Epidemiology of Non-communicable Diseases and Risk factors in South African Adolescents and Youth Living with HIV: Implications for Integrated Prevention

Monika Kamkuemah (monika.kamkuemah@gmail.com)
University of Cape Town School of Public Health and Family Medicine https://orcid.org/0000-0002-7603-2792

Blessings Gausi
University of Cambridge

Tolu Oni
University of Cambridge

Research

Keywords: Adolescents, HIV, Non-communicable diseases, Mental health, Risk factors, Prevention, Epidemiology, Multimorbidity

Posted Date: September 22nd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-75447/v1

Abstract

Background

Adolescents and youth living with HIV (AYLHIV) face an elevated NCD risk resulting from HIV, psychosocial challenges and the complications of antiretroviral therapy (ART).

Methods

We conducted a cross-sectional study in six primary care facilities to investigate the prevalence of common NCDs and risk factors among AYLHIV in Cape Town, South Africa between March 2019 and January 2020. We collected information on pre-existent and previously unidentified NCDs and risk factors and collected sociodemographic information of adolescents and youth enrolled for primary HIV care. Characteristics between sexes and age groups were compared using parametric or non-parametric statistical tests.

Results

Three out of four participants were female, and the median age was 20.5 years (IQR 18.9–22.9). More than a quarter were not in education, employment or training (NEET) and 44% were multidimensionally poor. Our results show an existent burden of hypertension (5%) and central obesity (37%) as well as high levels of depression (43%) and psychological distress symptoms (44%). AYLHIV further self-reported high levels of household food insecurity (70%), low fruit and vegetable consumption, high fast-food and sugar-sweetened beverage intake, low nutritional knowledge and insufficient physical activity. Beyond the NCD risk attributable to HIV and ART, these multiple risk factors coupled with early initiation of high-risk behaviours like smoking, alcohol and drug use, further increase risk.

Conclusions

Our findings highlight the importance of integrated prevention with NCD risk screening as part of HIV care for AYLHIV and the need for early intervention on social, environmental and economic determinants of NCDs targeting adolescents and youth.

Background

Global burden of NCDs and NCD risk factors

Globally, non-communicable diseases (NCDs) are the leading cause of disability and premature mortality accounting for 71% of deaths worldwide and 80.6% of years lived with disability (YLD) in 2016 [1, 2]. The largest number of NCD deaths are caused by cardiovascular diseases, followed by cancers, chronic

respiratory diseases and diabetes [1]. There has been a global epidemiological transition from communicable, maternal, neonatal, and nutritional deficiency (CMNN) diseases, to patterns of disease and mortality dominated by NCDs and injuries [3]. This transition is driven by multiple and interrelated factors including population growth, ageing, nutritional transition and increased urbanisation.

These factors are driving an increasing prevalence of NCD risk factors, with smoking, alcohol, insufficient physical activity and unhealthy diets contributing to the majority of the burden of NCDs [4]. For example, the global prevalence of daily smoking was 25.0% in men and 5.4% in women and 11.5% of global deaths were attributable to cigarette smoking in 2015 [5, 6]; while alcohol was the leading cause of premature death and disability in people aged 15–49 years in 2016 [7, 8]. Globally one in four adults are not sufficiently physically active and physical inactivity accounted for 1 in 10 deaths worldwide [9] and 34.6 million disability adjusted life years (DALYs) in 2016 [10], making physical inactivity the fourth leading risk factor for mortality globally [6]. Unhealthy diet contributes to a range of NCDs specifically diabetes, cancers, and cardiovascular diseases. Dietary risk factors - low intake of fruits, vegetables and wholegrains; high intake of sodium and added sugar from processed foods and sugar-sweetened beverages - are another significant contributor to mortality and DALYs globally [11]. In 2017, one in five global deaths were associated with unhealthy diets [11].

Depression and anxiety disorders are also important leading causes of disability worldwide [12] and together with substance use disorders, are the largest contributors to disability in young adults [2]. Mental health disorders commonly co-occur with NCDs and NCD risk factors like tobacco use, unhealthy diet and physical inactivity, while harmful use of alcohol has been shown to cluster in people with mental disorders [13].

NCDs affect low- and middle-income countries (LMICs) disproportionately, with more than three-quarters of NCD deaths occurring in LMICs [14]. In 2017, the burden of NCDs in sub-Saharan Africa (SSA) was higher than the global average, and was almost equivalent to the total burden associated with CMNN diseases [15]. South Africa, an upper-middle income country, faces a quadruple disease burden with high levels of HIV/AIDS and tuberculosis (TB); CMNN diseases and deficiencies; NCDs as well as injuries and trauma [16]. In 2016, 51% of deaths in South Africa were due to NCDs and the risk of premature mortality from NCDs was 26% [4].

Rising levels of NCD risk factors with increased urbanisation in sub-Saharan Africa

NCD risk factors are increasing in SSA where NCDs are emerging in the context of rapid urbanization, contributing to unhealthy diets and sedentary behaviour, especially amongst the poor residing in urban settings [17]. Most adults in SSA are exposed to at least one risk factor for NCDs, including tobacco, harmful alcohol use, unhealthy diet, physical inactivity, obesity, or high blood pressure [18]. Epidemiological analyses from 1980–2014 show that age-standardized average body mass index (BMI) and diabetes prevalence have increased steadily across Africa, at least as steeply as the global average [19]. In South Africa, the prevalence of NCD risk factors has increased over the last two decades. For

example, the prevalence of overweight and obesity among adult South African women increased from 56–68% between 1998 and 2016 [20]. One in three South African adults has hypertension, 16.2% smoke daily [21], and 18.3% engage in heavy episodic drinking [22]. South African adults aged 15 years and older who consume alcohol account for the fifth highest consumption rate of absolute alcohol in the world [22].

Young people are not immune to the scourge of NCDs. Of the global NCD deaths recorded in 2016, an estimated 1.7 million (4% of NCD deaths) occurred in people younger than 30 years [23]. Adolescents in SSA are growing up in a time of epidemiological and nutrition transition. Furthermore, many NCD-related risk factors are initiated or reinforced during adolescence, which makes it a critical period for intervention to prevent future disease.

Life-course approach to NCD prevention

A life-course perspective views human development as lifelong and recognizes that no life stage can be understood in isolation from others [24]. Many potentially harmful health behaviours begin in adolescence and many adult illnesses have been identified to have roots in childhood and adolescence [25]. About 70% of premature adult deaths are caused by behaviours started in adolescence [25]. Smoking, which frequently begins during adolescence, will lead to an estimated 150 million tobacco-related deaths during adulthood [26]. Childhood and adolescent obesity, which tend to persist into adulthood [27, 28], are associated with increased cardiovascular risk factors including hypertension, dyslipidaemia and hyperinsulinemia [29], which may culminate in adult cardiovascular morbidity and premature mortality [30, 31]. Half of all lifetime cases of mental health disorders emerge by the age of 14 years and three-quarters are established by the age of 24 [32]. Adolescence is thus a critical period of both opportunity and risk accompanied by rapid physical and psychological development that sets the foundation for adult health, and the health of the next generation of children [33, 34].

NCD risk factors in adolescents and youth in South Africa

In 2018 there were 9.5 million young people aged 15–24 years in South Africa, making up 16% of the population [35]. South Africa has the highest prevalence of childhood and adolescent overweight and obesity in sub-Saharan Africa (19% of boys and 26% of girls under 20 years) rivalling that of many high-income countries [36]. Overweight and obesity rates have increased steadily especially amongst adolescents residing in urban settings [37]. Paradoxically, South Africa faces a double burden of malnutrition; with undernutrition and overweight or obesity coexisting in the same populations and even within the same households [37].

Moreover, over 40% of young people have insufficient levels of physical activity, with significantly more inactivity in females compared to males [38]. A third of adolescents and youth (11–20 years) reported drinking alcohol in the Youth Risk and Behaviour Survey (YRBS), with a quarter engaging in heavy episodic/ binge drinking, 18% were current smokers and 13% reported smoking cannabis in their lifetime [38]. Significantly more males than females reported alcohol use, binge drinking, smoking, and illicit drug use [38].

Despite these data which highlight the existing burden of NCD risk factors among adolescents and youth in South Africa, evidence on effective strategies to intervene for NCD prevention are less clear, particularly as adolescents and youth are less likely to routinely present in the health care system [39]. This raises the potential for NCD prevention intervention among adolescents who do regularly have contact with the healthcare system by virtue of having a chronic disease such as HIV.

HIV and NCD multimorbidity and health system implications

Of the 1.6 million adolescents (10–19 years) reported to be living with HIV worldwide in 2018, 19% were South African [40]. Adolescents and youth living with HIV (AYLHIV) in South Africa bear a disproportionate burden of the HIV epidemic due partly to paediatric cohorts of mother-to-child transmission reaching adolescence [41] and increased sexual transmission amongst young adolescent girls associated with gender inequality and poverty [42].

AYLHIV face elevated health risks resulting from both infection with HIV and the complications of long-term antiretroviral treatment [43, 44]. Inflammation as a result of HIV replication causes vascular abnormalities which can result in heart disease, stroke, altered glucose metabolism, malignancy, and neurologic disease [45, 46]. Evidence on the increased risk of comorbidities, including osteoporosis, metabolic syndrome, cardiovascular and renal diseases, was initially documented in adult populations living with HIV, but similar patterns have since been identified in paediatric and adolescent cohorts [47–49]. An excess burden of NCD risk factors has also been documented in people living with HIV (PLHIV) compared to the general population [50]; 49% are insufficiently physically active [51], 40–70% are current smokers [52, 53] and 37–66% are current drinkers [54, 55]. Almost half (46%) of adult patients attending HIV clinics in Cape Town engaged in hazardous or harmful alcohol use, and 15% had problematic drug use [56].

In addition to physical health risks, AYLHIV face several psychosocial challenges associated with living with a highly stigmatized communicable disease [57]. HIV/AIDS in Africa occurs in the context of orphanhood, poverty and inconsistent guardianship, resulting in elevated risk of mental health problems [58–60]. AYLHIV are known to experience emotional and behavioural problems at higher rates in comparison to the general population, including post-traumatic stress disorder (PTSD), depression, severe anxiety and neurocognitive deficits which affect their school performance, career prospects, relationships and autonomy [57] and increase their susceptibility to risk-taking behaviours [61–63].

To date, NCD prevention efforts have focused on adults, despite evidence of an increasing burden of NCDs and NCD risk among PLHIV occurring at younger ages [50, 64, 65]. A previous study conducted in Cape Town demonstrated that, despite existing NCD comorbidity and risk factors in AYLHIV, there was limited integration of NCD screening and health promotion in adolescent and youth HIV healthcare services [66]. While a few studies have explored alcohol and tobacco use [67–69] in AYLHIV in SSA, there is overall data paucity on the burden of NCDs and other NCD risk factors in this population group in Africa. With the first cohorts of AYLHIV now entering adulthood and the move towards more

comprehensive health services aimed at improving the quality of life of PLHIV, questions remain on the prevalence of NCD comorbidity and NCD risk factors in AYLHIV and the best way to ensure holistic adolescent health and well-being. The main aim of this study was to investigate the prevalence of common NCDs and associated NCD risk factors as well as knowledge on health risks among AYLHIV accessing primary health care.

Methods

Study Setting and Population

This was a cross-sectional study of AYLHIV aged 15–24 years attending primary care health facilities in Cape Town. The study was conducted in Cape Town, the second biggest metropolitan city in South Africa with an estimated population of 4.2 million people [70]. In 2016, adolescents and youth aged 15–24 years comprised 16.3% of the population in the Western Cape province, within which Cape Town is located [71]. Cape Town is a city undergoing rapid nutritional and epidemiological transition with increasing prevalence of NCDs and high rates of associated risk factors like hypertension, obesity and smoking. The 2012 South African National Health and Nutrition Examination Survey (SANHANES) revealed that over 50% of Western Cape respondents were overweight or obese (43% males and 62.4% females), a third were smokers, and two-thirds were physically unfit [21]. The Western Cape also has the highest rates of tobacco smoking and alcohol use nationally for both men and women [21].

There has been an increasing trend in the prevalence of NCDs in the province with a hypertension prevalence of 30% and diabetes prevalence of 11% [21]. Provincial HIV prevalence in women and men aged 15–49 years was estimated at 18% in 2016 [20]. However, HIV prevalence amongst antenatal care (ANC) public sector clients within Cape Town Metro was slightly higher at 21.6% in 2015 [72], and as high as 34.3% in Khayelitsha sub-district in 2012 [73]. NCDs and HIV are ranked amongst the top causes of premature deaths in the City of Cape Town [74], with the top five causes of death in 2016 ranked as diabetes mellitus, HIV, ischaemic heart diseases, cerebrovascular diseases and TB [75]. NCDs alone accounted for approximately two-thirds of all deaths in the Western Cape in 2015 and 50% of the premature mortality burden [76].

The City of Cape Town delivers primary health care through four legislated substructures: Khayelitsha / Eastern, Mitchells Plain / Klipfontein, Western / Southern and Northern / Tygerberg [74]. Recruitment and data collection took place at six public sector HIV clinics, with 1–3 clinics selected within each of the four sub-structures (Fig. 1). These facilities serve patients living in peri-urban, high-density, low-income townships, collectively known as the Cape Flats, in the south-eastern part of Cape Town consisting of approximately 583 380 predominantly black African and ‘Coloured’ mixed-ancestry populations [77]. The area consists of a mix of formal and informal dwellings with 56% of the population residing in formal dwellings, high unemployment levels (29%) [77], and approximately 63% of households falling within the low-income bracket (earning < 280 USD per month) [78].

Study Design and Sampling

Sample size was determined using prevalence estimates from SANHANES-2012 for the 15–24 years age group [21]. The confidence level was set at 95%, with a 5% degree of precision, and an obesity prevalence of 5.6%. The minimum required sample size was 82 and the final sample size determined to accommodate a non-response rate of 5% was 86 participants.

Prior to data collection, we conducted stakeholder engagement, liaising with facility managers and adolescent healthcare providers. Each facility has different schedules and models of HIV care for AYLHIV necessitating customised recruitment plans. We previously described the method used to estimate the number of AYLHIV accessing care at each facility (author). Facilities in the Eastern and Khayelitsha substructure had the biggest number of adolescents and youth receiving care. The AYLHIV population size was used as a guide for the proportion required for recruitment at each facility. Given the challenges of recruiting adolescents, in order to reach the required sample size, a convenience sampling approach was used recruiting all AYLHIV who showed an interest in participating. Participant recruitment commenced in March 2019 after ethical clearance (HREC ref no: 520/2017) and approval from Provincial and Local Government Departments of Health. Recruitment and study procedures were then conducted after gaining written informed consent and assent (for participants under 18 years) at six facilities until January 2020 (Fig. 1). A total of 176 adolescents and youth were recruited and invited to participate, of which 92 attended the follow up appointment and were successfully interviewed, yielding a response rate of 52%.

Figure 1: Participant Recruitment and enrolment at respective facilities

Study Procedures

Informed Consent Process

Informed consent and assent forms were developed in English and translated into two local languages; isiXhosa and Afrikaans. At the first encounter, participants were given information sheets and a detailed overview of the study procedures and invited to participate during routine clinical visits. Prior to enrolment, those aged less than 18 years received the informed consent and assent forms in order to gain parental or caregiver approval and a return date was scheduled on which the interview would take place (usually the date of their next clinic appointment). Teach-back questions on the nature of the study were incorporated into the assent form to ascertain adequate understanding. Those of legal age (18–24 years) were immediately enrolled after signing the consent forms and a convenient, future time was scheduled for their interview if they were unable to participate on the same day.

On the scheduled appointment date, participants first underwent a 30-minute physical examination before completing a partially assisted self-administered questionnaire using electronic forms on a handheld Android tablet. The questionnaire, which was administered in English, took approximately 90 minutes to complete and included questions on socio-demographics, self-reported health status, family history, household characteristics, mental health, self-reported physical activity and dietary practices, use of alcohol, tobacco and illicit substances, and nutritional knowledge.

Physical Examination

Physical examinations were carried out according to the study protocol Standard Operating Procedures. Height and weight were measured using a sliding balance weight-and-height measuring scale with participants barefoot and wearing light clothing. Height was measured to the nearest 0.5 cm and weight to the nearest 0.1 kg. Waist and hip circumference were measured using stretch-resistant measuring tape according to the WHO STEPS Protocol [79]. Readings were taken to the nearest 0.1 cm. Two measurements were taken and recorded on the electronic form of which an average was computed during analysis. For weight, height and waist- and hip circumference, if the two readings differed by more than 100 g, 2 cm and 0.1 cm respectively, a third measurement was taken, and the two closest measurements were recorded.

Sitting blood pressure (BP) and pulse were measured using a Rossmax automatic blood pressure monitor (Rossmax (Shanghai) Incorporation Ltd). Two readings were taken at least two minutes apart and the average was computed. The procedures were repeated in instances where there was a significant difference between readings (more than two units) and the closest two readings were recorded.

Participants were asked whether they had a family history of diabetes or experienced any of the following symptoms over the past three months: frequent urination, increased thirst, unexplained weight loss of more than 1.5 kg in the last month, unexplained fatigue and blurry vision. Random blood glucose was measured in those with a family history or reported symptoms using a point-of-care (POC) glucometer with reactive test-strips (Glucocheck Evolve ® Homemed Pty).

Respiratory symptom screening was conducted determining any difficulty breathing or shortness of breath, prolonged cough for more than two weeks with sputum, chest tightness, noisy breathing (wheezing or whistling in the chest) or a history of asthma. Respiratory volume was measured in those reporting respiratory symptoms without known asthma or chronic respiratory conditions using a hand-held peak flow meter with disposable mouth pieces. Several repeated attempts were made in accordance with standard guidelines [80]. If the variation between attempts was greater than 20 litres/minute [80], a further two attempts were made. The two largest values were recorded and the average computed.

Data collection tools and definitions of composite measures

Structural and household risk factors

Adolescence is often categorized into three primary developmental stages: early adolescence (10–14 years), middle adolescence (15–17 years), and late adolescence / young adulthood (18–24 years) [81]. For the purposes of this study, we categorized participants into four age groups in line with these stages and further sub-divided the oldest age group as follows:15–17, 18–19, 20–21 and 22–24 years.

Questions on socioeconomic status were derived from the 2011 South African Census Questionnaire's subset of variables used to measure multidimensional poverty [82]. The Youth Multidimensional Poverty Index (YMPI) is a multidimensional individual-level measure of poverty comprised of 11 weighted indicators in five dimensions: educational attainment, general health and functioning, living environment, household assets and employment, using the method by Alkire and Santos [83]. Each of the indicators is associated with a deprivation cut-off that defines whether a young person is deprived in that area [84]. The cut-offs for the educational attainment dimension are designed to coincide with key stages in the South African schooling system, allowing for a degree of delay in an individual's schooling career [84]. A deprivation score was calculated for each dimension and an overall composite score was derived from the weighted indicators. An individual is identified as being multidimensionally poor – MPI poor– if they are deprived in a third or more of the weighted indicators, with a composite score ≥ 33.3% [83]. The extent of poverty is measured by the percentage of deprivations experienced [85].

Food insecurity was measured using the Household Food Insecurity Access Scale (HFIAS) score. The HFIAS score is a continuous measure of the degree of food insecurity experienced in a household in the past month [86]. The participant is expected to answer for all members of the household and not just themselves. The higher the score, the more food insecurity the household experienced. Participants were categorized as living in food secure, mildly–, moderately–, or severely food insecure households depending on the severity and frequency of food insecurity experiences according to the HFIAS protocol [87].

