this interplay, much of the research focuses on high-income countries, leaving gaps in understanding for populations undergoing epidemiological and nutrition transitions[6,11,12]. Specifically, much of the existing research has been conducted on European and white populations[13], with few studies examining this relationship in populations of African-origin. Given that African-origin populations may experience disparities in healthcare access, genetic predispositions, and cultural practices which plays a role in the relationship between depression and MetS, an examination of this relationship among African-origin populations is urgently needed. For instance, in the United States (US), African American women often show stronger links between depressive symptoms and MetS severity compared to men[14]. However, on the other hand, evidence from sub-Saharan Africa finds limited associations between depression and MetS[15,16] underscoring the importance of geographic, localized studies.

This study is a secondary data analysis leveraging data from the METS-Microbiome Study[17–23], a diverse cohort of African-origin adults from five countries, to explore these associations in greater depth. We analyse demographic, metabolic, and depression data collected between 2010 to 2019, with the aim to shed light on how depression and MetS interact in different socio-economic contexts. This research seeks to fill critical gaps in the literature, particularly regarding African populations, while informing culturally sensitive public health interventions. Understanding the broader context of these transitions will provide valuable insights into the dual burden of depression and MetS and help address their growing prevalence across different socio-economic settings.

2. Methods

2.1. Study Design

We performed secondary data analysis on the Modelling the Epidemiologic Transition Study (METS, 2008-2013) and its ancillary study; METS-Microbiome Study (2017-2022). METS is a prospective cohort study examining physical activity and weight change in African-origin adults from Ghana, Jamaica, SA, Seychelles and US[17–21,23–25].

2.2. Participants

Originally, METS (baseline) recruited 2506 adults of African-origin. The participants were aged 25-45 years and recruited between January 2010 and September 2011. The participants completed health checks at 12 and 24 months to assess change in body weight, composition, diabetes and CVD risk. Similarly, METS-Microbiome (2017-2022) continued yearly study visits, adding additional measures including the determination of the gut microbiota. The METS-Microbiome study participants completed two study visits between 2018 and 2021.The retention rate across all sites was 65% of the original cohort.

These five METS sites were chosen to represent the spectrum of the 'epidemiologic transition' with Ghana and the US representing the two extremes. For example, the mean BMIs of adults from the study sites varied from a low of about 24 kg/m^2 in rural Nkwantakese (Ghana) to a high of 31 kg/m^2 in suburban Chicago (US). At each study site, 500 participants were recruited based on sample size calculations. At baseline, individuals with obvious infectious diseases (including active malaria), pregnant or lactating women, and HIV positive individuals were excluded from the METS study. For our study, participants with only baseline data (i.e. not retained in METS-Microbiome) were excluded[3]. Different methods of recruiting a representative sample were used at the different sites based on what would be considered best practice in that context.

2.3. Procedures and Outcomes

Data for this study were collected from the METS (baseline) and METS-Microbiome (follow-up) using enrolment and follow-up questionnaires, biological samples, and measurements. The questionnaire gathered self-reported data on physical activity, dietary intake, medication and supplement use, smoking, alcohol consumption, health history, mental health, and demographics such as socioeconomic status, education, and occupation. Identical biological measurements were used for the METS baseline and METS-Microbiome follow-up visit, which were conducted at outpatient clinics and included; anthropometrics, body composition, blood pressure, fasting blood samples, and urine samples, with unused specimens stored for future analysis. See Appendices A and B for detailed data summaries.

This study protocol was approved (HREC: 563/2024) by the Research Ethics Committee of the University of Cape Town, South Africa. The protocol for the parent METS study was

[3] The baseline characteristics of participants included in the analysis (those with depression data) were compared to those who were excluded due to missing follow-up (See Table 2A in Appendix B). The comparison included demographic variables and baseline MetS risk factors. Results showed that included participants were slightly younger and more likely to be from Site Jamaica, while other characteristics such as sex and MetS risk variables did not differ significantly.

approved by the Institutional Review Board of Loyola University Chicago (the coordinating centre for this international study) IL, USA (LU209537); the Committee on Human Research Publication and Ethics of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; the Human Research Ethics Committee of the University of Cape Town, South Africa; the Board for Ethics and Clinical Research of the University of Lausanne, Switzerland; the Ethics Committee of the Ministry of Health of Seychelles; and the Ethics Committee of the University of the West Indies, Kingston, Jamaica. Written informed consent was obtained from all participants.

Clinical Measurements

All clinical measurements were performed at outpatient research clinics within the participating communities. Weight (kg) and height (m) were recorded using standardized procedures and identical equipment across all five sites, with participants wearing light clothing and no shoes. Body mass index (BMI) (kg/m²) was calculated from these measurements and reported both as a continuous variable and as a binary: "not obese" (BMI < 30 kg/m²) and "obese" (BMI ≥ 30 kg/m²). Waist circumference was measured using tape measures and recorded in both centimeters and inches.

Blood Pressure Assessment

Blood pressure (BP) was measured by trained personnel using an Omron HEM-747Ic automatic digital monitor. Measurements were taken with the participant's arm positioned at heart level. BP was recorded twice during the visit, with a minimum interval of one hour. Each assessment included three consecutive readings, resulting in a total of six measurements. Participants were classified as hypertensive if their systolic BP was ≥130 mmHg, diastolic BP was ≥85 mmHg, or if they were undergoing treatment for hypertension.

Biochemical Measures

Blood samples were collected to measure glucose (mg/dL), cholesterol (mg/dL), and triglyceride levels (mg/dL). Participants fasted for 10–12 hours prior to sample collection. Fasting blood glucose was measured using an Accu-Chek Aviva finger-stick device (Roche), and venous blood samples were drawn for further analysis. Plasma or serum was separated within two hours of collection, and all samples were stored at −80 °C for future analysis. Elevated glucose levels were defined as ≥100 mg/dL or current treatment for type 2 diabetes. Elevated triglyceride levels were defined as ≥150 mg/dL or ongoing treatment. Low HDL cholesterol was classified as <40 mg/dL for men and <50 mg/dL for women, or if the participant was receiving treatment for low HDL levels.

Depression

Participants were asked to complete the Centre for Epidemiologic Studies Depression (CES-D) Scale questionnaire during the second visit for the METS-Microbiome study. The depression outcome was assessed using the Kessler Psychological Distress Scale 10 item (K10) of CES-D and was scored as a sum of scores of the 20 items which ranges from 0 to 30. A score of 16 or above (CES-D score≥ 16) indicates the presence of mild to significant depression.

Metabolic syndrome

Metabolic syndrome is defined as the presence of abdominal obesity and two or more of the metabolic syndrome components, according to the Harmonized MetS criteria[26] .We defined abdominal obesity as those having a waist circumference of ≥94 cm for men and ≥80 cm for women. The criterion for US is ≥102 cm for men and ≥88 cm for women. Low High-density Lipoprotein Cholesterol (HDL-C) is defined to be <1.0 mmol/L (40 mg/dL) in men and <1.3 mmol/L (50 mg/dL) in women. Elevated blood pressure is defined as a systolic blood pressure≥130 mmHg or a diastolic blood pressure≥85 mmHg. Impaired fasting glucose is defined to be ≥ 5.6 mmol/L (100 mg/dL) or with a previous history of diabetes. Elevated Triglycerides (TG) was defined as ≥1.7 mmol/L (150 mg/dL).

Questionnaires

Trained personnel administered questionnaires to gather participants' health information. The questionnaires collected data on dietary habits, medication use, physical activity patterns, and age at diagnosis for relevant conditions. In addition, information on household characteristics, occupation, education level, parental education, and household assets was collected. The questions were adapted from the World Bank's Core Welfare Indicators Questionnaire[27].

2.4. Statistical analysis

Data are presented as median (interquartile range), proportions, odds ratios with 95% confidence intervals. The Shapiro-Wilk test was used to test for normality. Descriptive variables between groups were compared using Krustal-Wallis tests. Frequency differences between groups were analysed using Fisher's Exact tests.

We ran multivariate logistic regressions that examined the association between risk for depression and MetS. All models were adjusted for age and education years (both as continuous variables), sex (as Female, such that 0 if male), employment status (as Employed or Unemployed), marital status (as Married/Living with a partner), alcohol consumption (as drinker or non-drinker) and country (as dummy variables, US as the reference). Predictor variables were selected based on existing literature and theoretical relevance.

Three types of regression models were reported for each group to examine the relationship between MetS and depression. The first model (MetS), evaluates the association between baseline MetS and the subsequent risk of depression at follow-up, adjusting for demographic factors measured at baseline. The second model (MetS Risk) investigates the association between baseline MetS risk factors—including high WC, high BP, high TG, low HDL, and high glucose—and the subsequent risk of depression at follow-up, while controlling for baseline demographic variables. The third model (MetS Risk at Follow-up) assesses the cross-sectional relationship between MetS risk factors and depression risk, with all variables collected at follow-up. However, due to data limitations, not all five MetS risk factors were

included, as high TG and low HDL measurements were unavailable at follow-up. Consequently, obesity was included as an additional MetS risk factor in the analysis.

The results are stratified by overall population, women and men to identify gender-specific patterns. Data were analysed using R and p values of $\rho < 0.05$ were considered significant.

Assessing Multicollinearity

All models included theoretically relevant covariates drawn from the literature on depression and MetS[9,12,28,29]. Covariates were initially assessed in univariable models ($p < 0.20$) and then tested for confounding using a change-in-estimate criterion; any variable that altered the log odds ratio of the MetS exposure by more than 10% was retained. To assess potential multicollinearity, Variance Inflation Factors (VIFs) were computed for all models. All VIFs were below 2, except for site, which had a VIF of 2.96. Given its contextual importance as a proxy for geographic and socioeconomic variation, site was retained in all models. No other evidence of multicollinearity was observed.

To further evaluate model robustness and reduce the risk of overfitting, LASSO (Least Absolute Shrinkage and Selection Operator) logistic regression was conducted. Predictors were standardized and a 10-fold cross-validation approach was used to determine the optimal penalty value. The LASSO procedure identified a parsimonious model in which only marital status and site (Seychelles) were retained as non-zero predictors of depression. All other variables, including the five MetS components, were penalized to zero and excluded. A follow-up standard logistic regression using only the LASSO-selected variables confirmed the magnitude and direction of these associations. These steps ensured that both theory-driven and data-driven strategies informed the final models, and provided evidence that the primary associations observed were robust to multiple approaches to model selection and regularization.

3. Results

Cohort description

Table 1 presents descriptive characteristics for populations in Ghana, South Africa (SA), Jamaica, Seychelles, and the United States (US), ordered by Human Development Index (HDI), at baseline (2010) and follow-up (2019). Appendix B (Table 2 and 3) offers gender-stratified descriptives.

At baseline (2010), gender distributions were stable across countries, with the US recording the highest female representation (70%). Educational attainment varied, with the US and Seychelles having the highest median years of education (13.0 years, IQR: 11.0-14.8 years) and Ghana the lowest (9.0 years, IQR:7.0-10.0 years). Marital status remained consistent, while employment rates were highest in the US (71%) and lowest in SA (44%). Median BMI and waist circumference were highest in the US (104.4 cm, IQR: 27.8–39.7 cm). Glucose levels were lowest in Ghana (4.5 mmol/L, IQR: 4.3-4.8 mmol/L) and Seychelles (4.6

mmol/L, IQR:4.2-5.0 mmol/L), while the US had the highest prevalence of metabolic syndrome and obesity (66%). Smoking rates were highest in Jamaica, and alcohol consumption peaked in Seychelles.

By follow-up (2019), an aging trend was observed, which was expected given the longitudinal nature of the dataset. Employment rates declined significantly in the US (71% to 59%) and SA (44% to 18%), although other countries experienced improvements. Median BMI rose slightly, with the US leading at 32 kg/m² (IQR:28.7-39.0 kg/m²), and waist circumference increased, notably in the US (105.5 cm, IQR: 93.8-116.1 cm). Blood pressure levels rose across countries, with significant increases in Jamaica and Seychelles. Glucose levels surged in Ghana (4.5 to 5.9 mmol/L, IQR:5.5-6.4 mmol/L) and Seychelles (4.6 to 6.2 mmol/L, IQR:5.6-6.9 mmol/L), with Ghana's high glucose prevalence jumping from 5.8% to 70%. Smoking declined in Ghana and Seychelles but rose in Jamaica and the US. Alcohol consumption increased in the US and Seychelles but fell in Ghana. Depressive symptoms remained prevalent, with Seychelles reporting the highest rates (33% at follow-up). Table 2A in Appendix B compares differences between participants included and excluded from the analysis based on follow-up completion (or whether they have depression data). Participants included in the analysis were slightly younger on average and more likely to be from Jamaica than those excluded ($p < 0.05$), while sex and the MetS variables [high BP, high TG, high glucose, low HDL, high WC] did not differ significantly.

Figure 1 illustrates the percentage of individuals presenting with depression stratified by Metabolic Syndrome (MetS) status, site and sex during the follow-up visit. Those presenting with depression were categorized into two groups: those who had MetS and those without MetS, with the data displayed separately for men and women. Across all sites, there are notable variations in the proportion of those presenting with depression who had and did not have MetS. Among men, Ghana shows a small proportion of individuals presenting with depression who had MetS (9.1%), while the majority (90.9%) did not have MetS. Similarly, in SA and Jamaica, all men presenting with depression at follow-up did not have MetS at baseline. However, in Seychelles, men presenting with depression were equally distributed between those with MetS (50%) and those without (50%), while in the US, 33.3% of men presenting with depression have MetS, and 66.7% do not.

Among women, a higher proportion of individuals presenting with depression also reported MetS compared to men, particularly in Jamaica, Seychelles, and the US. In Ghana, 88.9% of women presenting with depression did not have MetS, and only 11.1% did. In SA, none of the women presenting with depression had MetS (100% "No MetS"), mirroring the pattern observed among men. In contrast, in Jamaica, 38.5% of women presenting with depression had MetS, while 61.5% did not. In Seychelles, 42.9% of women presenting with depression also had MetS. Similarly, in the US, 38.1% of women presenting with depression had MetS while 61.9% did not.

Figure 2 displays a comparison of CES-D scores (a measure of depressive symptoms) across sites (countries) and by sex. The y-axis represents the CES-D score, while the x-axis shows

the sites, with scores categorized by sex (men in red and women in blue). The dashed horizontal line at Y=16 indicates the CES-D cut-off score for clinically significant depressive symptoms. Boxplots are used to represent the median and interquartile range (IQR) of CES-D scores, while individual data points are overlaid to show the distribution within each group.

In all sites, most CES-D scores for men and women were below the cut-off of 16, indicating that the majority of individuals may not have clinically significant depressive symptoms. However, there are notable differences between sites and sexes in the distribution of scores. Outliers (points above the whiskers) are present in all sites, indicating a subset of individuals with much higher CES-D scores. Across most sites, women tend to have slightly higher CES-D scores compared to men, as evidenced by higher medians and wider IQRs in the blue (women) boxplots compared to the red (men) boxplots. This trend is most pronounced in sites like Jamaica, Seychelles, and the US, where the median CES-D scores for women are consistently higher than those for men.

In Ghana, both men and women had relatively low CES-D scores, with the medians for both sexes falling well below the cut-off score of 16. Men and women exhibit similar distributions, with minimal variability and very few individuals exceeding the cut-off. Similar to Ghana, most individuals in SA had CES-D scores below the cut-off. Women exhibited slightly higher scores compared to men, but the differences are small. Women in Jamaica had higher CES-D scores compared to men, with a larger proportion of women exceeding the cut-off of 16. The IQR for women is also wider, indicating greater variability in depressive symptoms among women compared to men. Men and women in Seychelles show similar distributions, but a noticeable portion of women have CES-D scores exceeding the cut-off of 16. Women also have a slightly higher median score compared to men.

Both men and women in the US exhibit the highest CES-D scores among all sites. Women show a larger proportion of scores exceeding the cut-off of 16, with a wider IQR and higher median compared to men. The US displays the most variability in depressive symptoms, especially among women.

The association between metabolic syndrome and risk for depression.

In the overall population (Table 4), there is no significant association between MetS and risk for depression across models (OR = 0.767, CI: [0.389, 1.463]) suggesting that MetS as a composite variable does not predict depression for the general population across sites. Looking into the individual components of MetS: high WC, high BP, high glucose and obesity all do not have a significant association with risk for depression. This means that the included individual MetS components do not independently increase the risk for depression. Alcohol consumption and employment also do not have significant associations. Living in Seychelles and Ghana was consistently associated with lower odds of depression compared to living in the US (OR = 0.189, CI: [0.078, 0.430], $P < 0.01$).

