NiPN-Ethiopia
National Information Platform for Nutrition

Ethiopian Public Health Institute

Trends and Factors Associated with Overweight/Obesity, Diabetes and Hypertension in Ethiopia

October, 2021

Authors

Meron Girma[1], Tom Norris[2], Alemayehu Hussein[1], Tirsit Genye[3], Rebecca Pradeilles[2], Cornelia van Zyl[3], Aregash Samuel[1]

[1] Ethiopian Public Health Institute/National Information Platform for Nutrition (NIPN)
[2] International Food Policy Research Institute Collaborator
[3] International Food Policy Research Institute (IFPRI)/NIPN

This report was prepared by the NIPN in Ethiopia, hosted by the Ethiopian Public Health Institute (EPHI). The NIPN is a global initiative funded by the European Union (EU), with support from the Foreign, Commonwealth and Development Office and the Bill and Melinda Gates Foundation.

For communication on this report, please address any queries to NIPN Ethiopia at ephi.nipn@gmail.com

Acknowledgements

We gratefully acknowledge Jemal Haider (Addis Ababa University, (AAU), Kaleab Baye (AAU), and Kalle Hirvonen (IFPRI) for their review of this research report.

Table of Contents

List of Tables

List of Figures

List of Acronyms

aOR	Adjusted Odds Ratio
DAG	Directed Acyclic Graph
BMI	Body Mass Index
DBP	Diastolic Blood Pressure
EDHS	Ethiopia Demographic and Health Survey
EDNP	Energy Dense Nutrient Poor
EPHI	Ethiopian Public Health Institute
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
LICs	Low Income Countries
NCD	Non-Communicable Disease
NR-NCDs	Nutrition-Related Non-Communicable Diseases
PA	Physical Activity
PCA	Principal Component Analysis
SBP	Systolic Blood Pressure
SD	Standard Deviation
STEPS	STEPwise approach to Surveillance
WC	Waist Circumference
WHO	World Health Organization
WRA	Women of Reproductive Age

Abstract

Non-communicable diseases (NCDs) account for 70% of all global deaths annually. Moreover, rates of overweight and obesity, which are risk factors for NCDs, have nearly tripled over the last half-century. In Ethiopia, the prevalence of overweight, obesity, and associated nutrition-related NCDs (NR-NCDs) such as hypertension and diabetes has been increasing considerably in the past decade. However, there are limited published data exploring temporal trends and factors which drive overweight, obesity, and NR-NCDs. We aimed to describe the trends and factors driving overweight and obesity among women of reproductive age (15-49 years) and identify modifiable factors associated with hypertension and prediabetes/diabetes among males and females (15-69 years) in Ethiopia. We produced directed acyclic graphs (DAGs) to map causal relationships between factors and outcomes. These causal diagrams were used to identify variables to include in statistical models. We used data from the four rounds of the Ethiopia Demographic and Health Survey (EDHS) and applied a non-linear regression decomposition analysis to assess how the change in each modifiable exposure factor contributed to the change in overweight/obesity between 2000-2016. Additionally, we used data from the Ethiopia STEPwise approach to Surveillance (STEPS) Non-communicable Disease Risk Factors survey (NCD STEPS) and performed a logistic regression analysis to identify modifiable factors associated with hypertension and prediabetes/diabetes. We observed a significant increase in overweight and obesity particularly among women residing in urban settings (an increase from 11% in 2000 to 21% in 2016). A rise in wealth was the main driver of the change in overweight/obesity between 2000 and 2016, accounting for 62% and 63% of the increase in rural and urban women, respectively. Education was protective among women residing in urban settings, with increased educational attainment contributing to a 16% decline in overweight/obesity between 2000 and 2016. Additional contributors to the rise in overweight/obesity were increases in engagement in more sedentary occupations and in screen time. Our analysis of modifiable risk factors showed that body mass index and waist circumference were positively associated with hypertension and prediabetes/diabetes in both males and females. In contrast, a higher educational attainment was associated with lower odds of hypertension and prediabetes/diabetes in both sexes. While residing in urban settings was associated with higher odds of hypertension in both males and females, it was only associated with prediabetes/diabetes in males. Males and females in pastoralist areas had lower odds of prediabetes/diabetes compared to their agrarian counterparts. Physical activity was associated with lower odds of prediabetes/ diabetes only among females. Our findings show that interventions to prevent and control overweight and obesity and NR-NCDs are urgently needed.

1. Background and Objectives

Non-communicable diseases (NCDs) are the leading causes of mortality among adults globally and account for 70% of all global deaths annually[1]. Furthermore, approximately two billion adults worldwide are obese (body mass index (BMI) $\geq$ 30 kg/m^2), and rates of obesity have nearly tripled over the last half-century[2]. Overweight and obesity are major risk factors for nutrition-related NCDs (NR-NCDs) such as diabetes and hypertension[2]. The public health burden of NCDs is increasing in low-and-middle-income countries (LMICs), with individuals facing a substantially higher risk of premature NCD death compared to high-income countries[3]. Diabetes, defined as fasting blood glucose > 126 mg/dl (7.0 mmol/L)[4], is one of the most prevalent forms of NR-NCDs with the incidence of diabetes increasing from 11.3 million in 1990 to 22.9 million in 2017[5]. The largest increase was seen in LMICs[5]. Additionally, prediabetes (fasting blood glucose: 100-125 mg/dl)[6], increases predisposition to future progression into diabetes and is associated with higher risk of diabetic complications[7]. Hypertension is another major contributor to the growing burden on NR-NCDs globally; 1.13 billion people worldwide have hypertension[8] with Africa displaying the highest prevalence (27%) [8].

In Ethiopia, the prevalence of overweight, obesity, and associated NR-NCDs such as hypertension and diabetes has been increasing considerably in the past decade[9-13]. This increase is driven by a transition towards a Western diet characterized by increased consumption of energy-dense foods alongside declining physical activity levels [2,14,15] . This shift has occurred alongside improvements in access to health services, which has seen NR-NCDs replace communicable diseases as the leading causes of mortality in Ethiopia. For example, cardiovascular diseases were the second leading causes of mortality in Ethiopia in 2019[1]. In response to the increasing burden of NR-NCDs and using the World Health Organization (WHO)'s global action plan for the prevention of NCDs by 2025 [16] as a framework, the Ethiopian Government designed the national strategic action plan (NSAP) for the prevention and control of NCDs in 2014 [17]. The main priority areas for action include health promotion and disease prevention to address behavioral risk factors and comprehensive NCD treatment, care and support[17]. The importance of tackling NCDs for sustainable development was also emphasized in the Sustainable Development Goals (SDGs) which aim to reduce premature deaths from NCDs by a third by 2030 (SDG3) [18].

Recent cross-sectional findings from a nationally representative survey showed that the prevalence of hypertension and diabetes in Ethiopia was approximately 15% and 3%, respectively[12], though significant regional disparities exist. However, there are limited published data available exploring temporal trends and factors that drive overweight, obesity and NR-NCDs. If progress is to be made in achieving the NCD-related SDGs and the targets set

out in the NSAP, then evidence regarding the magnitude of the NR-NCD burden, how it has changed over time and whether this burden is equitable across different population groups is required. In addition to quantifying the extent and temporal trend of the burden, it is vital to acquire knowledge of the modifiable metabolic and behavioral factors associated with NR-NCDs, in an attempt to identify priority interventions and target groups in order to mitigate the rising burden of these conditions. Accordingly, the aims of this work were twofold; i. to describe trends in the prevalence of overweight and obesity and associated factors among women of reproductive age (WRA) (15-49 years) in Ethiopia between 2000-2016 and ii. to assess modifiable factors associated with hypertension and prediabetes/diabetes among males and females (15-69 years) in Ethiopia.

2. Methods

2.1 Identification of Factors Associated with Overweight, Obesity, Hypertension and Diabetes

We conducted a systematic literature review to identify nutritional, behavioral, and socio-economic factors associated with overweight/obesity, diabetes, and hypertension in Sub-Saharan Africa. MEDLINE was used to identify peer-reviewed journal articles published in English from the year 2000 onwards. We included studies that were conducted on adult males and females. The inclusion and exclusion criteria, search strategy and the search log are included in Annex I. The search identified 3,442 studies that met the inclusion criteria. The abstracts of these studies were then reviewed. In the 750 studies fulfilling our criteria, we extracted data regarding factors significantly associated with overweight, obesity, diabetes and hypertension. Using the variables identified from the systematic review, a set of provisional causal path diagrams were constructed in order to visualize the relationships between factors, outcomes and covariates. These preliminary causal path diagrams were then used to facilitate discussion during a consultation with experts (n=14) from the fields of nutrition, non-communicable disease epidemiology and public health. Using the expert knowledge shared during this consultation, a set of formal causal path diagrams were produced and were used to inform the model-building process of the statistical analysis (see section 2.4).

2.2 Data Sources

2.2.1 Ethiopia Demographic and Health Survey

To describe the trends and factors that drive overweight and obesity among WRA (objective 1), we used data from the four rounds (2000, 2005, 2011, and 2016) of the Ethiopia Demographic and Health Survey (EDHS). The Demographic and Health Surveys are population-based

household surveys that are carried out in over 90 countries globally. The availability of data for multiple rounds makes these surveys suitable for exploring trends. The EDHS is nationally and regionally representative and uses a stratified two-stage cluster sampling method. In the first stage, each region is stratified as urban or rural and within these strata, enumeration areas are selected using probability proportional to size sampling. Enumeration areas are geographic areas that cover an average of 181 households. In the second stage, households are randomly selected from each enumeration area. For this analysis, we used the women's and household datasets of the EDHS. The women's dataset contains information on background characteristics (e.g., age, education and employment), status of women within the household, breastfeeding and nutrition. The household dataset provides information regarding the composition and characteristics (e.g., assets, housing conditions) of the household. Ethical approval for conducting the DHS surveys was obtained centrally by the ORC Macro Institutional Review Board and by individual review boards within the individual countries participating in the program. The DHS data sets are publicly available and accessible at https://dhsprogram.com.

2.2.2 NCD STEPwise Approach to Surveillance

To identify modifiable factors associated with prediabetes/diabetes and hypertension amongst both males and females aged 15-69 years (objective 2), we used data from the Ethiopia STEPwise approach to Surveillance (STEPS) Non-communicable Disease Risk Factors survey (NCD STEPS). The NCD STEPS survey was conducted in 2015 and followed the WHO STEPwise approach to surveillance for the identification of risk factors for NCDs in a nationally representative sample. The NCD STEPS survey collected information on five main NCD risk factors, namely: tobacco use, alcohol consumption, diet, physical activity, and history of chronic disease. Additionally, blood pressure and body size measurements were taken. Venous blood sampling was conducted, and cardio-metabolic biomarkers were obtained (e.g., blood glucose and blood lipids). Fasting blood glucose, total cholesterol and High Density Lipoprotein (HDL) cholesterol levels were measured using a CardioCheck PA Analyzer. Fasting triglyceride levels were measured using Cobas Integra 400 Plus (Roche Diagnostics GmbH, Mannheim, Germany) clinical chemistry analyzer. The study protocol was reviewed and approved by Institution Review Board of Ethiopian Public Health Institute (EPHI) and National Ethics Review Committee of Ministry of Science and Technology. Informed consent was obtained from each participant and consent obtained from parents and guardians for those participants between age 15–17 years.