Behaviour and Knowledge

Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) short form using the last seven days self-administered format [88] and graphic images of different kinds of vigorous and moderate-intensity forms of physical activity as an aid. The IPAQ has been validated in youth and adults in South Africa [89]. We used the Ainsworth et al. scoring algorithms to derive an average metabolic equivalent of task (MET) intensity level score for each type of physical activity: vigorous, moderate, walking and cycling [90]. Physical activity levels were further categorized according to the IPAQ scoring protocol into low, moderate and high [91]. Insufficient physical activity was defined as a score below 600 MET minutes/week according to the World Health Organization (WHO) recommendations [92]. The presence or absence of sedentary behaviour was dichotomized as spending three or more hours per day watching television, playing computer games, talking with friends or other sitting activities according to the Global School-based Student Health Survey criteria [93].

Dietary intake was assessed using a 23-item food frequency questionnaire (FFQ) adapted from the Health Behaviour in School-aged Children Survey [94]. Participants reported their 'usual' consumption frequency of 23 different food groups, with response categories ranging from 'never' to 'more than once a day'. The FFQ has been found to have moderate reliability and acceptable validity for assessing the consumption of most food groups among adolescents [95]. Dietary intake was summarized into weekly consumption frequencies: 1, never; 2, less than once a week; 3, once a week; 4, 2–4 days a week; 5, 5–6 days a week; 6, once a day, every day; and 7, every day, more than once. We estimated the proportion who

ate fresh fruits and vegetables daily (once or more than once a day in the previous week) and frequently (on 4 or more days in the previous week) and the proportion of respondents who reported daily consumption of sugar-sweetened beverages (SSB), deep-fried foods, fast foods, salty snacks, and processed meats. Skipping breakfast was defined as eating breakfast on 0–2 days/week; semi-skipping, 3–4 days/week and not skipping, 5–7 days/week.

Tobacco, alcohol use and substance use were assessed using questions from the 2011 South African Youth Risk Behaviour Survey [38]. Heavy episodic or binge drinking was defined as drinking five or more drinks in succession on one or more days in the preceding month. Risky drinking was defined as binge drinking or underage drinking (any alcohol consumption below the legal age of 18 years).

Nutritional knowledge was assessed using a revised form of the General Nutrition Knowledge Questionnaire (GNKQ-R) [96]. The GNKQ-R has demonstrated internal consistency and is a valid and reliable measure of nutrition knowledge among young people [96]. A nutritional knowledge score was generated by totalling correct answers in four nutrition domains. The maximum possible score was 88; 18 for questions on “dietary recommendations”, 36 for questions on food groups, 13 for “healthy food choices” and 21 for “associations between diet and disease”. No norms exist to determine an adequate nutrition knowledge score [97]. Hence we computed the average nutrition knowledge score and compared the mean scores for each of the nutrition domains by gender and age groups comparable to a previous study of South African adults [98]. The percentage of respondents who answered the questions correctly in each domain was calculated.

Comorbidities (pre-existing diagnoses or presence of symptoms)

Respiratory disease was defined as self-reported pre-existing diagnosis of asthma, tuberculosis, bronchitis, or other lung disease. Experiencing any of the following symptoms in the preceding three months was characterized as presence of respiratory symptoms: prolonged cough with sputum for more than two weeks, chest tightness, shortness of breath, difficulty breathing; or having an abnormal peak flow reading. Similarly, diabetes was defined either as i) a pre-existing self-reported diagnosis; ii) a random blood glucose reading of > 7 mmol/l and having a family history of diabetes; or iii) a random blood glucose reading of > 7 mmol/l and experiencing any of the following diabetes-related symptoms over the past three months: frequent urination, increased thirst, unexplained weight loss of more than 1.5 kg in the last month, unexplained fatigue, blurry vision.

Depression and psychological distress were defined using symptom screening questions from the 10-item Centre for Epidemiological Studies Short Depression Scale (CESD-10) [99, 100] and the Kessler Psychological Distress Scale (K10) [101]. Both tools have been validated in South African HIV-positive populations [102, 103] and in adolescents and young adults [104]. The CESD-10 scale assesses depressive symptoms in the past week, while the K10 scale assesses symptoms of distress during the previous 30 days. Depression was defined as a binary indicator using a cut-off score of 10 or more on the CESD-10 scale [99] and the likelihood of psychological distress was categorized according to the K10

score: K10 < 20, mentally well; K10 20–24, likely to have mild psychological distress; K10 25–29, likely to have moderate psychological distress; K10 30–50, likely to have severe psychological distress [105].

Measured clinical signs

Overweight and obesity were categorized using standard BMI categories and cut-offs for central obesity. The criterion used to identify overweight and obesity in children and adolescents using growth charts corresponds to the criteria used for adults thus we opted for the latter for ease of comparability [106]. The abdominal obesity cut-off point for a high waist circumference (WC) was ≥ 102 cm in males and ≥ 88 cm in females and a waist-hip ratio (WHR) > 0.85 for females and > 0.90 for males [79]. Waist-to-hip ratio was calculated by dividing the waist circumference by the hip circumference in centimeters rounded to two decimal places. A threshold value of 0.5 for the waist-to-height ratio (WHtR) was used as a measure of central obesity, calculated by dividing the waist circumference by the height in cm [107]. Blood pressure (BP) was categorized according to the South African Hypertension practice guidelines [108]: Normal (systolic BP, SBP < 130 mmHg and diastolic BP, DBP < 85 mmHg); elevated blood pressure (SBP 130–139 mmHg or DBP 85–89 mmHg) and hypertension (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg) or a self-reported pre-existing diagnosis of hypertension.

Data Management and Statistical Analysis

Data from the physical examination and self-administered interviews were captured into an electronic form on an Android device using a unique anonymous study ID for each participant. At the end of each day, data was synced to a password-protected server only accessible to the study team. Data was then imported into Stata version 14.0 (*StataCorp, College Station, Texas, USA*) for cleaning and statistical analyses.

Graphical data exploration and Shapiro-Wilk's tests were used to test for normality of variables. All data were analysed and reported by sex and age group. Demographic and socioeconomic variables are described using summary statistics (frequencies, percentages, median and interquartile range (IQR)). Characteristics between sexes and age groups were compared using Pearson's $\chi 2$ and Fisher's exact tests for categorical measures. The Wilcoxon-Mann-Whitney test was used to compare medians between groups and the Kruskal-Wallis test was used for comparing continuous measures in more than two groups. Point prevalence estimates for comorbidities and symptoms were described and their exact binomial 95% confidence intervals were computed. All tests of significance were two-tailed and performed at the 5% significance level ($p < 0.05$).

Ethical Considerations

This study was approved by the University of Cape Town Faculty of Health Sciences Human Research Ethics Committee (HREC ref no: 520/2017). Approval was also granted by the Western Cape and City of Cape Town Departments of Health to access facilities for participant enrolment. Parents or legal guardians gave permission for their children to participate in the study, and participants provided

informed assent (or consent if 18 years or older) for participation in the study. Participants received reimbursement for transport costs.

Results

Socio-demographic characteristics, structural and household risk factors

A total of 92 participants completed study procedures, 76% of whom were female. The median age was 20.5 years (IQR 18.9–22.9) and the majority of our respondents (60%) were in the young adulthood stage between 20–24 years old (See Table 1). Over half (58%) were enrolled in school/college/university or other tertiary education or training (median age 20.3 (IQR 18.8–22.7) years). The majority lived with a biological parent or a relative, and 2% reported living with non-family members in foster care or children's homes. More than a quarter of female respondents reported ever being pregnant (28%) compared to 5% of male participants reporting ever impregnating someone. Of those ever pregnant, the majority (70%) reported having one child.

Table 1
Participant Socio-demographic, Structural and Household Characteristics by Gender

Variable	Description Median (IQR) or n (%) ($p < 0.05$)[1]	Male: n = 22 (24%)	Female: n = 70 (76%)	Total n = 92
Age (years)		20.7 (18.9–21.6)	20.4 (19.0–23.0)	20.5 (18.9–22.9)
Adolescent stage by age group	middle adolescence: 15–17 years	3 (14%)	10 (15%)	13 (14%)
	late adolescence: 18–19 years	5 (23%)	18 (26%)	23 (26%)
	young adulthood: 20–21 years	9 (41%)	16 (24%)	25 (28%)
	young adulthood: 22–24 years	5 (23%)	24 (35%)	29 (32%)
Family structure- whom they live with	Biological parents	10 (45%)	35 (50%)	45 (49%)
	Grandparents	4 (18%)	8 (11%)	12 (13%)
	Relative (aunt or uncle)	6 (27%)	23 (33%)	29 (32%)
	Siblings	15 (68%)	33 (47%)	48 (52%)
	Non-family (foster care/ children's home)	0	2 (3%)	2 (2%)
Ever pregnant/ impregnated someone ($p = 0.023$)		1 (5%)	19 (28%)	20 (22%)
Parity (n = 20)	0 children	0	5 (26%)	5 (25%)
	1 child	1 (100%)	13 (68%)	14 (70%)
	2 children	0	1 (5%)	1 (5%)
Current occupation/ employment status	In school/college/university/ other tertiary education	7 (32%)	37 (54%)	44 (48%)
	In training	3 (14%)	6 (9%)	9 (10%)

P-value shown if significant at 5% level: $p < 0.05$;[2] Youth MPI poor: those with composite score > 33.3%;[3] Individual living in a household that does not own more than two of: radio, TV, landline, mobile phone, bike, motorbike or refrigerator AND does not own a motor car or truck

Variable	Description Median (IQR) or n (%) ($p < 0.05$)[1]	Male: n = 22 (24%)	Female: n = 70 (76%)	Total n = 92
	Employed	5 (23%)	8 (11%)	13 (14%)
	Not in education, employment or training (NEET)	7 (32%)	18 (26%)	25 (27%)
Ever repeated a grade at school		14 (64%)	33 (47%)	47 (52%)
Days absent from school or work in past month	0 days	13 (59%)	34 (49%)	47 (52%)
	1–2 days	7 (32%)	26 (38%)	33 (36%)
	3 or more days	2 (9%)	9 (13%)	11 (12%)
Youth multidimensionally poor[2] (n = 88)		9 (41%)	30 (45%)	**39 (44%)**
Educational attainment		4 (18%)	16 (24%)	20 (22%)
	Aged 17–20 & completed less than nine years of schooling	1 (5%)	2 (3%)	3 (3%)
	Aged 21–24 & completed less than matric or equivalent	3 (14%)	14 (21%)	17 (19%)
General health and functioning		16 (73%)	46 (67%)	62 (68%)
	Difficulty hearing	3 (14%)	13 (19%)	16 (18%)
	Difficulty seeing	7 (33%)	26 (39%)	33 (38%)
	Difficulty moving around	2 (10%)	15 (22%)	17 (20%)
	Difficulty concentrating	12 (57%)	32 (48%)	44 (50%)
	Difficulty with self-care	0	14 (21%)	14 (16%)

P-value shown if significant at 5% level: $p < 0.05$;[2] Youth MPI poor: those with composite score > 33.3%;[3] Individual living in a household that does not own more than two of: radio, TV, landline, mobile phone, bike, motorbike or refrigerator AND does not own a motor car or truck

Variable	Description Median (IQR) or n (%) ($p < 0.05$)[1]	Male: n = 22 (24%)	Female: n = 70 (76%)	Total n = 92
Living environment		0 (0–0.036)	0.036 (0–0.071)	0.036 (0–0.071)
	Fuel for lighting other than electricity, gas/ solar power	0	1 (1%)	1 (1%)
	Fuel for heating other than electricity, gas/ solar power	5 (23%)	21 (30%)	26 (28%)
	Fuel for cooking other than electricity or gas	0	1 (1%)	1 (1%)
	Sanitation: Household without a flush toilet	3 (14%)	5 (7%)	8 (9%)
	Water: Household without piped water on site	1 (5%)	15 (21%)	16 (17%)
	Dwelling that is an informal shack /caravan/ tent/ other	4 (18%)	28 (41%)	32 (35%)
Household assets[3]: Household with ≤ two assets below & no motor vehicle		3 (14%)	20 (29%)	23 (25%)
	no radio	9 (41%)	32 (46%)	41 (45%)
	no television	2 (9%)	6 (9%)	8 (9%)
	no landline	22 (100%)	67 (96%)	89 (97%)
	no cell phone	1 (5%)	14 (20%)	15 (16%)
	no refrigerator	6 (27%)	24 (34%)	30 (33%)
	no motor vehicle (*p = 0.003)*	10 (45%)	55 (79%)	65 (71%)
Household adult unemployment: no employed adults (18–64 years)		1 (5%)	13 (19%)	14 (15%)
Household Food Insecurity Access Score		2.5 (1–5)	3 (0–7)	3 (0–7)
	food secure	4 (19%)	24 (34%)	28 (30%)

P-value shown if significant at 5% level: $p < 0.05$;[2] Youth MPI poor: those with composite score > 33.3%;[3] Individual living in a household that does not own more than two of: radio, TV, landline, mobile phone, bike, motorbike or refrigerator AND does not own a motor car or truck

Variable	Description Median (IQR) or n (%) ($p < 0.05$)[1]	Male: n = 22 (24%)	Female: n = 70 (76%)	Total n = 92
	mildly food insecure	7 (32%)	11 (16%)	18 (20%)
	moderately food insecure	4 (19%)	7 (10%)	11 (12%)
	severely food insecure	7 (32%)	28 (40%)	35 (38%)

P-value shown if significant at 5% level: $p < 0.05$;[2] Youth MPI poor: those with composite score > 33.3%;[3] Individual living in a household that does not own more than two of: radio, TV, landline, mobile phone, bike, motorbike or refrigerator AND does not own a motor car or truck

Multidimensional Poverty

Overall, 44% of participants can be considered multi-dimensionally poor as they were deprived in a third or more of the five dimensions of MPI indicators as shown in Table 1. More than two-thirds (68%) were deprived in the general health and functioning dimension on account of experiencing some difficulty with either hearing, sight, movement, concentration or with self-care. Fifty-nine percent were living-environment deprived with more than one-third living in informal housing, a quarter living in asset-deprived households, 28% living in households that do not use electricity, gas or solar power for heating and 17% living in households without piped water available on site. Almost a quarter (22%) of our respondents were deprived in the educational attainment dimension, comprising 3% of those aged 17–20 years who had completed less than nine years of schooling, and 19% of those aged 21–24 years who did not have a high school degree (or the equivalent of 12 years of schooling). Overall, 39% were economically deprived: 27% were neither in education, employment or training (NEET) (median age 20.8 (IQR 19.8–23.3 years)), while 15% were living in households with no employed adults of working age and 3% were deprived in both economic indicators.

Food insecurity

Seventy percent of participants were living in food insecure households with 38% considered as severely food insecure: either having to cut back on meal size, number of meals or going a whole day and night without eating due to a lack of resources or receiving relief food in the last 30 days.

Behaviour and Knowledge

Physical activity

Overall, a third of respondents had insufficient levels of weekly physical activity, 41% had moderate levels and 27% had high levels of physical activity [91]. A greater proportion of males had high levels of physical activity compared to females (44% versus 22%). The total median MET-minutes of physical

activity a week (total of all activities including active transport) was higher for males (2504.25 minutes) compared to females (1173 minutes), but this was not statistically significant (Table 2). The youngest age group reported the highest rates of vigorous-intensity physical activity (Table 3). Over two-thirds of all participants reported using active transport in the preceding week (mostly walking to school/work for at least ten minutes continuously). Almost half of respondents (49%) spent more than three hours sedentary during a typical day, with no difference in sedentary behaviour by gender.

Table 2
Physical Activity, Sedentary and Dietary Behaviour and Nutritional Knowledge of AYLHIV by Gender

Variable: Median (IQR) or n (%)	Description	Male: n = 19 (22%)	Female: n = 67 (78%)	Total: n = 86
Vigorous-intensity Physical activity	Any vigorous-intensity PA for ≥ 10 minutes	11 (58%)	26 (39%)	37 (43%)
	Time spent doing vigorous-intensity PA per day in minutes	75 (30–240)	60 (30–120)	60 (30–120)
	Vigorous intensity activity MET-minutes/week	2400 (1200–4320)	1680 (480–3840)	1920 (720–4320)
Moderate-intensity Physical activity	Any moderate-intensity PA for ≥ 10 minutes	15 (79%)	53 (79%)	68 (79%)
	Time spent doing moderate-intensity PA per day in mins	75 (30–120)	60 (30–90)	60 (30–90)
	Moderate intensity activity MET-minutes/week	1440 (480–1680)	720 (480–1200)	720 (480–1440)
Active Travel	Walking or cycling for ≥ 10 minutes continuously for travel	16 (84%)	45 (67%)	61 (71%)
	Time spent walking or cycling on a typical day in minutes	40 (30–60)	30 (30–60)	35 (30–60)
	Walking MET-minutes/week	610.5 (396–1386)	495 (247.5–990)	528 (297–990)
Total physical activity MET-minutes/week		2504.25 (690–7146)	1173 (495–2826)	1215 (495–3348)
Insufficient physical activity (achieved < 600 MET-minutes per week)		4 (21%)	23 (34%)	27 (31%)
High physical activity (≥ 3000 MET minutes per week)		8 (42%)	15 (22%)	23 (27%)
Sedentary behaviour (≥ 3 hours of sedentary time per day)		10 (53%)	32 (48%)	42 (49%)
Dietary Behaviour (n = 82)				
Fruits consumption	Never	0	2 (3%)	2 (2%)
(p = 0.028)	Once a week / less than once a week	4 (21%)	27 (43%)	31 (28%)

MET = Metabolic equivalent of task; n = number; % = percentage; PA = physical activity;

p-value shown if significant at 5% level: p < 0.05.

Variable: Median (IQR) or n (%)	Description	Male: n = 19 (22%)	Female: n = 67 (78%)	Total: n = 86
	2–4 times a week	5 (26%)	15 (24%)	20 (24%)
	Frequently (5–6 times a week)	4 (21%)	2 (3%)	6 (7%)
	Daily or more than once daily	6 (32%)	17 (27%)	23 (2%)
Vegetables consumption	Never	0	4 (6%)	4 (5%)
	Once a week / less than once a week	3 (17%)	9 (14%)	12 (15%)
	2–4 times a week	1 (6%)	9 (14%)	10 (12%)
	Frequently (5–6 times a week)	6 (33%)	7 (11%)	13 (16%)
	Daily or more than once daily	8 (44%)	34 (54%)	42 (52%)
Wholegrain bread or cereal Consumption (n = 68)	Never	1 (5%)	4 (6%)	5 (6%)
	Once a week / less than once a week	5 (26%)	16 (25%)	21 (26%)
	2–4 times a week	2 (11%)	6 (10%)	8 (10%)
	Frequently (5–6 times a week)	3 (16%)	4 (6%)	7 (9%)
	Daily or more than once daily	5 (26%)	22 (35%)	27 (33%)
Daily consumption of sugar-sweetened beverages		5 (26%)	20 (30%)	25 (29%)
Daily consumption of deep-fried foods		3 (16%)	15 (22%)	18 (21%)
Daily consumption of fast foods		1 (5%)	12 (18%)	13 (15%)
Daily consumption of sweets & cakes		2 (11%)	25 (37%)	27 (31%)
Ate a meal prepared outside the home in the past week		10 (59%)	45 (73%)	55 (67%)
	Meals eaten outside the home in past week: (n = 55)	2 (1–10)	2 (2–3)	2 (2–4)
Breakfast consumption: number of days in the past week		5 (3–6)	5 (3–7)	5 (3–7)
Breakfast consumption	Skippers: ate breakfast 0–2 days/week	5 (23%)	13 (20%)	18 (21%)
	Semi-skippers: ate breakfast 3–4 days/week	5 (23%)	13 (20%)	18 (21%)

MET = Metabolic equivalent of task; n = number; % = percentage; PA = physical activity;

p-value shown if significant at 5% level: $p < 0.05$.