Among women, there is also no significant association between MetS and risk for depression (OR = 0.807, CI: [0.368, 1.718]). Similarly to the overall population, the individual MetS components (high WC, high BP, low HDL, high glucose, obesity) are also not significantly associated with depression. Age has a significant inverse association with risk for depression (OR = 0.934, CI: [0.885, 0.984], P < 0.05), meaning that older women are less likely to report depression. Women living in the Seychelles reported lower odds of risk for depression compared to women in the US. In the cross-sectional 2019 model (3), women in Jamaica reported lower odds of depression compared to women in the US (OR: 0.237, CI [0.079, 0.654], P<0.05).

Among men, there is still no significant association between MetS and risk for depression (OR = 0.841, CI: [0.166, 3.302]). However, high BP was a significant risk factor for depression in Model 3 (OR = 3.460, CI [1.301, 10.162], p<0.1), indicating that men with high BP were 3.40 times more likely to present with depression compared to men without high BP. This highlights high BP as a significant risk factor for depression in men. Low HDL was strongly associated with depression in Model 2 (OR = 3.450, CI: [1.051, 11.260], P < 0.1), indicating that men with poor lipid profiles have an elevated risk of depression. Interestingly, obesity was inversely associated with the risk of depression in men in Model 3 (OR=0.200, CI [0.038, 0.849], P<0.1), indicating that obese men were less likely to be depressed. Similarly to women, age has a significant association with the risk of depression in men. Living in the US was also risk factor for depression, particularly when compared to Seychelles and Jamaica.

4. Discussion

Across the five countries, notable trends were observed in metabolic health indicators, including increases in obesity, waist circumference, and blood pressure. For example, the prevalence of obesity was highest in the US, where it reached 66% at follow-up from 63% at baseline. Concurrently, significant rises in depression prevalence, waist circumference and fasting glucose levels were documented in Ghana and Seychelles. The differential patterns observed across countries reflect the varying stages of the epidemiological transition, likely driven by urbanization and changes in dietary patterns[30]. The US maintained the highest overall prevalence of obesity and depression. The observed increases in systolic and diastolic blood pressure across all countries further underscore the growing burden of cardiometabolic risks in these populations. These patterns align with the literature suggesting that countries undergoing epidemiological transitions experience increased prevalence of obesity and associated conditions[29,31].

Gender-specific analysis revealed that women with high BMI were more likely to exhibit depressive symptoms across all study sites, consistent with a wealth of prior research[31,32]. The risk of depression was notably higher among women, consistent with prior findings which suggest that women are more vulnerable to psychological distress due to the complex interplay of socio-cultural and biological factors[33]. In parallel, elevated metabolic risks, including high waist circumference and fasting glucose, were disproportionately observed in

women, reinforcing the interplay between metabolic dysregulation and mental health outcomes. Men showed higher rates of smoking and alcohol consumption compared to women (see Table 2 and 3 in Appendix), which are behaviours commonly linked to elevated blood pressure and increased cardiovascular risk[32].

Notably, triglyceride levels were not consistently associated with depression, suggesting variability in biochemical predictors across regions. The inconsistent association between triglyceride levels and depression contrasts with some existing research that suggests a link between these factors[9]. Furthermore, the absence of triglyceride data in the follow-up created a limitation in verifying these inconsistencies with a longitudinal analysis.

The regression results showed no evidence of the association between depression and MetS, contrast to other studies which find a significant association[13,28]. Increasing age emerged as a protective factor for women[33]. Among men, high BP and low HDL emerged as significant risk factors, while obesity appeared to be protective. Obesity appearing to be protective against depression in men contradicts the general understanding of obesity as a risk factor for both physical and mental health[34,35]. This unexpected result may be due to the nature of our data with a long lag between baseline and follow-up. It requires further investigation.

Across all groups, living in the US was consistently associated with higher odds of depression compared to other sites. Socio-cultural -and -regional effects may have contributed to the under-reporting of depression (or overreporting in the US) [36]. The consistent association of Ghana, Seychelles and Jamaica with lower odds of depression compared to the US emphasizes the importance of socio-cultural and environmental factors in shaping mental health outcomes[36,37]. Future research could also explore different tools for assessing depression instead of only using self-reported measures. In addition, further research could pursue a deeper understanding of the gender- and region-specific determinants of depression.

Overall, the study confirms several established findings regarding the relationship between depression and MetS, particularly in the context of the epidemiological transition. The link between high BMI and depression in women, and between elevated blood pressure and depression in men (particularly in SA and Jamaica) provides a more nuanced understanding of the depression and MetS relationship. This study also demonstrates the importance of considering regional context. The differing patterns of glucose levels, depression prevalence, and behavioural risk factors across the five countries, highlights the need for region-specific interventions.

While this study provides critical insights, it is limited by its reliance on secondary data with a large gap between baseline and follow-up. The depression data was collected only at follow-up whereas the data for all the components of MetS were only complete at baseline. Thus, we could not conduct a complete cross-sectional analysis nor a longitudinal analysis. The observed differences in age and site between included and excluded participants may limit the generalizability of the findings and suggest that study site influenced follow-up

completion. Longitudinal studies are more suitable for understanding causal pathways. The number of participants in each country who presented with both depression and MetS were very low. This produced skewed regression estimates when regressions were estimated by country.

The LASSO regression analysis (Table 4 in Appendix B) confirmed the primary findings, identifying only marital status and site (Seychelles) as predictors of depressive symptoms, while all five MetS components were excluded. This reinforces the limited role of baseline metabolic risk in predicting depression within this sample and highlights the importance of social and environmental factors, with alignment between LASSO and traditional models supporting the robustness and parsimony of the final results.

In conclusion, this study underscores key trends in metabolic and psychological health across five diverse countries, highlighting the complex intersection of metabolic risk factors, depression, and sociodemographic context. Consistent with global patterns, rising rates of obesity, central adiposity, and elevated blood pressure were observed, particularly among women, who also exhibited a higher burden of depressive symptoms. Although no overall association between MetS and depression was found, weak associations between specific MetS components and depression were identified in men—particularly elevated blood pressure, alongside behavioral risks such as smoking and alcohol use. Country-level differences also emerged, with participants in Ghana, Seychelles, and Jamaica demonstrating lower odds of depression relative to the US.

These findings have important implications for public health policy. They point to the need for integrated, gender-sensitive interventions that address both metabolic and mental health in a culturally responsive manner. Policymakers should prioritize context-specific strategies that account for the social determinants of health, including marital status and national development stage. Interventions must go beyond biomedical approaches, emphasizing preventive care, mental health promotion, and accessible community-based services, particularly in resource-constrained settings. Strengthening surveillance systems to monitor the dual burden of metabolic and mental health conditions across different HDI contexts will also be essential for informed, equitable policy responses.

Contributors

LD conceptualized the project. All authors contributed to the study design. VD developed the literature, methods and data presentation.

Declaration of interests

We declare no competing interests.

Data Availability

The datasets used for this project are merged, managed and stored by the data controller at the Loyola University Chicago, US. The original contributions presented in the study are included in the Article and its appendix. Further inquiries should be directed to VD.

Table 1: Overall population characteristics at baseline(2010) and follow-up (2019) by country site (ordered by HDI).

Characteristic	Ghana		South Africa		Jamaica		Seychelles		United States	
	2010, N = 189	2019, N = 189	2010, N = 52	2019, N = 52	2010, N = 91	2019, N = 91	2010, N = 122	2019, N = 122	2010, N = 92	2019, N = 92
Age(yrs)	43.0 (37.0–49.0)*	46.5 (40.8–52.0)*	41.0 (35.8–46.0)*	43.0 (38.0–48.0)*	46.0 (37.0–50.0)*	49.0 (40.0–52.0)*	44.0 (39.0–48.0)*	47.0 (42.0–50.0)*	46.0 (42.0–50.3)*	48.5 (45.0–53.0)*
Female	123 (65%)	123 (65%)	30 (58%)	30 (58%)	56 (62%)	56 (62%)	68 (56%)	68 (56%)	64 (70%)	64 (70%)
Education (yrs)	9.0 (7.0–10.0)*	-	11.0(10.0-11.0)*		11.0 (9.0–11.0)*	-	13.0 (11.0–14.8)*	-	13.0(12.0-15.0)*	
Married/Living with partner	137 (72%)*	137 (73%)	12 (23%)*	13 (25%)	43 (47%)*	40 (44%)	78 (64%)*	75 (61%)	32 (35%)*	30 (33%)
Employed	125 (66%)*	168 (89%)*	23 (44%)*	9 (18%)*	64 (70%)*	69 (77%)*	103 (84%)*	113 (93%)*	65 (71%)*	54 (59%)*
BMI (kg.m^{-2})	25.1 (21.6–29.7)*	25.6 (22.1–30.0)*	27.4 (23.3–32.0)*	25.9 (23.3–35.4)*	28.5 (24.1–33.1)*	28.8 (23.8–33.6)*	28.5 (24.7–31.9)*	29.2 (25.4–33.6)*	33.4 (27.8–39.7)*	32.5 (28.7–39.0)*
Waist (cm)	89.5 (81.1–98.1)*	90.0 (82.4–98.3)*	91.0 (81.1–101.7)*	94.0 (83.1–105.9)*	94.1 (83.9–103.9)*	91.9 (81.8–102.0)*	95.0 (86.3–103.1)*	101.8 (92.6–111.1)*	104.4 (92.8–117.1)*	105.5 (93.8–116.1)*
SBP (mmHg)	115.3 (107.7–124.3)*	117.5 (107.0–130.3)*	119.3 (110.1–129.8)*	122.3 (112.3–135.9)*	123.2 (112.9–134.0)*	131.2 (120.6–145.5)*	125.1 (114.1–133.7)*	125.8 (114.0–138.1)*	122.2 (113.3–133.9)*	125.3 (117.0–132.9)*
DBP (mmHg)	68.3 (61.2–76.2)*	71.0 (64.2–78.5)*	75.9 (68.6–85.4)*	78.6 (74.0–86.2)*	78.3 (70.0–84.5)*	84.3 (74.2–90.6)*	78.8 (70.0–87.3)*	80.3 (71.9–86.0)*	79.1 (71.3–88.5)*	83.9 (76.3–89.2)*
TG (mmol/L)	1.0 (0.7–1.3)	-	0.9 (0.7–1.1)	-	0.9 (0.7–1.2)	-	1.0 (0.7–1.4)	-	0.9 (0.7–1.3)	-
HDL (mmol/L)	1.2 (1.0–1.4)	-	1.2 (1.0–1.5)	-	1.2 (1.0–1.4)	-	1.2 (1.1–1.4)	-	1.3 (1.1–1.6)	-
Glucose (mmol/L)	4.5 (4.3–4.8)*	5.9 (5.5–6.4)*	4.6 (4.3–5.0)*	4.8 (4.5–5.4)*	4.3 (4.0–4.8)*	5.6 (5.2–6.3)*	4.6 (4.2–5.0)*	6.2 (5.6–6.9)*	5.1 (4.7–5.5)*	5.4 (5.0–6.2)*
Obese (count, %)	44 (23%)*	50 (26%)*	19 (37%)*	21 (40%)*	38 (42%)*	36 (40%)*	45 (37%)*	53 (43%)*	58 (63%)*	61 (66%)*
High WC (count, %)	122 (65%)*	121 (64%)*	28 (54%)*	33 (63%)*	64 (70%)*	58 (64%)*	94 (77%)*	107 (88%)*	70 (76%)*	69 (75%)*
High TG (count, %)	22 (12%)	-	5 (9.6%)	-	12 (13%)	-	24 (20%)	-	7 (7.6%)	-
Low HDL (count, %)	99 (52%)	-	23 (44%)	-	40 (44%)	-	45 (37%)	-	42 (46%)	-
High BP (count, %)	43 (23%)*	67 (35%)*	21 (40%)*	33 (63%)*	41 (45%)*	65 (71%)*	61 (50%)*	76 (62%)*	46 (50%)*	68 (74%)*
High Glucose (count, %)	11 (5.8%)*	132 (70%)*	1 (1.9%)*	10 (19%)*	7 (7.7%)*	47 (52%)*	17 (14%)*	91 (75%)*	27 (29%)*	41 (45%)*
METS (count, %)	23 (12%)*	-	9 (17%)*	-	26 (29%)*	-	33 (27%)*	-	36 (39%)*	-
Smoker (count, %)	0 (0%)*	3 (1.6%)*	20 (38%)*	2 (3.8%)*	4 (4.4%)*	23 (25%)*	10 (8.2%)*	0 (0%)*	14 (15%)*	28 (30%)*
Drinker (count, %)	30 (16%)*	6 (3.2%)*	23 (44%)*	9 (17%)*	35 (38%)*	35 (38%)*	73 (60%)*	80 (66%)*	38 (41%)*	53 (58%)*
CES-D Score	-	5.0 (0.0–10.0)*	-	10.5 (6.0–15.3)*	-	8.0 (3.0–13.0)*	-	6.0 (3.0–9.0)*	-	10.0 (4.0–18.3)*
Depressed (count, %)	-	29 (15%)*	-	13 (25%)*	-	16 (18%)*	-	11 (9.0%)*	-	30 (33%)*
Mets & Depression	3 (1.58%)		0 (0%)		5 (5.49%)		5 (4.09%)		11 (11.96%)	

Data a represented as Median(Interquartile Range: 25%–75%) or count(%). HDI :Human Development Index, , BMI: Body Mass Index, WC:Waist Circumference, TG:Triglycerides, HDL:High Density Lipoproteincholesterol, SBP:Systolic Blood Pressure, DBP:Diastolic Blood Pressure ,Mets :Metabolic Syndrome.* represents statistically significant p-values ($p<0.05$) from site comparisons tests at baseline(2010) and at follow-up(2019) using either Kruskal-Wallis or Fisher's Exact Tests.

Figure 1: Metabolic Syndrome status of individuals presenting with depression by Site (or country) and Sex.

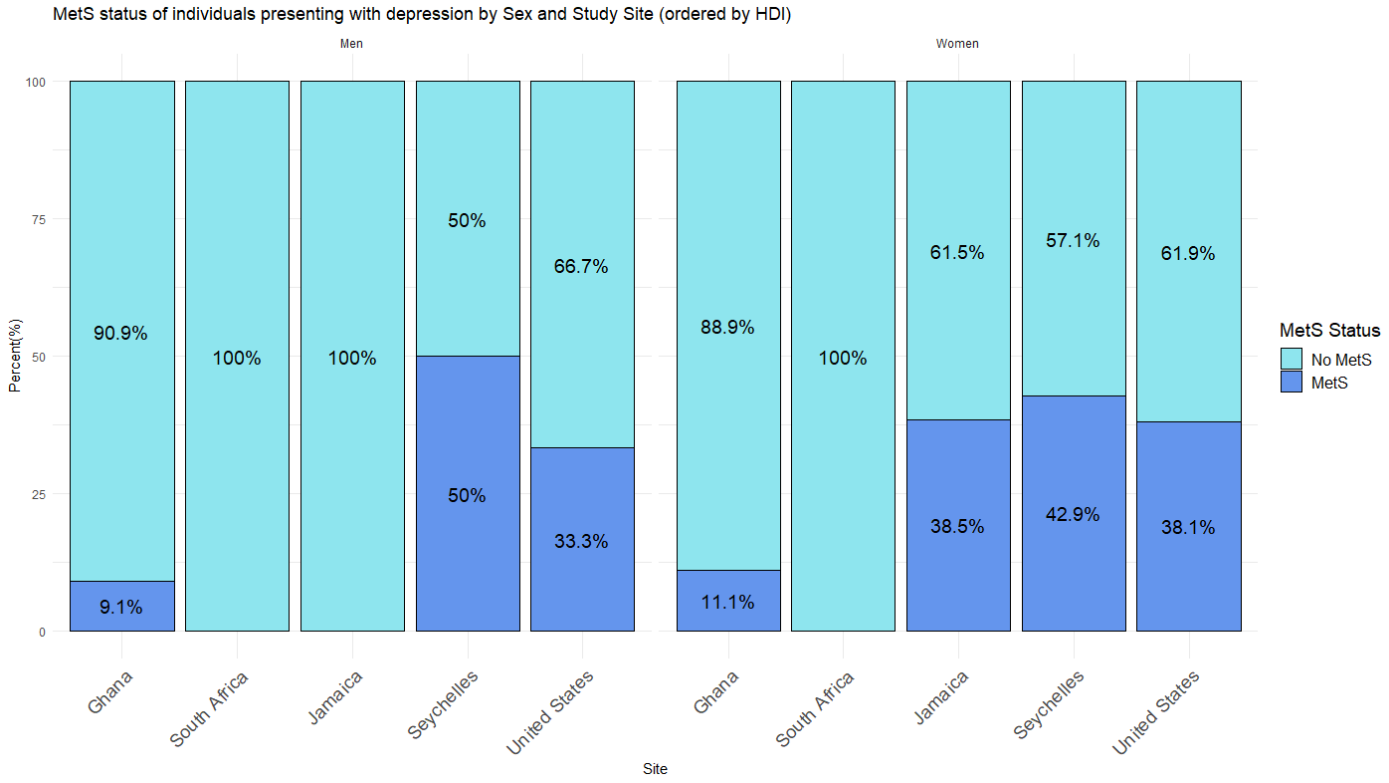


Figure 2: A comparison of CES-D scores (a measure of depressive symptoms) across sites (countries) and by sex.