2.3 Outcomes and Modifiable Factors

2.3.1 Analysis of Trends and Factors that Drive Overweight/Obesity Among WRA

Due to the likely low prevalence of obesity in Ethiopia, an a-priori decision was taken to combine overweight and obesity into a single outcome, which was subsequently defined as a BMI $\geq$25 kg/m^2. Of the 66 factors identified through the systematic review and expert consultation, data were available for 22 in the EDHS. The key modifiable factors which were of interest in our analysis were place of residence, wealth, educational attainment, occupation, screen time and livelihood (agrarian or pastoralists). We included livelihood as a factor to capture differences in food environments, access to health service and behavioral factors among pastoral and agrarian communities. Pastoralists in Ethiopia are mainly engaged in livestock production and are seasonally mobile. The remaining variables were used as covariates in accordance with the causal path diagrams. A description of the variables included in the EDHS analysis is included in Table A1. To assess change in wealth over time, we pooled data from the four rounds of the EDHS and constructed a rural and urban wealth index using Principal Component Analyses (PCA). The variables included in the PCA were asset ownership (radio, TV, bicycle, car, electric *mitad*, lamp, and electricity), cropland ownership, type of water source used, type of sanitary facility used, and housing conditions. The characteristics of the WRA are shown in Table A2. Figure A1 shows the number of WRA drawn from the EDHS sample for inclusion in this analysis.

2.3.2 Modifiable Factors Associated with Hypertension and Prediabetes/Diabetes Among Males and Females

The outcome variables for the analysis using NCD STEPS data were hypertension and prediabetes/diabetes. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg[19] or currently taking medication for raised blood pressure or hypertension. Prediabetes/diabetes was defined as fasting blood glucose > 100 mg/dl (5.6 mmol/L)[4,6] or currently taking any medication, such as insulin, prescribed for diabetes. Modifiable factors included in the analysis were fruit intake, vegetable intake, urban residence, educational attainment, occupation: non-agricultural work, income, alcohol intake, *khat* chewing, smoking, salt intake, physical activity and livelihood (pastoralist). A description of the variables included in the NCD STEPS analysis are included in the Annex Table A3.

2.4 Statistical Analyses

In both analyses and in conjunction with the findings from the systematic review and expert consultation, we produced a set of causal path diagrams of the hypothesized pathways relating the outcome variables (overweight/obesity, hypertension, and prediabetes/diabetes), factors

and covariates. Our causal path diagrams, or 'directed acyclic graphs' (DAGs) were constructed using the open-access software, DAGitty version 3.0[20], which enables the creation of a DAG in a robust, systematic and reproducible manner. Briefly, DAGitty employs graphical model theory in order to search for covariates sets that qualify as 'adjustment sets' which, upon adjusting for, remove all confounding from the specified DAG. A DAG was produced for each separate exposure of interest in relation to each of the outcome variables, resulting in the construction of a series of exposure-outcome specific multivariable regression models.

2.4.1 Analysis of Trends and Drivers of Overweight/Obesity Among Women

Trends in overweight/obesity were explored using data from the four rounds of EDHS. Sampling weights were applied when estimating the prevalence of outcomes to account for the cluster sampling used in the EDHS. Given the likely differences in the prevalence of overweight/obesity and the selected exposures (and their change over time) in urban vs. rural settings, an a-priori decision was made to stratify the analysis according to place of residence (urban vs rural). The prevalence of overweight/obesity at each time point, at the national level and split by place of residence, was plotted. In addition, equity plots were produced to show the temporal changes in overweight/obesity prevalence by wealth quintile and place of residence (urban vs rural).

To assess how the change in each modifiable exposure factor contributed to the change in overweight/obesity between 2000-2016, a regression decomposition analysis was applied. Decomposition analysis entails multiplying observed changes in the means of each modifiable exposure variable over time by its regression coefficient representing its association with overweight/obesity. This provides the predicted change in overweight/obesity from each change in modifiable exposure variable and thus shows the estimated contributions of each variable to changes in overweight/obesity. Such analyses have traditionally employed the Blinder-Oaxaca technique, however, this technique is inefficient if the outcome is binary, as is the case in our analyses. As such, we employed the non-linear decomposition method proposed by Fairlie[21], which enables the use of estimates obtained from logistic regression models.

The non-linear decomposition equation of $Y = F(X\hat{\beta})$, can be expressed as:

$$\bar{Y}^{2016} - \bar{Y}^{2000} = \left(\sum_{i=1}^{N^{2016}} \frac{F(X_i^{2016}\hat{\beta}^{2000})}{N^{2016}} - \sum_{i=1}^{N^{2000}} \frac{F(X_i^{2000}\hat{\beta}^{2000})}{N^{2000}}\right) + \left(\sum_{i=1}^{N^{2016}} \frac{F(X_i^{2016}\hat{\beta}^{2016})}{N^{2016}} - \sum_{i=1}^{N^{2016}} \frac{F(X_i^{2016}\hat{\beta}^{2000})}{N^{2016}}\right)$$

where N^j denotes the sample size of each time point (j = 2000, 2016), F is the cumulative distribution function of the logistic distribution, $\bar{X}^j$ denotes the set of mean values for the included exposure variables at each time point and $\hat{\beta}^j$ denotes the set of estimated coefficients for the relationship between each exposure variable and the outcome ($\bar{Y}^j$). To accommodate the sampling nature of the EDHS, we used sampling weights in the decomposition analyses. The

contributions of each of the modifiable exposure variables to the change in overweight/obesity prevalence were plotted in a bar charts.

2.4.2 Analysis of Factors Associated with Hypertension and Prediabetes/Diabetes

Using data from the NCD STEPS survey, we tested the association between modifiable factors and hypertension and prediabetes/diabetes by running exposure-specific multivariable logistic regression analyses. Associations are reported as adjusted odds ratios (aOR) and their 95% confidence intervals. Adjustment sets for each modifiable factor were identified using the DAGs constructed for each of the outcomes. As it has been shown that associations between a number covariates and hypertension and prediabetes/diabetes may differ between sexes[22-28], an a-priori decision was made to stratify the analysis by sex. Data management and statistical analysis were conducted in Stata Version 16.1.

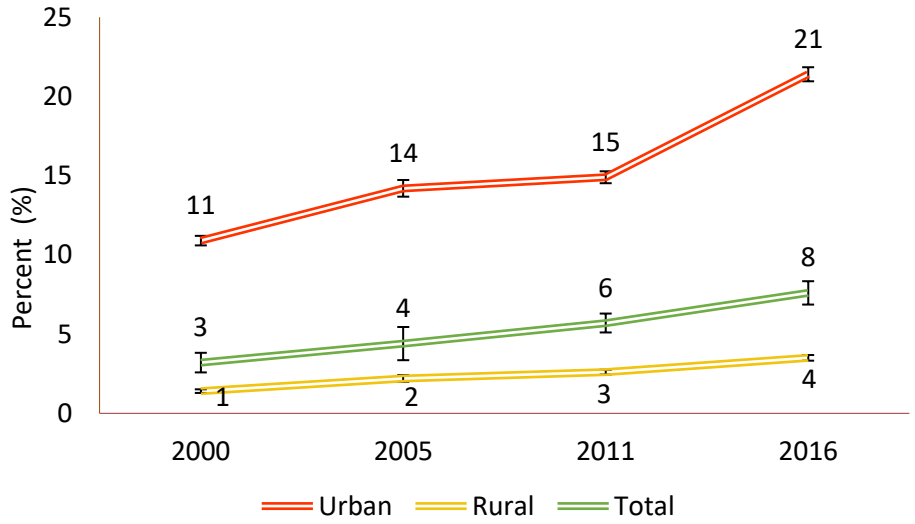
3. Results

3.1 Trends and Factors That Drive Overweight/Obesity Among WRA

A total of 47,509 WRA pooled from the four rounds of the EDHS were included in the analysis of trends and factors associated with overweight/obesity. The mean (SD) age of the women was 28 (10) years. Table A3 shows the characteristics of the study population. Figure 1 presents trends in overweight/obesity nationally and by residence. Overweight/obesity increased nationally from 3% in 2000 to 8% in 2016. The absolute increase in overweight/obesity among women residing in urban areas was greater; increasing from 11% in 2000 to 21% in 2016, with a marked increase between the 2011-2016 surveys (15% vs. 21%).

Figure 1*: Trends in overweight/obesity among women of reproductive age between 2000 and 2016 nationally and disaggregated by residence.*

Error bars present 95% confidence intervals.



3.2 Distribution of the Trends and Magnitude of Overweight/Obesity Among WRA

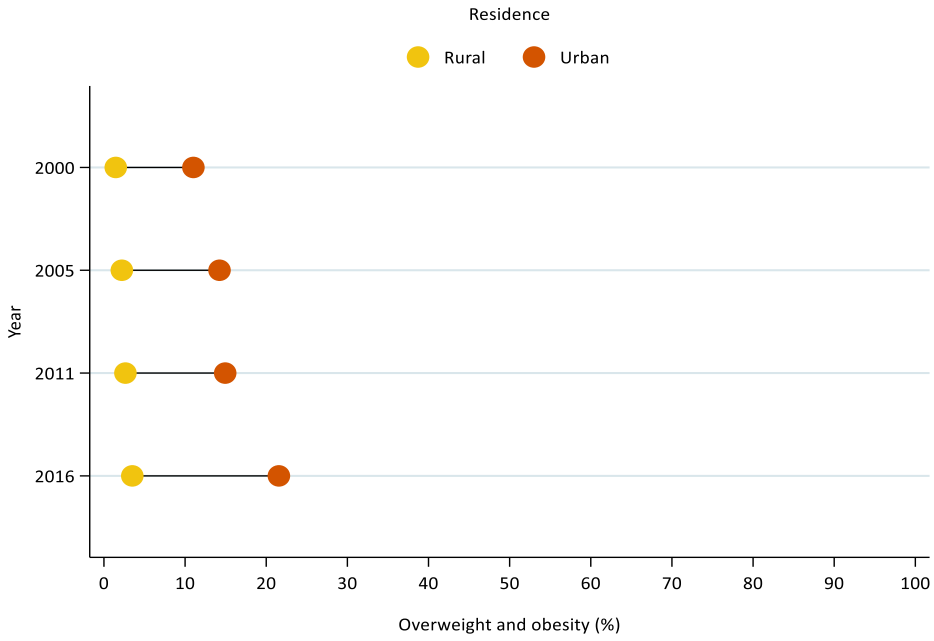
Figure 2 shows the trends in overweight/ obesity by wealth, residence and region. Absolute urban-rural differences in overweight/obesity prevalence, represented by the distance between dots (groups), were constant between 2000 and 2011. In 2016 however, a greater difference in the prevalence of overweight/obesity between rural (4%) and urban (21%) settings were observed. Between 2000 and 2016, absolute differences increased between the highest and lowest wealth quintiles. The difference in the prevalence of overweight/obesity between the poorest and the wealthiest women increased from 1.5% in 2000 to 17% in 2016. The

prevalence of overweight/obesity did not show a large increase between 2000 and 2005 for most regions with the exception of Somali where it increased from 4% in 2000 to 10% in 2005. Between 2011 and 2016, rates of overweight/obesity increased markedly in Addis Ababa (20% to 29%) and Harari (14% to 20%).

Figure 2. *Change in overweight/obesity prevalence between 2000-2016 disaggregated by residence, wealth, and region.*

2A. Residence

Dots show the prevalence of overweight/obesity among rural (yellow) and urban (red) residents.