Variable: Median (IQR) or n (%)	Description	Male: n = 19 (22%)	Female: n = 67 (78%)	Total: n = 86
	Non-skippers: ate breakfast 5–7 days/week	12 (54%)	39 (60%)	51 (58%)
Overall General Nutrition Knowledge score percentage % (score /88) (95% CI)		40.3% (34.5–46.1)	36.5% (34.0–38.9)	37.3% (35.1–39.6)
	1. Dietary recommendations (score/18)	44.2% (35.3–53.0)	42.5% (38.7–46.3)	42.9% (39.4–46.4)
	2. Food Groups (score/36)	40.4 (35.5–45.4)	37.1 (34.1–40.1)	37.9 (35.3–40.4)
	3. Healthy food choices (score/13)	36.8 (27.3–46.2)	30.5 (26.0–35.1)	31.9 (27.9–36.0)
	4. Diet, disease and weight management (score/21)	36.8 (28.2–45.3)	33.9 (30.6–37.1)	34.5 (31.4–37.6)
MET = Metabolic equivalent of task; n = number; % = percentage; PA = physical activity;				
p-value shown if significant at 5% level: $p < 0.05$.				

Table 3
Physical Activity, Sedentary and Dietary Behaviour and Nutritional Knowledge by Age Group

Variable: Median (IQR) or n (%)	**Description**	**15–17 years: n = 11 (13%)**	**18–19 years: n = 23 (27%)**	**20-21years: n = 23 (27%)**	**22–24 years: n = 29 (34%)**	**Total: n = 86**
Vigorous intensity Physical Activity	Prevalence of PA for ≥ 10 min	8 (80%)	9 (39%)	11 (50%)	9 (31%)	37 (43%)
	Time spent per day in minutes	120 (30–240)	90 (30–120)	105 (30–180)	60 (30–60)	60 (30–120)
	MET-minutes/week	4800 (720–9600)	2160 (1200–2400)	2520 (960–4320)	1440 (480–1920)	1920 (720–4320)
Moderate-intensity Physical Activity	Prevalence of PA for ≥ 10 minutes	5 (50%)	17 (74%)	19 (86%)	25 (86%)	68 (79%)
	Time spent per day in mins	60 (30–60)	60 (40–120)	30 (30–120)	30 (30–60)	60 (30–90)
	MET-minutes/week	720 (360–720)	1440 (640–1680)	600 (420–1680)	600 (480–840)	720 (480–1440)
Active Travel Walking or cycling	Walking or cycling for ≥ 10 minutes	7 (70%)	19 (83%)	14 (64%)	20 (69%)	60 (71%)
	Time spent daily in mins	30 (30–120)	30 (30–60)	60 (30–60)	30 (30–60)	35 (30–60)
	Walking MET-minutes/week	495 (495–495)	693 (396–1386)	742.5 (495–1188)	495 (198–693)	528 (297–990)
Total physical activity MET-minutes/week		984 (280–5295)	2160 (800–3756)	1638.75 (420–6624)	876 (508.5–1878)	1215 (495–3348)
Insufficient physical activity (< 600 MET-mins per week)		5 (45%)	5 (22%)	7 (30%)	10 (34%)	27 (31%)
High physical activity (≥ 3000 MET mins per week)		3 (27%)	8 (35%)	9 (39%)	3 (10%)	23 (27%)

n = number; % = percentage; mins = minutes; PA = physical activity; MET = Metabolic equivalent of task;

p-value from Kruskal Wallis test shown if significant at 5% level: $p < 0.05$.

Variable: Median (IQR) or n (%)	Description	15–17 years: n = 11 (13%)	18–19 years: n = 23 (27%)	20-21years: n = 23 (27%)	22–24 years: n = 29 (34%)	Total: n = 86
Sedentary behaviour (≥ 3 hours of sedentary time per day)		7 (70%)	9 (39%)	12 (54%)	14 (49%)	42 (49%)
Dietary Behaviour (n = 82)						
Fruits consumption	Never	0	0	0	2 (7%)	2 (2%)
	Once a week / less than once a week	5 (50%)	9 (39%)	10 (45%)	7 (26%)	31 (38%)
	2–4 times a week	2 (20%)	5 (22%)	4 (18%)	9 (33%)	20 (24%)
	Frequently (5–6 times a week)	2 (20%)	0	3 (14%)	1 (4%)	6 (7%)
	Daily or more than once daily	1 (10%)	9 (39%)	5 (23%)	8 (30%)	23 (28%)
Vegetables consumption	Never	0	1 (4%)	1 (5%)	2 (7%)	4 (5%)
	Once a week / less than once a week	2 (20%)	5 (22%)	3 (14%)	2 (7%)	12 (15%)
	2–4 times a week	2 (20%)	1 (4%)	0	7 (265)	10 (12%)
	Frequently (5–6 times a week)	2 (20%)	4 (17%)	6 (29%)	1 (4%)	13 (16%)
	Daily or more than once daily	4 (40%)	12 (52%)	11 (52%)	15 (56%)	42 (52%)
Whole-grain bread or cereal consumption (n = 68)	Never	0	1 (4%)	1 (5%)	3 (11%)	5 (6%)
	Once a week / less than once a week	5 (50%)	7 (30%)	5 (23%)	4 (15%)	21 (26%)
	2–4 times a week	2 (20%)	1 (4%)	1 (5%)	4 (15%)	8 (10%)
	Frequently (5–6 times a week)	1 (10%)	4 (17%)	1 (5%)	1 (4%)	7 (9%)
	Daily or more than once daily	1 (10%)	9 (39%)	7 (32%)	10 (37%)	27 (33%)

n = number; % = percentage; mins = minutes; PA = physical activity; MET = Metabolic equivalent of task;

p-value from Kruskal Wallis test shown if significant at 5% level: $p < 0.05$.

Variable: Median (IQR) or n (%)	Description	15–17 years: n = 11 (13%)	18–19 years: n = 23 (27%)	20-21years: n = 23 (27%)	22–24 years: n = 29 (34%)	Total: n = 86
Daily consumption of sugar-sweetened beverages		3 (27%)	6 (26%)	9 (39%)	7 (24%)	25 (29%)
Daily consumption of deep-fried foods *(p = 0.031)*		1 (9%)	8 (35%)	5 (22%)	4 (14%)	18 (21%)
Daily consumption of fast foods		2 (18%)	6 (26%)	2 (9%)	3 (10%)	13 (15%)
Daily consumption of sweets & cakes		4 (36%)	9 (39%)	6 (26%)	8 (28%)	27 (31%)
Dietary Behaviour (n = 82)						
Ate meal prepared outside the home in past week		5 (50%)	14 (64%)	15 (68%)	21 (78%)	55 (67%)
	Meals eaten outside the home in past week: (n = 55)	2 (1–3)	2 (2–4)	2 (2–4)	2 (2–3)	2 (2–4)
Breakfast consumption	Skippers: ate breakfast 0–2 days/week	2 (20%)	7 (30%)	3 (14%)	7 (26%)	19 (23%)
	Semi-skippers: ate breakfast 3–4 days/week	1 (10%)	4 (17%)	6 (27%)	3 (11%)	14 (17%)
	Non-skippers: ate breakfast 5–7 days/week	7 (70%)	12 (52%)	13 (59%)	17 (63%)	49 (60%)
Overall General Nutrition Knowledge score percentage (score /88) mean (95% CI)		35.6 (28.4 - 42.9)	38.1 (34.1–42.1)	34.3 (28.9–39.6)	39.6 (35.7–43.4)	37.3 (35.1 - 39.6)
	1. Dietary recommendations (score/18)	39.9 (27.8–52.0)	46.1 (39.8–52.4)	40.2 (32.3 - 48.1)	43.4 (37.5 - 49.3)	42.9 (39.4–46.4)
	2. Food Groups (score/36)	37.6 (31.6 - 43.7)	37.4 (32.3 - 42.5)	35.0 (29.7 - 40.3)	40.4 (35.5 - 45.4)	37.9 (35.3–40.4)

n = number; % = percentage; mins = minutes; PA = physical activity; MET = Metabolic equivalent of task;

p-value from Kruskal Wallis test shown if significant at 5% level: $p < 0.05$.

Variable: Median (IQR) or n (%)	Description	15–17 years: n = 11 (13%)	18–19 years: n = 23 (27%)	20-21years: n = 23 (27%)	22–24 years: n = 29 (34%)	Total: n = 86
	3. Healthy Food choices (score/13)	33.6 (21.5 - 45.6)	35.1 (28.4 - 41.8)	27.7 (17.8 - 37.6)	31.6 (24.2 - 39.0)	31.9 (27.9–36.0)
	4. Diet, disease relationship (score/21)	29.9 (20.6 - 39.2)	34.4 (29.4 - 39.3)	30.2 (23.3–37.1)	39.7 (34.0 - 45.3)	34.5 (31.4–37.6)
n = number; % = percentage; mins = minutes; PA = physical activity; MET = Metabolic equivalent of task;						
p-value from Kruskal Wallis test shown if significant at 5% level: $p < 0.05$.						

Dietary intake

Overall, less than a third of respondents ate fruits and wholegrains daily (Table 2). Significantly more males ate fruit frequently compared to females (53% versus 28%). More than half ate vegetables daily (either dark green, orange or other vegetables). Younger adolescents had the lowest daily consumption of fruits, vegetables and wholegrains compared to older age groups. A third of respondents had a high dietary intake of sugar; with 29% reporting drinking SSB daily (including regular soft drinks, energy drinks and sports drinks) and 31% eating sweets and cakes daily. SSB consumption was similar across gender and age groups. One in five participants ate deep-fried foods daily and 15% ate fast-foods daily. Older adolescents aged 18–19 years had the highest daily consumption of deep-fried (35%) and fast foods (26%) (See Table 3).

Meals eaten outside the home

Two-thirds of respondents ate at least one meal that was prepared outside the home in the previous week. Those who ate food prepared outside the home, ate a median of two take-away or sit-down meals in the past week (IQR 2–4 meals). Males had a larger variability in meals consumed that were prepared outside the home compared to females; median 2 meals (IQR 1–10 meals) versus (IQR 2–3 meals) respectively.

Breakfast

Over half of participants (58%) reported eating breakfast on at least five days in the previous week, 21% ate breakfast on 3–4 days in the week and 21% reported skipping breakfast or eating breakfast on less than two days in the previous week. Breakfast skipping did not differ significantly by gender or age.

Nutrition Knowledge

Overall, the mean general nutrition knowledge score achieved by adolescents was 33 out of a total of 88 points (37.5%). Knowledge of dietary recommendations was the highest-scoring domain with an average of 7.9 points out of 18 (44%) while knowledge of healthy food choices was the lowest-scoring domain (average of 4.2 out of 13 points; (32%)). Participants scored an average of 13.45 points out of 36 for knowledge of food groups (37%); and 7.3/21 points for knowledge of diet-disease relationships (35%). There were no significant differences in nutrition knowledge amongst adolescents by sex and age group (See Fig. 2).

Tobacco use and exposure

Significantly more males (58%) than females (30%) reported ever smoking cigarettes (Table 4). The median age when participants first smoked cigarettes was 16 years (IQR 15–17 years). Overall, 30% had smoked cigarettes in the past month: 9% reported smoking daily while 21% smoked less often than daily (37% males and 16% females). The oldest age group (22–24 years) reported the highest rates of ever smoking (41%) while the prevalence of daily smoking was highest for those aged 18–19 years (13%). In the youngest age group of 15–17-year olds, 45% reported smoking cigarettes (less often than daily) in the past month (see Fig. 3). Overall, 21% reported using tobacco products other than cigarettes (including water or hookah pipes and vaping) during the past month, with 6% reporting using these products on six or more days in the past month. Those in the youngest age group reported the most use of tobacco products other than cigarettes in the past month; 45% compared to less than 30% in the other age groups (Table 5). Almost half the participants (45%) reported being exposed to secondary smoke from people who smoked in their presence in the past week. More than half (15/26) of current smokers also drank alcohol in the preceding month.

Table 4
Tobacco Use and Exposure, Alcohol and Substance use by Gender

Variable: Median (IQR) or n (%)	Description	Male: n = 19 (22%)	Female: n = 67 (78%)	Total: n = 86
Tobacco and Alcohol Use				
Ever smoked cigarettes in lifetime *(p = 0.025)*		11 (58%)	20 (30%)	31 (36%)
Age when first smoked cigarettes		15 (13–16)	16 (15–17)	16 (15–17)
Days smoked during the past 30 days	0 days	10 (53%)	50 (75%)	60 (70%)
	1 or 2 days	3 (16%)	8 (12%)	11 (13%)
	3 to 5 days	4 (21%)	2 (3%)	6 (7%)
	20 to 29 days	0	1 (1%)	1 (1%)
	Daily: all 30 days	2 (11%)	6 (9%)	8 (9%)
Days used any tobacco products other than cigarettes, during past month *(p = 0.055)*	0 days	13 (68%)	55 (82%)	68 (79%)
	1 or 2 days	3 (16%)	8 (12%)	11 (13%)
	3 to 5 days	2 (11%)	0	2 (2%)
	6 or more days	1 (5%)	4 (6%)	5 (6%)
People smoked around you during past 7 days		10 (53%)	29 (43%)	39 (45%)
Days people smoked in their presence during the past 7 days	0 days	4 (21%)	20 (30%)	24 (28%)
	1 or 2 days	4 (21%)	25 (37%)	29 (34%)
	3 or 4 days	6 (32%)	8 (12%)	14 (16%)
	5 or 6 days	2 (10%)	5 (7%)	7 (8%)

[1] *Inhalants = glue, aerosols, paint thinners, petrol or benzene;*

[2] *OTC = over-the-counter;*

p-value shown if significant at 10% level: $p < 0.10$.

Variable: Median (IQR) or n (%)	Description	Male: n = 19 (22%)	Female: n = 67 (78%)	Total: n = 86
	All 7 days	3 (16%)	9 (13%)	12 (14%)
Ever drunk alcohol (n = 85)		13 (68%)	45 (67%)	58 (67%)
	Age at alcohol initiation in years	16 (14–19)	17 (15–18)	16.5 (15–18)
	Drunk alcohol in the past 30 days	11 (58%)	24 (36%)	35 (41%)
	Binge drinking in past 30 days	7 (37%)	14 (21%)	21 (24%)
Illegal and Other Drug Use				
Ever used cannabis (dagga) (p = 0.087)		8 (42%)	15 (22%)	23 (27%)
	Age at first cannabis use	16 (13–19)	16 (15–18)	16 (14.5–18.5)
	Cannabis use in the past year	6 (32%)	13 (19%)	19 (22%)
Frequency of dagga use in past year	Almost every day	2 (11%)	3 (4%)	5 (6%)
	Once a week or more	1 (5%)	3 (4%)	4 (5%)
	About once a month	1 (5%)	5 (7%)	6 (7%)
	Only once or twice	2 (11%)	2 (3%)	4 (5%)
	Never	13 (68%)	54 (81%)	67 (78%)
Ever taken cocaine, heroin, mandrax, club drugs or methamphetamine		1 (5%)	5 (7%)	6 (7%)
Lifetime use of cocaine, heroin, mandrax, club drugs or methamphetamine	0 times	18 (95%)	62 (93%)	80 (93%)

[1] *Inhalants = glue, aerosols, paint thinners, petrol or benzene;*

[2] *OTC = over-the-counter;*

p-value shown if significant at 10% level: p < 0.10.

Variable: Median (IQR) or n (%)	Description	Male: n = 19 (22%)	Female: n = 67 (78%)	Total: n = 86
	1 or 2 times	0	2 (3%)	2 (2%)
	3 to 9 times	0	1 (1%)	1 (1%)
	20 or more times	1 (5%)	2 (3%)	3 (3%)
Ever used inhalants[1] "to get high"		4 (21%)	5 (7%)	9 (10%)
Lifetime use of inhalants to get high	0 times	16 (84%)	64 (96%)	80 (93%)
	1 or 2 times	2 (11%)	3 (4%)	5 (6%)
	3 to 9 times	1 (5%)	0	1 (1%)
Ever used OTC[2] or prescription drugs "to get high"		5 (26%)	8 (12%)	13 (15%)
Lifetime use of OTC to "to get high"	0 times	15 (79%)	61 (91%	76 (88%)
	1 or 2 times	3 (16%)	6 (9%)	9 (10%)
	3 to 9 times	1 (5%)	0	1 (1%)
Ever used any illegal drugs or substance "to get high" (*p = 0.088*)		10 (53%)	21 (31%)	31 (36%)

[1] *Inhalants = glue, aerosols, paint thinners, petrol or benzene;*

[2] *OTC = over-the-counter;*

p-value shown if significant at 10% level: p < 0.10.

Table 5
Tobacco Use and Exposure, Alcohol and Substance use by Age Group

Variable: Median (IQR) or n (%)	**Description**	**15–17 years: n = 11 (13%)**	**18–19 years: n = 23 (27%)**	**20–21 years: n = 23 (27%)**	**22–24 years: n = 29 (34%)**	**Total: n = 86**
Tobacco and Alcohol Use						
Ever smoked cigarettes in lifetime		5 (45%)	7 (30%)	7 (30%)	12 (41%)	31 (36%)
Age when first smoked cigarettes *([1]p= 0.0686)*		16 (13–16)	15.5 (13–16)	15 (14–16)	17 (16–20)	16 (15–17)
Days smoked during the past 30 days	0 days	6 (55%)	16 (70%)	17 (74%)	21 (72%)	60 (70%)
	1 or 2 days	5 (45%)	2 (9%)	1 (4%)	3 (10%)	11 (13%)
	3 to 5 days	0	1 (4%)	3 (13%)	2 (7%)	6 (7%)
	20 to 29 days	0	1 (4%)	0	0	1 (1%)
	All 30 days	0	3 (13%)	2 (9%)	3 (10%)	8 (9%)
Days used any tobacco products other than cigarettes, during past month	0 days	6 (55%)	19 (83%)	17 (74%)	26 (90%)	68 (79%)
	1 or 2 days	4 (36%)	3 (13%)	2 (9%)	2 (7%)	11 (13%)
	3 to 5 days	0	0	2 (9%)	0	2 (2%)
	6 or more days	1 (9%)	1 (4%)	2 (9%)	1 (3%)	5 (6%)
People smoked around you during past 7 days		5 (45%)	11 (48%)	10 (43%)	13 (45%)	39 (45%)

[1]P-value associated with Kruskal-Wallis equality-of-populations rank test;

[2] Fisher's exact p-value;

[3] Inhalants = glue, aerosols, paint thinners, petrol or benzene;

[4] OTC = over-the-counter.