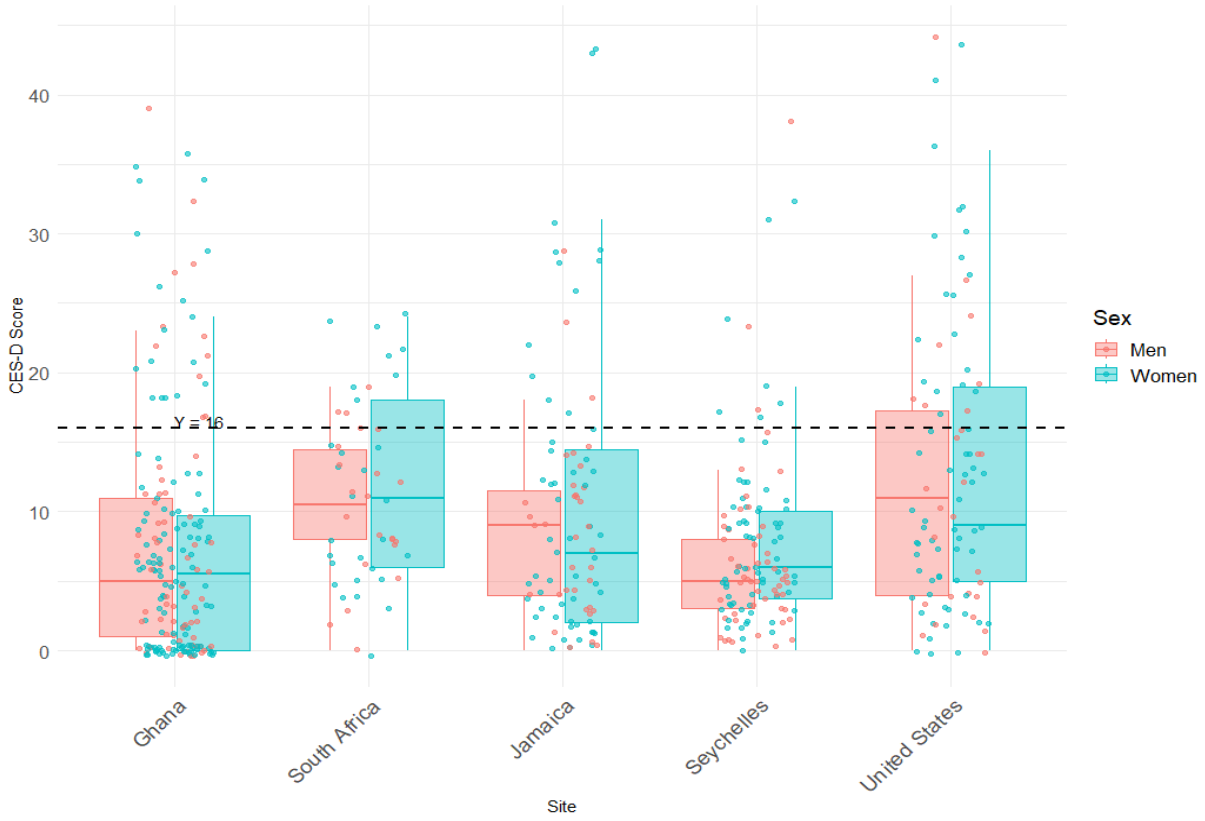


Table 2: Logistic Regression Analysis of Risk of Depression (Y = Depressed) by MetS Components and Demographic Factors for Overall sample, Women and Men.

Logistic Regression (Y=Depressed)	Overall (N=546)			Women(N=338)			Male(N=204)		
	(1) Mets	(2) Mets Risk	(3) Mets Risk 2019	(1) Mets	(2) Mets Risk	(3) Mets Risk2019	(1) Mets	(2) Mets Risk	(3) Mets Risk 2019
MetS	0.767 [0.389,1.463]			0.807 [0.368, 1.718]			0.841 [0.166, 3.302]		
High WC		1.195 [0.572, 2.543]	1.151 [0.571, 2.340]		1.594 [0.503, 6.216]	1.038 [0.377, 3.197]		0.966 [0.282, 3.190]	2.060 [0.651, 6.433]
High BP		0.668 [0.366, 1.199]	1.411 [0.848, 2.375]		0.681 [0.310, 1.459]	1.030 [0.552, 1.931]		0.627 [0.219, 1.714]	3.460* [1.301, 10.162]
High TG		0.555 [0.192, 1.375]			0.859 [0.218, 2.776]			0.245 [0.026, 1.341]	
Low HDL		1.526 [0.824, 2.855]			1.131 [0.534, 2.460]			3.450* [1.051, 11.260]	
High Glucose		1.338 [0.542, 3.131]	1.433 [0.868, 2.395]		1.706 [0.542, 5.115]	1.373 [0.741, 2.584]		1.154 [0.218, 4.805]	1.940 [0.726, 5.627]
Obese			1.022 [0.586, 1.792]			1.481 [0.782, 2.856]			0.200* [0.038, 0.849]
Age	0.971* [0.932, 1.011]	0.981 [0.940, 1.023]	0.968* [0.937, 1.000]	0.934* [0.885, 0.984]	0.937* [0.884, 0.990]	0.937** [0.899, 0.976] 0	1.029 [0.954, 1.112]	1.052 [0.970, 1.146]	1.030 [0.960, 1.103]
Female	1.453 [0.819, 2.627]	1.008 [0.478, 2.138]	1.109 [0.610, 2.041]						
Married/Living with Partner	0.851 [0.490, 1.477]	0.831 [0.476, 1.453]	0.913 [0.557, 1.499]	0.802 [0.406, 1.574]	0.815 [0.409, 1.618]	0.788 [0.428, 1.444]	1.031 [0.328, 3.482]	1.087 [0.329, 3.848]	1.020 [0.388, 2.791]
Education(yrs)	0.980 [0.890, 1.079]	0.981 [0.890, 1.083]		0.988 [0.867, 1.127]	0.996 [0.873, 1.137]	0.624 [0.322, 1.220]	0.880 [0.730, 1.041]	0.844 [0.692, 1.013]	0.660 [0.166, 2.801]
Employed	0.795 [0.385, 1.698]	0.883 [0.419, 1.919]	0.692 [0.395, 1.230]	1.069 [0.444, 2.714]	1.215 [0.488, 3.178]	1.254 [0.594, 2.655]	0.348 [0.075, 1.604]	0.277 [0.054, 1.413]	0.500 [0.172, 1.403]
Drinks Alcohol	1.179 [0.669, 2.070]	1.371 [0.760, 2.473]	0.912 [0.508, 1.629]	1.446 [0.694, 2.978]	1.611 [0.743, 3.487]	0.401 [0.143, 1.114]	0.897 [0.353, 2.293]	1.018 [0.384, 2.723]	0.310 [0.068, 1.463]
US vs Ghana	0.275** [0.102, 0.712]	0.311* [0.112, 0.832]	0.401* [0.178, 0.897]	0.185* [0.044, 0.695]	0.224* [0.052, 0.869]	0.678 [0.214, 2.045]	0.380 [0.083, 1.657]	0.290 [0.054, 1.411]	0.420 [0.073, 2.300]
US vs SA	0.447 [0.168, 1.147]	0.563 [0.206, 1.508]	0.586 [0.236, 1.407]	0.452 [0.126, 1.545]	0.587 [0.158, 2.109]	0.673 [0.275, 1.612]	0.437 [0.075, 2.200]	0.597 [0.093, 3.399]	0.140* [0.023, 0.697]
US vs Jamaica	0.350* [0.143, 0.822]	0.418 [0.164, 1.025]	0.446* [0.209, 0.925]	0.455 [0.152, 1.295]	0.573 [0.183, 1.725]	0.237** [0.079, 0.654]	0.153* [0.018, 0.849]	0.180 [0.020, 1.096]	0.100** [0.017, 0.474]
US vs Seychelles	0.189*** [0.078, 0.430]	0.216*** [0.087, 0.502]	0.207*** [0.086, 0.473]	0.153*** [0.050,0.426]	0.174** [0.056, 0.492]	0.788 [0.428, 1.444]	0.210* [0.039, 0.926]	0.286 [0.046, 1.451]	1.020 [0.388, 2.791]

*All models estimates are Odds Rations with [95% confidence intervals]. Model (3) is cross-sectional with the outcome and dependent variables from 2019. All other models have the outcome from 2019 and predictors from 2017. ***P<0.01,**P<0.05,*P<0.1.*

5. References

1. Jacques Noubiap J, Richie Nansseu J, Lontchi-Yimagou E, René Nkeck J, Flore Nyaga U, Ngouo AT, et al. Geographic distribution of metabolic syndrome and its components in the general adult population: A meta-analysis of global data from 28 million individuals. Diabetes Res Clin Pract [Internet]. 2022 [cited 2025 Feb 6];188:109924. Available from: https://doi.org/10.1016/j.diabres.2022.109924

2. WHO. Depressive disorder (depression) [Internet]. 2023 [cited 2025 Feb 5]. Available from: https://www.who.int/news-room/fact-sheets/detail/depression

3. Cristóbal-Narváez P, Haro JM, Koyanagi A. Perceived stress and depression in 45 low- and middle-income countries. J Affect Disord. 2020 Sep 1;274:799–805.

4. Kiingati J. Unearthing-Depression. 2023.

5. Brody DJ, Pratt LA, Hughes JP. Prevalence of Depression Among Adults Aged 20 and Over: United States, 2013-2016 Key findings Data from the National Health and Nutrition Examination Survey [Internet]. 2013. Available from: https://www.cdc.gov/nchs/data/databriefs/db303_table.pdf#3.

6. Grundy SM. Metabolic syndrome: a multiplex cardiovascular risk factor. J Clin Endocrinol Metab [Internet]. 2007 [cited 2025 Feb 5];92(2):399–404. Available from: https://pubmed.ncbi.nlm.nih.gov/17284640/

7. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Vol. 112, Circulation. 2005. p. 2735–52.

8. Marazziti D, Rutigliano G, Baroni S, Landi P, Dell'Osso L. Metabolic syndrome and major depression. Vol. 19, CNS Spectrums. Cambridge University Press; 2014. p. 293–304.

9. Heiskanen TH, Niskanen LK, Hintikka JJ, Koivumaa-Honkanen HT, Honkalampi KM, Haatainen KM, et al. Metabolic syndrome and depression: a cross-sectional analysis. J Clin Psychiatry [Internet]. 2006 [cited 2025 Feb 5];67(9):1422–7. Available from: https://pubmed.ncbi.nlm.nih.gov/17017829/

10. Zhang M, Chen J, Yin Z, Wang L, Peng L. The association between depression and metabolic syndrome and its components: a bidirectional two-sample Mendelian randomization study. Transl Psychiatry. 2021 Dec 1;11(1).

11. Al-Khatib Y, Akhtar MA, Kanawati MA, Mucheke R, Mahfouz M, Al-Nufoury M. Depression and Metabolic Syndrome: A Narrative Review. Cureus. 2022 Feb 12;

12. Vaccarino V, McClure C, Johnson BD, Sheps DS, Bittner V, Rutledge T, et al. Depression, the metabolic syndrome and cardiovascular risk. Psychosom Med. 2008 Jan;70(1):40–8.

13. Moradi Y, Albatineh AN, Mahmoodi H, Gheshlagh RG. The relationship between depression and risk of metabolic syndrome: a meta-analysis of observational studies. Clin Diabetes Endocrinol. 2021 Dec;7(1).

14. Gurka MJ, Vishnu A, Santen RJ, Deboer MD. Progression of Metabolic Syndrome Severity During the Menopausal Transition. J Am Heart Assoc [Internet]. 2016 Aug 1 [cited 2025 Feb 5];5(8). Available from: https://pubmed.ncbi.nlm.nih.gov/27487829/

15. Gelaye B, Williams MA, Lemma S, Berhane Y, Fann JR, Stoep A Vander, et al. Major depressive disorder and cardiometabolic disease risk among sub-Saharan African adults. Diabetes and Metabolic Syndrome: Clinical Research and Reviews. 2015 Jul 1;9(3):183–91.

16. Brinkmann V, Schiavi A, Shaik A, Puchta DR, Ventura N. Dietary and environmental factors have opposite AhR-dependent effects on C. elegans healthspan. Aging [Internet]. 2020 Jan 15 [cited 2025 Feb 5];13(1):104–33. Available from: https://pubmed.ncbi.nlm.nih.gov/33349622/

17. Ettinger AS, Bovet P, Plange-Rhule J, Forrester TE, Lambert E V., Lupoli N, et al. Distribution of metals exposure and associations with cardiometabolic risk factors in the “modeling the Epidemiologic Transition Study.” Environ Health. 2014;13(1).

18. Cooper RS, Forrester TE, Plange-Rhule J, Bovet P, Lambert E V., Dugas LR, et al. Elevated hypertension risk for African-origin populations in biracial societies: Modeling the Epidemiologic Transition Study. J Hypertens. 2015 Mar 6;33(3):473–81.

19. Rae DE, Dugas LR, Roden LC, Lambert EV, Bovet P, Plange-Rhule J, et al. Associations between self-reported sleep duration and cardiometabolic risk factors in young African-origin adults from the five-country modeling the epidemiologic transition study (METS). Sleep Health. 2020 Aug 1;6(4):469–77.

20. Shoham DA, Dugas LR, Bovet P, Forrester TE, Lambert E V., Plange-Rhule J, et al. Association of car ownership and physical activity across the spectrum of human development: Modeling the Epidemiologic Transition Study (METS). BMC Public Health. 2015 Dec 12;15(1).

21. Dugas LR, Forrester TE, Plange-Rhule J, Bovet P, Lambert E V., Durazo-Arvizu RA, et al. Cardiovascular risk status of Afro-origin populations across the spectrum of economic development: findings from the Modeling the Epidemiologic Transition Study. BMC Public Health. 2017 May 12;17(1).

22. Stringhini S, Forrester TE, Plange-Rhule J, Lambert E V., Viswanathan B, Riesen W, et al. The social patterning of risk factors for noncommunicable diseases in five countries: Evidence from the modeling the epidemiologic transition study (METS). BMC Public Health. 2016 Sep 9;16(1).

23. Atiase Y, Farni K, Plange-Rhule J, Luke A, Bovet P, Forrester TG, et al. A comparison of indices of glucose metabolism in five black populations: Data from modeling the epidemiologic transition study (METS). BMC Public Health. 2015 Sep 15;15(1).

24. Luke A, Bovet P, Forrester TE, Lambert E V., Plange-Rhule J, Schoeller DA, et al. Protocol for the modeling the epidemiologic transition study: A longitudinal observational study of energy balance and change in body weight, diabetes and cardiovascular disease risk. BMC Public Health [Internet]. 2011 Dec 14 [cited 2025 Feb 5];11(1):1–10. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-11-927

25. Lie L, Brown L, Forrester TE, Plange-Rhule J, Bovet P, Lambert E V., et al. The association of dietary fiber intake with cardiometabolic risk in four countries across the epidemiologic transition. Nutrients. 2018 May 16;10(5).

26. Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: A joint interim statement of the international diabetes federation task force on epidemiology and prevention; National heart, lung, and blood institute; American heart association; World heart federation; International atherosclerosis society; And international association for the study of obesity. Vol. 120, Circulation. 2009. p. 1640–5.