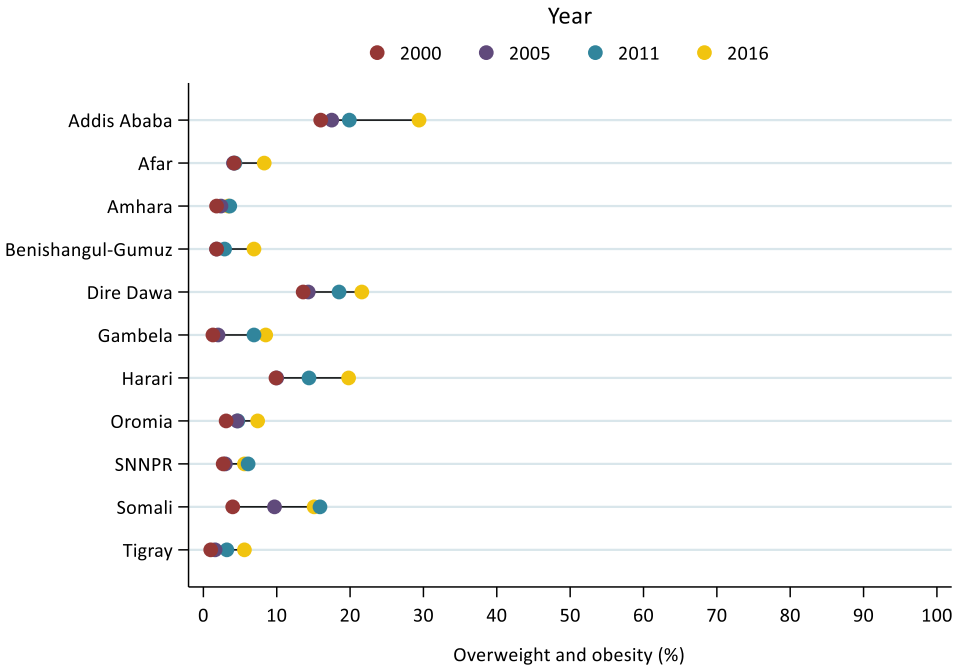


2B. Wealth quintiles

Dots show prevalence of overweight/obesity across wealth quintiles (poorest, poorer, middle, wealthier and wealthiest)

2C. Region

Dots show prevalence of overweight/obesity in 2000,2005,2011 and 2016 by region.

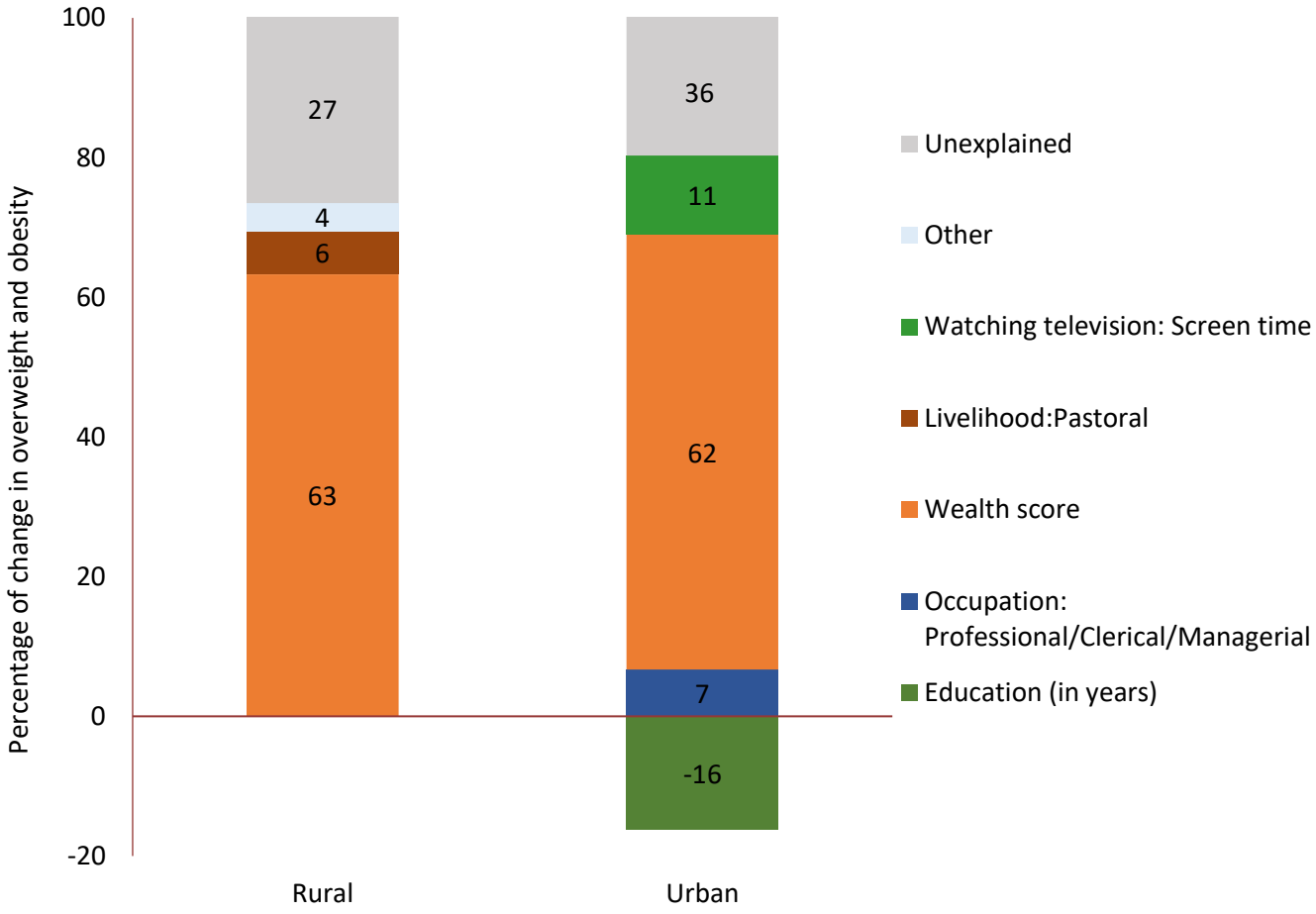


3.3 Factors Driving Overweight/Obesity Among WRA

The contribution of changes in the modifiable exposure variables to the increase in overweight/obesity between 2000-2016 can be seen in Figure 3. The factors included in our model accounted for 80% of the rise in overweight/obesity in urban women and 69% of the increase in rural women. In both urban and rural women, the relative contribution of increased wealth to the change in overweight/obesity prevalence, was similar, at 62% and 63%, respectively. In urban women, an increase in the prevalence of any screen time contributed to 11% of the rise in overweight/obesity, while an increased engagement in professional/clerical/managerial work accounted for 7% of the increase in this group. Conversely, the observed increases in educational attainment between 2000-2016 contributed to a 16% decline in prevalence of overweight/obesity. Among rural women, residing in a pastoralist area contributed to 6% of the rise in overweight/obesity.

Figure 3.*Factors driving overweight/obesity among WRA (2000-2016).*

Percent contribution of factors to the change in overweight/obesity between 2000-2016. Other refers to modifiable factors whose contribution to the change in overweight/obesity was not statistically significant.



3.4 Modifiable Factors Associated with NR-NCDs

A total of 3,977 males and 5,823 females from the original NCD STEPS survey were included in this analysis. The mean (SD) age was 31 (13) years among males and 31 (12) years among females. Intake of five or more servings of fruit and vegetable was low in both males and females (< 6%). In contrast, more than 96% of males and females consumed more than 5g of salt daily. The majority of males (94.7%) and females (91.1%) met the WHO physical activity recommendations of more than 150 minutes/week. The characteristics of males and females included in the NCD STEPS survey are shown in Table A2.

3.4.1 Hypertension Risk Factors

BMI, waist circumference (WC) and residing in an urban setting (vs. rural) were positively associated with hypertension in both males and females (Figure 4). A 1 kg/m^2 higher BMI was associated with 20% and 10% higher odds of hypertension in males [[aOR): 1.2 (: 1.1, 1.2)] and females [aOR: 1.1 (1.0, 1.1)], respectively. Similarly, a 1 cm largerWC was associated with 60% [aOR: 1.6 (1.4, 1.8)] and 30% [aOR: 1.3 (1.2, 1.5)] higher odds of hypertension in males and females, respectively. Males [aOR: 1.8 (1.5, 2.2)] and females [aOR: 1.7 (1.5, 1.9)] who resided in urban areas had higher odds of hypertension compared to their rural counterparts. Males who were engaged in non-agricultural work had higher odds of hypertension compared to agricultural workers [aOR: 1.3 (1.07, 1.64)]. Pastoral females had higher odds of hypertension [aOR: 1.6 (1.1, 2.5)] compared to agrarian females. In contrast, a 1-year higher educational attainment was associated with lower odds of hypertension in females [aOR: 0.95 (0.9, 1.0)]. Fruit and vegetable intake, daily salt intake greater than 5 g/day, physical activity; and alcohol and *khat* intake were not associated with hypertension.

3.4.2 Diabetes Risk Factors

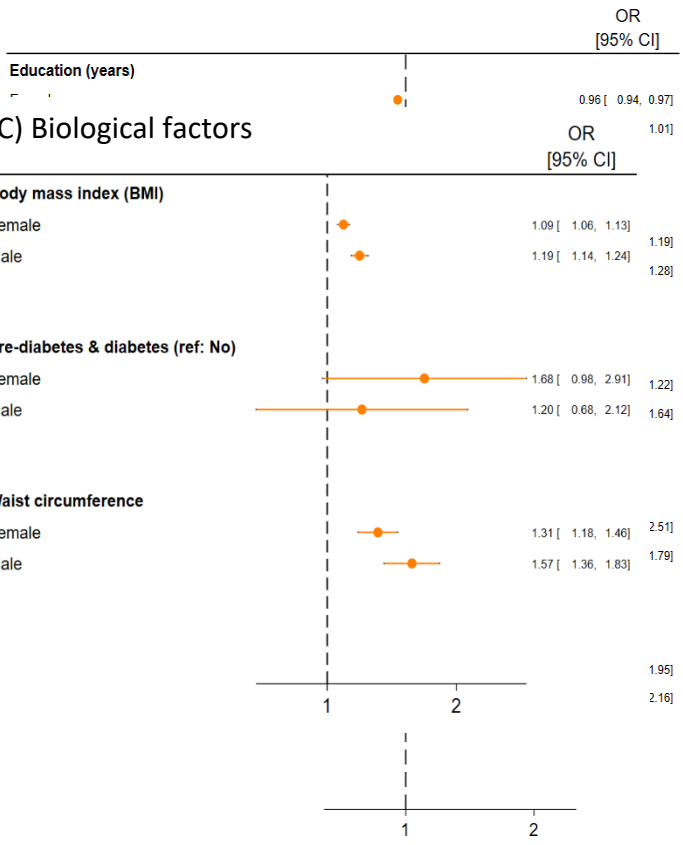
A 1 kg/m^2 higher BMI was positively associated with prediabetes/diabetes in both males [aOR: 1.07 (1.0, 1.1)] and females [aOR: 1.03 (1.0, 1.1)]. A 1 cm larger WC was associated with 10% [aOR: 1.1 (0.9, 1.2)] and 19% [aOR: 1.2 (1.1, 1.3)] higher odds of prediabetes/ diabetes in males and females, respectively. Females who were engaged in non-agricultural work had higher odds of prediabetes/diabetes compared to agricultural workers [aOR: 1.4 (1.1, 1.8)].