Variable: Median (IQR) or n (%)	Description	15–17 years: n = 11 (13%)	18–19 years: n = 23 (27%)	20–21 years: n = 23 (27%)	22–24 years: n = 29 (34%)	Total: n = 86
Days people smoked in their presence during the past 7 days	0 days	1 (9%)	7 (30%)	5 (22%)	11 (38%)	24 (28%)
	1 or 2 days	5 (45%)	9 (39%)	8 (35%)	7 (24%)	29 (34%)
	3 or 4 days	2 (18%)	0	5 (22%)	7 (24%)	14 (16%)
	5 or 6 days	2 (18%)	1 (4%)	3 (13%)	1 (3%)	7 (8%)
	All 7 days	1 (9%)	6 (26%)	2 (9%)	3 (10%)	12 (14%)
Ever drunk alcohol		9 (82%)	14 (61%)	14 (61%)	21 (75%)	58 (68%)
Age at alcohol initiation in years *([1]p= 0.0009)*		14 (12–14)	16.5 (15–18)	15.5 (15–18)	17 (16–19)	16.5 (15–18)
Drunk alcohol in the past 30 days		5 (45%)	10 (43%)	7 (30%)	13 (45%)	35 (41%)
Binge drinking in past 30 days *([2]p= 0.076)*		6 (55%)	6 (26%)	4 (17%)	5 (17%)	21 (24%)
Illegal and Other Drug Use						
Ever used cannabis (dagga)		3 (27%)	7 (30%)	5 (22%)	8 (28%)	23 (27%)
	Age at first cannabis use	15 (13–16)	16.5 (14–18)	16 (15–16)	18.5 (16–21)	16 (14.5–18.5)
	Cannabis use in the past year	3 (27%)	5 (22%)	4 (17%)	7 (24%)	19 (22%)

[1]P-value associated with Kruskal-Wallis equality-of-populations rank test;

[2] Fisher's exact p-value;

[3] Inhalants = glue, aerosols, paint thinners, petrol or benzene;

[4] OTC = over-the-counter.

Variable: Median (IQR) or n (%)	Description	15–17 years: n = 11 (13%)	18–19 years: n = 23 (27%)	20–21 years: n = 23 (27%)	22–24 years: n = 29 (34%)	Total: n = 86
Frequency of dagga use in past year	Almost every day	0	1 (4%)	2 (9%)	2 (7%)	5 (6%)
	Once a week or more	0	2 (9%)	1 (4%)	1 (3%)	4 (5%)
	About once a month	2 (18%)	1 (4%)	1 (4%)	2 (7%)	6 (7%)
	Only once or twice	1 (9%)	1 (4%)	0	2 (7%)	4 (5%)
	Never	8 (73%)	18 (78%)	19 (83%)	22 (76%)	67 (78%)
Ever taken cocaine, heroin, mandrax, club drugs or meth		0	1 (4%)	1 (4%)	4 (14%)	6 (7%)
Lifetime use of cocaine, heroin, mandrax, club drugs or methamphetamine	0 times	11 (100%)	22 (96%)	22 (96%)	25 (86%)	80 (93%)
	1 or 2 times	0	1 (4%)	0	1 (3%)	2 (2%)
	3 to 9 times	0	0	0	1 (3%)	1 (1%)
	20 or more times	0	0	1 (4%)	2 (7%)	3 (3%)
Ever used inhalants[3] "to get high"		1 (9%)	1 (4%)	5 (22%)	2 (7%)	9 (10%)
Lifetime use of inhalants to get high	0 times	10 (91%)	22 (96%)	20 (87%)	28 (97%)	80 (93%)
	1 or 2 times	1 (9%)	1 (4%)	2 (9%)	1 (3%)	5 (6%)
	3 to 9 times	0	0	1 (4%)	0	1 (1%)

[1] P-value associated with Kruskal-Wallis equality-of-populations rank test;

[2] Fisher's exact p-value;

[3] Inhalants = glue, aerosols, paint thinners, petrol or benzene;

[4] OTC = over-the-counter.

Variable: Median (IQR) or n (%)	Description	15–17 years: n = 11 (13%)	18–19 years: n = 23 (27%)	20–21 years: n = 23 (27%)	22–24 years: n = 29 (34%)	Total: n = 86
Ever used OTC[4] or prescription drugs "to get high"		2 (18%)	4 (17%)	5 (22%)	2 (7%)	13 (15%)
Lifetime use of OTC to get high	0 times	9 (82%)	20 (87%)	20 (87%)	27 (93%)	76 (88%)
	1 or 2 times	2 (18%)	3 (13%)	2 (9%)	2 (7%)	9 (10%)
	3 to 9 times	0	0	1 (4%)	0	1 (1%)
Ever used any illegal drugs or substance "to get high"		4 (36%)	9 (39%)	8 (35%)	10 (34%)	31 (36%)

[1] P-value associated with Kruskal-Wallis equality-of-populations rank test;

[2] Fisher's exact p-value;

[3] Inhalants = glue, aerosols, paint thinners, petrol or benzene;

[4] OTC = over-the-counter.

Alcohol use

Over two-thirds of participants reported ever drinking alcohol (68%). Overall, the median age of first alcohol use was 16.5 years (IQR 15–18 years) with no significant difference by gender. However, age of first alcohol use was significantly earlier in the youngest age group with 82% of 15–17-year olds reporting ever drinking alcohol and a median age of first alcohol use of 14 (IQR 12–14) years (See distribution in Table 5). Overall, 41% had drunk alcohol in the past 30 days and 24% reported binge drinking in the past month. Those who reported binge drinking were significantly younger (median 18.8 (IQR 16.9–21.5) years) than those who did not binge drink (median 21.1 (IQR 19.5–23.4) years) (p = 0.0152). Current drinking and binge drinking did not differ by gender. The youngest age group (15–17 years) reported the highest rates of risky drinking: 45% had drunk alcohol in the past 30 days (underage drinking) and 55% reported binge drinking compared to less than 30% in older age groups as shown in Table 5.

Substance use

More than a quarter (27%) reported ever using cannabis. The median age at first cannabis use was 16 (IQR 14.5–18.5) years and did not differ significantly by gender. The frequency of cannabis use in the past year ranged from never (78%) to almost every day (6%) (See Table 4). Participants aged 18–19 and 20–21 years reported the most frequent use of cannabis with 13% reporting daily or weekly cannabis use each in the past year. Six participants (7%), all over 18 years old, reported ever taking "hard" drugs

(cocaine, methamphetamine or mandrax); three of whom reported taking hard drugs 20 or more times in their lifetime. Nine participants (10%) reported ever using inhalants such as glue, aerosols, paint thinners, petrol or benzene “to get high” and 15% reported ever using over-the-counter or prescription drugs at least once or twice “to get high”. Overall, more males (53%) reported ever using any illegal drugs or substances “to get high” compared to females (31%).

Comorbidities and symptom screening

Pre-existing diagnosis

Overall, 35% reported a previous comorbidity diagnosis (95% CI: 25–45%). The most common pre-existing diagnoses or previous comorbidities were TB (23%; 95% CI: 15–33%) and depression/anxiety (8.7%; 95% CI 3.8–16%), followed by asthma (4.3%; 95% CI 1.2–11%) and high blood pressure (3.2%; 95% CI: 0.68–9.2%). There were no significant differences in the proportions of male and female participants diagnosed with pre-existing conditions (Table 6).

Table 6
Comorbidities, Pre-existing diagnoses, Measured clinical signs and symptoms by Gender

Variable: median (IQR) or n (%) or proportion [95% CI]		**Male: n = 22**	**Female: n = 70**	**Total n = 92**	**p-value[1]**
Self-reported pre-existing diagnosis: prop [95% CI] [2]		0.45 [0.24–0.68]	0.31 [0.21–0.44]	0.35 [0.25–0.45]	0.228
	Tuberculosis	0.32 [0.14–0.55]	0.2 [0.11–0.31]	0.23 [0.15–0.33]	0.229
	Depression or Anxiety	0.14 [0.029–0.35]	0.071 [0.024–0.16]	0.087 [0.038–0.16]	0.332
	Asthma	0.045 [0.0012–0.23]	0.043 [0.0089–0.12]	0.043 [0.012–0.11]	0.946
	High Blood Pressure	0 [0–0.15]	0.043 [0.089–0.12]	0.033 [0.0068–0.092]	0.327
	Diabetes	0 [0–0.15]	0.014 [0.00036–0.077]	0.011 [0.00028–0.061]	0.576
Respiratory Symptoms over past 3 months (n = 89): prop [95% CI]		0.10 [0.012–0.30]	0.13 [0.062–0.24]	0.12 [0.063–0.21]	0.651
Diabetes Symptoms over past 3 months: prop [95% CI]		0.29 [0.11–0.52]	0.24 [0.14–0.35]	0.25 [0.16–0.35]	0.640
Symptoms n (%)	Frequent urination	1 (5%)	3 (4%)	4 (4%)	0.969
	Increased thirst	2 (9%)	7 (10%)	9 (10%)	0.900
	Weight loss > 1.5 kg in past month	0	6 (9%)	6 (7%)	0.152
	Unexplained fatigue	5 (23%)	9 (13%)	13 (15%)	0.261
	Blurry vision	2 (10%)	5 (7%)	7 (8%)	0.747
Family history of diabetes: prop [95% CI]		0.38 [0.18–0.62]	0.24 [0.14–0.35]	0.27 [0.18–0.37]	0.189

Wilcoxon rank-sum test p-value for continuous variables and Pearson X2 test for categorical variables;

[2] Proportion and Binomial exact 95% Confidence interval;

[3] Blood glucose measured only if had one or more symptoms of diabetes and OR family history;

[4] Abdominal obesity: WC > 88 cm in females, WC > 102 cm in males.

Variable: median (IQR) or n (%) or proportion [95% CI]		Male: n = 22	Female: n = 70	Total n = 92	p-value[1]
Random Blood Glucose in mmol/l (n = 31) [3] median (IQR)		3.7 (0.75–4.95)	4.8 (4.0–5.5)	4.7 (3.1–5.3)	0.1672
CESD-10 Depression Score (n = 82) median (IQR)		8 (4–9)	10 (6–14)	9 (6–14)	0.055
	Significant depression (CESD ≥ 10): prop [95% CI]	0.19 [0.054–0.42]	0.51 [0.38–0.64]	0.43 [0.32 - 0.54]	0.011
Kessler Psychological Distress Score (K10) (n = 85) median (IQR)		17 (13–23)	19 (13–25)	19 (13–25)	0.959
Categories n (%)	Mentally well (K10 < 20)	12 (57%)	35 (55%)	47 (55%)	0.407
	Mild distress (K10 20–24)	4 (19%)	10 (16%)	14 (16%)	
	Moderate distress (K10 25–29)	2 (10%)	15 (23%)	17 (20%)	
	Severe distress (K10 ≥ 30)	3 (14%)	4 (6%)	7 (8%)	
Measured Clinical Signs					
BMI in kg/m^2 ; median (IQR)		21.0 (19.1–22.6)	23.3 (20.2–27.2)	22.8 (19.9–26.2)	0.0102
Categories n (%)	Underweight (BMI < 18.5)	5 (23%)	5 (7%)	10 (11%)	0.032
	Normal weight (18.5 ≤ BMI < 25)	14 (64%)	33 (49%)	47(53%)	
	Overweight (25 ≤ BMI < 30)	3 (14%)	19 (28%)	22 (25%)	
	Obese (BMI ≥ 30)	0	10 (15%)	10 (11%)	
Waist circumference (WC) in cm; median (IQR)		74 (71.5–81.0)	78.4 (71.5–88.0)	76 (71.5–87)	0.2135
	Abdominal obesity[4]	1 (5%)	17 (24%)	18 (20%)	0.049
Hip circumference in cm; median (IQR)		87.5 (84–94)	97.5 (90.5–108)	95 (86.75–106.5)	0.0011

Wilcoxon rank-sum test p-value for continuous variables and Pearson X2 test for categorical variables;

[2] Proportion and Binomial exact 95% Confidence interval;

[3] Blood glucose measured only if had one or more symptoms of diabetes and OR family history;

[4] Abdominal obesity: WC > 88 cm in females, WC > 102 cm in males.

Variable: median (IQR) or n (%) or proportion [95% CI]		Male: n = 22	Female: n = 70	Total n = 92	p-value[1]
Waist-hip ratio (WHR) median (IQR)		0.85 (0.82–0.87)	0.82 (0.77–0.85)	0.82 (0.78–0.87)	0.0265
Waist-to-height ratio (WHtR) median (IQR)		0.43 (0.42–0.48)	0.49 (0.45–0.56)	0.48 (0.44–0.54)	0.0006
Central obesity	WHR > 0.85 in females and > 0.95 in males	0	19 (27%)	19 (21%)	0.007
	WHtR > 0.5	3 (14%)	31 (44%)	34 (37%)	0.020
Blood Pressure in mmHg		119.5/74.75	115/74	117.5/74.25	0.9635
(Systolic/ Diastolic Blood Pressure) median (IQR)		(110/66.5 – 131.5/80.5)	(109.5/68.5–124.5/78)	(109.5/68–125.5/79)	0.2097
Categories n (%)	Normal BP: SBP < 130 & DBP < 85	13 (59%)	56 (80%)	69 (75%)	0.056
	Elevated BP: SBP 130–139 or DBP 85–89	6 (27%)	12 (17%)	18 (20%)	
	Hypertension: SBP 140–159/ DBP 90–99	3 (14%)	2 (3%)	5 (5%)	

Wilcoxon rank-sum test p-value for continuous variables and Pearson X2 test for categorical variables;

[2] Proportion and Binomial exact 95% Confidence interval;

[3] Blood glucose measured only if had one or more symptoms of diabetes and OR family history;

[4] Abdominal obesity: WC > 88 cm in females, WC > 102 cm in males.

Respiratory symptoms

Eleven participants (12%; 95% CI: 6.3–21%) reported experiencing one or more of the following respiratory symptoms over the past three months: shortness of breath (3%), chest tightness (3%), prolonged cough with sputum for more than two weeks (7%), or difficulty breathing (3%). Of those who reported difficulty breathing, 2/3 reported it to be worse at night, with wheezing or whistling in the chest or occurring during exercise. Peak flow measurement was done for five participants who reported respiratory symptoms but had no known asthma diagnosis. All the measurements were within the normal –green– peak flow zone.

Diabetes

Only one participant (who also reported diabetes symptoms) reported a previous diabetes diagnosis. A quarter of participants (95% CI: 16–35%) reported experiencing one or more of the following diabetes-related symptoms over the past three months: frequent urination (4%), increased thirst (10%), unexplained weight loss of more than 1.5 kg in the last month (7%), unexplained fatigue (15%) and blurry vision (8%).

Younger age groups (15–17 years and 18–19 years) reported more diabetes-related symptoms compared to older age groups (See Table 7). Overall, 27% reported a family history of diabetes (95% CI: 18–37%). Of those with reported symptoms or a reported family history of diabetes who had their blood glucose measured (n = 31), none had a measured random blood glucose of more than 7 mmol/L.

Table 7
Comorbidities, Pre-existing diagnoses, Measured clinical signs and symptoms by Age Group

Variable: median (IQR) or n (%)		**15–17 years: n = 14 (15%)**	**18–19 years: n = 23 (25%)**	**20–21 years: n = 26 (28%)**	**22–24 years: n = 29 (32%)**	**Total: n = 92**
Self-reported past diagnosis: n (%)	1 (7%)		9 (39%)	9 (35%)	13 (45%)	32 (35%)
	Tuberculosis	1 (7%)	5 (22%)	6 (23%)	9 (31%)	21 (23%)
	Depression or Anxiety	0	4 (17%)	2 (8%)	2 (7%)	8 (9%)
	Asthma	0	2 (9%)	2 (8%)	0	4 (4%)
	High Blood Pressure	0	0	1 (4%)	2 (7%)	3 (3%)
	Diabetes	0	1 (11%)	0	0	1 (3%)
Respiratory Symptoms over the past 3 months (n = 89)		4 (29%)	4 (17%)	2 (8%)	1 (3%)	11 (12%)
Diabetes Symptoms over past 3 months *(p = 0.047)*		**6 (46%)**	**8 (35%)**	**4 (16%)**	**4 (14%)**	**23 (25%)**
Symptoms n (%)	Frequent urination *(p = 0.026)*	2 (15%)	2 (9%)	0	0	4 (4%)
	Increased thirst *(p = 0.011)*	4 (31%)	3 (13%)	2 (8%)	0	9 (10%)
	Weight loss > 1.5 kg in past month	1 (8%)	2 (9%)	1 (4%)	2 (7%)	6 (7%)
	Unexplained fatigue	4 (31%)	5 (22%)	4 (16%)	1 (3%)	14 (16%)
	Blurry vision	1 (8%)	3 (14%)	1 (4%)	2 (7%)	7 (8%)
Family history of diabetes		6 (46%)	7 (30%)	4 (16%)	7 (24%)	24 (27%)
Random Blood Glucose in mmol/l (n = 31) [3] median (IQR)		3.65 (1–4.9)	4.4 (2.75–5.5)	5 (2.4–5.45)	5.2 (4.7–5.5)	4.7(3.1–5.3)
CESD-10 Depression Score (n = 81) median (IQR)		9 (6–12)	10.5 (7.5–14)	9 (7.5–13.5)	8.5 (6–12)	9 (6–14)

Binomial exact 95% Confidence interval;

[2] *P-value derived from Fisher's exact text;*

[3] *Blood glucose measured only if had one or more symptoms of diabetes and OR family history;*

[4] *Abdominal obesity: WC > 88 cm female, WC > 102 cm in male.*

Variable: median (IQR) or n (%)		15–17 years: n = 14 (15%)	18–19 years: n = 23 (25%)	20–21 years: n = 26 (28%)	22–24 years: n = 29 (32%)	Total: n = 92
	Significant depression (CESD ≥ 10)	5 (38%)	12 (60%)	8 (33%)	10 (42%)	35 (43%)
Kessler Distress Score (K10) (n = 85) median (IQR)		15 (14–24)	19 (15–25)	18 (12–25)	18.5 (13–25)	19 (13–25)
Categories n (%)	Mentally well (K10 < 20)	7 (54%)	12 (55%)	13 (54%)	15 (58%)	47 (55%)
	Mild distress (K10 20–24)	3 (23%)	3 (14%)	5 (21%)	3 (12%)	14 (16%)
	Moderate distress (K10 25–29)	1 (8%)	5 (23%)	4 (17%)	7 (27%)	17 (20%)
	Severe distress (K10 ≥ 30)	2 (15%)	2 (9%)	2 (8%)	1 (4%)	7 (8%)
Measured Clinical Signs						
BMI in kg/m^2 (n = 87); median (IQR)		20.8 (19.5–24.1)	23.2 (19.3–26.4)	22.1 (20.6–25.9)	24.2 (20.2–27.1)	22.8 (19.9–26.2)
Categories n (%)	Underweight (BMI < 18.5)	2 (14%)	4 (19%)	1 (4%)	3 (10%)	10 (11%)
	Normal weight (18.5 ≤ BMI < 25)	9 (64%)	8 (38%)	15 (60%)	15 (52%)	47 (53%)
	Overweight (25 ≤ BMI < 30)	1 (7%)	7 (33%)	6 (24%)	8 (28%)	22 (25%)
	Obese (BMI ≥ 30)	2 (14%)	2 (10%)	3 (12%)	3 (10%)	10 (11%)
Waist circumference (WC) in cm; median (IQR)		74.5 (71–76)	74.6 (67.5–88)	78.8 (73–85)	79 (71–88)	76 (71.5–87)
	Abdominal obesity[4]	2 (15%)	5 (23%)	4 (12%)	7 (24%)	17 (19%)

Binomial exact 95% Confidence interval;

[2] P-value derived from Fisher's exact text;

[3] Blood glucose measured only if had one or more symptoms of diabetes and OR family history;

[4] Abdominal obesity: WC > 88 cm female, WC > 102 cm in male.