27. World Bank Group. 2013 World Development Indicators [Internet]. 2013 [cited 2025 Feb 11]. Available from: www.worldbank.org

28. Skilton MR, Moulin P, Terra JL, Bonnet F. Associations between anxiety, depression, and the metabolic syndrome. Biol Psychiatry [Internet]. 2007 Dec 1 [cited 2025 Feb 5];62(11):1251–7. Available from: https://pubmed.ncbi.nlm.nih.gov/17553465/

29. Mendenhall E, Kohrt BA, Norris SA, Ndetei D, Prabhakaran D. Non-communicable disease syndemics: poverty, depression, and diabetes among low-income populations. Lancet [Internet]. 2017 Mar 4 [cited 2025 Feb 5];389(10072):951. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5491333/

30. McKeown RE. The Epidemiologic Transition: Changing Patterns of Mortality and Population Dynamics. Am J Lifestyle Med [Internet]. 2009 Jul [cited 2025 Feb 6];3(1 Suppl):19S. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC2805833/

31. Toker S, Shirom A, Melamed S. Depression and the metabolic syndrome: Gender-dependent associations. Depress Anxiety. 2008;25(8):661–9.

32. Lee J, Go TH, Min S, Koh SB, Choi JR. Association between lifestyle factors and metabolic syndrome in general populations with depressive symptoms in cross-setional based cohort study of Ansung-Ansan. PLoS One. 2022 Mar 1;17(3 March).

33. Albert PR. Why is depression more prevalent in women? J Psychiatry Neurosci [Internet]. 2015 Jul 1 [cited 2025 Feb 5];40(4):219. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC4478054/

34. Fulton S, Décarie-Spain L, Fioramonti X, Guiard B, Nakajima S. The menace of obesity to depression and anxiety prevalence. Trends in Endocrinology & Metabolism. 2022 Jan 1;33(1):18–35.

35. Lassale C, Batty GD, Baghdadli A, Jacka F, Sánchez-Villegas A, Kivimäki M, et al. Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. Mol Psychiatry [Internet]. 2019 Jul 1 [cited 2025 Feb 5];24(7):965–86. Available from: https://pubmed.ncbi.nlm.nih.gov/30254236/

36. Kessler RC, Bromet EJ. The epidemiology of depression across cultures. Annu Rev Public Health [Internet]. 2013 Mar [cited 2025 Feb 5];34:119. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC4100461/

37. Moussavi S, Chatterji S, Verdes E, Tandon A, Patel V, Ustun B. Depression, chronic diseases, and decrements in health: results from the World Health Surveys. Lancet [Internet]. 2007 Sep 8 [cited 2025 Feb 5];370(9590):851–8. Available from: https://pubmed.ncbi.nlm.nih.gov/17826170/

38. WHO. Global action plan for the prevention and control of noncommunicable diseases, 2013-2020. 2013;103.

Part D: Appendices

Appendix A

Table 1: METS Study measure collected at baseline, 12-months and 24-months follow-up[24].

Table 1: METS study measures collected at baseline and during follow-ups.

Study Measures

	Baseline	12-Months	24-Months
Objectively Measured Energy Expenditure			
Physical activity (Actical)	X		X
Total energy expenditure (DLW; subset N = 375)	X		
Resting energy expenditure (indirect calorimetry; subset N = 375)	X		
Self-Reported Measures			
Physical Activity (GPAQ)	X		X
Dietary Intake (24-hr Recall)	X		
Medication & supplement use	X	X	X
Smoking status & alcohol consumption	X	X	X
Health history	X	X	X
Household SES, education level, industry & occupation	X		X
Body Composition			
Bioelectrical impedance analysis	X		X
Isotope Dilution (subset N = 375)	X		X
Clinical Measures			
Weight, height, waist & hip circumferences, blood pressure & pulse	X	X	X
Biochemical Measures			
Hba1c, total cholesterol, HDL and LDL cholesterol, triglyceride, glucose, insulin, adiponectin, leptin, ghrelin, urinary albumin & creatinine, and T4, T3 & TSH in subset (N = 375)	X		

Table 2 : Variables to be used from parent study in proposed study[24]

Variable	Scale	Categories
Demographics		
Age	Numerical - Continuous	
	Categorical - Ordinal	25-35
		36-45
Sex	Categorical - Binary	Female
		Male
Marital Status	Categorical	Never Married
		Married/Partner
		Divorced/Widowed
Education	Categorical - Ordinal	No Schooling
		Below High School
		High School Completed
		Tertiary
Occupation	Categorical	To Be Confirmed
Employment Status	Categorical	Never Worked
		Unemployed
		Employed
Site	Categorical	South Africa
		Jamaica
		Ghana
		Seychelles
		United States
Self-Reported Measures		
Depression	Categorical - Binary	Not Depressed (CES-D<12)
		Depressed (CES-D≥ 12)
Physical Activity	Numeric - Continuous	Interquartile Ranges
Family or Previous History of Diabetes	Categorical - Binary	Yes
		No
Currently Taking Medications for Diabetes	Categorical - Binary	Yes
		No
Currently Taking Medications for Hypertension	Categorical - Binary	Yes
		No
Other Medication	Categorical - Binary	Yes
		No
Smoking	Categorical	Current Smoker
		Previous Smoker
		Never Smoked
Alcohol Use	Categorical	Non-Drinker
		Moderate (1-21 Beverages A Week)
		Excessive (>21 Beverages A Week)
Objective Measures (Categories Will Be Computed from Objectively Measured Data)		
BMI	Categorical - Ordinal	Underweight (<18.5kg/M2)
		Normal (18.5-24.9 Kg/M2)
		Overweight (25.0-29.9 Kg/M2)
		Obese (≥ 30.0 Kg/M2)
Blood Pressure	Categorical - Ordinal	Normal (Systolic<120mmHg)
		Elevated (Systolic 120-139 mmHg)
		Hypertension (Systolic ≥ 140mmHg)
Diabetes	Categorical - Binary	Yes (Fasting glucose: 126 mg/dL)
		No

Appendix B: Manuscript Tables

Table 2 presents the baseline and follow-up characteristics of women in Ghana, SA, Jamaica, Seychelles, and the US(ordered by HDI) at baseline and follow-up, highlighting notable trends and gender-specific differences over time. As expected, the median age of women increased between baseline and follow-up due to the longitudinal design of the study. Jamaica had the oldest female population, with a median age of 49 years at follow-up. This aging trend reflects the consistent cohort being followed over time.

The US had the highest median years of education (at 14years), followed by Seychelles (at 13years) whereas Ghana had the lowest (at just 9 years). Marital or partnership rates showed little changes over time. Employment rates among women were consistently lower compared to men. While male employment showed an increase in Seychelles, female employment remained relatively stable or declined in some regions. This disparity underscores ongoing gender differences in labor market participation across the sites.

Women exhibited increasing BMI scores and obesity across all sites, except Jamaica. Women demonstrated rising glucose levels and blood pressure (both SBP and DBP) across most sites, with Ghana experiencing a sharp increase in high glucose prevalence from 4.9% at baseline to 71% at follow-up. Low HDL prevalence was also more common among women, contributing to a heightened cardiovascular risk profile. SA women report the highest abdominal obesity at baseline (at 90%) but this changes to Jamaica at follow-up.

The US has the highest proportion of women with MetS (47%, followed by Jamaica at 39%) whereas Ghana had the lowest at 15%. The US also has the highest number of women reporting depression at 33% followed by SA at 27%. Seychelles reported the lowest depression among women at 10%.

Table 3 presents the baseline and follow-up characteristics of men across the different sites. The median age of men increased between baseline and follow-up, with men generally being slightly older than women in Table 2. For example, in the United States, the median age for men was 50.0 years at follow-up compared to 47.0 years for women. The US and Seychelles both had the highest median education years (at 13years). Employment increase between baseline and follow-up [from 63% to 85%] in Ghana, while both SA and US experienced a decline of about 5 percentage points.

BMI scores were the highest in the US and Seychelles and lowest in Ghana. High waist circumference prevalence among men in Seychelles rose from 65% at baseline to 76% at follow-up. The US and Seychelles again reported the highest prevalence of MetS, at 21% and 28%, respectively. The US and SA had the highest number of men with depression, at 32% and 23%, respectively. The number of men who drink or smoke changes by site between baseline and follow-up, although there is no clear pattern of change which could be a result of data collection.

Table 3: Female Characteristics at baseline(2017) and follow-up (2019) by country site (ordered by HDI).

	Ghana		South Africa		Jamaica		Seychelles		United States	
Characteristic	**Baseline, N = 123**	**Follow-up, N = 123**	**Baseline, N = 30**	**Follow-up, N = 30**	**Baseline, N = 56**	**Follow-up, N = 56**	**Baseline, N = 68**	**Follow-up, N = 68**	**Baseline, N = 64**	**Follow-up, N = 64**
Age(yrs)	42.0 (36.0–48.0)*	45.5 (39.0–51.0)	42.5 (37.3–47.8)*	45.0 (40.3–50.0)	46.0 (38.8–49.3)*	49.0 (40.8–52.0)	42.0 (38.0–48.0)*	45.0 (40.0–50.0)	45.0 (41.8–51.0)*	47.0 (44.0–53.0)
Education (yrs)	9.0 (6.0–9.0)	-	10.0(10.0-11.0)*		11.0 (10.0–11.0)*	-	13.0(11.8-15.0)*		14.0(.0-16.0)*	
Married†	83 (67%)	84 (68%)	10 (33%)*	10 (33%)	24 (43%)*	23 (41%)	36 (53%)*	35 (51%)	21 (33%)*	20 (31%)
Employed	77 (63%)	105 (85%)	11 (37%)*	8 (28%)*	35 (63%)*	37 (66%)*	61 (90%)*	61 (90%)*	41 (64%)*	38 (59%)*
BMI (kg.m-2)	27.5 (23.8–30.8)	27.7 (23.7–31.8)	31.1 (27.7–39.0)*	33.6 (26.6–40.0)*	31.3 (25.6–35.6)*	30.9 (26.7–35.3)*	28.4 (24.5–32.9)*	29.2 (25.8–34.2)*	35.7 (29.5–41.8)*	35.0 (30.5–39.8)*
Waist (cm)	92.9 (86.0–100.6)	94.4 (86.4–102.6)	97.6 (90.1–108.6)*	100.5 (92.5–115.0)*	96.8 (88.4–105.6)*	96.3 (86.8–103.3)*	93.0 (83.8–103.0)*	100.4 (91.8–111.5)*	110.1 (93.4–121.2)*	106.6 (94.7–117.5)*
SBP (mmHg)	114.5 (105.4–122.3)	116.8 (105.5–130.0)	116.4 (107.3–127.1)*	117.7 (105.4–139.8)*	120.4 (109.0–128.8)*	127.5 (117.8–146.2)*	117.7 (107.5–130.5)*	120.7 (110.2–128.0)*	122.1 (111.7–133.5)*	124.7 (116.1–131.5)*
DBP (mmHg)	70.0 (62.3–76.6)	72.3 (65.2–78.6)	75.0 (70.4–79.9)*	78.8 (73.2–86.6)*	76.5 (69.5–83.0)*	85.4 (71.5–91.1)*	78.0 (68.8–86.5)*	77.6 (69.6–84.6)*	79.4 (72.1–87.8)*	82.3 (75.8–88.6)*
TG (mmol.L-1)	1.0 (0.7–1.3)	-	0.8 (0.6–1.0)	-	0.9 (0.7–1.1)	-	0.9 (0.6–1.2)	-	0.9 (0.7–1.3)	-
HDL (mmol.L-1)	1.2 (1.1–1.4)	-	1.1 (0.9–1.4)	-	1.2 (1.0–1.5)	-	1.3 (1.1–1.5)	-	1.3 (1.1–1.5)	-
Glucose (mmol.L-1)	4.5 (4.3–4.8)	5.9 (5.5–6.4)	4.6 (4.4–5.1)*	5.0 (4.5–5.5)*	4.3 (3.9–4.8)*	5.5 (5.1–6.2)*	4.5 (4.1–4.8)*	6.0 (5.3–6.6)*	5.1 (4.8–5.7)*	5.4 (5.0–6.2)*
Obese (count, %)	42 (34%)	45 (37%)	18 (60%)*	20 (67%)*	31 (55%)*	30 (54%)*	28 (41%)*	32 (47%)*	47 (73%)*	48 (75%)*
High WC (count, %)	109 (89%)	110 (89%)	27 (90%)	28 (93%)	50 (89%)	47 (84%)	59 (87%)	66 (97%)	57 (89%)	55 (86%)
High TG (count, %)	12 (9.8%)	-	2 (6.7%)	-	5 (8.9%)	-	7 (10%)	-	5 (7.8%)	-
Low HDL (count, %)	83 (67%)	-	22 (73%)	-	37 (66%)	-	36 (53%)	-	37 (58%)	-
High BP (count, %)	26 (21%)	45 (37%)	11 (37%)*	20 (67%)*	23 (41%)*	39 (70%)*	27 (40%)*	34 (50%)*	31 (48%)*	46 (72%)*
HighGlucose(count,%)	6 (4.9%)	87 (71%)	0 (0%)*	6 (20%)*	5 (8.9%)*	27 (48%)*	8 (12%)*	44 (65%)*	20 (31%)*	27 (42%)*
METS (count, %)	19 (15%)	-	8 (27%)*	-	22 (39%)*	-	18 (26%)*	-	30 (47%)*	-
Smoker (count, %)	0(0%)	0(0%)	3 (10%)*	0 (0%)*	2 (3.6%)*	7 (13%)*	3 (4.4%)*	0 (0%)*	6 (9.4%)*	14 (22%)*
Drinker (count, %)	11 (8.9%)	1 (0.8%)	9 (30%)*	2 (6.7%)*	10 (18%)*	14 (25%)*	37 (54%)*	40 (59%)*	21 (33%)*	35 (55%)*
CES-D Score	-	6.0 (0.0–9.5)	-	9.5 (6.0–17.3)*	-	7.5 (2.0–14.3)*	-	6.0 (3.8–10.0)*	-	9.0 (5.0–19.0)*
Depressed (count, %)	-	18 (15%)	-	8 (27%)*	-	13 (23%)*	-	7 (10%)*	-	21 (33%)*

Data a represented as Median(Interquartile Range: 25%–75%) or count(%). HDI :Human Development Index, Married† includes those who live with/without partner, BMI: Body Mass Index, WC:Waist Circumference, TG:Triglyceride, HDL:High Density Lipoproteincholesterol, SBP:Systolic Blood Pressure, DBP:Diastolic Blood Pressure,Mets:Metabolic Syndrome. represents statistically significant p-values ($p<0.05$) from site comparisons tests at baseline(2017) and at follow-up(2019) using either Kruskal-Wallis or Fisher's Exact Tests for non-normal variables with unequal variance, and ANOVA for normal variables.*

Table 4: Male Characteristics at baseline(2017) and follow-up (2019) by country site (ordered by HDI).