Residing in an urban setting (vs. rural) was positively associated with prediabetes/diabetes in males only [aOR: 1.6 (1.2, 2.0)]. In contrast, pastoralist males [aOR: 0.3 (0.1, 0.5)] and females [aOR: 0.3 (0.2, 0.6)] had lower odds of prediabetes/diabetes compared to their agrarian counterparts. As was the case with hypertension, a 1-year higher educational attainment was also associated with lower odds of prediabetes/diabetes amongst females [aOR: 0.98 (0.95, 0.99)] and males [aOR: 0.96 (0.95, 0.99)]. Females, but not males, who met WHO recommendations for physical activity (> 150 minutes/week) had lower odds of prediabetes/diabetes [aOR: 0.8 (0.6, 1.0)].

Figure 4. *Modifiable A) Socio-economic factors B) Dietary factors C) Biological factors and D) Behavioral factors associated with hypertension in males and females.*

Forest plots present odds ratios (orange dots) and 95% confidence intervals (orange lines).

A) Socio-economic factors



B) Dietary factors

C) Biological factors

D) Behavioral

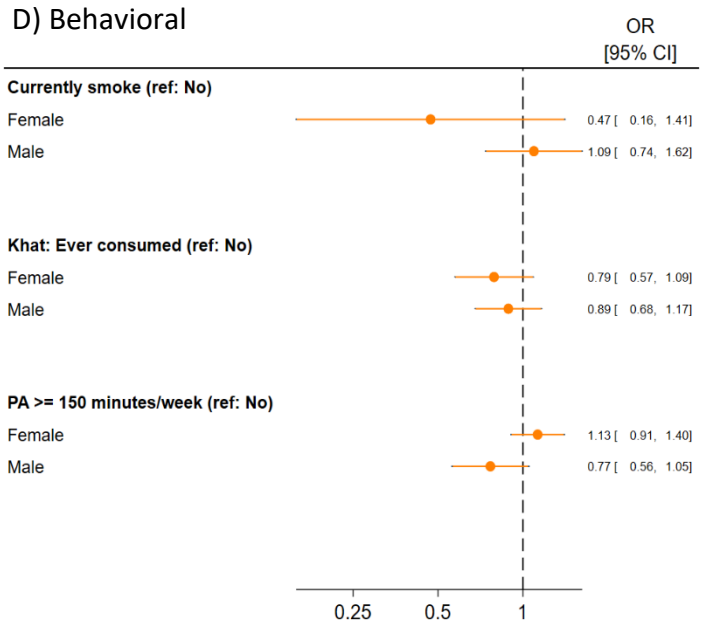
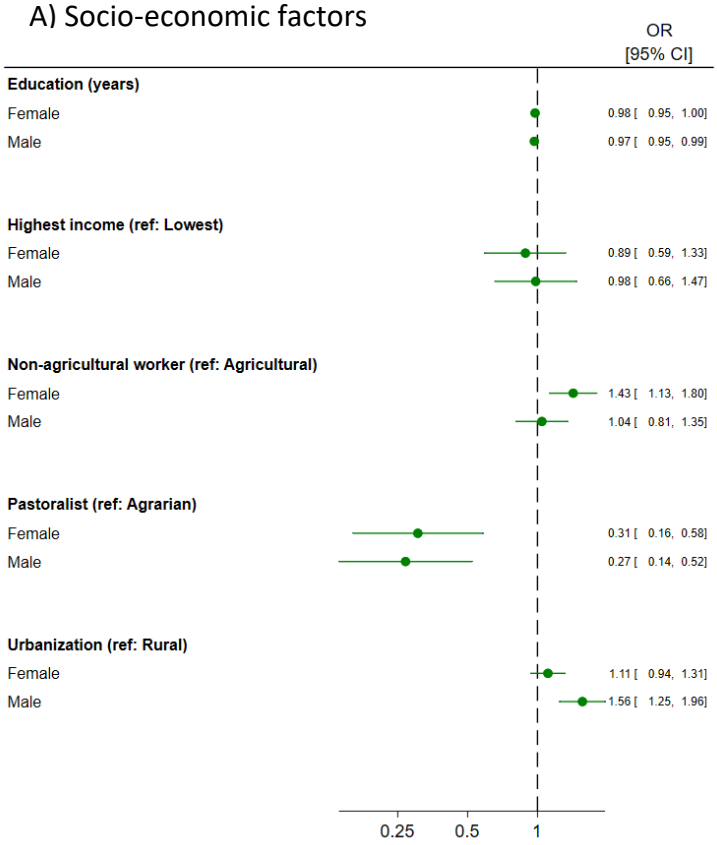


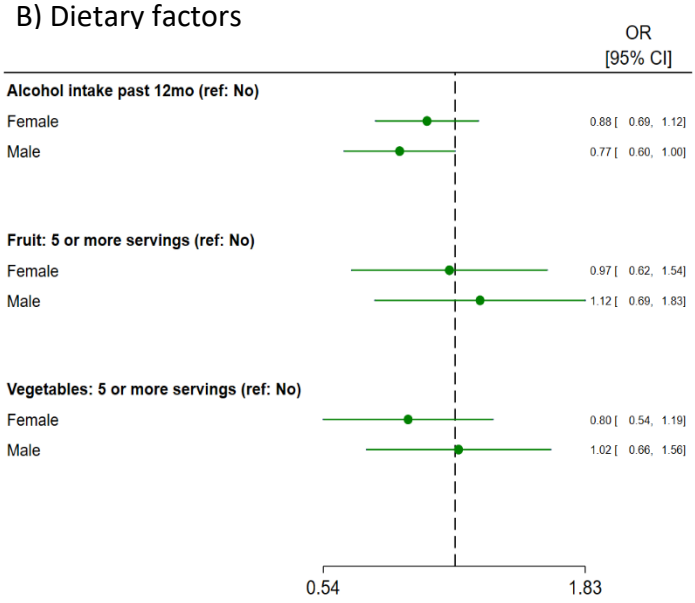
Figure 5. *Modifiable A) Socio-economic factors B) Dietary factors C) Biological factors and D) Behavioral factors associated with prediabetes/diabetes in males and females.*

Forest plots present odds ratios (green dots) and 95% confidence intervals (green lines).

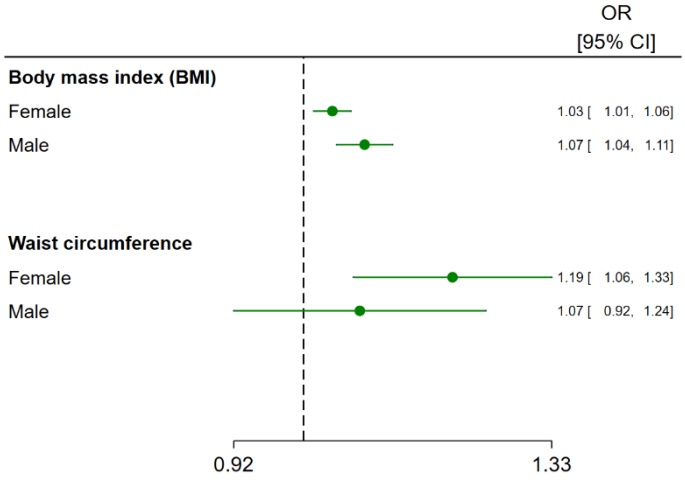
A) Socio-economic factors



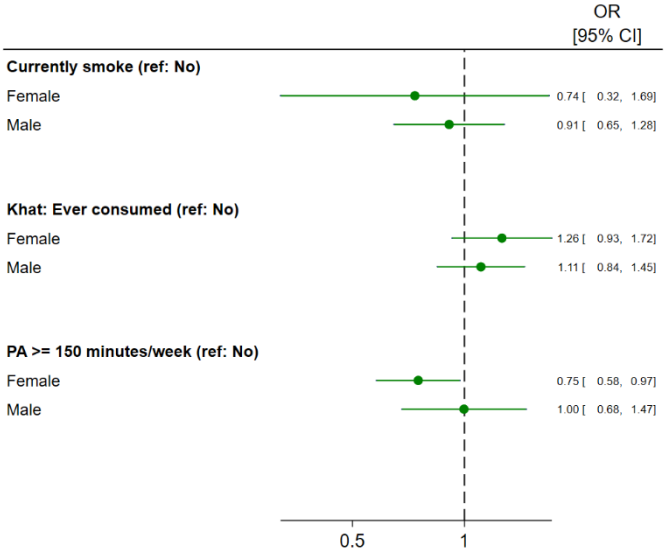
B) Dietary factors



C) Biological factors



D) Behavioral factors



4. Discussion

4.1 Summary of Findings

The first objective of this report was to describe the trends and factors associated with overweight/obesity among WRA. Nationally, overweight/obesity among WRA showed a 5% increase between 2000 and 2016. In urban women, the prevalence of overweight/obesity increased from 11% in 2000 to 21% in 2016. A rise in wealth was the main driver of the change in overweight/obesity between 2000 and 2016, explaining 62% and 63% of the increase in urban and rural women respectively. In urban women, additional contributors to the rise in overweight/obesity were increases in engagement in more sedentary occupations (including professional, technical, managerial or clerical work) and in screen time. Education was protective, with an improvement in educational attainment contributing to a reduction in overweight/obesity.

The second objective of this report was to investigate associations between a comprehensive list of modifiable risk factors and hypertension and prediabetes/diabetes amongst both males and females in Ethiopia. Nationally, the prevalence of hypertension and prediabetes/diabetes was approximately 17% and 11%, respectively, which was similar between the two sexes. Our analysis of modifiable risk factors showed that BMI and WC were positively associated with hypertension and prediabetes/diabetes for both males and females. A 1cm larger WC was associated with higher odds of hypertension and prediabetes/diabetes in males and females. In contrast, a 1 year higher educational attainment was associated with lower odds of hypertension and prediabetes/diabetes in both males and females. While residing in urban settings was associated with higher odds of hypertension in both males and females, it was only associated with prediabetes/diabetes in males. Males and females in pastoralist areas had lower odds of prediabetes/diabetes compared to their agrarian counterparts. In contrast, females in pastoralist areas had significantly higher odds of hypertension. Physical activity was associated with lower odds of prediabetes/diabetes among women only. Consumption of fruit and vegetables, alcohol, salt, smoking, *khat* consumption and income were not associated with either hypertension or prediabetes/diabetes. The low consumption of fruit and vegetables and the limited variability in salt intake and physical activity levels likely contributed to these findings.

4.2. Interpretation of Findings

At 8%, our estimates of overweight/obesity prevalence at the national level suggest a relatively low burden of overweight/obesity in Ethiopia. However, this neglects the urban-rural disparity which exists in the country, with more than 1 in 5 women in urban areas classified as overweight/obese in 2016, compared to 1 in 25 women in rural areas. Furthermore, we observed a doubling in the

prevalence of overweight/obesity in women residing in urban areas between 2000-2016, which is in accordance with previous evidence[29]. Our findings also suggest that the burden of overweight/obesity in this setting has increased disproportionately in more recent years. For example, we observed relatively gradual increases between 2000-2011, in line with previous evidence[30], followed by a much larger increase over the five years between the most recent sweeps of the EDHS (2011-2016).