Variable: median (IQR) or n (%)		15–17 years: n = 14 (15%)	18–19 years: n = 23 (25%)	20–21 years: n = 26 (28%)	22–24 years: n = 29 (32%)	Total: n = 92
Hip circumference in cm; median (IQR)		91 (83.5–104)	90.5 (84.8–107)	96.7 (93–107)	95 (90–105)	95 (86.5–106)
Waist-hip ratio (WHR); median (IQR)		0.83 (0.79–0.87)	0.83 (0.77–0.87)	0.82 (0.78–0.85)	0.82 (0.79–0.87)	0.82 (0.78–0.87)
Waist-to-height ratio (WHtR); median (IQR)		0.47 (0.43–0.48)	0.45 (0.43–0.53)	0.48 (0.44–0.52)	0.49 (0.44–0.57)	0.48 (0.44–0.54)
Central obesity	WHR > 0.85 in female and > 0.95 in male	3 (23%)	5 (23%)	3 (8%)	8 (28%)	18 (20%)
	WHtR > 0.5	2 (14%)	9 (39%)	11 (42%)	12 (41%)	34 (37%)
Systolic Blood Pressure in mmHg; median (IQR)		117.5 (112–125.5)	118 (108.5–124.5)	118 (111–131)	117 (107.5–123.5)	117.5 (109.5–125.5)
Diastolic Blood Pressure in mmHg; median (IQR)		73.5 (66.5–77)	75 (67–76.5)	76 (71–80)	74 (68.5–80)	74.25 (68–79.5)
Categories n (%)	Normal BP: SBP < 130 & DBP < 85	11 (79%)	18 (78%)	18 (69%)	22 (76%)	69 (75%)
	Elevated BP: SBP 130–139 or DBP 85–89	3 (21%)	4 (17%)	6 (23%)	5 (17%)	18 (20%)
	Hypertension: SBP 140–159/ DBP 90- 99	0	1 (4%)	2 (8%)	2 (7%)	5 (5%)

Binomial exact 95% Confidence interval;

[2] *P-value derived from Fisher's exact text;*

[3] *Blood glucose measured only if had one or more symptoms of diabetes and OR family history;*

[4] *Abdominal obesity: WC > 88 cm female, WC > 102 cm in male.*

Mental health screening

According to the CESD-10 depression scale, 43% of participants were classified as experiencing significant depression in the past week (95% CI: 32–54%). CESD-10 scores differed significantly by gender with female participants more likely to report depressive symptoms compared to males as shown in Table 6 and Fig. 4 (51% versus 19%, $p = 0.011$). Of those with significant depression, 6/35 (17%)

reported a previous diagnosis of depression or anxiety. There were no significant differences in depression scores by age. Almost half the participants reported some level of psychological distress over the past month (45%; 95% CI: 34–56%) with 8% indicating symptoms of severe psychological distress on the K10 scale (See Fig. 5). Only 11% of those with mild, moderate or severe psychological distress reported previously being diagnosed with depression or anxiety. The prevalence of psychological distress symptoms was comparable across age groups (See Table 7).

Measured Clinical Signs

Overweight/obesity

Overall, 36% of participants were either overweight (25%) or obese (11%), with significant differences by gender; 14% males and 43% of females (See Fig. 7). The median BMI for males (21.0; IQR 19.1–22.6 kg/m^2) was significantly lower than for females (23.3; IQR 20.2–27.2 kg/m^2). A greater proportion of participants aged 18–19 years were overweight or obese (43%) compared to the other age groups (23% in 15–17-year olds; 33% in 20–21-year olds and 38% in 22–24-year olds) (See Table 7).

Abdominal obesity

There was a markedly significant difference in the waist-hip ratio (WHR) of males and females. A total of 27% of females and no males had central obesity as shown in Table 6. Using the WHtR, 44% of females had central obesity compared to 14% of males. Waist circumference increased with age, with those aged 22–24 years having the highest waist circumference of 79 cm (IQR 71–88), but WHR did not differ by age. It is important to note that 12 (26%) participants with normal BMI had abnormal WHR and/or WHtR and could be classified as having central obesity.

Measured Blood Pressure

Overall, 75% of participants had a normal blood pressure, 20% had an elevated blood pressure and 5% had hypertension. Figure 6 shows that the prevalence of elevated blood pressure and hypertension was higher in males compared to females (41% and 20% respectively, $p = 0.0367$). Systolic and diastolic blood pressure showed an increasing trend with age (Table 7). The median age of those with elevated blood pressure or hypertension was 21.2 (IQR 18.8–22.7) years, similar to those with normal blood pressure (median 20.2, IQR: 19.0–22.8 years). Of those with elevated blood pressure or hypertension, 11 (35%) were overweight or obese and 2 (6%) reported a previous diagnosis of hypertension (data not shown in tables).

Discussion

This study describes the prevalence of NCDs and NCD risk factors among South African AYLHIV in an urban setting. Previous studies in sub-Saharan Africa have described NCD comorbidities in adults living with HIV [44, 109–112]. Besides mental health [113–121] and lung diseases [122–126], few studies have assessed the prevalence of NCDs and particularly NCD risk factors in AYLHIV in SSA other than as incidental findings [127–134]. Risk behaviour research on AYLHIV in sub-Saharan Africa has

predominantly focused on sexual risk behaviour [135]. We therefore set out to investigate NCD risk factors given the emerging NCD epidemic in SSA occurring against a background of a high HIV burden and increased comorbidity risk in PLHIV.

We highlight several key findings. Almost half of our participants faced multiple deprivations of poverty, significant symptoms of depression and psychological distress, and multiple risk factors for NCDs. More than a third were overweight or obese, a third had insufficient levels of weekly physical activity and the majority did not meet dietary guidelines for fruit and vegetable intake. There was low nutritional knowledge, particularly on healthy food choices and diet-disease relationships. Tobacco use and exposure and harmful use of alcohol were highly prevalent with male participants engaging in more substance use than females. An alarming pattern of early initiation of high-risk behaviours including underage and binge drinking, smoking and experimentation with cannabis emerged in the youngest age group. A detailed interpretation of these findings, comparisons to the general population and previous findings in PLHIV as well as implications for integrated prevention are discussed below.

76% of participants were female

More than two-thirds of our respondents were female which is consistent with national laboratory data for adolescents in HIV care [136]. This reflects the gendered nature of the HIV epidemic in South Africa, where almost a quarter of all new HIV infections occur in young women aged 15–24 years [137], and much higher rates of health care-seeking among young women compared to young men [42, 138].

44% of AYLHIV were multidimensionally poor

This is higher than national estimates which indicate that 33,4% of young people aged 15–24 years are MPI poor [139]. Nationally 34% of young people aged 15–24 years were not in education, employment, or training (NEET) in 2019 [140]. An “idle” youth population, not only impacts on the social cohesion and safety of a community, but is also linked to uptake of risk behaviours [141]. Although the proportion of NEETs in this study was lower than the national average with 73% of respondents either in education or engaged in income-generating activities, they experienced other deprivations which may interact to exacerbate vulnerability to NCDs and poor mental health. The highest deprivation was in general health and functioning dimension; with 68% experiencing difficulties with general health and functioning, 35% lived in informal housing, and 38% reported experiencing severe food insecurity.

Previous studies in South Africa have demonstrated that HIV/AIDS-affected and infected youth face multiple deprivations of poverty [60, 119], including poor educational outcomes [142], informal housing, lack of basic necessities like warm clothing, toiletries and school fees [143] and food insecurity [144]. Socioeconomic barriers such as poverty and food insecurity are commonly cited challenges for adolescents receiving HIV treatment and care in SSA [145]. This is concerning because socioeconomic factors like food insecurity impact adherence to ART and retention in HIV care [146], which has implications for viral suppression and chronic disease pathways [64, 147, 148]. These factors also have an impact on mental health and may increase susceptibility to alcohol and substance use [149–152].

Addressing this challenge requires a multi-sectoral approach for NCD prevention with appropriate social protection systems to meet the needs of the most vulnerable [143].

36% overweight or obese and 37% had abdominal obesity

More than a third of our respondents were overweight or obese (36%), with significantly more overweight and centrally obese females compared to males. Although our rates of overweight and obesity are slightly lower than prevalence rates for youth in the Western Cape (31.5% overweight and 11.3% obese) [38], the rates for ALYHIV appear similar to obesity trends in the general population. A previous study in adult patients attending primary health care HIV-clinics in South Africa found that more than half of female patients were overweight or obese compared to 16% of male patients [153]. Obesity in PLHIV is well documented in high-income countries and is emerging as a major challenge in Africa [50] with numerous studies showing increased rates of obesity in PLHIV [153–158]. But few studies in Africa have reported on overweight and obesity levels in AYLHIV other than in the context of ART-associated dyslipidaemia [129, 159, 160].

One study conducted among South African university students living with HIV (the majority aged 20–25 years) found that 21% were overweight and 30% were obese [161]. Findings from the United States Adolescent Trials Network showed that more than 40% of behaviourally HIV-infected young women (14–24 years) were overweight or obese [162] and approximately 36% of perinatally HIV-infected adolescents were overweight or obese [163]. Our results are consistent with these findings and confirm results from a folder review conducted in this same population that reported similar levels of overweight and obesity [66]. Overweight and obesity in AYLHIV may accelerate their lifetime risk of cardiovascular diseases, additional to the effects of HIV-infection and exposure to ART [162]. In our study, obesity co-occurred with hypertension – 35% of those with elevated blood pressure or hypertension were also overweight or obese. By screening for obesity, other related conditions which tend to cluster with obesity can also be detected. Closer monitoring of overweight and obesity profiles in young PLHIV in SSA is needed as they transition into adulthood, especially with prolonged exposure to ART regimens which are linked to obesity, altered glucose metabolism and dyslipidaemia [164].

In addition to BMI, we assessed central obesity using waist and hip circumference indicators. We found that 26% of our respondents with normal BMI had high WHR or WHtR, meeting criteria for central obesity. Another South African study in adults attending three HIV-clinics reported a high prevalence of central obesity, primarily in women – 45% (4% in men) [161]. In contrast, in a study conducted in Brazil, only 2.5% of children and adolescents on ART were overweight or obese based on subscapular skinfold thickness and less than 1% had a high WC [165]. In that study, the authors highlight that they expected a higher prevalence of overweight and obesity, but this was likely influenced by parallel gains in height and weight observed in adolescents [165]. In a comparison of anthropometric measures for predicting cardiometabolic risk in HIV patients in Cameroon, Dimala et al found that markers of adiposity like WC, WHR and WHtR are better than BMI at identifying HIV/AIDS patients with increased cardiometabolic risk [166].

The WHO and the International Diabetes Federation (IDF) recommend monitoring changes in waist circumference in addition to measuring BMI, as this can provide an estimate of increased abdominal fat even without a change in BMI, particularly in HIV-positive populations on ARV medication and in female patients who have a higher prevalence of obesity [79, 167]. Waist circumference and WHtR have been shown to be better predictors of cardiovascular disease risk factors in children and adolescents than BMI [168]. Waist-to-height ratio has the additional merit of not being dependent on age, sex or ethnicity, as the standard cut-off value of 0.5 is indicative of an increased cardiometabolic risk universally [107]. These findings underline the importance of anthropometry beyond BMI, especially in females. Anthropometric measurements and calculations are non-invasive, low-cost and easy-to-use interventions that can be used in primary care to identify AYLHIV who are at increased cardiometabolic risk.

High levels of depression and psychological distress

Almost half our participants reported symptoms of psychological distress, compared to less than a quarter of young people nationally [21]. Only 11% of those with mild, moderate or severe psychological distress reported previously being diagnosed with a mental health condition. Mental health conditions are prevalent in AYLHIV in both high-income and resource-limited settings [169]. Our results are generally consistent with prevalence rates of depression among children and adolescents living with HIV from other African countries which ranged from 18.9% in Malawi [67], 25% in Rwanda [170], 27% in Tanzania [171] and 51.2% prevalence of psychological distress in Uganda [172]. These results are difficult to pool together due to non-uniformity in the methods used for mental health screening [169].

Significantly more female participants reported depressive symptoms compared to males (51% compared to 19%) which is in line with global statistics on depression [173]. After the age of 15, girls and women are twice more likely to be depressed compared to boys and men [174]. Our findings show that only 17% of those identified as having significant depression via CESD-10 reported being previously diagnosed with anxiety or depression. In a previous retrospective review in the same population, mental health conditions were documented in less than 5% of folders reviewed [66]. These findings highlight that there is a missed opportunity for identifying youth with mental health problems before suboptimal ART adherence or other adverse HIV, NCD and mental health outcomes occur.

A recent study conducted amongst AYLHIV aged 9–19 years attending a primary care clinic in Johannesburg found that 8% screened positive for symptoms of depression which is much lower than our findings. However, 60% of those study participants were young adolescents aged 9–12 years and almost all were perinatally-infected (92%) [116]. Older adolescents in that study (aged 16–19) were more likely to screen positive for depression compared to younger adolescents, which is in line with our findings of higher depression scores in older adolescents and young adults. It has been documented that perinatally-infected adolescents may present with less psychological problems compared to behaviourally-infected adolescents [119, 175]. But similar rates of mental health conditions have been reported in HIV-exposed but uninfected youth entering adolescence [176]. The use of inappropriate comparison groups in studies showing higher rates of mental health disorders in AYLHIV, makes it difficult to determine whether these impairments are in fact due to HIV-infection or other social

confounding factors. In a recent study conducted in Soweto, South Africa, the authors found similar rates of mental illness in perinatally-infected and uninfected adolescents, suggesting that other contributing social factors prevalent in the community may override the effect of HIV, especially in the era of highly active antiretroviral treatment [177].

Mental health screening is crucial in HIV care due to multiple psychological vulnerabilities associated with living with HIV and high rates of suicide in PLHIV [178–180]. Recommendations calling for integration of mental health services into HIV care have been made for adults [181]. It is important that adolescents are not overlooked in this respect. A study conducted in Johannesburg found that a simple way of identifying youth struggling with mental health problems at primary care level is by asking them about their future aspirations. Those who do not feel like they have control of their future or do not have a dream for the future are more likely to have symptoms of depression, anxiety or PTSD requiring further support [114].

Low nutritional knowledge, especially on healthy food choices

Participants scored less than 40% on general nutrition knowledge questions and particularly had poor knowledge of healthy food choices and associations between diet and diseases. Only 10% recognised that eating thick-cut instead of thin or crinkle cut chips could help reduce the amount of fat in someone's diet and 22% correctly identified that eating less trans-fats can prevent heart disease. To our knowledge, this is the first study to assess nutrition knowledge in AYLHIV in Africa. A South African study in school-going adolescents aged 15–18 years found that 77.5% scored below average on diet and nutrition knowledge questions [182]. The poor knowledge on nutrition-related NCDs amongst AYLHIV in our study is concerning in a country undergoing nutritional transition [183]. Nutrition knowledge is strongly correlated with dietary intake and is needed for better dietary habits [97]. Although adolescents may lack autonomy in navigating their food environment, this life stage is characterised by increasing independence and as such they need to be informed about the importance of diet and how it can affect their current health status or future adult health [182]. Some practices like healthy cooking methods requiring steaming, roasting or baking can be adopted in their homes with cooperation of parents and caregivers [184]. With adequate knowledge, older adolescents in our study who ate more fast-food and more meals prepared outside the home, could be encouraged to make healthier food choices.

High fast-food and SSB consumption, and low physical activity

Almost three-quarters of AYLHIV did not eat fruit daily and almost half did not eat vegetables daily, falling below recommended dietary guidelines of eating at least five portions of fruit and vegetables daily in order to reduce the risk of NCDs [185]. Female participants ate less fruit and ate more fast-food, deep-fried foods and foods with added sugar daily compared to males. Younger adolescents ate less fruits, vegetables and wholegrains compared to older age groups.

More respondents, particularly females, consumed deep-fried foods and fast-foods daily compared to provincial estimates for youth in the Western Cape, while the proportion who consumed SSB daily was lower (29% compared to 42%) [20]. Our results are comparable to local estimates that one in five school-going youth skip breakfast [38]. A recent study on fast food and carbonated soft drink consumption among adolescents aged 12–15 years in 44 LMICs (not including South Africa) found that 44% of adolescents consumed a carbonated soft drink at least once per day in the past month [186]. A meta-analysis on SSB intake found that individuals who consumed 1–2 servings per day, had a 26% greater risk of developing type 2 diabetes, and a 20% greater risk of metabolic syndrome compared to those who did not consume SSB or had less than one serving/month [187]. In order to promote healthy diet, a multi-sectoral approach that promotes a healthy food environment is required. The South African government has made strides in promoting healthier food environments by implementing mandatory legislation for salt reduction in processed foods in June 2016 [188] and a tax on sugar-sweetened beverages in April 2018 [189]. These measures were introduced in efforts to reduce the prevalence of hypertension, obesity, NCDs and excess salt and sugar consumption [190]. More efforts are needed to translate these measures into action at a community and household level, especially amongst young girls who have higher prevalence of obesity which is likely to persist till adulthood without intervention.

Our results support findings of gender differences in physical activity levels among South African adolescents similar to global reports [191, 192]. Despite more than two-thirds of our respondents using active transport; either walking to and from school or work, fewer than one-third had sufficient levels of physical activity necessary to promote health and prevent chronic diseases. Almost half spent three or more hours per day of their leisure time sedentary. This is similar to physical inactivity levels reported in urban-based South African students [191]. Sedentary behaviour was higher than general population estimates which showed that 30% of youth watched TV or played computer games for over three hours per day [38] and higher than estimates from other LMICs which found that 27.0% of adolescents engaged in three or more hours of sedentary behaviour per day. Our results are consistent with those from a study in Brazil which found that 71% of ALHIV were sedentary with a higher proportion among girls [193]. Another study conducted in Botswana, found that youth living with HIV had significantly lower levels of daily PA compared to uninfected controls [129]. Similarly, a study in Brazil in 10–15-year-old perinatally-infected adolescents and age-sex matched controls also found that participants living with HIV had lower physical activity scores compared to healthy peers [194]. Additional research is needed in this setting to explore the relationship between PA and HIV in adolescents. A study with an age-and sex-matched uninfected control group from the same community would help to elucidate whether this relationship exists in South Africa.

Early initiation of high-risk behaviours (smoking, alcohol, drugs)

The median age at smoking initiation of 16 years found in our study was similar to the national average of 15.8 years for youth aged 15–24 years. However, our findings that 48% of male and 25% of female AYLHIV smoked daily or occasionally was much higher than national estimates for young people aged

15–24 years reported in the 2016 Demographic and Health Survey (29% of males and 5% of females [20]). Furthermore, almost half of those in the youngest age group reported at least occasional cigarette smoking in the past month and used more alternative tobacco products like water-pipes compared to older age groups. Young adolescents in South Africa increasingly use water-pipes (known as hookah pipes) which are often available without restriction [195, 196]. Our results likely reflect trends in the Western Cape – the province with the highest prevalence of tobacco smoking in South Africa– where a quarter of school-going youth are current smokers [38] and the mean age of smoking initiation is significantly lower than the national average at 14.5 years [21]. There are only a few studies, most from high-income settings, that address the prevalence of smoking among AYLHIV [197–199]. These studies report higher rates of smoking among AYLHIV compared to the general population, particularly among those who were behaviourally-infected [200]. Our findings corroborate this and add to the limited literature from low and middle-income settings.