Characteristic	Ghana		South Africa		Jamaica		Seychelles		United States	
	Baseline, N = 66	Follow-up, N = 66	Baseline, N = 22	Follow-up, N = 22	Baseline, N = 35	Follow-up, N = 35	Baseline, N = 54	Follow-up, N = 54	Baseline, N = 28	Follow-up, N = 28
Age(yrs)	45.5 (39.0–52.0)*	49.0 (43.0–54.8)*	38.0 (35.0–43.8)*	41.0 (37.3–46.3)*	45.0 (36.5–50.0)*	47.0 (39.5–53.0)*	46.0 (42.3–48.0)*	48.0 (44.3–50.0)*	46.0 (42.0–50.0)*	50.0 (45.8–52.3)*
Education (yrs)	9.0 (9.0–10.0)*	-	11.0(9.2-11.8)*		10.5 (9.0–11.0)*	-	13.0(11.0-14.0)*		13.0(12.0-14.0)*	
Married*	54 (82%)*	53 (80%)	2 (9.1%)*	3 (14%)	19 (54%)*	17 (49%)	42 (78%)*	40 (74%)	11 (39%)*	10 (36%)
Employed	48 (73%)	63 (95%)*	12 (55%)	1 (4.5%)*	29 (83%)	32 (94%)*	42 (78%)	52 (96%)*	24 (86%)	16 (57%)*
BMI (kg.m-2)	21.8 (20.2–25.2)*	22.5 (20.5–24.8)*	23.1 (20.0–25.1)*	22.9 (20.3–24.9)*	26.0 (20.7–29.1)*	24.8 (21.2–29.3)*	28.7 (25.0–31.2)*	29.1 (25.1–31.3)*	28.5 (24.9–32.3)*	29.4 (25.1–31.4)*
Waist (cm)	82.3 (76.3–90.8)*	83.0 (77.2–88.3)*	81.9 (77.3–90.9)*	83.5 (78.9–89.2)*	89.9 (77.4–96.1)*	87.8 (75.0–97.0)*	97.1 (89.3–103.7)*	103.1 (94.4–109.8)*	101.0 (88.4–107.0)*	103.7 (90.7–107.7)*
SBP (mmHg)	119.8 (111.8–128.9)*	118.1 (109.3–132.0)*	124.9 (113.2–136.8)*	125.3 (118.4–134.4)*	127.7 (119.7–139.8)*	131.7 (127.2–144.6)*	129.5 (119.9–138.3)*	131.7 (125.3–140.8)*	123.6 (118.5–135.2)*	126.3 (121.3–135.3)*
DBP (mmHg)	66.8 (59.0–72.8)*	69.5 (63.5–78.4)*	78.3 (68.3–86.1)*	78.0 (74.7–85.2)*	80.3 (72.1–86.9)*	83.2 (78.2–88.9)*	81.1 (73.5–87.7)*	82.3 (76.7–87.1)*	77.9 (71.3–88.5)*	85.6 (79.0–89.2)*
TG (mmol.L-1)	0.9 (0.7–1.4)*	-	0.9 (0.8–1.2)*	-	0.8 (0.7–1.3)*	-	1.3 (1.0–2.0)*	-	0.9 (0.7–1.2)*	-
HDL (mmol.L-1)	1.1(1.0-1.4)*		1.4(1.1-1.7)*		1.2(1.1-1.4)*		1.2(1.1-1.3)*		1.3(1.1-1.7)*	
Glucose (mmol.L-1)	4.6 (4.3–4.8)*	5.9 (5.4–6.2)*	44.6 (4.1–5.0)*	4.8 (4.6–5.2)*	4.3 (4.0–4.8)*	5.8 (5.3–6.3)*	4.8 (4.4–5.2)*	6.6 (5.9–7.3)*	5.1 (4.7–5.5)*	5.6 (5.1–6.1)*
Obese (count, %)	2 (3.0%)*	5 (7.6%)*	1 (4.5%)*	1 (4.5%)*	7 (20%)*	6 (17%)*	17 (31%)*	21 (39%)*	11 (39%)*	13 (46%)*
High WC (count, %)	13 (20%)*	11 (17%)*	1 (4.5%)*	5 (23%)*	14 (40%)*	11 (31%)*	35 (65%)*	41 (76%)*	13 (46%)*	14 (50%)*
High TG (count, %)	10 (15%)	-	3 (14%)	-	7 (20%)	-	17 (31%)	-	2 (7.1%)	-
Low HDL (count, %)	16 (24%)	-	1 (4.5%)	-	3 (8.6%)	-	9 (17%)	-	5 (18%)	-
High BP (count, %)	17 (26%)*	22 (33%)*	10 (45%)*	13 (59%)*	18 (51%)*	26 (74%)*	34 (63%)*	42 (78%)*	15 (54%)*	22 (79%)*
High Glucose (count, %)	5 (7.6%)*	45 (68%)*	1 (4.5%)*	4 (18%)*	2 (5.7%)*	20 (57%)*	9 (17%)*	47 (87%)*	7 (25%)*	14 (50%)*
METS (count, %)	4 (6.1%)*	-	1 (4.5%)*	-	4 (11%)*	-	15 (28%)*	-	6 (21%)*	-
Smoker (count, %)	0 (0%)*	3 (4.5%)*	17 (77%)*	2 (9.1%)*	2 (5.7%)*	16 (46%)*	7 (13%)*	0 (0%)*	8 (29%)*	14 (50%)*
Drinker (count, %)	19 (29%)*	5 (7.6%)*	14 (64%)*	7 (32%)*	25 (71%)*	21 (60%)*	36 (67%)*	40 (74%)*	17 (61%)*	18 (64%)*
CES-D Score	-	4.5 (1.0–11.0)*	-	10.5 (8.0–14.5)*	-	9.0 (4.0–11.5)*	-	5.0 (3.0–8.0)*	-	11.0 (4.0–17.3)*
Depressed count, %)	-	11 (17%)*	-	5 (23%)*	-	3 (8.6%)*	-	4 (7.4%)*	-	9 (32%)*

Data a represented as Median(Interquartile Range: 25%–75%) or count(%). HDI :Human Development Index, Married† includes those who live with/without partner, BMI: Body Mass Index, WC:Waist Circumference, TG:Triglyceride, HDL:High Density Lipoproteincholesterol, SBP:Systolic Blood Pressure, DBP:Diastolic Blood Pressure,Mets:Metabolic Syndrome. represents statistically significant p-values (p<0.05) from site comparisons tests at baseline(2017) and at follow-up(2019) using either Kruskal-Wallis or Fisher's Exact Tests.*

Table 2A: Differences between included and excluded participants based on the presence of depression data.

Variable	**Excluded, N = 1,075[1]**	**Included, N = 546[1]**	**p-value[2]**
Age	43 (36, 49)	44 (38, 49)	0.011
Female	688 (64%)	341 (62%)	0.5
High WC	704 (65%)	354 (65%)	0.8
High BP	453 (42%)	212 (39%)	0.2
High Glucose	138 (13%)	63 (12%)	0.5
Low HDL	520 (48%)	249 (46%)	0.3
High TG	139 (13%)	70 (13%)	>0.9
Site			<0.001
Ghana	144 (13%)	92 (17%)	
SA	276 (26%)	52 (9.5%)	
Jamaica	169 (16%)	189 (35%)	
Seychelles	271 (25%)	91 (17%)	
US	215 (20%)	122 (22%)	

[1] Excluded indicates participants who did not have the outcome data; depression. Included indicates participants with depression data. Median (IQR); n (%)

[2] Wilcoxon rank sum test; Pearson's Chi-squared test

Table 4: Poisson (Modified) Regression Model for Overall Cohort

Y=Depression	**RR**	**Lower_95_CI**	**Upper_95_CI**
(Intercept)	1.2755333	0.2176541	7.4750944
MetS	0.8093136	0.4915490	1.3324989
Age	0.9776962	0.9475340	1.0088184
Female	1.3437568	0.8473934	2.1308667
Marital Status	0.8934165*	0.5917381	1.3488958
Education	0.9825853	0.9158909	1.0541364
Employed	0.8287814	0.4843719	1.4180810
Alcohol	1.1202897	0.7370117	1.7028888
US vs Ghana	0.3702903	0.1824380	0.7515700
US vs SA	0.5647353	0.2884342	1.1057147
US vs Jamaica	0.4564812	0.2440188	0.8539306
US vs Seychelles	0.2699533*	0.1384185	0.5264818
* represents statistically significant p-values ($p<0.05$)			

Part E: Policy Brief

Globally, nearly 30% of adults have MetS[1], while 5% of adults suffer from depression[2]. Both conditions contribute substantially to the global burden of disease and often overlap, compounding adverse outcomes such as increased mortality, reduced quality of life, and economic costs.

Policy Context

The WHO's Global Action Plan for the Prevention and Control of Non-Communicable Diseases (2013-2030)[38] and its Mental Health Action Plan (2013-2030) [38] emphasize the need for integrated, equitable, and context-specific interventions targeting both NCDs and mental health disorders. Key recommendations include:

- Primary Prevention: Reducing exposure to risk factors such as unhealthy diets, physical inactivity, and harmful use of alcohol.
- Integrated Care: Promoting health system integration of mental health and NCD prevention and treatment services.
- Universal Health Coverage (UHC): Ensuring equitable access to care, particularly for vulnerable populations.
- Strengthening Surveillance: Enhancing data collection and research to monitor trends and improve policy responses.

Findings

A key theme emerging from the data is the gender-specific nature of the relationship between MetS and risk for depression. Women consistently showed higher rates of depression with MetS than men, particularly in Jamaica, Seychelles, and the US. This pattern suggests a potential sex-specific biological or behavioral link between depression and MetS, reinforced by the higher prevalence of obesity, increased waist circumference, and low HDL levels among women. In contrast, men demonstrated unique risk factors, including higher systolic and diastolic blood pressure, elevated triglyceride levels, and greater prevalence of smoking and alcohol consumption.

The findings also reveal significant geographical variability. For instance, in Seychelles, the proportion of men presenting with depression and MetS (50%) was equal to those not presenting with depression and without MetS (50%). Meanwhile, SA, stood out as a country with no reported MetS among individuals presenting with depression, regardless of sex. These observations highlight the influence of local environmental, cultural, and socioeconomic factors on health outcomes.

Women were more vulnerable to obesity-related health risks, psychological distress, and depression, with higher CES-D scores and depression prevalence compared to men. For example, in Jamaica, 23% of women presented with depression at follow-up compared to only 8.6% of men. However, men also faced elevated cardiovascular risks, as reflected in consistently higher blood pressure and triglyceride levels, particularly in Jamaica and

Seychelles. Behavioral differences were also stark, with men exhibiting substantially higher smoking and alcohol consumption rates compared to women.

Recommendations

- Context-specific interventions: Address obesity-linked depression in women from the US, Seychelles and Jamaica through subsidized nutritional programs, psychosocial support and maternal health campaigns. In Seychelles, implement cardiovascular and substance abuse interventions targeting men, especially in urbanizing regions. In South Africa, reinforce dual screening for MetS and depression in primary healthcare settings, especially for men where silent cardiovascular risk is prevalent. In Ghana, health promotion strategies should reinforce the consumption of traditional diets rich in whole grains, vegetables, and legumes—as these are protective against MetS.
- Implement Gender-Sensitive Interventions: Develop programs addressing obesity and depression among women through weight management, physical activity promotion, and access to mental health services. Target men with interventions to reduce smoking, alcohol use, and hypertension, leveraging community-based approaches.
- Strengthen Integration of Mental and Physical Health Services: Train healthcare providers to screen for both depression and MetS during routine visits, consistent with WHO's mhGAP Intervention Guide for mental health integration into primary care. Depression tends to be underreported many in communities where people fear being shamed, thus integrating it with physical health services could with early identification.
- Promote Healthy Lifestyles: Launch public awareness campaigns focused on healthy diets, physical activity, and stress reduction, tailored to regional and cultural contexts. Subsidize access to nutritious foods and promote local agricultural practices to combat dietary transitions linked to urbanization.
- Enhance Surveillance and Research: Invest in longitudinal studies to explore causal pathways between MetS and depression, with a focus on populations of African origin.
- Address Socioeconomic Determinants: Expand UHC to reduce barriers to care for low-income populations. Implement social support programs targeting vulnerable groups, such as women in LMICs, to mitigate the impact of poverty on health outcomes.

Interventions targeted at early identification and prevention will reduce the prevalence of depression and MetS, while increasing reporting of disease prevalence. It would also improve the quality of life and reduce mortality in affected populations.

This policy brief underscores the urgent need for coordinated global and local action to address the interconnected pathways of MetS and depression, leveraging existing WHO frameworks to promote holistic and equitable health strategies. It advocates for tailored public health interventions to address the distinct health risks and behavioral profiles of the men and women of African-origin across different regions.

References

1. Jacques Noubiap, J., Richie Nansseu, J., Lontchi-Yimagou, E., René Nkeck, J., Flore Nyaga, U., Ngouo, A. T., Noelle Tounouga, D., Tianyi, F.-L., Joyce Foka, A., Laetitia Ndoadoumgue, A., & Joel Bigna, J. (2022). Geographic distribution of metabolic syndrome and its components in the general adult population: A meta-analysis of global data from 28 million individuals. *Diabetes Research and Clinical Practice*, *188*, 109924. https://doi.org/10.1016/j.diabres.2022.109924.

2. WHO. (2023, March 31). Depressive disorder (depression). https://www.who.int/news-room/fact-sheets/detail/depression.
3. WHO. (2013). *Global action plan for the prevention and control of noncommunicable diseases, 2013-2020*. 103.

4. WHO. (2021). *Comprehensive Mental Health Action Plan 2013-2030*. https://iris.who.int/bitstream/handle/10665/345301/9789240031029-eng.pdf?sequence=1

METS-Microbiome Visit Checklist Baseline Visit:

Informed Consent _____

Form 1 – Demographics _____

Form 2 - Anthropometrics _____

Form 3 – Biochemical measures

- Urine _____
- Blood _____
- OGTT _____
- Accelerometer Placement _____

Form 4 – GPAQ _____

Form 5 – FFQ _____

Form 6 – SES _____

Form 7 – Microbiome _____

Form 8 – Discrimination _____

Return Appointment _____

Visit 2:

Was monitor returned? _____

Was stool collected? _____

Did participant receive reimbursement? _____

Did participant receive feedback forms? _____

Future appointments reminder _____

IRB NUMBER: 209537021517

LOYOLA UNIVERSITY CHICAGO
HEALTH SCIENCES DIVISION
MAYWOOD, ILLINOIS
DEPARTMENT OF

INFORMED CONSENT

Participant's Name: _____

Medical Record Number: _____

PROJECT TITLE: Gut microbiota, short chain fatty acids, and adiposity across the epidemiologic transition.

THE APPROVAL FOR THIS PROJECT EXPIRES ON 01/16/2020.

Participant Information

PRINCIPLES CONCERNING RESEARCH: You are being asked to take part in a research project. It is important that you read and understand the principles that apply to all individuals who agree to participate in the research project described below:

1. Taking part in the research is entirely voluntary.

2. We do not know if you will benefit from taking part in the research but the knowledge obtained may help others.

3. You may withdraw from the study at any time without anyone objecting and without penalty or loss of any benefits to which you are otherwise entitled.

4. If during your participation in the research project new information becomes available which would affect your being in the research project, your doctor will discuss this new information with you and will help you make a decision about your continuing in the research.

The purpose of the research, how it is to be done, and what your part in the research will be is described below. Also described are the risks, inconveniences, discomforts and other important information which you need to make a decision about whether or not you wish to participate. You are urged to discuss any questions you have about this research with the staff members.

PURPOSE OF RESEARCH: You are being asked to participate in this study because we are investigating the relationship between the bacteria in your gut, short chain fatty acids and the risk for the development of obesity, diabetes and cardiovascular disease.

This research is sponsored by the Department of Public Health Sciences, Loyola University Chicago. Components of this project are also being conducted by researchers at the University of West Indies, Kingston, Jamaica; Kwame Nkrumah University of Science and Technology, Ghana; Minstry of Heatlth, Victoria, Seychelles, and the University of Cape Town, Cape Town, South Africa

Approximately 500 people will participate in this research.

The goal of this research is not to diagnose or treat any problems you may have. Therefore, participation in this study is not a substitute for the care you are receiving from your doctor. During the time you are in this study you should continue to see your doctor or if you have a problem contact your doctor.

DESCRIPTION AND EXPLANATION OF PROCEDURES: If you agree to participate in this study, you will complete the following research procedures outlined below.

Your initial participation in the study will last 8 days; you will be contacted for a follow-up visit each for two years from your initial visit. Your participation in the last year will also last 8 days.

Procedures for initial visit:

Time involved:
Day 1 - you will be at the clinic for about 2.5 hrs
Day 8 - you will be at the clinic for about 45 minutes
1 year later - you will be at the clinic for about 45 minutes
2 years later - Day 1; you will be at the clinic for about 1.5 hrs
2 years later - Day 8; you will be at the clinic for about 45 minutes.
3 years later – you will be at the clinic for about 45 minutes.
4 years later – you will be at the clinic for about 45 minutes.

During the initial visit:
1. We ask that you arrive at the clinic after not eating anything from 10pm in the evening before your visit.

2. We will ask you about foods you have eaten in the last 24 hours. We will do this twice, separated by 7 days. This information will allow us to calculate your daily food calories, the time at which you eat 50% of your calories, and the types of foods that you eat.

We will also ask you about your activity patterns, your health and sleep habits, as well as your personal wellbeing.

3. We will take the following body measurements: height, weight, blood pressure, waist, hip, and percent body fat. Body fat will be measured by bioimpendance analysis. With this method, we will place 4 electrodes on your hands and feet, and apply a small amount of electricity to measure

the amount of water in the body. This test does not cause any pain or discomfort. If you have a pacemaker, you will be excluded from having your body fat measured and from the bone scan.