In terms of the factors driving the observed increases in overweight/obesity prevalence, the greatest contribution was attributed to increases in relative wealth over the time period, contributing to 62% and 63% of the observed increase in overweight/obesity in women in urban and rural settings, respectively. A positive relationship between wealth and overweight/obesity prevalence has been observed in various low income countries (LICs)[31-34] and is a reflection of the relatively early stage of the nutrition transition that many of these countries, including Ethiopia, are in. For example, compared to women from less wealthy households, women from wealthier households may have increased access to energy-dense nutrient poor (EDNP) foods alongside greater periods of time spent physically inactive, culminating in a positive energy balance and the development of overweight/obesity[33,35-40]. As such, our finding that increases in wealth contribute substantially to the increased burden of overweight/obesity is unsurprising. The second largest contributor to the increase in overweight/obesity prevalence amongst women residing in urban areas, was the increased prevalence of women watching television, accounting for 11% of the increase. Sedentary behaviors, including watching television, are known risk factors for overweight/obesity[41,42] and this relationship has been confirmed in previous studies in LICs[42,43], including Ethiopia[29]. Such associations likely reflect a reduced level of physical activity among individuals as a result of increased sitting time[41,42], but additionally, in LMICs having a television may also be a proxy for a higher socioeconomic position, which as outlined previously, may increase access to EDNP foods.

Our finding that hypertension prevalence was approximately 17% and distributed similarly across both sexes is in line with other studies in Ethiopia[44,45]. Residing in urban settings (vs. rural) was a consistent risk factor increasing the risk of hypertension in both sexes. This is consistent with previous findings from Ethiopia [44] but also the wider Sub-Saharan[46] and African regions[46]. Another risk factor for hypertension in both sexes was a higher BMI and WC, with a 1-cm larger WC associated with 57% and 31% higher odds of hypertension in males and females, respectively. Given the much greater burden of overweight/obesity in urban settings in Ethiopia, as demonstrated in our study, our finding of urban/rural disparities in hypertension prevalence is unsurprising. It has been speculated that other contributors to this urban/rural dichotomy include a greater use of motorized transport, sedentary types of occupation such as office work and an increased consumption of the high-salt and high-fat containing processed foods[47]. Surprisingly, we did not find

strong evidence for a relationship between hypertension and each of physical activity, salt intake or consumption of fruits and vegetables. Reasons for this between-study discrepancy may include differences related to the sample (e.g., age, sex and ethnic composition etc.), differences in the way variables were derived or different covariates used in multivariable models across studies or may be a result of the lack of variation in these variables, particularly for salt intake. However existing evidence links salt intake and hypertension. A meta-analysis of 34 Randomized Controlled Trials (RCTs) found that a reduction in salt intake significantly reduces hypertension[48]. Similarly, existing evidence also links fruit and vegetable intake with risk of death from cardiovascular disease including hypertension. A systematic review and meta-analysis of 16 cohort studies found a 4% reduction in the risk of death from cardiovascular disease for each additional serving of fruits and vegetables, 5% reduction for each additional serving of fruit and a 4% reduction for each additional serving of vegetables[49].

Around 1 in 10 adults were classified as prediabetic or diabetic in this sample, with no differences between the sexes. We are not aware of any national studies in the country which have reported on the prevalence of prediabetes/diabetes. However, two recent studies in the North of Ethiopia observed prevalence rates of prediabetes which were approximately 1.5-2 times higher than in our study[50]. Reasons for this discrepancy could relate to the criteria used to classify prediabetes, differences in the socio-demographic profiles of the samples and thus differential exposure to prediabetes risk factors or, given the recency of the studies, may reflect real increases in the burden of prediabetes in more recent years. A recent meta-analysis estimated the prevalence of diabetes in Ethiopia at between 2-6.5%, with the higher prevalence rates observed in urban settings[51]. Unsurprisingly, we also observed that the risk of prediabetes or diabetes was greater in those in urban settings. However, this association was much stronger in males. While previous studies have shown disparities in the prevalence of prediabetes/diabetes in Ethiopia across sexes[50-52] and between urban/rural settings, we are not aware of any studies that have identified an interaction between the two. We observed a protective effect of a pastoralist livelihood on risk for prediabetes/diabetes. While we are unaware of any literature supporting this association, it may be a reflection of a higher level of physical activity in this group. Although we did not find a significant association between fruit and vegetable intakes and prediabetes/diabetes, a meta-analysis of 23 studies found that higher fruit and vegetable intake is associated with a lower risk of type 2 diabetes[53].

4.3 Strengths and Limitations

This analysis utilized data from multiple rounds of a large-scale nationally representative survey to identify the trends and factors associated with overweight/obesity among WRA. Another strength of this analysis is the use of DAGs to guide multivariable model building and ensure that the correct covariates are (and are not) adjusted for. To our knowledge, this is the first study that has explored

the influence of a comprehensive list of factors that affect hypertension and prediabetes/diabetes in the same study subjects. This analysis has some limitations. At the time of analysis, nationally representative data that could be used to explore trends and factors that drive overweight/obesity were not available after 2016. Similarly, while the NCD STEPS survey provides data on a wide range of demographic and biomedical variables, it was also conducted at a similar time (i.e., 2015). Thus it is likely that the burden of overweight/obesity, hypertension, and diabetes has increased since the time of the data collection for these surveys.

4.4 Policy Implications/Recommendations

Overweight/obesity has increased among women between 2000 and 2016. A rise in wealth was the main driver of this increase. The major modifiable risk factors for hypertension and prediabetes/diabetes were a higher BMI and WC. Physical inactivity was also a risk factor for prediabetes/diabetes among women. Thus the following recommendations were made to prevent and control overweight/obesity, hypertension, and prediabetes/diabetes:

Action 1: Promote Healthy Eating and Physical Activity; and Reduce Sedentary Time.

Promotional activities should target urban residents to prevent further increase in overweight/obesity and NR-NCDs.

Healthy diets including increased consumption of fruits and vegetables and reduced consumption of unhealthy foods can be achieved through the following actions:

- Implement new agricultural and food system policies to support healthy diets and specifically increase production of fruits and vegetables.
- Develop food based dietary guidelines and monitor adherence to guidelines through periodic dietary intake assessment.
- Improve food environments through:
    - The implementation of policies that monitor the availability and marketing of unhealthy foods (i.e., energy-dense nutrient-poor foods, ultra-processed foods).
    - The implementation of policies that impose targeted taxation on unhealthy foods.
    - The implementation of food price policies and programs to increase economic access to healthy foods such as fruit and vegetables.

Healthy physical activity behaviors can be achieved through the following actions:

- Promote physical activity (moderate-to-vigorous intensity activities) by increasing public awareness of the health benefits associated with these.
- Improve the availability of facilities to promote physical activity, e.g., green spaces, gymnasiums.
- Implement workplace/school programs to promote physical activity.

- Develop national guidelines for physical activity for health.

Action 2: Strengthen NCD Surveillance to Generate Evidence on the Burden of NR-NCDs, Risk Factors and Effective Interventions.

High-quality and timely data are needed to inform the implementation of NR-NCDs programs and redesign some aspects of existing programs where necessary.

Action 3: Incorporate NCD Services in the Primary Health Care System to Prevent and Control Overweight/Obesity as well as NR-NCDs.

NCD-related services should be incorporated into the healthcare system to mitigate the effect of NR-NCDs and to prevent further increases. For this to be implemented effectively, the following actions are needed:

- Improve the capacity of healthcare providers to incorporate NCD-related services into existing programs.
- Expand screening for overweight/obesity, hypertension, and diabetes in urban and rural settings.
- Expand the availability of diagnostic and treatment services for NR-NCDs.
- Ensure availability and affordability of essential medicines for diagnosis, treatment, and monitoring of NR-NCDs.

5. Conclusion

The current analysis highlighted the trends and factors driving overweight/ obesity among WRA in Ethiopia. We have also provided empirical findings relating to the factors associated with hypertension and prediabetes/diabetes among Ethiopian males and females. We observed that a rise in wealth was the main driver of the increase in overweight/obesity between 2000 and 2016. Other factors that contributed to the increase in overweight/ obesity were urban residence, engagement in more sedentary occupations and increased screen time. Education was protective, with an improvement in educational attainment contributing to a reduction in overweight/obesity. BMI and WC were the main factors that were positively associated with hypertension and prediabetes/diabetes among males and females. In contrast, an increase in educational attainment was associated with reduced odds of hypertension and prediabetes/diabetes in both males and females. Other modifiable factors such as fruit and vegetables intake, salt intake, and smoking were not associated with either hypertension or prediabetes/diabetes. Our findings highlight the need to implement interventions that promote healthy eating and increase physical activity in order to control the rise of overweight/obesity and NR-NCDs.

References

1. Institute for Health Metrics and Evaluation. 2019 April 14. Global Burden of Disease data visualizations 2019. <https://vizhub.healthdata.org/gbd-compare/>. Accessed 2021 April 14.
2. WHO. 2020 April 14. Obesity and overweight <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>. Accessed 2021 April 14.
3. Allen L, Cobiac L, Townsend N. Quantifying the global distribution of premature mortality from non-communicable diseases. J Public Health (Oxf) 2017;39(4):698-703.
4. World Health Organization and International Diabeted Federation. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia: Report of a WHO/IDF consultation WHO; 2006.
5. Lin X, Xu Y, Pan X, Xu J, Ding Y, Sun X, Song X, Ren Y, Shan PF. Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. Sci Rep 2020;10(1):14790.
6. American Diabetes Association. 2021 Diagnosis.
7. Hostalek U. Global epidemiology of prediabetes - present and future perspectives. Clin Diabetes Endocrinol 2019;5:5.
8. WHO. 2019 April 14. Hypertension <https://www.who.int/news-room/fact-sheets/detail/hypertension>. Accessed 2021 April 14.
9. Central Statistical Agency [Ethiopia] and ICF. Ethiopia demographic and health survey 2016. Addis Ababa, Ethiopia and Calverton, Maryland, USA: CSA and ICF; 2016.
10. Central Statistical Agency [Ethiopia] and ORC Macro. Ethiopia demographic and health survey 2000. Addis Ababa, Ethiopia and Calverton, Maryland, USA: CSA and ORC Macro; 2001.
11. Ethiopian Public Health Institute, Federal Ministery of Health, World Health Organization. Ethiopia STEPS report in risk factors for non-communicable diaseses and prevalence of selected NCDs Addis Ababa,Ethiopi: Ethiopian Public Health Institute 2016.
12. Gebreyes YF, Goshu DY, Geletew TK, Argefa TG, Zemedu TG, Lemu KA, Waka FC, Mengesha AB, Degefu FS, Deghebo AD and others. Prevalence of high bloodpressure, hyperglycemia, dyslipidemia, metabolic syndrome and their determinants in Ethiopia: Evidences from the National NCDs STEPS Survey, 2015. PLoS One 2018;13(5):e0194819.
13. Misganaw A, Mariam DH, Ali A, Araya T. Epidemiology of major non-communicable diseases in Ethiopia: a systematic review. J Health Popul Nutr 2014;32(1):1-13.
14. WHO. The double burden of manlutrition:Policy Brief. WHO; 2017.
15. Melaku YA, Temesgen AM, Deribew A, Tessema GA, Deribe K, Sahle BW, Abera SF, Bekele T, Lemma F, Amare AT and others. The impact of dietary risk factors on the burden of non-communicable diseases in Ethiopia: findings from the Global Burden of Disease study 2013. Int J Behav Nutr Phys Act 2016;13(1):122.
16. WHO. Global action plan for the prevention and control of non-communicable diseases (2013-2020). WHO; 2013.
17. Federal Democratic Republic of Ethiopia: Ministry of Health. National Strategic Action Plan (NSAP) for prevention and control of non-communicable diseases Ministry of Health,; 2014.
18. United Nations. Transforming our world: The 2030 agenda for sustainable development. 2015.

19. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, Ramirez A, Schlaich M, Stergiou GS, Tomaszewski M and others. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. Hypertension 2020;75(6):1334-1357.
20. Textor J, van der Zander B, Gilthorpe MS, Liskiewicz M, Ellison GT. Robust causal inference using directed acyclic graphs: the R package 'dagitty'. Int J Epidemiol 2016;45(6):1887-1894.
21. Fairlie RW. Addressing path dependence and incorporating sample weights in the nonlinear Blinder-Oaxaca decomposition technique for logit, probit and other nonlinear models. In: (17-013) WP, editor: Stanford Institute for Economic Policy Research 2017.
22. Meisinger C, Thorand B, Schneider A, Stieber J, Döring A, Löwel H. Sex differences in risk factors for incident type 2 diabetes mellitus: the MONICA Augsburg cohort study. Arch Intern Med 2002;162(1):82-89.
23. Njolstad I, Arnesen E, Lund-Larsen PG. Sex differences in risk factors for clinical diabetes mellitus in a general population: a 12-year follow-up of the Finnmark Study. Am J Epidemiol 1998;147(1):49-58.
24. Ghosh S, Mukhopadhyay S, Barik A. Sex differences in the risk profile of hypertension: a cross-sectional study. BMJ Open 2016;6(7):e010085.
25. Choi HM, Kim HC, Kang DR. Sex differences in hypertension prevalence and control: Analysis of the 2010-2014 Korea National Health and Nutrition Examination Survey. PLoS One 2017;12(5):e0178334.
26. Everett B, Zajacova A. Gender differences in hypertension and hypertension awareness among young adults. Biodemography Soc Biol 2015;61(1):1-17.
27. Kautzky-Willer A, Harreiter J, Pacini G. Sex and Gender Differences in Risk, Pathophysiology and Complications of Type 2 Diabetes Mellitus. Endocr Rev 2016;37(3):278-316.
28. McKenzie BL, Santos JA, Geldsetzer P, Davies J, Manne-Goehler J, Gurung MS, Sturua L, Gathecha G, Aryal KK, Tsabedze L and others. Evaluation of sex differences in dietary behaviours and their relationship with cardiovascular risk factors: a cross-sectional study of nationally representative surveys in seven low- and middle-income countries. Nutr J 2020;19(1):3.
29. Ahmed KY, Abrha S, Page A, Arora A, Shiferaw S, Tadese F, Seifu CN, Yeneabat T, Alemu E, Gebremichael DY and others. Trends and determinants of underweight and overweight/obesity among urban Ethiopian women from 2000 to 2016. BMC Public Health 2020;20(1):1276.
30. Amugsi DA, Dimbuene ZT, Mberu B, Muthuri S, Ezeh AC. Prevalence and time trends in overweight and obesity among urban women: an analysis of demographic and health surveys data from 24 African countries, 1991-2014. BMJ Open 2017;7(10):e017344.
31. Lopez RP. Neighborhood risk factors for obesity. Obesity (Silver Spring) 2007;15(8):2111-9.
32. Sundquist K, Malmstrom M, Johansson SE. Neighbourhood deprivation and incidence of coronary heart disease: a multilevel study of 2.6 million women and men in Sweden. J Epidemiol Community Health 2004;58(1):71-7.
33. Fezeu L, Minkoulou E, Balkau B, Kengne AP, Awah P, Unwin N, Alberti GK, Mbanya JC. Association between socioeconomic status and adiposity in urban Cameroon. Int J Epidemiol 2006;35(1):105-11.

34. Christensen DL, Eis J, Hansen AW, Larsson MW, Mwaniki DL, Kilonzo B, Tetens I, Boit MK, Kaduka L, Borch-Johnsen K and others. Obesity and regional fat distribution in Kenyan populations: impact of ethnicity and urbanization. Ann Hum Biol 2008;35(2):232-49.
35. Biritwum R, Gyapong J, Mensah G. The epidemiology of obesity in ghana. Ghana Med J 2005;39(3):82-5.
36. Forrest KY, Bunker CH, Kriska AM, Ukoli FA, Huston SL, Markovic N. Physical activity and cardiovascular risk factors in a developing population. Med Sci Sports Exerc 2001;33(9):1598-604.
37. Amoah AG. Sociodemographic variations in obesity among Ghanaian adults. Public Health Nutr 2003;6(8):751-7.
38. Bourne LT, Lambert EV, Steyn K. Where does the black population of South Africa stand on the nutrition transition? Public Health Nutr 2002;5(1A):157-62.
39. Sodjinou R, Agueh V, Fayomi B, Delisle H. Obesity and cardio-metabolic risk factors in urban adults of Benin: relationship with socio-economic status, urbanisation, and lifestyle patterns. BMC Public Health 2008;8:84.
40. WHO. Global strategy on diet, physical activity and Health 2004.
41. Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, Zimmet PZ, Owen N. Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Diabetes Care 2008;31(2):369-71.
42. Ghose B. Frequency of TV viewing and prevalence of overweight and obesity among adult women in Bangladesh: a cross-sectional study. BMJ Open 2017;7(1):e014399.
43. Das Gupta R, Sajal IH, Hasan M, Sutradhar I, Haider MR, Sarker M. Frequency of television viewing and association with overweight and obesity among women of the reproductive age group in Myanmar: results from a nationwide cross-sectional survey. BMJ Open 2019;9(3):e024680.
44. Kibret KT, Mesfin YM. Prevalence of hypertension in Ethiopia: a systematic meta-analysis. Public Health Rev 2015;36:14.
45. Dereje N, Earsido A, Temam L, Abebe A. Uncovering the high burden of hypertension and its predictors among adult population in Hosanna town, southern Ethiopia: a community-based cross-sectional study. BMJ Open 2020;10(10):e035823.
46. Addo J, Smeeth L, Leon DA. Hypertension in sub-saharan Africa: a systematic review. Hypertension 2007;50(6):1012-8.
47. Tesfaye F, Byass P, Wall S. Population based prevalence of high blood pressure among adults in Addis Ababa: uncovering a silent epidemic. BMC Cardiovasc Disord 2009;9:39.
48. He FJ, Li J, Macgregor GA. Effect of longer-term modest salt reduction on blood pressure. Cochrane Database Syst Rev 2013(4):CD004937.
49. Wang X, Ouyang Y, Liu J, Zhu M, Zhao G, Bao W, Hu FB. Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. BMJ 2014;349:g4490.
50. Endris T, Worede A, Asmelash D. Prevalence of Diabetes Mellitus, Prediabetes and Its Associated Factors in Dessie Town, Northeast Ethiopia: A Community-Based Study. Diabetes Metab Syndr Obes 2019;12:2799-2809.

51. Bishu KG, Jenkins C, Yebyo HG, Atsbha M, Wubayehu T, Gebregziabher M. Diabetes in Ethiopia: A systematic review of prevalence, risk factors, complications, and cost. Obesity Medicine 2019;15:100132.
52. Woldegebriel AG, Fenta KA, Aregay AB, Aregay AD, Mamo NB, Wubayehu TW, Bayray A, Mulugeta A. Effectiveness of Anthropometric Measurements for Identifying Diabetes and Prediabetes among Civil Servants in a Regional City of Northern Ethiopia: A Cross-Sectional Study. J Nutr Metab 2020;2020:8425912.
53. Wang PY, Fang JC, Gao ZH, Zhang C, Xie SY. Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. J Diabetes Investig 2016;7(1):56-69.

Annex I: Rapid Review Protocol and Search Log

Review question

What are the nutritional, behavioral, socio-economic, predictors of overweight, obesity, diabetes and hypertension among adult men and women in Sub-Saharan Africa?

Searches

Databases to be searched: MEDLINE only

Journal articles published in English language, peer-reviewed journals from 2000 onwards.

Search words limited to title and abstract.

Search strategy (split into PICO concepts)

Participants:

((Adult[Mesh] OR Adult* OR male* OR female* OR m?n OR wom?n) AND (Angola[Mesh] OR Benin[Mesh] OR Botswana[Mesh] OR Burkina Faso[Mesh] OR Burundi[Mesh] OR Cabo Verde[Mesh] OR Cameroon[Mesh] OR Central African Republic[Mesh] OR Chad[Mesh] OR Comoros[Mesh] OR Congo[Mesh] OR Cote d'Ivoire[Mesh] OR "Ivory Coast" OR Democratic Republic of the Congo[Mesh] OR Djibouti[Mesh] OR Equatorial Guinea[Mesh] OR Eritrea[Mesh] OR Eswatini[Mesh] OR Ethiopia[Mesh] OR Gabon[Mesh] OR Gambia[Mesh] OR Ghana[Mesh] OR Guinea[Mesh] OR Guinea-Bissau[Mesh] OR Kenya[Mesh] OR Lesotho[Mesh] OR Liberia[Mesh] OR Madagascar[Mesh] OR Malawi[Mesh] OR Mali[Mesh] OR Mauritania[Mesh] OR Mauritius[Mesh] OR Mozambique[Mesh] OR Namibia[Mesh] OR Niger[Mesh] OR Nigeria[Mesh] OR Rwanda[Mesh] OR Sao Tome and Principe[Mesh] OR Senegal[Mesh] OR Seychelles[Mesh] OR Sierra Leone[Mesh] OR Somalia[Mesh] OR South Africa[Mesh] OR South Sudan[Mesh] OR Sudan[Mesh] OR "Swaziland" OR Tanzania[Mesh] OR Togo[Mesh] OR Uganda[Mesh] OR Zambia[Mesh] OR Zimbabwe[Mesh] OR Africa South of the Sahara[Mesh]))

AND

Intervention:

(Driver* OR predictor* OR exposure* OR Risk Factors[Mesh] OR Epidemiologic Factors[Mesh] OR factor* OR cause* OR determinant*)

AND

Comparator: N/A

Outcome:

(Overweight[Mesh] OR overweight OR Obesity[Mesh] OR obes* OR “excess weight” OR obesity, abdominal[Mesh] OR “abdominal obesity” OR “central obesity” OR Diabetes Mellitus, Type 2[Mesh] OR “type II diabetes” or “type 2 diabetes” OR “type two diabetes” OR “non-insulin dependent diabetes” OR NIDDM OR Hyperinsulinism[Mesh] OR hyperinsulinemia OR Glucose Intolerance[Mesh] OR “impaired glucose tolerance” OR “impaired fasting blood glucose” OR “impaired fasting glucose” OR “insulin sensitivity” OR Insulin Resistance[Mesh] OR “insulin resistance” OR Hypertension[Mesh] OR hypertensi* OR Prehypertension[Mesh] OR pre?hypertensi*)

Types of study to be included

Any study design (e.g. case-control, RCT, cohort) (retrospective and prospective) including at least 20 cases, limited to quantitative studies.