Smoking increases the vulnerability of PLHIV for adverse lung health and multiplies their risk of developing cardiovascular diseases compared to HIV-negative smokers [201–203]. Smoking often co-occurs with other health risk behaviours like alcohol consumption [204]. More than half (58%) of current smokers in our study had also drunk alcohol in the preceding month. Our results also indicate higher rates of current alcohol consumption compared to national estimates for South African youth (41% versus 33%) [38]. A few studies in SSA have reported higher occurrence of alcohol consumption in AYLHIV compared to HIV-negative adolescents [135]. Auvert et al reported that 29% of AYLHIV in a South African mining town drank alcohol at least once a month although this study was conducted almost 20 years ago [134]. Another study conducted in Zimbabwe reported that 5.6% of adolescent females living with HIV drank alcohol in past month, compared to 4.5% of HIV-negative females [133]. Several studies conducted in young people from other regions have reported increased alcohol and drug use especially among male AYLHIV [205]. Our results suggest that this may be the case, but further research is needed in South Africa and SSA to elucidate whether HIV infection is associated with increased alcohol consumption in young people living in settings like South Africa where heavy drinking is endemic [22].

Our respondents reported higher rates of binge drinking in the past month compared to estimates for the general population [20] (21% of females and 37% of males in our study, compared to 5% and 21% nationally). Alarmingly, half of the underage respondents (< 18 years) were current drinkers and 55% of them engaged in recent binge drinking. Males reported significantly more use of illegal drugs or substances to-get-high compared to females. Previous studies on risk behaviour among AYLHIV in SSA report a high prevalence of alcohol and substance use behaviour, especially among males in late adolescence [135, 206]. In a study conducted amongst young people aged 15–26 years in the rural Eastern Cape province of South Africa, 4% of female AYLHIV reported problem alcohol drinking and 5% reported ever using drugs [131], whilst 31% of male AYLHIV reported problem drinking and 54% reported ever using drugs [132]. Alcohol and drug use did not differ from HIV-uninfected young people residing in the same setting [131].

The Western Cape has significant rates of stimulant use such as methamphetamine and cocaine compared to the rest of the country [207]. Approximately 5% of learners in the Western Cape have used methamphetamine within their lifetime [208]. Our findings may indicate a general underlying substance use problem in young people in this setting, not necessarily related to HIV, but which predisposes AYLHIV to more vulnerability. High rates of substance use and implications for brain development, particularly amongst males and younger adolescents, is concerning and warrants targeted intervention. Prevention and early intervention strategies aimed at harm reduction are needed that incorporate environmental factors beyond individual behaviour.

Other NCD comorbidity

Our blood pressure findings are consistent with findings from studies in general adolescents in urban South Africa which have reported hypertension prevalence rates ranging from 8–16% [209] and elevated BP prevalence of 35% [210]. Chatterton-Kirchmeier et al reported a significantly higher prevalence of elevated blood pressure in a cohort of HIV-infected, predominantly African-American adolescents and young adults in the US compared to healthy children [211]. Globally, studies involving HIV-infected adults have demonstrated higher hypertension prevalence than the general population [212] and hypertension has been found to be associated with ART [213, 214]. One in five young adults (18–35 years) attending an HIV clinic in the same setting in Khayelitsha had comorbid hypertension [65]. There is no clear link in the literature between HIV infection and elevated BP in paediatric populations. Nevertheless, routine monitoring of blood pressure in HIV care, even in younger populations, is warranted in settings like South African with a high background prevalence of hypertension, in order to avert future disease. This is especially relevant in light of evidence that blood pressure trajectories in childhood and adolescence predict future elevated BP and cardiovascular risk in adulthood [209, 210, 215].

None of the 25% with self-reported diabetes symptoms in our study had an abnormal measured random blood glucose. In a cohort study of South African youth living with perinatally-acquired HIV, the authors found a high prevalence of insulin resistance but it did not differ from that in uninfected age-matched adolescents [128]. A systematic review and meta-analysis of African studies, recently reported that there was no statistically significant association between HIV infection or ART exposure and type 2 diabetes (T2DM) prevalence in adults [216]. This is in contrast with study findings from European and North American settings that have shown a higher prevalence of T2DM in HIV-infected adults particularly those on ART [217–219]. However, the cumulative incidence of T2DM in patients with HIV across Africa was higher than international incidence data for HIV-infected individuals. The International Diabetes Federation estimates that 60% of people with diabetes in Africa are undiagnosed [220] suggesting that T2DM might be a major, underdiagnosed public health problem in African populations in general due to the presence of traditional risk factors.

Strengths and Limitations

Our study adds to the limited evidence base on NCD prevalence and risk factors in AYLHIV in sub-Saharan Africa. To our knowledge, only four other studies in sub-Saharan Africa have investigated

modifiable NCD risk factors besides alcohol and substance use in AYLHIV [127, 129, 161, 221]. While our study provides novel findings for the sub-Saharan African context, the findings should be interpreted within the following limitations. Firstly, participants were recruited using convenience sampling from healthcare facilities in a peri-urban setting. Second, there was an almost 50% non-response rate. The low response rate and lack of random sampling may limit the generalizability of our findings, however sampling from six different facilities across all substructures in the City of Cape Town, proportional to the total numbers of AYLHIV within each substructure) mitigated unmeasured facility-specific effects. Limited participation and low response rates are a major challenge in adolescent research due to the complexities of enrolment and consent procedures [222, 223]. Although we recruited younger adolescents, requiring parental consent may have led to participant bias as the majority enrolled were older adolescents and young adults (aged ≥ 18 years) who could provide independent consent to participate. We therefore conducted an age-stratified analysis of participant characteristics.

Although we were not statistically powered to detect differences by gender or age groups, some clear differences emerged particularly gender differences in physical activity, obesity levels and mental health which have been previously documented. Striking differences in high-risk behaviours were also identified in the younger age group. Due to the cross-sectional design, we were unable to establish temporality and whether NCD risk factors and risky behaviours preceded an HIV diagnosis amongst behaviourally-infected youth. Our study did not include a control group of HIV-uninfected adolescents, neither did we differentiate between perinatally and behaviourally-infected adolescents who may have very different risk profiles [57, 119]. Nevertheless, since young people come from the same communities and access the same HIV services, irrespective of mode of transmission, interventions targeting risk factors generally may be more effective.

We used subjective recall methods of measuring physical activity which may be prone to over-reporting [224, 225], recall bias and cultural misinterpretation [226, 227]. However, self-report methods like the IPAQ have acceptable validity and are most widely used to measure physical activity in PLHIV [51]. The use of point-of-care random blood glucose testing may have underestimated diabetes risk, however, POC methods are better suited for community screening of diabetes, have high specificity (90%) and provide reliable and immediate results [228, 229]. Similarly, the mental health tools used are screening tools– a diagnosis of depression or anxiety was not confirmed using these tools. But they are appropriate for case-finding in primary care and have been validated in HIV-positive populations in South Africa [103, 230]. Despite using a self-administered questionnaire, there remains a possibility that social desirability or other reporting biases may affect reports of mental health and substance use, with potential for underreporting. To minimise this risk, we used tablet computers for data collection which have been found to reduce reporting bias on sensitive questions [231, 232]. Moreover, the reported rates were still significant and if underreported, warrant further attention. Despite these limitations, this study is an important contribution to the limited literature in sub-Saharan Africa.

Conclusions

This paper contributes to a key gap in the literature on NCD risk in AYLHIV in SSA. The findings highlight the existence of cardiometabolic risk factors (obesity, abdominal obesity, hypertension, physical inactivity, unhealthy diet), smoking, excessive drinking, and mental health problems in this vulnerable population, highlighting the need for NCD screening and integrated primary and secondary prevention.

NCDs and their ensuing burden of disability and premature mortality are costly to health systems and to wider societal development. Beyond primary care, the complex and interlinked social, economic and environmental factors that influence these behaviours highlight the importance of intersectoral action for disease prevention. It is therefore necessary to go beyond the healthcare sector to address the root causes and multiple deprivations that increase the risk of NCDs and ill-health, and to support equitable access to the necessary physical and social infrastructure required to make the healthy choice the easy choice. Upstream strategies that incorporate the basic living conditions and environments in which young people live are necessary to ensure well-being and interrupt disease pathways. More studies are needed to assess risk factors at a broader socio-ecological level and explore inter-relationships between NCD/HIV comorbidity and the environment in order to identify effective and sustainable risk-reduction interventions.

Abbreviations

AYLHIV
Adolescents and youth living with HIV;
BMI
Body mass index;
BP
Blood pressure;
CESD-10
Centre for Epidemiological Studies Short Depression Scale;
CMNN
Communicable, Maternal, Neonatal, and Nutritional;
FFQ
Food frequency questionnaire;
GNKQ
General Nutrition Knowledge Questionnaire;
HFIAS
Household Food Insecurity Access Scale;
IPAQ
International Physical Activity Questionnaire;
K10
Kessler Psychological Distress Scale;
LMIC
Low- and middle-income countries;

MET
Metabolic equivalent of task;
NCD
Non-communicable disease;
NEET
Neither in education, employment or training;
PA
Physical activity;
PLHIV
People living with HIV;
SSA
Sub-Saharan Africa;
SSB
Sugar-sweetened beverages;
SANHANES
South African National Health and Nutrition Examination Survey;
WC
Waist circumference;
WHR
Waist-hip ratio;
WHtR
Waist-to-height ratio;
YMPI
Youth Multidimensional Poverty Index;
YRBS
Youth Risk Behaviour Survey;

References

1. Naghavi M. Global, regional, and national burden of suicide mortality 1990 to 2016: systematic analysis for the Global Burden of Disease Study 2016. *BMJ.* 2019:l94.
2. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1211-1259.
3. Naghavi M, Abajobir AA, Abbafati C, et al. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1151-1210.
4. World Health Organization. *Noncommunicable diseases progress monitor 2020.* Geneva: World Health Organization; 10 February 2020 2020. 978-92-4-000049-0.

5. Reitsma MB, Fullman N, Ng M, et al. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990–2015: a systematic analysis from the Global Burden of Disease Study 2015. *Lancet.* 2017;389(10082):1885-1906.
6. Forouzanfar MH, Afshin A, Alexander LT, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet.* 2016;388(10053):1659-1724.
7. Degenhardt L, Charlson F, Ferrari A, et al. The global burden of disease attributable to alcohol and drug use in 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Psychiatry.* 2018;5(12):987-1012.
8. Griswold MG, Fullman N, Hawley C, et al. Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2018;392(10152):1015-1035.
9. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet.* 2012;380(9838):219-229.
10. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *Lancet Glob. Health.* 2018;6(10):e1077-e1086.
11. Afshin A, Sur PJ, Fay KA, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet.* 2019;393(10184):1958-1972.
12. James SL, Abate D, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet.* 2018;392(10159):1789-1858.
13. Stein DJ, Benjet C, Gureje O, et al. Integrating mental health with other non-communicable diseases. *BMJ.* 2019:l295.
14. World Health Organization. Noncommunicable diseases. 2018; Media centre, Fact sheet Available at: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases. Accessed 21 April 2020, 2020.
15. Gouda HN, Charlson F, Sorsdahl K, et al. Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: results from the Global Burden of Disease Study 2017. *Lancet Glob. Health.* 2019;7(10):e1375-e1387.
16. Pillay-Van Wyk V, Msemburi W, Laubscher R, et al. Mortality trends and differentials in South Africa from 1997 to 2012: second National Burden of Disease Study. *Lancet Glob. Health.* 2016;4(9):e642-e653.

17. Remais JV, Zeng G, Li G, Tian L, Engelgau MM. Convergence of non-communicable and infectious diseases in low-and middle-income countries. *Int J Epidemiol.* 2013;42(1):221-227.
18. World Health Organization. Report on the status of major health risk factors for noncommunicable diseases: WHO African Region, 2015. 2016.
19. Kengne AP. Trends in obesity and diabetes across Africa from 1980 to 2014: an analysis of pooled population-based studies. *Int J Epidemiol.* Oct 1 2017;46(5):1421-1432.
20. National Department of Health (NDoH); Statistics South Africa (Stats SA); South African Medical Research Council (SAMRC); ICF. South Africa demographic and health survey 2016.
21. Shisana O. *The South African National Health and Nutrition Examination Survey: SANHANES-1*: HSRC press; 2013.
22. World Health Organization. *Global status report on alcohol and health 2018*: World Health Organization; 2019.
23. Bennett JE, Stevens GA, Mathers CD, et al. NCD Countdown 2030: worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4. *Lancet.* 2018;392(10152):1072-1088.
24. Steinberg L, Morris AS. Adolescent development. *J Cogn Educ Psychol.* 2001;2(1):55-87.
25. World Health Organization. *The second decade: improving adolescent health and development*: Geneva: World Health Organization;2001.
26. World Health Organization. Orientation programme on adolescent health for health care providers. 2006.
27. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N. Engl. J. Med.1997;337(13):869-873.
28. Daniels SR. The consequences of childhood overweight and obesity. *Future Child.* 2006;16(1):47-67.
29. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics.* 1999;103(6):1175-1182.
30. Freedman DS, Khan LK, Dietz WH, Srinivasan SR, Berenson GSJP. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa Heart Study. 2001;108(3):712-718.
31. Reilly JJ, Methven E, McDowell ZC, et al. Health consequences of obesity. Health consequences of obesity. *Arch. Dis. Child.* 2003 Sep 1;88(9):748-52.
32. Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry.* 2005;62(6):593-602.
33. Sawyer SM, Afifi RA, Bearinger LH, et al. Adolescence: a foundation for future health. *Lancet.* Apr 28 2012;379(9826):1630-1640.
34. Azzopardi P. Adolescent health comes of age. *Lancet.* 2012;379(9826):1583-1584.

35. Statistics South Africa. Statistical release P0302: mid-year population estimates. Available at: https://www.statssa.gov.za/publications/P0302/P03022016.pdf. Accessed June 04, 2020.
36. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014 Aug 30;384(9945):766-81.
37. Rossouw HA, Grant CC, Viljoen M. Overweight and obesity in children and adolescents: The South African problem. *S. Afr. J. Sci.* 2012;108(5-6):31-37.
38. Reddy S, James S, Sewpaul R, et al. Umthente uhlaba usamila: the 3rd South African national youth risk behaviour survey 2011. 2013.
39. Otwombe K, Dietrich J, Laher F, et al. Health-seeking behaviours by gender among adolescents in Soweto, South Africa. *Glob Health Action.* 2015;8(1):25670.
40. UNAIDS. 2016; Available at: http://aidsinfo.unaids.org/. Accessed 15 June 2017, 2017.
41. Sohn AH, Hazra R. The changing epidemiology of the global paediatric HIV epidemic: keeping track of perinatally HIV-infected adolescents. *J Int AIDS Soc.* 2013;16:18555.
42. Dellar RC, Dlamini S, Karim QA. Adolescent girls and young women: key populations for HIV epidemic control. *J Int AIDS Soc.* 2015;18(2(Suppl 1)):19408.
43. Battles HB, Wiener LS. From adolescence through young adulthood: psychosocial adjustment associated with long-term survival of HIV. *J Adolesc Health.* 2002;30(3):161-168.
44. Achwoka D, Waruru A, Chen TH, et al. Noncommunicable disease burden among HIV patients in care: a national retrospective longitudinal analysis of HIV-treatment outcomes in Kenya, 2003-2013. *BMC Public Health.* Apr 3 2019;19(1):372.
45. Miller TL, Borkowsky W, DiMeglio LA, et al. Metabolic abnormalities and viral replication are associated with biomarkers of vascular dysfunction in HIV-infected children. *HIV Med.* 2012;13(5):264-275.
46. Deeks SG. HIV infection, inflammation, immunosenescence, and aging. *Annu. Rev. Med.* 2011;62:141.
47. Agwu AL, Fairlie L. Antiretroviral treatment, management challenges and outcomes in perinatally HIV-infected adolescents. *J Int AIDS Soc.* 2013;16(1).
48. Eckard AR, Mora S. Bone health in HIV-infected children and adolescents. *Curr Opin HIV AIDS.* 2016;11(3):294-300.
49. Eckard AR, Fowler SL, Haston JC, Dixon TC. Complications of Treatment in Youth with HIV. *Curr. HIV/AIDS Rep.* 2016;13(4):1-8.
50. Deeks SG, Lewin SR, Havlir DV. The End of AIDS: HIV Infection as a Chronic Disease. *Lancet.* 10/23 2013;382(9903):1525-1533.
51. Vancampfort D, Mugisha J, De Hert M, et al. Global physical activity levels among people living with HIV: a systematic review and meta-analysis. *Disabil. Rehabil.* 2018;40(4):388-397.

52. Reynolds NR. Cigarette smoking and HIV: more evidence for action. *AIDS Educ Prev.* Jun 2009;21(3 Suppl):106-121.
53. Petrosillo N, Cicalini S. Smoking and HIV: time for a change? *BMC Med.* 2013;11(1):16.
54. Scott-Sheldon LAJ, Walstrom P, Carey KB, Johnson BT, Carey MP. Alcohol Use and Sexual Risk Behaviors among Individuals Infected with HIV: A Systematic Review and Meta-Analysis 2012 to Early 2013. *Curr. HIV/AIDS Rep.* 2013;10(4):314-323.
55. Kalichman S, Mathews C, Banas E, Kalichman M. Alcohol-related intentional nonadherence to antiretroviral therapy among people living with HIV, Cape Town, South Africa. *AIDS Care.* 2019;31(8):951-957.
56. Kader R, Govender R, Seedat S, Koch JR, Parry C. Understanding the Impact of Hazardous and Harmful Use of Alcohol and/or Other Drugs on ARV Adherence and Disease Progression. *PLoS One.* 2015;10(5):e0125088.
57. Mellins CA, Malee KM. Understanding the mental health of youth living with perinatal HIV infection: lessons learned and current challenges. *J Int AIDS Soc.* 2013;16(1).
58. Betancourt TS, Rubin-Smith JE, Beardslee WR, Stulac SN, Fayida I, Safren S. Understanding locally, culturally, and contextually relevant mental health problems among Rwandan children and adolescents affected by HIV/AIDS. *AIDS Care.* 2011;23(4):401-412.
59. Langhaug LF, Pascoe SJ, Mavhu W, et al. High prevalence of affective disorders among adolescents living in Rural Zimbabwe. *J Community Health.* 2010;35(4):355-364.
60. Cluver L, Gardner F, Operario D. Poverty and psychological health among AIDS-orphaned children in Cape Town, South Africa. *AIDS Care.* 2009;21(6):732-741.
61. Murphy DA, Durako SJ, Moscicki A-B, et al. No change in health risk behaviors over time among HIV infected adolescents in care: role of psychological distress. *J Adolesc Health.* 2001;29(3):57-63.
62. Mellins CA, Elkington KS, Bauermeister JA, et al. Sexual and Drug Use Behavior in Perinatally HIV–Infected Youth: Mental Health and Family Influences. *J Am Acad Child Adolesc Psychiatry.* 2009;48(8):810-819.
63. Anand P, Springer SA, Copenhaver MM, Altice FL. Neurocognitive Impairment and HIV Risk Factors: A Reciprocal Relationship. *AIDS Behav.* 2010;14(6):1213-1226.
64. Innes S, Patel K. Noncommunicable diseases in adolescents with perinatally acquired HIV-1 infection in high-income and low-income settings. *Curr Opin HIV AIDS.* May 2018;13(3):187-195.
65. Oni T, Youngblood E, Boulle A, McGrath N, Wilkinson RJ, Levitt NS. Patterns of HIV, TB, and non-communicable disease multi-morbidity in peri-urban South Africa- a cross sectional study. *BMC Infect. Dis.* 2015;15:20.
66. Kamkuemah M, Gausi B, Oni T. Missed opportunities for NCD multimorbidity prevention in adolescents and youth living with HIV in urban South Africa. *BMC Public Health.* 2020;20(821).
67. Kim MH, Mazenga AC, Yu X, et al. Factors associated with depression among adolescents living with HIV in Malawi. *BMC Psychiatry.* Oct 26 2015;15:264.