4. You will either have an IV catheter placed in your arm or you will undergo phlebotomy to provide blood samples. If you receive an IV catheter, it will be flushed with 0.9% normal saline following each blood draw.

5. Three tablespoons of blood will be drawn to measure substances in the blood that may be related to diabetes, nutritional status and cardiovascular disease.

6. You will be asked to provide a urine sample. We will use this urine sample to check your kidney function.

7. You will be given a stool collection kit and the clinic staff will detail the collection method. You will be instructed to provide the sample in the preceeding 24 hrs prior to your second clinic visit.

8. You will complete a standard oral glucose tolerance test. You will be given a sugar solution to drink and we will measure the sugar in your blood after 30, 60 and 120 mins. The total amount of blood is one table spoon.

9. An activity monitor will be strapped around your waist by a staff member. This monitor is the size of a watch and is attached to an elastic belt. The activity monitor measures physical activity patterns. You will be instructed to wear the monitor at all times during the next 7 days, including during the night unless you are unable to sleep with it on. You will be asked to remove the monitor for bathing and swimming and to avoid completely submerging the monitor in water.

10. You may have two skin sensitivity tests to evaluate your risk for nerve damage from having prediabetes or diabetes. These tests will be performed by a study physician. The first test uses tiny wire filaments, which will individually be gently pressed on your hand until you feel the pressure from the wire filaments. During the second test, the physician will use a safety pin, and gently press both the sharp and dull side onto your hand to evaluate your skin sensation.

11. You may be asked to wear a sleep monitor around your wrist. This measurement may coincide with either first, second or third year follow-up. The monitor is the size of a watch and is attached by a velcro band. The sleep monitor will record your sleep patterns. You will be instructed to wear the sleep monitor at all times during the next 7 days, including at night. You will be asked to remove the sleep monitor for bathing and swimming and to avoid completely submerging the monitor in water.

11. You will be given a light snack and may leave the clinic.

After the first visit:

After the first night, a staff member will call you at a phone number you provide to insure that you are comfortable with the monitor and to answer any questions you may have.

7 days later (Day 8): You will be asked to return to the clinic. You will bring the stool sample, collected in the preceding 24hrs with you. You will have the activity and sleep monitor removed, and you will be asked about the foods you have eaten the previous 24 hours.

1 year later (Day 1): You will be contacted and asked to return to the clinic. We will measure your weight, blood pressure, waist, hip and percent body fat and the bone mineral content as you had at the beginning of the study.

2 years later (Day 1): You will be contacted and asked to return to the clinic. We ask that you refrain from eating from 10pm in the evening before your clinic visit. We will measure your weight, blood pressure, waist, hip and percent body fat and bone mineral content. We wills strap a monitor to your waist, and a sleep monitor to your wrist and ask you some health, physical activity and dietary questions. You will have two tablespoons of blood drawn, and we will provide you with a stool collection kit. We will provide you with a snack, and you will be free to leave the clinic.

2 years later (Day 8): You will be asked to return to the clinic. You will bring the stool sample, collected in the preceding 24hrs with you. You will have the activity and sleep monitors removed, and you will be asked about the foods you have eaten the previous 24 hours.

3 years later (Day 1): You will be contacted and asked to return to the clinic. We will measure your weight, blood pressure, waist, hip and percent body fat as you had at the beginning of the study.

4 years later (Day 1): You will be contacted and asked to return to the clinic. We will measure your weight, blood pressure, waist, hip and percent body fat as you had at the beginning of the study.

RISKS/DISCOMFORTS: There are no risks with having your percent body fat measured. In addition, there are no risks from wearing an activity or sleep monitor. You may experience a minor and temporary discomfort and bruising at the site of the blood draw or IV catheter site. You may experience an infection at the site of the blood draw or IV catheter site. You may feel lightheaded during the OGTT test. If you participate in the skin sensitivity tests, you may experience some discomfort at the site where the wire filaments or safety pin is pressed onto your skin.

There is a small risk of loss of confidentiality.

REPRODUCTIVE AND SEXUAL ACTIVITY INFORMATION: The intervention in this study could affect a developing baby. Therefore, you cannot participate in this research project if you are pregnant at the time that you would start the study.
BENEFITS: Your participation will help us better understand the relationships between the composition of bacteria in your gut and your health, short chain fatty acids and the risk for obesity, diabetes and cardiovascular disease. It is unlikely that you will benefit directly from being in this research project. We will notify you if the blood test indicates high blood sugar or fat, or if your blood pressure is high. We will inform you if you have an increased risk of kidney disease based on results from your blood test and urine test. We will not provide any additional evaluations but would recommend that you see your doctor to discuss the results.

ALTERNATIVES: You do not have to participate in this project if you do not want to.

FINANCIAL INFORMATION: To compensate you for the time spent in the study, you will be given $75.00. Compensation will be provided at the clinic on Day 8. You will be compensated $20.00 for the time spent in the study for the 1-year follow-up study. You will be compensated $75.00 for the time spent in the study for the 2-year follow-up study. You will receive this payment at the clinic on Day 8. You will be compensated $20.00 for the visit during the 3rd year follow-up and $20.00 for the visit during the 4th year. If you participate in the skin sensitivity test, you will receive an additional $30.00. If you participate in the 7-day sleep monitoring activity, you will receive an additional $75.00. If you receive payment for participating in this research, personal information about you, including your name, address, and Social Security number, will be released to the Loyola University Chicago Accounting Office for the purpose of recording the payment and for tax reporting to the United States Internal Revenue Service (IRS). You will need to complete a W-9 form. This form will be provided to you. If you choose not to complete the W-9, you will not receive reimbursement.

You will not charged for any of the tests that are performed in this research project. In the event we recommend that you see your doctor for additional testing because of abnormal results obtained from the study tests, you will be financially responsible for the cost of care.

RESEARCH RELATED INJURY: In the event that you are injured or have side effects as a result of participating in this research project, there are no funds available from Loyola University Chicago to pay for the cost of care of the problem. You will be financially responsible for the cost of care of any problems. By signing this form, you are not giving up any legal rights to seek to obtain compensation of injury. .

INFORMATION COLLECTED AND WHAT WILL HAPPEN TO IT: In order to meet the goals of the research study (see Purpose of Research section of this consent), we will collect information on you, and your research test results. The information will be collected by Lara Dugas, Ph.D., MPH, and the research staff.

Information about you will be provided to Loyola University Chicago; The National Institutes of Health (the research sponsor); data collection and study verification agencies.

In this way, we will learn about the relationships between the gut microbiota, short chain fatty acids and the risk for obesity, diabetes and cardiovascular disease.

The information we will collect and send includes:

- X DEMOGRAPHIC AND QUESTIONNAIRE INFORMATION (e.g., name, address, phone number, physical activity patterns, health, sleep, wellbeing, and foods eaten)
- X PHYSICAL AND SLEEP ACTIVITY MEASUREMENTS
- X BODY MEASUREMENTS (e.g. blood pressure, weight, height, waist, hip, and percent body fat)
- X URINE AND BLOOD SAMPLES
- X SALIVA AND STOOL SAMPLES

We will collect and provide this information about you for as long as you are in the study which will be about 3 years.

It is possible that the sponsor, The National Institutes of Health, research nurses, data collection and/or study verification agencies, data administrators or staff. They may take notes or copy pages of the medical record. This is done to verify the accuracy of the information.

The results of this research study may be published in a journal for the purpose of advancing medical knowledge. You will not be identified by name or by any other identifying information in any publication or report about this research.

Consent for LUC to use and disclose your medical information is required in order for you to participate in the study.

A new Federal law, called the Genetic Information Nondiscrimination Act (GINA), generally makes it illegal for health insurance companies, group health plans, and most employers to discriminate against you based on your genetic information. This law generally will protect you in the following ways:

- Health insurance companies and group health plans may not request your genetic information that we get from this research.[2]
- Health insurance companies and group health plans may not use your genetic information when making decisions regarding your eligibility or premiums.
- Employers with 15 or more employees may not use your genetic information that we get from this research when making a decision to hire, promote, or fire you or when setting the terms of your employment.

All health insurance companies and group health plans must follow this law by May 21, 2010. All employers with 15 or more employees must follow this law as of November 21, 2009.

Be aware that this new Federal law does not protect you against genetic discrimination by companies that sell life insurance, disability insurance, or long-term care insurance.

WITHDRAWAL OF CONSENT: Your consent to use and disclose your medical information for the purpose of this research study is completely voluntary. You can withdraw your consent for LUMC to use and disclose your information and your consent to participate in this study at any time without affecting your ability to receive care and treatment at LUMC unrelated to the research study. Withdrawal means that all study procedures and follow-up will stop and we will not send any more information about you to the sponsor of this research or its designees. However, information already used and disclosed to the research sponsor prior to the time of your withdrawal from this study may continue to be used and disclosed by LUMC and the sponsor.

If you withdraw from the study, we will ask that you sign the form attached to this consent and send it to Lara Dugas, Ph.D., MPH or give it to the study staff. Your withdrawal from the study will not have any effect on any actions by LUC taken before the attached form is received by LUC.

Your study doctor, the Institutional Review Board, the regulatory authorities, or the sponsor, The National Institutes of Health, may terminate the study at any time with or without your consent.

CONSENT

I have fully explained to _____ the nature and purpose of the above-described procedure and the risks that are involved in its performance. I have answered and will answer all questions to the best of my ability. I may be reached at 708-327-9029.

_____Date:____/_____/____
Signature

Lara Dugas, Ph.D., MPH, the principal investigator for this study, or her associates will be available to answer any questions you may have. Dr. Dugas can be reached at: 708-327-9029.

If you ever feel that you have been injured by participating in this study or if you have any questions concerning your rights as a research participant, you may contact Kenneth Micetich, MD, Chair of the Institutional Review Board for the Protection of Human Subjects-Loyola University Chicago Health Sciences Division, at 708-216-4608.

Although you have the right to revoke this authorization, you accept that such revocation will not apply to any uses and disclosures of your information that are described in the Loyola University Health System Notice of Privacy Practices or otherwise allowable under any Federal or State laws.

You will receive a signed copy of this informed consent document.

You have been fully informed of the above-described research program with its possible benefits and risks. Your signature below indicates that you are willing to participate in this research study and agree to the use and disclosure of information about you as described above. You do not give up any of your legal rights by signing this consent document.

_____Date:____/_____/____
Signature: Participant

FORM 1 **METS-MICROBIOME** **DEMOGRAPHICS FORM**

Participant ID: _____ **Exam date: _____/_____/_____** (MM/DD/YYYY)

☐ Clinic visit ☐Home visit **Interviewer Initials _____**

New participant ☐ Yes ☐ No

CONTACT INFORMATION **Email _____**

Last name _____ **First names _____** **MI _____**

Address _____

City _____ **State _____** **Zip_____**

Home phone _____ **Work phone _____** **Alternate/cellular phone _____**

Nearest intersection: _____

BASIC DEMOGRAPHICS

Age: _____ **Birth date: _____ /_____/_____** (MM/DD/YYYY)

Birth place: _____

Country _____ **State _____** **City _____**

1. **When did you move to your current residence?**
   - ☐ Less than 1 year ago
   - ☐ 1-2 years ago
   - ☐ 2-10 years ago
   - ☐ More than 10 years ago

2. **Have you travelled outside of the country in the past:**

Month ☐ Yes ☐ No
6 Months ☐ Yes ☐ No
1 year ☐ Yes ☐ No
☐ I have not travelled outside my country in the past year.

3. **What is your ethnic group?**
   - ☐ American Indian/Alaskan Native
   - ☐ Asian (Chinese)
   - ☐ Asian (Indian)
   - ☐ Black or African American
   - ☐ Native Hawaiian or Pacific Islander
   - ☐ White
   - ☐ White Hispanic (USA)
   - ☐ Mixed (i.e. not predominantly in an other groups, e.g. Creole)
   - ☐ Other ethnic group
   - ☐ Refused to answer
   - ☐ Don't know

BACKGROUND DEMOGRAPHICS

4. **Where were you born**
   ☐ At home ☐ In a hospital: Name of hospital _____ ☐ Don't know

5. **Were you born via caesarean section (C-section):**
   ☐ No ☐ Yes ☐ Don't know

6. **Gender** ☐ Male ☐Female

7. **Marital status:**
   - ☐ Married/living with a partner as married
   - ☐ Living without a partner
   - ☐ Refused to answer

8. **If you don't know the amount, can you give an estimate of the annual household income if I read some options to you? Is it** (READ OPTIONS)
   - ☐ ≤ $23 000
   - ☐ More than $23 000, ≤ $43 000
   - ☐ More than $43 000, ≤ $72 000
   - ☐ More than $72 000, ≤ $112 000
   - ☐ More than $112 000
   - ☐ Don't know
   - ☐ Refused

9. **On average, what is your gross personal income per year, including allowances, bonuses and other benefits?**
   - ☐ ≤ $15 000
   - ☐ More than $15 000, ≤ $30 000
   - ☐ More than $30 000, ≤ $46 000
   - ☐ More than $46 000, ≤ $75 000
   - ☐ More than $75 000
   - ☐ Don't know
   - ☐ Refused

For females only:

10. **Are you pregnant?**
    - ☐ No
    - ☐ Yes. **You are not eligible to participate in this study now. Please come back 6months after giving birth.**
    - ☐ Don't know

11. **Are you breastfeeding currently?**
    ☐ No ☐ Yes ☐ Refuse to answer

12. **Time since last pregnancy (years, if 6 months: 0.5) _____**

13. **Number of biological children _____**

14. **Are you currently menopausal?** ☐ No ☐ Yes

HEALTH HISTORY

15. **Have you seen a primary care physician in the last year?** ☐ No ☐ Yes

16. **If yes, what was the reason for the visit, select all that apply?**
    - ☐ Surgery/ accident
    - ☐ Simple short illness such as cold
    - ☐ Chronic condition such as diabetes or hypertension
    - ☐ Other situation (if yes, which one: _____)

17. **How do you pay for routine health care?**
    - ☐ Mostly cash/ out of pocket
    - ☐ Mostly covered by medical insurance
    - ☐ Medical insurance with some cash/out of pocket expenses
    - ☐ Public/government (Medicaid or universal health system with free or largely free provision of health care)

18. **Have you ever been told that you have:**
    - ☐ Heart attack or coronary heart disease, age _____
    - ☐ Rheumatic heart disease or other heart problem, age _____
    - ☐ Stroke, age _____
    - ☐ Cancer, age _____; type _____
    - ☐ High blood cholesterol, age _____
    - ☐ Diabetes/elevated blood sugar, age _____
      If yes to diabetes, do you take insulin now? ☐ Yes ☐ No

- ☐ Osteoarthritis, age _____
- ☐ Rheumatoid arthritis, age _____
- ☐ Kidney failure, age _____
- ☐ Mental health problems like depression, age _____
- ☐ Any other chronic disease? If so, what _____
- ☐ High blood pressure, age _____

19. If you were told you have high blood pressure:

Have you ever been told by a doctor or health care provider to:	Are you now:
☐ Take prescribed medicine for more than 1 month	☐ Taking prescribed medicine for >1 month
☐ Control your weight or lose weight	☐ Controlling or losing weight
☐ Cut down on salt	☐ Using less salt
☐ Exercise more	☐ Exercising more
☐ Reduce your alcohol intake ☐ Stop smoking	☐ Reducing your alcohol intake ☐ Trying to stop smoking

20. Medications

Did participant bring medications and supplements: ☐ No ☐ Yes

Is participant taking any of the following prescription medications

- ☐ Glucocorticoids/Corticosteroids (e.g. Entocort, Prednisone, Prednisolone, Decadron)
- ☐ Anticonvulsants (e.g. Depakote, Diazepam, Dilantin, Tegretol)
- ☐ Loop or Thiazide Diuretics (e.g. Furosemide, Bumatanide, Hydrocholorthiazide)
- ☐ Other medications for hypertension (ACEIs, ARB, BB, CCB, etc))
- ☐ Metformin or another oral antidiabetic medicine
- ☐ Other:

Other currently prescribed medications	Reason for Taking Medication

FOR FEMALES ONLY

- ☐ Estrogens (e.g. Premarin, Climara, Vivelle, Estraderm, Cenestin)
- ☐ Oral contraceptive
- ☐ Injectable contraceptive (Depo-Provera)