Condition or domain being studied

Overweight and obesity and associated non-communicable risk factors, namely type II diabetes and hypertension

Participants/population

Adult males and females (age>18 years) living in Sub-Saharan Africa.

Intervention(s), exposure(s)

Any identified predictor of overweight, obesity, type II diabetes and hypertension.

Comparator(s)/control

Adults not exposed to putative risk factors.

Context

Main outcome(s)

Overweight and obesity, defined either using a body mass index (BMI) >25kg/m^2, or abdominal obesity which is more deleterious in terms of NCD risk. For abdominal obesity, can use either waist circumference (WC: males>102cm; women>88cm) or waist:hip ratio (WHO cut-offs: above 0.90 for men and above 0.86 for women).

Diabetes: Diagnosis of type II diabetes, impaired fasting blood glucose, reduced insulin sensitivity, insulin resistance, hyperinsulinemia.

Hypertension: Diagnosis of hypertension (SBP>140 and/or DBP>90mmHg), pre-hypertension(SBP>120 and/or DBP>80mmHg).

Additional outcome(s)

None.

Data extraction (selection and coding)

Titles and abstracts will be examined by a two reviewer for potentially relevant studies.

Risk of bias (quality) assessment

N/A

Strategy for data synthesis

N/33=**+\A

Analysis of subgroups or subsets -*N/A

Search log

1:

((((((Adult[Mesh] OR Adult* OR male* OR female* OR m?n OR wom?n) AND (Angola[Mesh] OR Benin[Mesh] OR Botswana[Mesh] OR Burkina Faso[Mesh] OR Burundi[Mesh] OR Cabo Verde[Mesh] OR Cameroon[Mesh] OR Central African Republic[Mesh] OR Chad[Mesh] OR Comoros[Mesh] OR Congo[Mesh] OR Cote d'Ivoire[Mesh] OR "Ivory Coast" OR Democratic Republic of the Congo[Mesh] OR Djibouti[Mesh] OR Equatorial Guinea[Mesh] OR Eritrea[Mesh] OR Eswatini[Mesh] OR Ethiopia[Mesh] OR Gabon[Mesh] OR Gambia[Mesh] OR Ghana[Mesh] OR Guinea[Mesh] OR Guinea-Bissau[Mesh] OR Kenya[Mesh] OR Lesotho[Mesh] OR Liberia[Mesh] OR Madagascar[Mesh] OR Malawi[Mesh] OR Mali[Mesh] OR Mauritania[Mesh] OR Mauritius[Mesh] OR Mozambique[Mesh] OR Namibia[Mesh] OR Niger[Mesh] OR Nigeria[Mesh] OR Rwanda[Mesh] OR Sao Tome and Principe[Mesh] OR Senegal[Mesh] OR Seychelles[Mesh] OR Sierra Leone[Mesh] OR Somalia[Mesh] OR South Africa[Mesh] OR South Sudan[Mesh] OR Sudan[Mesh] OR "Swaziland" OR Tanzania[Mesh] OR Togo[Mesh] OR Uganda[Mesh] OR Zambia[Mesh] OR Zimbabwe[Mesh] OR Africa South of the Sahara[Mesh])))) AND ((Driver*[Title/Abstract] OR predictor*[Title/Abstract] OR exposure*[Title/Abstract] OR Risk Factors[Mesh] OR Epidemiologic Factors[Mesh] OR factor*[Title/Abstract] OR cause*[Title/Abstract] OR determinant*[Title/Abstract]))) AND ((Overweight[Mesh] OR overweight[Title/Abstract] OR Obesity[Mesh] OR obes*[Title/Abstract] OR "excess weight"[Title/Abstract] OR obesity, abdominal[Mesh] OR "abdominal obesity"[Title/Abstract] OR "central obesity"[Title/Abstract] OR Diabetes Mellitus, Type 2[Mesh] OR "type II diabetes"[Title/Abstract] or "type 2 diabetes"[Title/Abstract] OR "type two diabetes"[Title/Abstract] OR "non-insulin dependent diabetes"[Title/Abstract] OR NIDDM[Title/Abstract] OR Hyperinsulinism[Mesh] OR hyperinsulinemia[Title/Abstract] OR Glucose Intolerance[Mesh] OR "impaired glucose tolerance"[Title/Abstract] OR "impaired fasting blood

glucose”[Title/Abstract] OR “impaired fasting glucose”[Title/Abstract] OR “insulin sensitivity”[Title/Abstract] OR Insulin Resistance[Mesh] OR “insulin resistance”[Title/Abstract] OR Hypertension[Mesh] OR hypertensi*[Title/Abstract] OR Prehypertension[Mesh] OR pre?hypertensi*[Title/Abstract])))

Ran on 27/4/20 and returned: 4157 results

2:

(((((((Adult[Mesh] OR Adult* OR male* OR female* OR m?n OR wom?n) AND (Angola[Mesh] OR Benin[Mesh] OR Botswana[Mesh] OR Burkina Faso[Mesh] OR Burundi[Mesh] OR Cabo Verde[Mesh] OR Cameroon[Mesh] OR Central African Republic[Mesh] OR Chad[Mesh] OR Comoros[Mesh] OR Congo[Mesh] OR Cote d'Ivoire[Mesh] OR “Ivory Coast” OR Democratic Republic of the Congo[Mesh] OR Djibouti[Mesh] OR Equatorial Guinea[Mesh] OR Eritrea[Mesh] OR Eswatini[Mesh] OR Ethiopia[Mesh] OR Gabon[Mesh] OR Gambia[Mesh] OR Ghana[Mesh] OR Guinea[Mesh] OR Guinea-Bissau[Mesh] OR Kenya[Mesh] OR Lesotho[Mesh] OR Liberia[Mesh] OR Madagascar[Mesh] OR Malawi[Mesh] OR Mali[Mesh] OR Mauritania[Mesh] OR Mauritius[Mesh] OR Mozambique[Mesh] OR Namibia[Mesh] OR Niger[Mesh] OR Nigeria[Mesh] OR Rwanda[Mesh] OR Sao Tome and Principe[Mesh] OR Senegal[Mesh] OR Seychelles[Mesh] OR Sierra Leone[Mesh] OR Somalia[Mesh] OR South Africa[Mesh] OR South Sudan[Mesh] OR Sudan[Mesh] OR “Swaziland” OR Tanzania[Mesh] OR Togo[Mesh] OR Uganda[Mesh] OR Zambia[Mesh] OR Zimbabwe[Mesh] OR Africa South of the Sahara[Mesh])))) AND ((Driver* OR predictor* OR exposure* OR Risk Factors[Mesh] OR Epidemiologic Factors[Mesh] OR factor* OR cause* OR determinant*))) AND ((Overweight[Mesh] OR overweight OR Obesity[Mesh] OR obes* OR “excess weight” OR obesity, abdominal[Mesh] OR “abdominal obesity” OR “central obesity” OR Diabetes Mellitus, Type 2[Mesh] OR “type II diabetes” OR “type 2 diabetes” OR “type two diabetes” OR “non-insulin dependent diabetes” OR NIDDM OR Hyperinsulinism[Mesh] OR hyperinsulinemia OR Glucose Intolerance[Mesh] OR “impaired glucose tolerance” OR “impaired fasting blood glucose” OR “impaired fasting glucose” OR “insulin sensitivity” OR Insulin Resistance[Mesh] OR “insulin resistance” OR Hypertension[Mesh] OR hypertensi* OR Prehypertension[Mesh] OR pre?hypertensi*)))))

Ran on 27/4/20 and returned: 4427 results- limited to English, human participants, 2000-2020= 3,442 results

Annex II: Additional Tables

Table A1. Variables included in the EDHS analysis

Variable	Definition
Outcome	
Overweight/obesity	Percentage of women aged 15-49 with BMI $\geq$ 25
Exposures	
Urbanization	Percentage of women living in urban areas.
Wealth index	A wealth score ranging from 0 to 10.
Educational attainment	Education attainment in single years.
Occupation	Percentage of women engaged in professional, technical, managerial or clerical work.
Livelihood	Percentage of women living in pastoralist livelihood zones.
Screen time	Percentage of women who watch television.