68. Senyonyi RM, Underwood LA, Suarez E, Musisi S, Grande TL. Cognitive behavioral therapy group intervention for HIV transmission risk behavior in perinatally infected adolescents. *Health.* 2012;04(12):1334-1345.
69. Mbalinda SN, Kiwanuka N, Kaye DK, Eriksson LE. Reproductive health and lifestyle factors associated with health-related quality of life among perinatally HIV-infected adolescents in Uganda. *Health Qual. Life Outcomes.* 2015;13(1).
70. Western Cape Government 2017 Socio-economic Profile: City of Cape Town. Department of Social Development, ed. Cape Town. 2017.
71. Western Cape Government. Annual Performance Plan 2016 - 2017. Health Department, ed. Cape Town. 2016.
72. Republic of South Africa National Department of Health. The 2015 national antenatal sentinel HIV & syphilis survey, South Africa. 2017.
73. Republic of South Africa National Department of Health. The 2012 National Antenatal Sentinel HIV & Herpes Simplex Type-2 Prevalence Survey in South Africa. 2013
74. Cape Metro Health District. CAPE METRO DISTRICT HEALTH PLAN 2018/19 - 2020/21. District Management Team, ed. Cape Town. 2018.
75. Statistics South Africa. Mortality and Causes of Death in South Africa, 2016: Findings from Death Notification: Statistics South Africa; 2018.
76. Western Cape Government. Annual Performance Plan 2019. Health Department, ed. Cape Town. 2019.
77. City of Cape Town. *City of Cape Town – 2011 Census - Cape Flats Planning District.* Cape Town. 2013.
78. City of Cape Town. 2016 Socio-economic Profile: City of Cape Town. 2016.
79. World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008. 2011.
80. Miller MR, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J.* 2005;26(2):319-338.
81. Klein H. Adolescence, youth, and young adulthood: Rethinking current conceptualizations of life stage. *Youth Soc.* 1990;21(4):446-471.
82. Statistics South Africa. Census Questionnaire. 2011; Available at: http://www.statssa.gov.za/?page_id=3852. Accessed 29 April, 2020.
83. Alkire S, Santos ME. Acute multidimensional poverty: A new index for developing countries. 2010.
84. Frame E, De Lannoy A, Leibbrandt M. Measuring multidimensional poverty among youth in South Africa at the sub-national level. 2016.
85. Alkire S, Conconi A, Pinilla-Roncancio M, Vaz A. How to Build a National Multidimensional Poverty Index (MPI): Using the MPI to inform the SDGs.2018

86. Ballard T, Coates J, Swindale A, Deitchler M. Household hunger scale: indicator definition and measurement guide. Washington, DC: Food and Nutrition Technical Assistance II Project, FHI. 2011 Aug;360.
87. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3. 2007.
88. Craig C, Marshall A, Sjostrom M, et al. International Physical Activity Questionnaire-Short Form. 2017.
89. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc.* 2003;35(8):1381-1395.
90. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc.* 2000;32(9):S498-S516.
91. IPAQ Research Committee. Guidelines for the data processing and analysis of the International Physical Activity Questionnaire. 2005.
92. World Health Organization. WHO Global recommendations on physical activity for health. Geneva: World Health Organization; 2011. Geneva, Switzerland: World Health Organization; 2011.
93. Guthold R, Cowan MJ, Autenrieth CS, Kann L, Riley LM. Physical activity and sedentary behavior among schoolchildren: a 34-country comparison. *J Pediatr.* 2010;157(1):43-49. e41.
94. Katzmarzyk PT, Barreira TV, Broyles ST, et al. The international study of childhood obesity, lifestyle and the environment (ISCOLE): design and methods. *BMC Public Health.* 2013;13(1):900.
95. Saloheimo T, González SA, Erkkola M, et al. The reliability and validity of a short food frequency questionnaire among 9–11-year olds: a multinational study on three middle-income and high-income countries. *Int J Obes (Lond)* 2015;5(S2):S22-S28.
96. Kliemann N, Wardle J, Johnson F, Croker H. Reliability and validity of a revised version of the General Nutrition Knowledge Questionnaire. *Eur J Clin Nutr.* 2016;70(10):1174-1180.
97. Wardle J, Parmenter K, Waller J. Nutrition knowledge and food intake. *Appetite.* 2000;34(3):269-275.
98. Karl Peltzer K-N. Nutrition knowledge among a sample of urban black and white South Africans. *South Afr J Clin Nutr.* 2004;17(1):24-31.
99. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: Evaluation of a short form of the CES-D. *Am J Prev Med.* 1994;10(2):77-84.
100. Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1(3):385-401.
101. Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. *Arch. Gen. Psychiatry.* 2003;60(2):184-189.
102. Myer L, Smit J, Roux LL, Parker S, Stein DJ, Seedat S. Common mental disorders among HIV-infected individuals in South Africa: prevalence, predictors, and validation of brief psychiatric rating scales. *AIDS patient care and STDs.* 2008;22(2):147-158.

103. Spies G, Kader K, Kidd M, et al. Validity of the K-10 in detecting DSM-IV-defined depression and anxiety disorders among HIV-infected individuals. *AIDS Care.* 2009;21(9):1163-1168.

104. Radloff LS. The use of the Center for Epidemiologic Studies Depression Scale in adolescents and young adults. *J Youth Adolesc.* 1991;20(2):149-166.

105. Andrews G, Slade T. Interpreting scores on the Kessler psychological distress scale (K10). *Aust N Z J Public Health.* 2001;25(6):494-497.

106. Barlow SE. Expert Committee Recommendations Regarding the Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity: Summary Report. *Pediatrics.* 2007;120(Supplement 4):S164-S192.

107. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. *Nutr Res Rev.* 2010;23(2):247-269.

108. Seedat Y, Rayner B, Veriava Y. South African hypertension practice guideline 2014. *Cardiovasc J Afr.* 2014;25(6):288.

109. Smit M, Olney J, Ford NP, et al. The growing burden of noncommunicable disease among persons living with HIV in Zimbabwe. *AIDS.* Mar 27 2018;32(6):773-782.

110. Meghji J, Nadeau G, Davis KJ, et al. Noncommunicable Lung Disease in Sub-Saharan Africa. A Community-based Cross-Sectional Study of Adults in Urban Malawi. *Am J Respir Crit Care Med.* Jul 1 2016;194(1):67-76.

111. Sobieszczyk ME, Werner L, Mlisana K, et al. Metabolic Syndrome After HIV Acquisition in South African Women. *J Acquir Immune Defic Syndr.* Dec 1 2016;73(4):438-445.

112. Patel P, Rose CE, Collins PY, et al. Noncommunicable diseases among HIV-infected persons in low-income and middle-income countries: a systematic review and meta-analysis. *AIDS (London, England).* 2018;32(Suppl 1):S5.

113. Wright J, Lubben F, Mkandawire MB. Young Malawians on the interaction between mental health and HIV/AIDS. *Afr J AIDS Res.* Nov 2007;6(3):297-304.

114. Woollett N, Cluver L, Bandeira M, Brahmbhatt H. Identifying risks for mental health problems in HIV positive adolescents accessing HIV treatment in Johannesburg. *J Child Adolesc Ment Health.* May 2017;29(1):11-26.

115. Willis N, Mavhu W, Wogrin C, Mutsinze A, Kagee A. Understanding the experience and manifestation of depression in adolescents living with HIV in Harare, Zimbabwe. *PLoS One.* 2018;13(1):e0190423.

116. West N, Schwartz S, Mudavanhu M, et al. Mental health in South African adolescents living with HIV. *AIDS Care.* Jan 2019;31(1):117-124.

117. Webster KD, de Bruyn MM, Zalwango SK, et al. Caregiver socioemotional health as a determinant of child well-being in school-aged and adolescent Ugandan children with and without perinatal HIV exposure. *Trop Med Int Health.* May 2019;24(5):608-619.

118. Taylor Salisbury T, Kinyanda E, Levin J, et al. Clinical correlates and adverse outcomes of ADHD, disruptive behavior disorder and their co-occurrence among children and adolescents with HIV in Uganda. *AIDS Care.* Mar 19 2020:1-9.
119. Sherr L, Cluver LD, Toska E, He E. Differing psychological vulnerabilities among behaviourally and perinatally HIV infected adolescents in South Africa - implications for targeted health service provision. *AIDS Care.* Jun 2018;30(sup2):92-101.
120. Sam-Agudu NA, Pharr JR, Bruno T, et al. Adolescent Coordinated Transition (ACT) to improve health outcomes among young people living with HIV in Nigeria: study protocol for a randomized controlled trial. *Trials.* Dec 14 2017;18(1):595.
121. Ramaiya MK, Sullivan KA, K OD, et al. A Qualitative Exploration of the Mental Health and Psychosocial Contexts of HIV-Positive Adolescents in Tanzania. *PLoS One.* 2016;11(11):e0165936.
122. Desai SR, Nair A, Rylance J, et al. Human immunodeficiency virus-associated chronic lung disease in children and adolescents in Zimbabwe: chest radiographic and high-resolution computed tomographic findings. *Clin Infect Dis.* 2018 Jan 6;66(2):274-81.
123. Githinji LN, Gray DM, Hlengwa S, Myer L, Zar HJ. Lung Function in South African Adolescents Infected Perinatally with HIV and Treated Long-Term with Antiretroviral Therapy. *Ann. Am. Thorac. Soc.* 2017;14(5):722-729.
124. Rylance J, McHugh G, Metcalfe J, et al. Chronic lung disease in HIV-infected children established on antiretroviral therapy. *AIDS.* Nov 28 2016;30(18):2795-2803.
125. Mwalukomo T, Rylance SJ, Webb EL, et al. Clinical Characteristics and Lung Function in Older Children Vertically Infected With Human Immunodeficiency Virus in Malawi. *J. Pediatric Infect. Dis. Soc.* 2016;5(2):161-169.
126. Ferrand RA, Desai SR, Hopkins C, et al. Chronic lung disease in adolescents with delayed diagnosis of vertically acquired HIV infection. *Clin Infect Dis.* Jul 2012;55(1):145-152.
127. Ssewanyana D, Newton CR, van Baar A, et al. Beyond Their HIV Status: the Occurrence of Multiple Health Risk Behavior Among Adolescents from a Rural Setting of Sub-Saharan Africa. *Int J Behav Med.* Mar 25 2020.
128. Frigati LJ, Jao J, Mahtab S, et al. Insulin Resistance in South African Youth Living with Perinatally Acquired HIV Receiving Antiretroviral Therapy. *AIDS Res. Hum. Retroviruses.* 2019;35(1):56-62.
129. Malete L, Tladi DM, Etnier JL, Makhanda J, Anabwani GM. Examining psychosocial correlates of physical activity and sedentary behavior in youth with and without HIV. *PLoS One.* 2019;14(12):e0225890.
130. Gleason RL, Jr., Caulk AW, Seifu D, et al. Efavirenz and ritonavir-boosted lopinavir use exhibited elevated markers of atherosclerosis across age groups in people living with HIV in Ethiopia. *J Biomech.* Sep 6 2016;49(13):2584-2592.
131. Jewkes R, Dunkle K, Nduna M, et al. Factors associated with HIV sero-status in young rural South African women: connections between intimate partner violence and HIV. *Int J Epidemiol.* 2006;35(6):1461-1468.

132. Jewkes R, Dunkle K, Nduna M, et al. Factors associated with HIV sero-positivity in young, rural South African men. *Int J Epidemiol.* 2006;35(6):1455-1460.

133. Gavin L, Galavotti C, Dube H, et al. Factors associated with HIV infection in adolescent females in Zimbabwe. *J Adolesc Health.* 2006;39(4):596. e511-596. e518.

134. Auvert B, Ballard R, Campbell C, et al. HIV infection among youth in a South African mining town is associated with herpes simplex virus-2 seropositivity and sexual behaviour. *AIDS.* 2001;15(7):885-898.

135. Ssewanyana D, Mwangala PN, Van Baar A, Newton CR, Abubakar A. Health risk behaviour among adolescents living with HIV in sub-Saharan Africa: a systematic review and meta-analysis. *BioMed Res. Int.* 2018;2018.

136. Maskew M, Bor J, MacLeod W, Carmona S, Sherman GG, Fox MP. Adolescent HIV treatment in South Africa's national HIV programme: a retrospective cohort study. *Lancet HIV.* 2019;6(11):e760-e768.

137. Shisana O, Rehle T, Simbayi LC, et al. South African national HIV prevalence, incidence and behaviour survey, 2012. 2014.

138. Shisana O, Rice K, Zungu N, Zuma K. Gender and poverty in South Africa in the era of HIV/AIDS: a quantitative study. *J Womens Health (Larchmt).* Jan 2010;19(1):39-46.

139. Statistics South Africa. Living Conditions of Households in South Africa 2014/2015. In: Africa SS, ed. Pretoria2017.

140. Statistics South Africa. Quarterly Labour Force Survey, Quarter 1: 2019: Statistics South Africa Pretoria; 2019.

141. Hall K, De Lannoy A. Children’s access to education. *ChildGauge.* 2019.

142. Orkin M, Boyes ME, Cluver LD, Zhang Y. Pathways to poor educational outcomes for HIV/AIDS-affected youth in South Africa. *AIDS Care.* 2014;26(3):343-350.

143. Cluver LD, Orkin FM, Campeau L, et al. Improving lives by accelerating progress towards the UN Sustainable Development Goals for adolescents living with HIV: a prospective cohort study. *Lancet Child Adolesc. Health.* Apr 2019;3(4):245-254.

144. Young S, Wheeler AC, McCoy SI, Weiser SD. A review of the role of food insecurity in adherence to care and treatment among adult and pediatric populations living with HIV and AIDS. *AIDS Behav.* 2014;18(5):505-515.

145. Mark D, Armstrong A, Andrade C, et al. HIV treatment and care services for adolescents: a situational analysis of 218 facilities in 23 sub-Saharan African countries. *J Int AIDS Soc.* 2017;20(0):21591.

146. Harrison S, Li X. Toward an enhanced understanding of psychological resilience for HIV youth populations. *AIDS Care.* 2018;30(sup4):1-4.

147. Agu CE, Uchendu IK, Nsonwu AC, Okwuosa CN, Achukwu PU. Prevalence and associated risk factors of peripheral artery disease in virologically suppressed HIV-infected individuals on antiretroviral therapy in Kwara state, Nigeria: a cross sectional study. *BMC Public Health.* Aug 20 2019;19(1):1143.

148. Barai N, Monroe A, Lesko C, et al. The Association Between Changes in Alcohol Use and Changes in Antiretroviral Therapy Adherence and Viral Suppression Among Women Living with HIV. *AIDS Behav.* Jul 2017;21(7):1836-1845.
149. Cagle A, McGrath C, Richardson BA, et al. Alcohol use and immune reconstitution among HIV-infected patients on antiretroviral therapy in Nairobi, Kenya. *AIDS Care.* Sep 2017;29(9):1192-1197.
150. Morojele NK, Kekwaletswe CT, Nkosi S. Associations between alcohol use, other psychosocial factors, structural factors and antiretroviral therapy (ART) adherence among South African ART recipients. *AIDS Behav.* Mar 2014;18(3):519-524.
151. Shacham E, Agbebi A, Stamm K, Overton ET. Alcohol consumption is associated with poor health in HIV clinic patient population: a behavioral surveillance study. *AIDS Behav.* Jan 2011;15(1):209-213.
152. Bajunirwe F, Tisch DJ, King CH, Arts EJ, Debanne SM, Sethi AK. Quality of life and social support among patients receiving antiretroviral therapy in Western Uganda. *AIDS Care.* Mar 2009;21(3):271-279.
153. Huis In 'T Veld D, Pengpid S, Colebunders R, Peltzer K. Body Mass Index and Waist Circumference in Patients with HIV in South Africa and Associated Socio-demographic, Health Related and Psychosocial Factors. *AIDS Behav.* 2018;22(6):1972-1986.
154. Castro ADCO, Silveira EA, Falco MDO, Nery MW, Turchi MD. Overweight and abdominal obesity in adults living with HIV/AIDS. *Revista da Associação Médica Brasileira.* 2016;62(4):353-360.
155. Crum-Cianflone N, Tejidor R, Medina S, Barahona I, Ganesan A. Obesity among patients with HIV: the latest epidemic. *AIDS Patient Care STDS.* Dec 2008;22(12):925-930.
156. Kintu A, Liu E, Hertzmark E, et al. Incidence and Risk Factors for Overweight and Obesity after Initiation of Antiretroviral Therapy in Dar es Salaam, Tanzania. *J Int Assoc Provid AIDS Care.* Jan-Dec 2018;17:2325958218759759.
157. Thompson-Paul AM, Wei SC, Mattson CL, et al. Obesity Among HIV-Infected Adults Receiving Medical Care in the United States: Data From the Cross-Sectional Medical Monitoring Project and National Health and Nutrition Examination Survey. *Medicine (Baltimore).* Jul 2015;94(27):e1081.
158. Guehi C, Badjé A, Gabillard D, et al. High prevalence of being Overweight and Obese HIV-infected persons, before and after 24 months on early ART in the ANRS 12136 Temprano Trial. *AIDS Res. Ther.* 2016;13(1).
159. Okechukwu A, Lawson J, Dalilo M. Dyslipidemia in HIV Infected Children and Adolescents on Highly Active Antiretroviral Therapy in Abuja, Nigeria. *J Adv Med Med Res.* 2017:1-11.
160. Innes S, Abdullah KL, Haubrich R, Cotton MF, Browne SH. High prevalence of dyslipidemia and insulin resistance in HIV-infected pre-pubertal African children on antiretroviral therapy. *Pediatr Infect Dis J.* 2016;35(1):e1.
161. Steenkamp L, Truter I, Williams M, et al. Nutritional status and metabolic risk in HIV-infected university students: challenges in their monitoring and management. *S Afr Fam Pract (2004).* 2017;59(1):9-13.

162. Mulligan K, Harris DR, Monte D, et al. Obesity and dyslipidemia in behaviorally HIV-infected young women: Adolescent Trials Network study 021. *Clin Infect Dis.* Jan 1 2010;50(1):106-114.