21. Are you taking any nutritional/ herbal supplement?

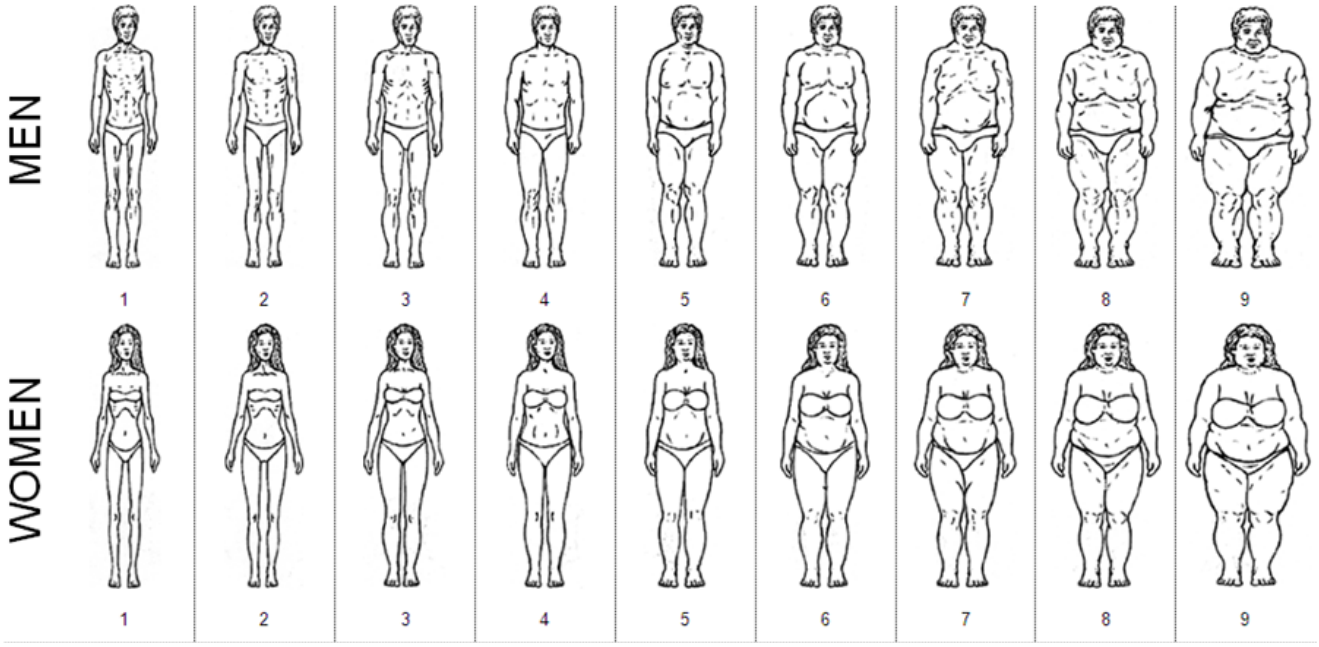
- ☐ No
- ☐ Yes _____

RISK FACTORS

22. Approximately how many hours do you sleep each night? _____

23. Do you consider your current weight to be:

- ☐ Largely underweight
- ☐ Slightly underweight
- ☐ About right
- ☐ Slightly overweight
- ☐ Largely overweight
- ☐ Refused to answer



24. In the drawing, which figure best reflects how you think you look like with regards to your body shape?

Answer (1-9): ____

25. In the drawing, which figure best represents how you would like to look like with regards to your body shape, ideally?

Answer (1-9): ____

26. Have you been intentionally trying to lose weight over the last year? ☐ No ☐ Yes

If yes, what method? ☐ Exercise ☐ Diet ☐ Other _____

If diet, what diet? _____

Smoking

27. Smoking (any tobacco use excluding e-cigarettes)

- ☐ Smoker: is currently smoking cigarettes (at least 1 per day). How many per day on average? _____
- ☐ Occasional: Smokes, but not every day. How many per week on average? _____
- ☐ Ex-smoker: Stopped smoking for at least 1 month.
- ☐ Non-user: Never smoked regularly

28. E-cigarettes usage

Do you ever use e-cigarettes: ☐ No ☐ Yes, occasionally ☐ Yes, regularly?

During the past 5 days, including today, on how many days did you smoke an e-cigarette? _____

Recreational Drug Use

29. Smoking (marijuana, hashish, pot)

☐ No ☐ Yes, Occasionally ☐ Yes, regularly Times per week _____

30. Cocaine, heroin, methamphetamine, amphetamines, ecstasy

☐ No ☐ Yes, Occasionally ☐ Yes, regularly Times per week _____

Alcohol

Note: 1 standard drink= 12 oz (350ml) beer= 5 oz (150 ml) glass of wine= 1.5 oz (44ml) glass of spirit (whiskey, gin, vodka)

31. Have you ever consumed any alcohol such as beer, wine, spirits or home-made alcohol?

☐ Yes
☐ No

32. Have you consumed any alcohol within the past 12 months?

☐ Yes
☐ No

33. If yes, during the past 12 months, how frequently have you had at least one standard alcoholic drink, on average?

☐ Daily
☐ 5-6 days per week
☐ 3-4 days per week
☐ 1-2 days per week
☐ 1-3 days per month
☐ Less than once a month

34. Have you consumed any alcohol within the past 30 days?

☐ Yes
☐ No

35. If yes, during the past 30 days, on how many occasions, approximately, did you have at least one standard alcoholic drink (standard drink: 1 bottle beer or 1 shot whisky or 1 glass wine)? _____

36. During the past 30 days, when you drank alcohol, how many standard drinks on average did you have during one drinking occasion? _____

37. During the past 30 days, what was the largest number of standard drinks you had on a single occasion on one single day/night, counting all types of alcoholic drinks together? _____

38. During the past 30 days, on how many days did you have six or more standard drinks in a single drinking occasion? _____

39. During each of the past 7 days, how many standard drinks did you have each day, on average?

Monday	_____		
Tuesday	_____	Friday	_____
Wednesday	_____	Saturday	_____
Thursday	_____	Sunday	_____

Life events

40. In the past year, have you experienced any of the following major life events:

☐ Death of a spouse
☐ Death of a family member or friend
☐ Divorce or separation
☐ Major injury or illness
☐ Change in financial state
☐ Imprisonment
☐ Dismissal from work
☐ Marriage
☐ Birth of a child

FORM 2 **METS-MICROBIOME** **ANTHROPOMETRICS FORM**

Interviewer Initials: _____ **Exam Date: _____/_____/_____** (MM/DD/YYYY)

1. **Age: _____**
2. **Weight: _____ . _____** kilograms **SCALE ID** _____
3. **Height: _____. _____** m

Note: third measurements for all of the following are only required if first two differ by 0.5cm or more

4. **Waist circumference** **_____. ___** cm
   _____. ___ cm
   _____. ___ cm
5. **Hip circumference** **_____. ___** cm
   _____. ___ cm
   _____. ___ cm
6. **Upper mid-arm circumference** **_____. ___** cm
   _____. ___ cm
   _____. ___ cm

BIOELECTRICAL IMPEDANCE ANALYSIS (BIA) **BIAID _____**

If participant has pacemaker or any other metal medical device, BIA cannot be done.
All piercings and jewelry must be removed before proceeding.

7. **During the BIA measurement, the participant was:** Lying down _____
8. **Resistance measure: _____**
9. **Reactance measure: _____**

BLOOD PRESSURE **OMRON ID _____**
Time of day ____: _____ (hh:mm, e.g. 14.23, 24 hour time)

10. **Have you had any food, alcohol, coffee or cigarettes within the last 30 minutes?**
    - ☐ Food
    - ☐ Alcohol
    - ☐ Coffee
    - ☐ Cigarette
    - ☐ Recreational drugs

11. **Arm Circumference _____. ____cm**

12. **Cuff size selected**

Adult Arm Circumference	Recommended Cuff Size
22-26cm	12x 22cm (small adult)
27- 34cm	16x 30cm (adult)
35-44cm	16x 36cm (large adult)
45- 52cm	16x 42cm (adult thigh)

13. **Arm selected** ☐ Right ☐ Left. Specify reason: _____

14. **Blood Pressure measure refused?** ☐ No ☐ Yes

15. **First Blood Pressure Measurement**

SBP _____

DBP _____

60-second pulse rate _____

16. **Second Blood Pressure Measurement**

SBP _____

DBP _____

60-second pulse rate _____

17. **Third Blood Pressure Measurement**

SBP _____

DBP _____

60-second pulse rate _____

A second set of blood pressure measures follows the placement of the Actical.

18. **Repeat Blood Pressure measure refused?** ☐ No ☐ Yes

19. **First Repeat Blood Pressure Measurement**

SBP _____

DBP _____

60-second pulse rate _____

20. **Second Repeat Blood Pressure Measurement**

SBP _____

DBP _____

60-second pulse rate _____

21. **Third Repeat Blood Pressure Measurement**

SBP _____

DBP _____

60-second pulse rate _____

FORM 3 **METS-MICROBIOME** **BIOCHEMICAL MEASURES FORM**

Interviewer Initials: _____ **Exam Date: _____/_____/_____** (MM/DD/YYYY)

FOR FEMALES ONLY:

1. **Date of Last Menstrual Period: _____ /_____/_____** (MM/DD/YYYY)
2. **If greater than four weeks, is participant on Depo provera? Or other device (IUD); which one**; _____

Phlebotomist Initials: _____

When was the last time you had something to eat or drink?

3. Date last ate **_____ /_____/_____** (MM/DD/YYYY)
4. Time last ate **_____ :_____** (hh:min, Record in 24-hour time)

Glucose Check (Accuchek)

5. ☐ No ☐ Yes 6. **Result _____ (mg/dL) or _____(mmol/l)**

If the glucose check is ≥ 125 mg/dL (7.0 mmol/L), participant may not participate in the oral glucose tolerance test.

Baseline blood draw (timepoint 0:00)

6. Time of blood draw **_____ :_____** (hh:min, Record in 24-hour time)

Baseline BLOOD COLLECTION TUBES

2 tubes of 6 ml with K2EDTA

- ☐ No
- ☐ Yes

3 tubes of 6ml with no EDTA

- ☐ No
- ☐ Yes

Glucose drink:

7. Time at which entire 75 gram glucose drink was completed **____ :____** (hh:min, Record in 24-hour time)

2nd blood draw (timepoint **30min** after drink was completed)

8. Time of blood draw **_____ :_____** (hh:min, Record in 24-hour time)

1 BLOOD COLLECTION TUBE

1 tube of 6 ml with no EDTA

- ☐ No
- ☐ Yes

3rd blood draw (timepoint **60min** after drink was completed)

9. Time of blood draw **_____ :_____** (hh:min, Record in 24-hour time)

1 BLOOD COLLECTION TUBE

1 tube of 6 ml with no EDTA

- ☐ No
- ☐ Yes

Worksheet for Phlebotomist	
Time of drink	
Time for 2nd blood draw (30min)	
Time for 3rd blood draw (60min)	
Time for 4th blood draw (120min)	

Participant ID: _____

4th blood draw (timepoint **120min** after drink was completed)

10. Time of blood draw **_____ :_____** (hh:min, Record in 24-hour time)

1 BLOOD COLLECTION TUBES

1 tube of 6 ml with no EDTA

☐ No
☐ Yes

URINE

11. **Spot urine**

☐ No ☐ Yes

ACCELEROMETER 12. **Serial Number _____**

13**. Was accelerometer placed on right hip?**

☐ Yes ☐ No Reason for using left hip: _____

14. **Start date _____ /_____/_____** (MM/DD/YYYY)

15. **Start time ___ ___ :___ ___** (hh:min, Record in 24-hour time)

16. **Epoch period** 60 seconds☐ No ☐ Yes

17. **Mode** Record steps ☐ No ☐ Yes

☐ *Retrieve Anthropometrics (Form 2) and record second set of blood pressure measures*

Check date ___ ___ /___ ___/_____ (MM/DD/YY)

Comments: _____

FOLLOW UP

Interviewer initials: _____

18. **Was monitor returned?** ☐ No ☐ Yes

19. **End date ___ ___ /_____/_____** (MM/DD/YYYY)

20. **End time ___ ___ :___ ___** (hh:min, Record in 24-hour time)

21. **Would you say this period represents your usual activity level?**

☐ No ☐ Yes

If no, what was different about this period? _____

_____

STOOL SAMPLE

22. **Date that stool was passed: _____/ _____/_____** (MM/DD/YYYY)

23. **Approximate time that stool was passed: ____: _____** (hh:mm, e.g. 14.23, 24 hour time)

24. **Date that stool was received: _____/_____/_____** (MM/DD/YYYY)

25. **Approximate time that stool was received and stored at -80: ____: _____** (hh:mm, e.g. 14:23, 24 hour time)

26. How has stool been stored since it was passed:

- ☐ Refrigerated
- ☐ On ice
- ☐ At room temperature
- ☐ Other _____

27. Occult blood test result:

- ☐ Positive
- ☐ Negative

Interviewer Initials: _____

Physical Activity

Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person.

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food, seeking employment. *[Insert other examples if needed].* In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

	Questions	Response	Code
Activity at work			
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 4*	P1
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days ⌊__⌋	P2
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P3 (a-b)
4	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 7*	P4
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days ⌊__⌋	P5
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P6 (a-b)
Travel to and from places			
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed]			
7	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 *If No, go to P 10*	P7
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days ⌊__⌋	P8
9	How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P9 (a-b)
Recreational activities			
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure), [insert relevant terms].			
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 13*	P10
11	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊__⌋	P11
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P12 (a-b)

Participant ID: _____

Physical Activity (recreational activities) contd.			
Questions		**Response**	**Code**
13	Do you do any moderate-intensity sports, fitness or recreational *(leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking,(*cycling, swimming, volleyball*)for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P16*	P13
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊__⌋	P14
15	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins	P15 (a-b)
Sedentary behaviour			
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*			
16	How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs min s	P16 (a-b)

1. Food frequency questionnaire

	In a typical week, on how many days do you have the following on average:	**On these days, how many servings of the same do you take on average?**
Water (bottled, tap water)		(200-300ml glass)
Tea		(200ml cup) :
Coffee		(200ml cup):
Do you generally add milk in coffee or tea (powder or liquid)	Yes/No :	
Do you generally add sugar in coffee or tea (powder or liquid)	tea spoons/cup: 0,1,2, 3:	
Commercial soft drink (Cola, Fanta, etc) (3dl ~1 small bottle)		(300mll serving):
Commercial diet drink (Diet coke, etc) (3dl ~1 small bottle)		(300ml small bottle):
Fresh fruit juice (pressed, 1-2dl ~1 glass)		(200-300mll serving):
Fruit juice canned/packet (1 small packet ~2.5dl~1 serving)		(200-300mll serving):
Milk in glass (fresh, reconstituted, etc)		(200-300ml serving):
Soup (homemade, packet, etc)		(1,2,3 meals/day)
Beer		(300mll bottle or equivalent):
Wine or liquor (Porto, Irish coffee, etc)		(200mll glass):
Spirit (whisky, rum, gin, vodka, etc)		(20mll peg):
Locally made alcohol (moonshine)		(300-500ml glass):
Rice (white polished or brown unpolished)		Meals per day 1,2 3
Corn/maize (grits,hominy, crude, cooked, roasted, etc)		Meals per day 1,2 3
Potato (boiled, cooked, fries, hashbrown, fries)		Meals per day 1,2 3
Yam, taro, cassava, sweet potato (roots)		Meals per day 1,2 3
Bread (white or brown; buns, muffin, biscuit, bagel, sandwich, crackers, hamburger)		Slices or equivalent/d
Pasta (macaroni, spaghetti, ramen noodles)		Meals per day 1,2 3
Grains, beans and legumes		Meals per day 1,2 3
Raw vegetables (fresh, green, tomato, carrots, lettuce, avocado, guacamole, etc)		(1,2,3 meals/d)
Cooked Vegetables -canned, frozen, stirred e.g. cabbage, pumpkin, (but not salad, not roots):		(1,2,3 meals/d)
Cereals "for breakfast" (oatmeal, cornflakes, porridge)		(1,2,3 meals/d)
Local/commercial savory snacks (e.g. chips, peanuts, etc)		(servings per day)
Fruit (fresh, canned, frozen, etc, but not counting juice)		(portions/d)
Fast food (McDonalds, fried chicken, pizza, taco)		(1,2,3 meals/d)
Chicken (roasted, grilled, cooked, curry, etc)		(1,2,3 meals/day)