***Figure A1**. Flow diagram showing the number of WRA drawn from the EDHS sample for inclusion in this analysis*

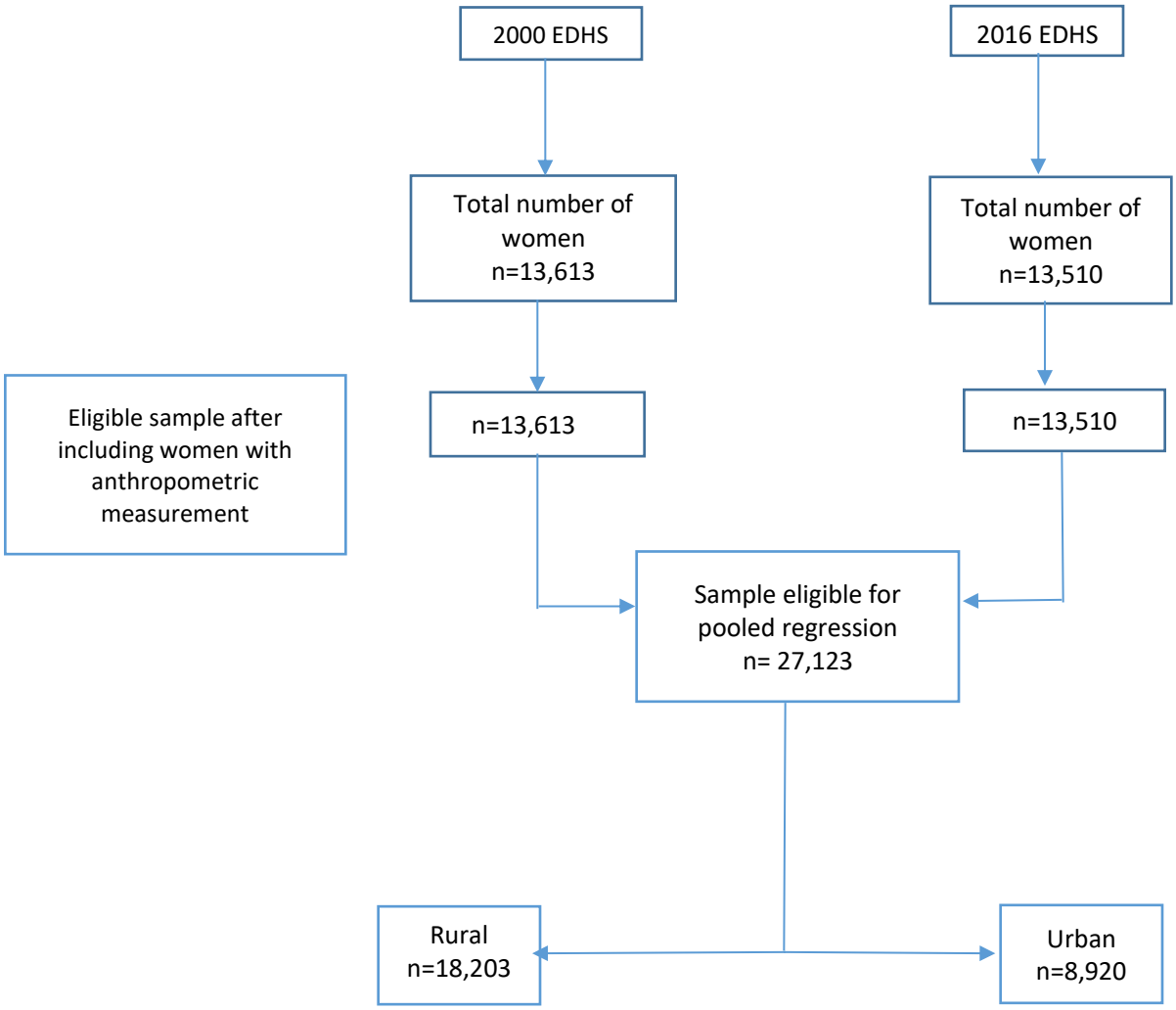
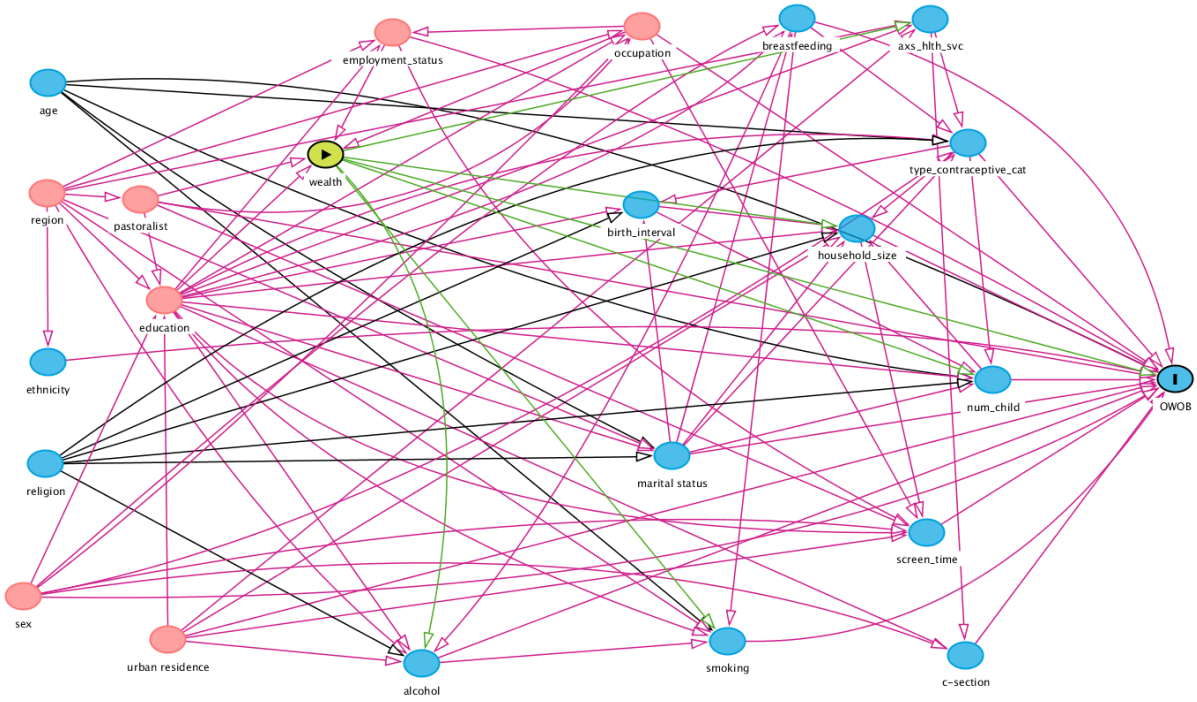


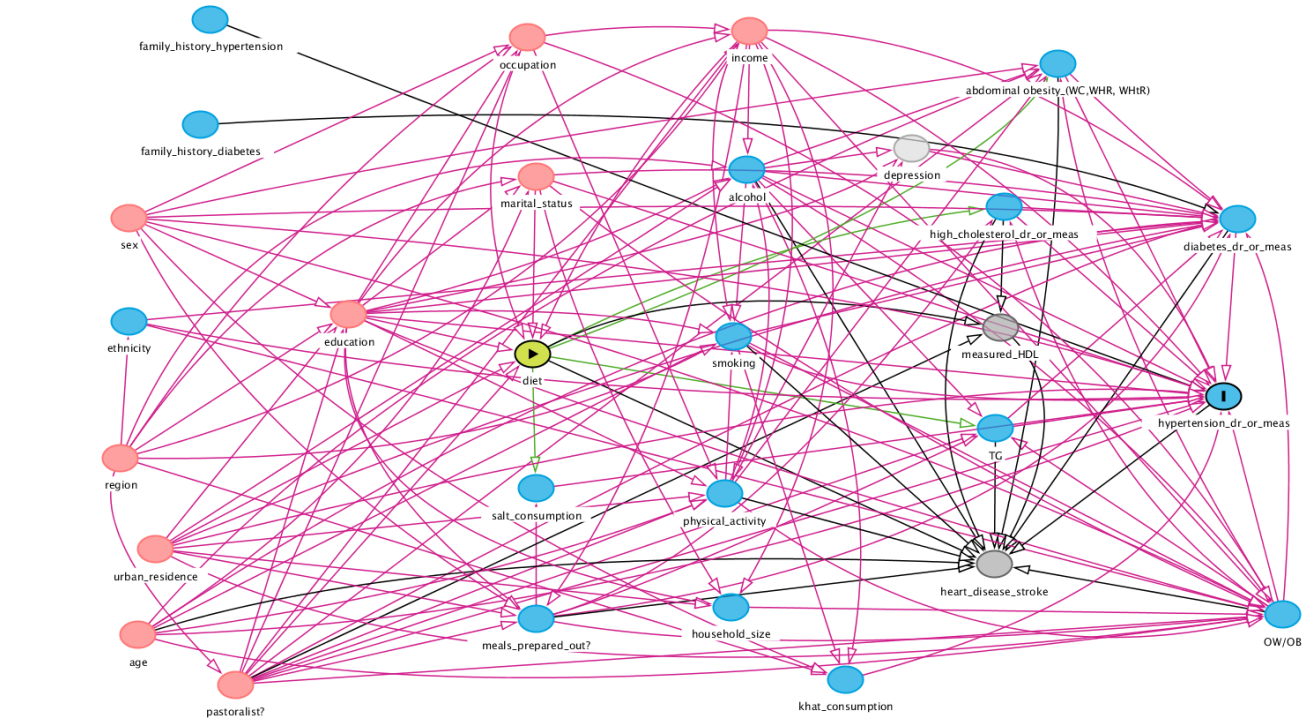
***Figure A2**. An example of directed acyclic graph (DAG): here mapping the proposed causal relationship between wealth and overweight/obesity.*



exposure outcome ancestor of exposure *and* outcome ancestor of outcome ancestor of exposure Other variables

OWOB: Overweight and obesity, axs_Hlth_svc: Access to health service

Figure A3. *An example of directed acyclic graph (DAG): here mapping the proposed causal relationship between diet and hypertension.*



OWOB: Overweight and obesity

***Table A2**. Characteristics of women included in the analysis using EDHS data*

Variables	Rural		Urban	
	2000	2016	2000	2016
Overweight/obesity n(%)	159 (1.5)	371 (3.5)	282 (11)	671 (21.6)
Occupation: Professional, technical or managerial, or Clerical n(%)	34 (0.3)	101 (0.9)	150 (5.8)	377 (12.1)
Livelihood: Pastoralist n(%)	207 (1.9)	250 (2.4)	0 (0)	28 (0.9)
Screen time: Watch television n(%)	297 (2.7)	1523 (14.4)	1347 (52.6)	2398 (77.1)
Education in single years (mean (SD))	0.5 (1.6)	2.3 (3.5)	5.5 (4.6)	7.5(4.9)
Wealth Score (mean (SD))	-0.9 (1.2)	1.0 (1.7)	9.5(5.5)	11.7 (5.0)

Table A3. *Description of variables included in the NCD STEPS analysis*

Variable	Definition
Outcomes	
Hypertension	Percentage of males and females with hypertension defined as Systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg OR currently taking medication for raised blood pressure or hypertension.
Prediabetes/diabetes	Percentage of males and females who are pre-diabetic (fasting blood glucose> 100 mg/dl) or diabetic (fasting blood glucose > 100 mg/dl) OR currently taking any medication or insulin prescribed for diabetes
Overweight/obesity	Percentage of males and females with BMI $\underline{>}$ 25 BMI
Exposures	
Fruit intake (ref= < 5 servings)	Percentage of males and females who consume five or more servings (80g) of fruits per day.
Vegetable intake (ref= < 5 servings)	Percentage of males and females who consume five or more servings (80g) of vegetables per day.
Urbanization (ref= rural)	Percentage of males and females living in urban areas.
Education (years)	Education in single years.
Occupation (ref= agricultural worker)	Percentage of males and females who were engaged in non-agricultural work over the past 12 months.
Income (ref= <12, 000 birr (lowest category)	Percentage of males and females who have an annual income in the highest income category (more than 30,000 birr).
Alcohol intake (ref= no alcohol)	Percentage of males and females who have consumed alcohol in the past 12 months.
Currently smoke (ref= non-smoker)	Percentage of males and females who currently smoke.
Livelihood (ref=agrarian)	Percentage of males and females who reside in predominantly pastoralist livelihood areas.
Body Mass Index (kg/m2)	Weight in kg divided by height in meter squared.
Waist circumference (cm)	Waist circumference measured at the mid-point between the lower part of the last rib and the top of the hip.
Salt intake (ref= <5g)	Percentage of males and females who consume more than 5g of salt per day.
Physical activity (ref= <150 minutes per week)	Percentage of males and females engage in physical activity for at least 150 minutes per week.
Khat intake (ref= never)	Percentage of males and females who have ever chewed *khat*.
Covariates	

Age	Age in years
Region	Region of residence
Ethnicity	Ethnic background
Marital status	Marital status codec as not married and married/co-habiting
Meals prepared outside of home	Number of meals per week eaten outside the home.
Triglycerides	Fasting triglycerides (mg/dL)
Total cholesterol	Total cholesterol (mg/dL)

***Table A4**. Characteristics of males and females included in the analysis using NCD STEPS data*

	Males (n=3977)	**Females (n=5823)**
Hypertension (%)	17.2	17.6
Prediabetes and diabetes (%)	11.2	11.3
Age (mean (SD))	31 (13)	31 (12)
Residence: Urban (%)	15.6	23.3
Fruit intake: five or more servings per day (yes, %)	4.7	5.2
Vegetable intake: five or more servings per day (yes, %)	7.4	6.4
Education (years, mean (SD))	5 (4)	3(4)
Occupation: non-agricultural worker (yes, %)	38	70
Income: >30, 000 birr (yes, %)	8.4	7.1
Consumed alcohol in past 12 month (yes, %)	90.7	87.9
Currently smoke (%)	0.4	7.3
Livelihood: pastoralist	1.7	1.5
Salt intake > 5g/day (yes, %)	97.1	96.3
Physical activity: > 150 minutes per week (yes, %)	94.7	91.1
Ever chewed Khat (yes, %)	25.5	11.2
Average weekly meals prepared outside the home (mean (SD))	0.7(1.7)	0.2 (1.0)
Triglycerides (mean (SD))	124.6 (96.2)	121 (92.1)
Total cholesterol (mg/dl) (mean (SD))	124.4 (29.2)	140.5 (36.5)
HDL (mg/dL) (mean (SD))	37.9 (11.9)	43.4 (13.4)
LDL (mg/dL) (mean (SD))	87.2 (34.9)	102.1(37.2)