Meat (beef, pork, goat cooked, grilled, curry, etc but not processed)		(1,2,3 meals/day)
Meat processed (sausage, bacon, ham, bologna, burger, hot dog, etc)		(1,2,3 meals/day)
Fish (fresh, frozen, fried, cooked, grilled, can [tuna])		(1,2,3 meals/day)
Eggs (boiled, poached, omelet, etc)		(1,2,3 meals/day)
Cheese (processed, piece)		(1,2,3 meals/d)
Dessert, chocolate, cake, ice cream, shake, candy, cookie, donut		(1,2,3 meals/d)

General pattern of meals:

2. On a typical week day (Monday to Friday), do you usually eat for:
   Breakfast (Y/N) _____ Lunch (Y/N) _____ Dinner (Y/N) _____

3. On a typical week day (Monday to Friday), do you usually take a solid snack (not just a drink):
   Between breakfast & lunch Y/N) _____; between lunch & dinner Y/N) _____; after dinner Y/N) _____

4. In a typical week, how many times do you buy food, for lunch or for dinner, from a take away business, vendor or food truck? (1-5) _____

5. In a typical week, on how many days do you usually eat food from a workplace canteen? (1-5) _____

6. In a typical month, how many times do you eat in a restaurant/from a fast food vendor/ street food vendor? _____

7. In a typical week, how often do you buy a salty or sugary snack (not as main meal, not drink) from a vendor?
   1) Not every week
   2) 1-2 times /week
   3) 3-5 times per week
   4) Every day or almost every day
   5) More than once on most day of week

8. Do you substitute artificial sweetener for sugar (in your tea, coffee, etc) ?
   1) Never or nearly never
   2) Sometimes
   3) Regulary (every day)

9. How often do you drink water from the tap ?
   1) Never or virtually never
   2) Occasionally (not every week)
   3) Often, at least once every week
   4) Often, every day or nearly every day

10. In a typical week, do you usually use water from a water dispenser at home Y/N) ___ ; at work Y/N) ___

Interviewer Initials: _____

Section A: General household characteristics

1. How many people are part of this household, including yourself, and what gender are they? [The household is defined as people who normally live and eat together in the household, sleeping at least 4 nights per week in the household on a regular basis]

males _____ females _____

2. How many of the household members are in the following age ranges. Include yourself.

0-2 years old	_____	40-65	_____
3-15	_____	over 65	_____
16-40	_____		

3. How many of the household members contribute to the household income. Include yourself. _____

4. How many of the household members are currently enrolled in school, including up to university degree? _____

Section B: Subject's socioeconomic characteristics

5. Can you read and write? ☐ No ☐ Yes

6. What is the highest grade you completed, or how many years of formal education (including primary, secondary, tertiary/university but excluding pre-school/creche) do you have? _____

7. Do you have any of the following degrees? [Choose only the highest degree]

- ☐ No formal education or less than primary school
- ☐ Primary School (i.e. school between 3-5 and 15-16, often considered "obligatory school" in some countries)
- ☐ Some High School (i.e beyond age of 15-16, generally beyond what is considered "obligatory school"
- ☐ Completed High School
- ☐ Vocational degree or certification (e.g., electrician's license, auto repair certificate)
- ☐ Bachelor's degree (college or university undergraduate,BA, BS, BArch, BEng, etc.)
- ☐ Graduate or advanced professional degree (MBA, PhD, JD, MD, etc.)

8. How many days of work did you miss in the past 12 months due to sickness, illness, or injury?

- ☐ none, but did work last year
- ☐ 1 week or less
- ☐ 1-2 weeks
- ☐ more than 2 weeks
- ☐ did not work last year

9a. Did you do any type of work for pay in the last month? ☐ No ☐ Yes

9b. If you did not work in the last month, what was the main reason you did not work?

- ☐ No work available
- ☐ Seasonal inactivity
- ☐ Student
- ☐ Household/family duties
- ☐ Too old or too young to work
- ☐ Infirmity/sickness
- ☐ Other (Write in "Other" reason_____)

10. How were you paid for your work?

- ☐ Regular Wages or salary
- ☐ Payment in kind
- ☐ Casual labor (hourly/daily)
- ☐ Unpaid contributing worker
- ☐ Self-employed or own my own business

11. What is the main industry or activity at your primary job? (If currently unemployed, please use your last job)

- ☐ Agriculture
- ☐ Mining/quarrying
- ☐ Manufacturing/ processing

☐ Construction
☐ Transport
☐ Trade/selling
☐ Services (e.g.: restaurant, beauty salon, lodging)
☐ Education/health
☐ Administration
☐ Other (Write in "Other" industry_____)

12. What is the main occupation at your primary job? (If currently unemployed, please use your last job)
☐ Senior managers or administrators (finance manager - chief executive)
☐ Traditional professional occupations (accountant - solicitor/lawyer - physician - scientist/engineer)
☐ Modern professional occupations (teacher - nurse - social worker - artist - police officer sergeant+))
☐ Middle or junior managers (office manager - bank manager - restaurant manager)
☐ Clerical and intermediate occupations (secretary - clerical worker - call center agent - nursing aid)
☐ Technical and craft occupations (car mechanic - inspector - plumber - printer - electrician)
☐ Semi-routine manual and service occupations (postal worker - machine operator - security guard)
☐ Routine manual and service occupations (driver - cleaner - porter - laborer – waiter)
☐ Farming or agricultural occupations (farmer, herder)
☐ Fishing
☐ Other occupation (Write in occupation here: _____)

13. How many other people work in your workplace? (if currently unemployed, answer for your last job)
☐ 0 (I work alone or freelance)
☐ 1
☐ 2-9
☐ 10-24
☐ 25 or more

14. How many employees do you supervise? (if currently unemployed, answer for your last job)
☐ 0 (I do not supervise anyone)
☐ 1
☐ 2-9
☐ 10-24
☐ 25 or more

15. In the course of your work, do you make management decisions, such as how many people to hire? (if currently unemployed, answer for your last job) ☐ No ☐ Yes

16. Not counting the place where you currently stay (and whether you own it or rent it), do you own a house, an apartment or another building that you rent to others? ☐ No ☐ Yes

Section C: Significant other's information

17. Does your significant other have any of the following degrees? [Pick only one, the highest degree obtained]
☐ No formal education or less than primary school
☐ Primary School
☐ Some High School
☐ Completed High School
☐ Vocational degree or certification (e.g., electrician's license, auto repair certificate)
☐ Bachelor's (college or university undergraduate) degree (BA, BS, BArch, BEng, etc.)
☐ Graduate or advanced professional degree (MBA, PhD, JD, MD, etc.)
☐ Don't Know

☐ Not applicable. Not living with a significant other

Section D: Household assets and amenities

19. Does the household or a household member own the dwelling you live in?
☐ Owns the dwelling

☐ Rents the dwelling
☐ Uses without paying rent
☐ Nomadic or temporary dwelling

21. Does the household use land it does not own? ☐ No ☐ Yes

22. Does the household own any cattle or other livestock, like cows, horses, donkeys, pigs, goats, sheep, (even 1-2) ?

☐ No ☐ Yes

23. Does the household have electricity? ☐ No ☐ Yes

24. Does the household or any member of the household (including yourself) own or have any of the following? (Include only if they are in working condition)

☐ Electric iron
☐ Refrigerator
☐ Television
☐ Satellite Dish or Cable Television
☐ DVD player or VCR
☐ Computer (only include a computer purchased by you or a member of your household)
☐ Mattress or bed
☐ Sofa
☐ Sprayer (Jamaica, Ghana only)
☐ Radio or CD player
☐ Telephone (land line)
☐ Cell phone
☐ Fan
☐ Air conditioner
☐ Bicycle
☐ Motorcycle
☐ Car or truck

25. Do you personally own any of the following? (Include only if they are in working condition; include any items that were listed above)

☐ Cell phone
☐ Bicycle
☐ Motorcycle
☐ Car or truck

26. In the past year, did your household have problems satisfying the food needs of the household members?

☐ Never
☐ Seldom
☐ Sometimes
☐ Often
☐ Always

27. How do you compare the overall economic situation of your household compared with other households in your local area?

☐ Much worse now
☐ A little worse now
☐ Same
☐ A little better now
☐ Much better now
☐ Don't know

28. What is the material of the roof of the house?

☐ Mud
☐ Thatch
☐ Wood

- ☐ Iron/ Aluminum sheets
- ☐ Cement/ concrete
- ☐ Roofing tiles
- ☐ Asbestos
- ☐ Other (please name other roofing material:_____)

29. What is the material of the walls of the house?
- ☐ Mud/ mud brick
- ☐ Stone
- ☐ Burnt bricks
- ☐ Iron/ Aluminum sheets
- ☐ Cement/ sandcrete
- ☐ Wood/Bamboo
- ☐ Cardboard
- ☐ Dry Wall
- ☐ Other (please name other material :_____)

30. What is the main source of drinking water?
- ☐ Public piped into dwelling or compound
- ☐ Public outdoor tap or borehole
- ☐ Protected well
- ☐ Unprotected well or rain water
- ☐ River, lake, or pond
- ☐ Vendor, truck, or bottled
- ☐ Other (name other source :_____)

31. What type of toilet facility does your household have?
- ☐ None
- ☐ Flush
- ☐ Pan/bucket
- ☐ Covered pit latrine
- ☐ Uncovered pit latrine
- ☐ Ventilation improved pit latrine
- ☐ Other (please name other type:_____)

32. What is the main fuel used for cooking?
- ☐ Firewood
- ☐ Charcoal
- ☐ Kerosene/oil
- ☐ Gas
- ☐ Electricity
- ☐ Crop residue/ saw dust
- ☐ Animal waste
- ☐ Other (please name other fuel:_____)

33- 38. How many minutes does it take from your home to reach the nearest …? (circle one)

	0-14	15-29	30-44	45-59	60+
33. Supply of drinking water:	1	2	3	4	5
34. Food market:	1	2	3	4	5
35. Public transportation:	1	2	3	4	5
36. Pharmacy:	1	2	3	4	5
37. Health clinic or hospital:	1	2	3	4	5
38. Primary School:	1	2	3	4	5

Interviewer Initials: _____ **Exam Date: ____/_____/_____**(MM/DD/YYYY)

General Lifestyle and Hygiene Information

1. Do you bite your fingernails? ☐ Yes ☐No

2. How often do you swim in a river/lake/swimming pool/hot tub?
   - ☐ Daily
   - ☐ Regularly (3-5 times/week)
   - ☐ Occasionally (1-2 times/week)
   - ☐ Rarely (few times/month)
   - ☐ Never

3. Do you have any animals inside your home?
   - ☐ Dog ☐ None
   - ☐ Cat ☐ Other _____

4. Do you have daily or weekly contact with some kind of animal that may be kept outside
   - ☐ Dog ☐ Chicken ☐ Sheep
   - ☐ Cat ☐ Goat ☐ Cow
   - ☐ Other _____

General Health Information

5. How many times do you have a bowel movement in an average day?
   - ☐ Less than one ☐ Two ☐ Four
   - ☐ One ☐ Three ☐ Five or more

6. Have you had diarrhea in the last 3 months? ☐ No ☐ Yes

7. Describe the quality of your bowel movements:
   - ☐ I tend to be constipated (have difficulty passing stool) – Type 1 and 2;
   - ☐ I tend to have diarrhea (watery stool) – Type 5, 6 and 7;
   - ☐ I tend to have normal formed stool – Type 3 and 4.

   Use the chart below as a reference:

8. I have taken antibiotics in the last _____.
   - ☐ Week (Name of antibiotic) _____
   - ☐ Month (Name of antibiotic) _____
   - ☐ 6 months
   - ☐ Year
   - ☐ I have not taken antibiotics in the past year.

9. I have received a flu vaccine in the last _____.
   - ☐ Week ☐ 6 months ☐ I have not gotten the flu vaccine in the past year.
   - ☐ Month ☐ Year

10. My weight has _____ within the last 6 months.

- ☐ Increased more than 10 pounds/6kg.
- ☐ Decreased more than 10 pounds/6kg.
- ☐ Remained stable

11. Have you had your tonsils removed?
    ☐ No ☐ Yes ☐ Not sure

12. Have you had you appendix removed?
    ☐ No ☐ Yes ☐ Not sure

13. Have you had chickenpox?
    ☐ No ☐ Yes ☐ Not sure

14. How were you fed as an infant?
    ☐ Primarily breast milk ☐ A mixture of breast milk and formula
    ☐ Primarily infant formula ☐ Not sure

15. Do you have seasonal allergies? ☐ No ☐Yes

16. Do you have any of the following non-food allergies? (check all that apply)
    ☐ Drug (e.g. Penicillin) ☐ Beestings ☐Sun
    ☐ Pet dander ☐ Poison ivy/oak

17. Are you intolerant to milk (lactose intolerant)? ☐ No ☐ Yes

18. Are you gluten intolerant?
    ☐ I was diagnosed with celiac disease
    ☐ I was diagnosed with gluten allergy (anti-gluten IgG), but not celiac disease
    ☐ I do not eat gluten because it makes me feel bad
    ☐ No

19. I am allergic to _____ (mark all that apply)
    ☐ Peanuts ☐ Shellfish
    ☐ Tree nuts ☐Other _____
    ☐ I have no food allergies that I know of.

Interviewer Initials: _____ **Exam Date: _____/_____/_____** (MM/DD/YYYY)

In your day-to-day life, how often do any of the following things happen to you?

1. You are treated with less courtesy than other people are.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

2. You are treated with less respect than other people are.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

3. You receive poorer service than other people at restaurants or stores.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

4. People act as if they think you are not smart.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

5. People act as if they are afraid of you.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

6. People act as if they think you are dishonest.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year

- ☐ Less than once a year
- ☐ Never

7. People act as if they're better than you.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

8. You are called names or insulted.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

9. You are threatened or harassed.
   - ☐ Almost every day
   - ☐ At least once a week
   - ☐ A few times a month
   - ☐ A few times a year
   - ☐ Less than once a year
   - ☐ Never

Follow-up Question (Asked only of those answering, "A few times a year" or more frequently to at least one question): (Check more than one options if participant indicates)

What do you think is the <u>main</u> reason for these experiences?

- ☐ Your ancestry or national origins
- ☐ Your gender
- ☐ Your race
- ☐ Your religion
- ☐ Your height
- ☐ Your weight
- ☐ Some other aspect of your physical appearance
- ☐ Your education or income level

Loyola University Chicago

METS – Microbiome Study

Results Form

Name: _____ **Date:** _____

Height: _____ ft. _____ in. **Weight:** _____ lbs.

Age: _____

Body Mass Index (BMI): _____

Underweight	Below 18.5
Normal	18.5 – 24.9
Overweight	25.0 – 29.9
Obese	30.0 or Higher

National Heart, Lung, and Blood Institute (NHLBI), NIH

Blood Pressure #1: _____/_____ _____/_____ _____/_____

Blood Pressure #2: _____/_____ _____/_____ _____/_____

	Systolic (Top Number)		**Diastolic (Bottom Number)**
Normal	Below 120 mmHg	And	Below 80 mmHg
Pre - Hypertension	120 – 139 mmHg	Or	80 – 89 mmHg
Hypertension	140 or Higher	Or	90 or Higher

American Heart Association (AHA)

Blood Glucose Results: _____ mg/dL

Normal FASTING glucose	70 – 99 mg/dL
Normal glucose 2hrs after eating	70 – 145 mg/dL
Impaired fasting glucose (pre-diabetes)	100 – 125 mg/dL
Indicates diabetes	126 mg/dL & above on more than one occasion

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), NIH

Fecal Occult Blood Test: _____

Negative	No blood was detected in your stool sample.
Positive	Blood was detected in your stool sample. You may need additional testing such as a colonoscopy to locate the source of the bleeding and rule out colon cancer, ulcers or hemorrhoids.

Mayo Clinic

METS Referral Program

As a participant of our study, you are eligible to participate in the METS referral program. **For every person you refer to the METS research study, you may receive $20**. In order to receive payment the person you refer must complete both initial appointments and agree to participate in the follow-up appointments after one year and two years. **For every five participants referred who complete both initial visits, you will receive an extra $50.** Call 708-216-7881 or email metsbiome@luc.edu.

- **Participants must be African American and between 35-55 years old.**

Date: _____ Your Name: _____

Your Phone Number(s): _____

#1

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#2

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#3

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#4

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#5

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#6

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#7

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____

#8

Name of Person You are Referring: _____ Phone #: _____

How do you know this person? _____ Alternate #: _____