163. Arbeitman LE, O'Brien RC, Somarriba G, et al. Body mass index and waist circumference of HIV-infected youth in a Miami cohort: comparison to local and national cohorts. *J Pediatr Gastroenterol Nutr*. 2014 Oct;59(4):449.

164. Bakal DR, Coelho LE, Luz PM, et al. Obesity following ART initiation is common and influenced by both traditional and HIV-/ART-specific risk factors. *J Antimicrob Chemother.* Aug 1 2018;73(8):2177-2185.

165. Souza DT, Rondo PHC, Reis LC. The Nutritional Status of Children and Adolescents with HIV/AIDS on Antiretroviral Therapy. *J.Trop.Pediatr.* 2011;57(1):65-68.

166. Dimala CA, Ngu RC, Kadia BM, Tianyi FL, Choukem SP. Markers of adiposity in HIV/AIDS patients: Agreement between waist circumference, waist-to-hip ratio, waist-to-height ratio and body mass index. *PLoS One.* 2018;13(3):e0194653.

167. Zimmet P, Alberti KGM, Kaufman F, et al. The metabolic syndrome in children and adolescents ? an IDF consensus report. *Pediatr Diabetes.* 2007;8(5):299-306.

168. Savva S, Tornaritis M, Savva M, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. *Int J Obes (Lond).* 2000;24(11):1453-1458.

169. Vreeman RC, McCoy BM, Lee S. Mental health challenges among adolescents living with HIV. *J Int AIDS Soc.* May 16 2017;20(Suppl 3):21497.

170. Binagwaho A, Fawzi MCS, Agbonyitor M, et al. Validating the Children's Depression Inventory in the context of Rwanda. *BMC Pediatr.* Feb 22 2016;16:29.

171. Lwidiko A, Kibusi SM, Nyundo A, Mpondo BCT. Association between HIV status and depressive symptoms among children and adolescents in the Southern Highlands Zone, Tanzania: A case-control study. *PLoS One.* 2018;13(2):e0193145.

172. Musisi S, Kinyanda E. Emotional and behavioural disorders in HIV seropositive adolescents in urban Uganda. *East Afr Med J.* 2009;86(1).

173. Petersen AC, Sarigiani PA, Kennedy RE. Adolescent depression: Why more girls? *J Youth Adolesc.* 1991;20(2):247-271.

174. Nolen-Hoeksema S, Girgus JS. The emergence of gender differences in depression during adolescence. *Psychol Bull.* 1994;115(3):424.

175. Marhefka SL, Lyon M, Koenig LJ, et al. Emotional and behavioral problems and mental health service utilization of youth living with HIV acquired perinatally or later in life. *AIDS Care.* Nov 2009;21(11):1447-1454.

176. Hazra R, Siberry GK, Mofenson LM. Growing up with HIV: children, adolescents, and young adults with perinatally acquired HIV infection*. *Annu. Rev. Med.* 2010;61:169-185.

177. Buckley J, Otwombe K, Joyce C, et al. Mental Health of Adolescents in the Era of Antiretroviral Therapy: Is There a Difference Between HIV-Infected and Uninfected Youth in South Africa?. *J Adolesc Health*. Apr 5 2020.
178. Oladeji BD, Taiwo B, Mosuro O, et al. Suicidal Behavior and Associations with Quality of Life among HIV-Infected Patients in Ibadan, Nigeria. *J Int Assoc Provid AIDS Care.* Jul/Aug 2017;16(4):376-382.
179. Kinyanda E, Nakasujja N, Levin J, et al. Major depressive disorder and suicidality in early HIV infection and its association with risk factors and negative outcomes as seen in semi-urban and rural Uganda. *J Affect Disord.* Apr 1 2017;212:117-127.
180. Casale M, Boyes M, Pantelic M, Toska E, Cluver L. Suicidal thoughts and behaviour among South African adolescents living with HIV: Can social support buffer the impact of stigma? *J Affect Disord.* Feb 15 2019;245:82-90.
181. Petersen I, Hancock JH, Bhana A, Govender K, Mental Health Care MOPFI. Closing the treatment gap for depression co-morbid with HIV in South Africa: Voices of afflicted women. *Health.* 2013;05(03):557-566.
182. Letlape SV, Mokwena K, Oguntibeju O. Knowledge of students attending a high school in pretoria, South Africa, on diet, nutrition and exercise. *West Indian Med J.* 2010;59(6):633-640.
183. Bourne LT, Lambert EV, Steyn K. Where does the black population of South Africa stand on the nutrition transition? *Public Health Nutr.* Feb 2002;5(1a):157-162.
184. Choukem S-P, Tochie JN, Sibetcheu AT, Nansseu JR, Hamilton-Shield JP. Overweight/obesity and associated cardiovascular risk factors in sub-Saharan African children and adolescents: a scoping review. *Int J Pediatr Endocrinol.* 2020;2020:1-13.
185. World Health Organization. *Healthy diet*: World Health Organization. Regional Office for the Eastern Mediterranean;2019.
186. Ashdown-Franks G, Vancampfort D, Firth J, et al. Association of leisure-time sedentary behavior with fast food and carbonated soft drink consumption among 133,555 adolescents aged 12–15 years in 44 low- and middle-income countries. *Int. J. Behav. Nutr. Phys. Act.* 2019;16(1).
187. Malik VS, Popkin BM, Bray GA, Despres JP, Willett WC, Hu FB. Sugar-Sweetened Beverages and Risk of Metabolic Syndrome and Type 2 Diabetes: A meta-analysis. *Diabetes Care.* 2010;33(11):2477-2483.
188. National Assembly Republic of South Africa. Foodstuffs, Cosmetics and Disinfectants Act of 1972. Regulations: Reduction of sodium in certain foodstuffs and related matters. Africa GoS, ed. *R. 533/2012*: Government Gazette; 2012.
189. Arthur R. South Africa introduces sugar tax. *Beverage Daily, Available at: www. beveragedaily. com/Article/2018/04/03/South-Africa-introduces-sugar-tax.2018* Accessed 30 January 2019.
190. Myers A, Fig D, Tugendhaft A, Mandle J, Myers J, Hofman K. Sugar and health in South Africa: Potential challenges to leveraging policy change. *Glob Public Health.* 2017;12(1):98-115.
191. Van Biljon A, McKune AJ, Dubose KD, Kolanisi U, Semple SJ. Physical activity levels in urban-based South African learners: A cross-sectional study of 7 348 participants. *S. Afr. Med. J.* 2018;108(2):126.

192. McVeigh J, Meiring R. Physical activity and sedentary behavior in an ethnically diverse group of South African school children. *J Sports Sci Med.* 2014;13(2):371.

193. Tanaka LF, Latorre Mdo R, Silva AM, Konstantyner TC, Peres SV, Marques HH. [High prevalence of physical inactivity among adolescents living with HIV/Aids]. *Rev Paul Pediatr.* Jul-Sep 2015;33(3):327-332.

194. Martins PC, Lima LRA, Teixeira DM, Carvalho AP, Petroski EL. PHYSICAL ACTIVITY AND BODY FAT IN ADOLESCENTS LIVING WITH HIV: A COMPARATIVE STUDY. *Rev Paul Pediatr.* Jan-Mar 2017;35(1):69-77.

195. Combrink A, Irwin N, Laudin G, Naidoo K, Plagerson S, Mathee A. High prevalence of hookah smoking among secondary school students in a disadvantaged community in Johannesburg. *S. Afr. Med. J.* 2010;100(5):297-299.

196. Kader Z, Roman NV, Crutzen R. Determinants of Adolescent Hookah Pipe Use: A Systematic Review. *J Child Adolesc Subst Abuse.* 2020:1-20.

197. Starks TJ, MacDonell KK, Pennar AL, Dinaj-Koci V, Millar BM, Naar S. Drug Use Among Adolescents and Young Adults with Unsuppressed HIV Who Use Alcohol: Identifying Patterns of Comorbid Drug Use and Associations with Mental Health. *AIDS Behav.* Apr 4 2020.

198. Alperen J, Brummel S, Tassiopoulos K, Mellins CA, Kacanek D, Smith R, Seage III GR, Moscicki AB. Prevalence of and risk factors for substance use among perinatally human immunodeficiency virus–infected and perinatally exposed but uninfected youth. *J Adolesc Health.* Mar 2014;54(3):341-349.

199. Sainz T, Diaz L, Navarro ML, et al. Cardiovascular biomarkers in vertically HIV-infected children without metabolic abnormalities. *Atherosclerosis.* Apr 2014;233(2):410-414.

200. Escota G, Onen N. HIV-infected adolescent, young adult and pregnant smokers: important targets for effective tobacco control programs. *Int. J. Environ. Res. Public Health.* Jun 2013;10(6):2471-2499.

201. Rossouw TM, Anderson R, Feldman C. Impact of HIV infection and smoking on lung immunity and related disorders. *Eur Respir J.* Dec 2015;46(6):1781-1795.

202. Triant VA, Lee H, Hadigan C, Grinspoon SK. Increased acute myocardial infarction rates and cardiovascular risk factors among patients with human immunodeficiency virus disease. *J. Clin. Endocrinol. Metab.* 2007;92(7):2506-2512.

203. Gutierrez J, Elkind MS, Marshall RS. Cardiovascular profile and events of US adults 20-49 years with HIV: results from the NHANES 1999-2008. *AIDS Care.* 2013;25(11):1385-1391.

204. Falk DE, Yi H-y, Hiller-Sturmhöfel S. An epidemiologic analysis of co-occurring alcohol and tobacco use and disorders: findings from the National Epidemiologic Survey on Alcohol and Related Conditions. *Alcohol Research & Health.* 2006;29(3):162.

205. Mellins CA, Tassiopoulos K, Malee K, et al. Behavioral health risks in perinatally HIV-exposed youth: co-occurrence of sexual and drug use behavior, mental health problems, and nonadherence to antiretroviral treatment. *AIDS Patient Care STDS.* Jul 2011;25(7):413-422.

206. Toska E, Pantelic M, Meinck F, Keck K, Haghighat R, Cluver L. Sex in the shadow of HIV: A systematic review of prevalence, risk factors, and interventions to reduce sexual risk-taking among HIV-positive

adolescents and youth in sub-Saharan Africa. *PLOS ONE.* 2017;12(6):e0178106.

207. Harker N, Kader R, Myers B, et al. Substance abuse trends in the Western Cape: A review of studies conducted since 2000. 2008.
208. Weybright EH, Caldwell LL, Wegner L, Smith E, Jacobs J. The state of methamphetamine ('tik') use among youth in the Western Cape, South Africa. *S. Afr. Med. J.* 2016;106(11):1125-1128.
209. Kagura J, Adair LS, Musa MG, Pettifor JM, Norris SA. Blood pressure tracking in urban black South African children: birth to twenty cohort. *BMC pediatrics.* 2015;15(1):78.
210. Naidoo S, Kagura J, Fabian J, Norris SA. Early Life Factors and Longitudinal Blood Pressure Trajectories Are Associated With Elevated Blood Pressure in Early Adulthood. *Hypertension.* 2019;73(2):301-309.
211. Chatterton-Kirchmeier S, Camacho-Gonzalez AF, McCracken CE, Chakraborty R, Batisky DL. Increased prevalence of elevated blood pressures in HIV-infected children, adolescents and young adults. *The Pediatric infectious disease journal.* Jun 2015;34(6):610-614.
212. Fahme SA, Bloomfield GS, Peck R. Hypertension in HIV-Infected Adults. *Hypertension.* 2018;72(1):44-55.
213. Nduka C, Stranges S, Sarki A, Kimani P, Uthman O. Evidence of increased blood pressure and hypertension risk among people living with HIV on antiretroviral therapy: a systematic review with meta-analysis. *J Hum Hypertens.* 2016;30(6):355-362.
214. Pangmekeh PJ, Awolu MM, Gustave S, Gladys T, Cumber SN. Association between highly active antiretroviral therapy (HAART) and hypertension in persons living with HIV/AIDS at the Bamenda regional hospital, Cameroon. *Pan Afr Med J.* 2019;33:87.
215. Järvelin M-R, Sovio U, King V, et al. Early life factors and blood pressure at age 31 years in the 1966 northern Finland birth cohort. *Hypertension.* 2004;44(6):838-846.
216. Prioreschi A, Munthali RJ, Soepnel L, et al. Incidence and prevalence of type 2 diabetes mellitus with HIV infection in Africa: a systematic review and meta-analysis. *BMJ open.* Mar 29 2017;7(3):e013953.
217. Brown TT, Cole SR, Li X, et al. Antiretroviral therapy and the prevalence and incidence of diabetes mellitus in the multicenter AIDS cohort study. *Archives of internal medicine.* 2005;165(10):1179-1184.
218. De Wit S, Sabin CA, Weber R, et al. Incidence and risk factors for new-onset diabetes in HIV-infected patients the data collection on adverse events of anti-HIV drugs (D: A: D) study. *Diabetes Care.* 2008;31(6):1224-1229.
219. Tripathi A, Liese AD, Jerrell JM, et al. Incidence of diabetes mellitus in a population-based cohort of HIV-infected and non-HIV-infected persons: the impact of clinical and therapeutic factors over time. *Diabet Med.* Oct 2014;31(10):1185-1193.
220. International Diabetes Federation. IDF diabetes atlas ninth edition 2019. 2019.

221. Jemmott JB, 3rd, Jemmott LS, O'Leary A, et al. Cognitive-behavioural health-promotion intervention increases fruit and vegetable consumption and physical activity among South African adolescents: a cluster-randomised controlled trial. *Psychol Health.* Feb 2011;26(2):167-185.
222. Woollett N, Peter J, Cluver L, Brahmbhatt H. Enrolling HIV-positive adolescents in mental health research: A case study reflecting on legal and ethical complexities. *S Afr Med J.* Jul 28 2017;107(8):679-683.
223. Oliveras C, Cluver L, Bernays S, Armstrong A. Nothing About Us Without RIGHTS-Meaningful Engagement of Children and Youth: From Research Prioritization to Clinical Trials, Implementation Science, and Policy. *J Acquir Immune Defic Syndr.* Aug 15 2018;78 Suppl 1(1):S27-s31.
224. Lee PH, Macfarlane DJ, Lam T, Stewart SM. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *Int. J. Behav. Nutr. Phys. Act.* 2011;8(1):115.
225. Ekelund U, Sepp H, Brage S, et al. Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Public Health Nutr.* 2006;9(2):258-265.
226. Steene-Johannessen J, Anderssen SA, Van der Ploeg HP, et al. Are self-report measures able to define individuals as physically active or inactive? *Med Sci Sports Exerc.* 2016;48(2):235.
227. Corder K, Van Sluijs EMF. Invited Commentary: Comparing Physical Activity Across Countries–Current Strengths and Weaknesses. *Am. J. Epidemiol.* 2010;171(10):1065-1068.
228. Engelgau MM, Narayan KM, Herman WH. Screening for type 2 diabetes. *Diabetes Care.* 2000;23(10):1563-1580.
229. Engelgau MM, Thompson TJ, Smith PJ, et al. Screening for diabetes mellitus in adults: the utility of random capillary blood glucose measurements. *Diabetes Care.* 1995;18(4):463-466.
230. Baron EC, Davies T, Lund C. 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.* 2017;17(1):6.
231. Dupont A, Wheeler J, Herndon J, et al. Use of tablet personal computers for sensitive patient-reported information. *J Support Oncol.* 2009;7(3):91-97.
232. Jaspan HB, Flisher AJ, Myer L, et al. Brief report: Methods for collecting sexual behaviour information from South African adolescents—a comparison of paper versus personal digital assistant questionnaires. *J Adolesc.* 2007;30(2):353-359.

Figures

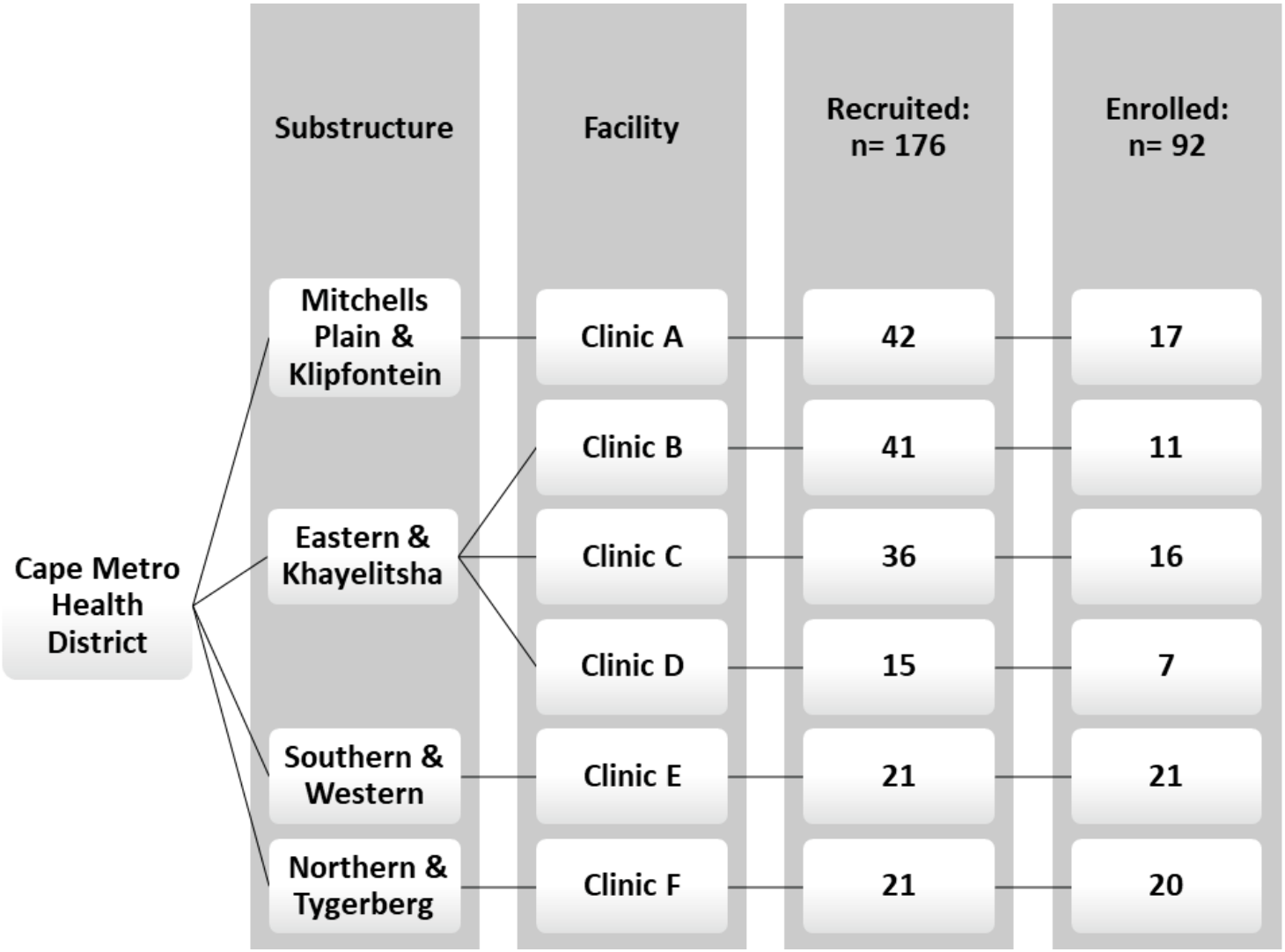

Figure 1

Participant Recruitment and enrolment at respective facilities

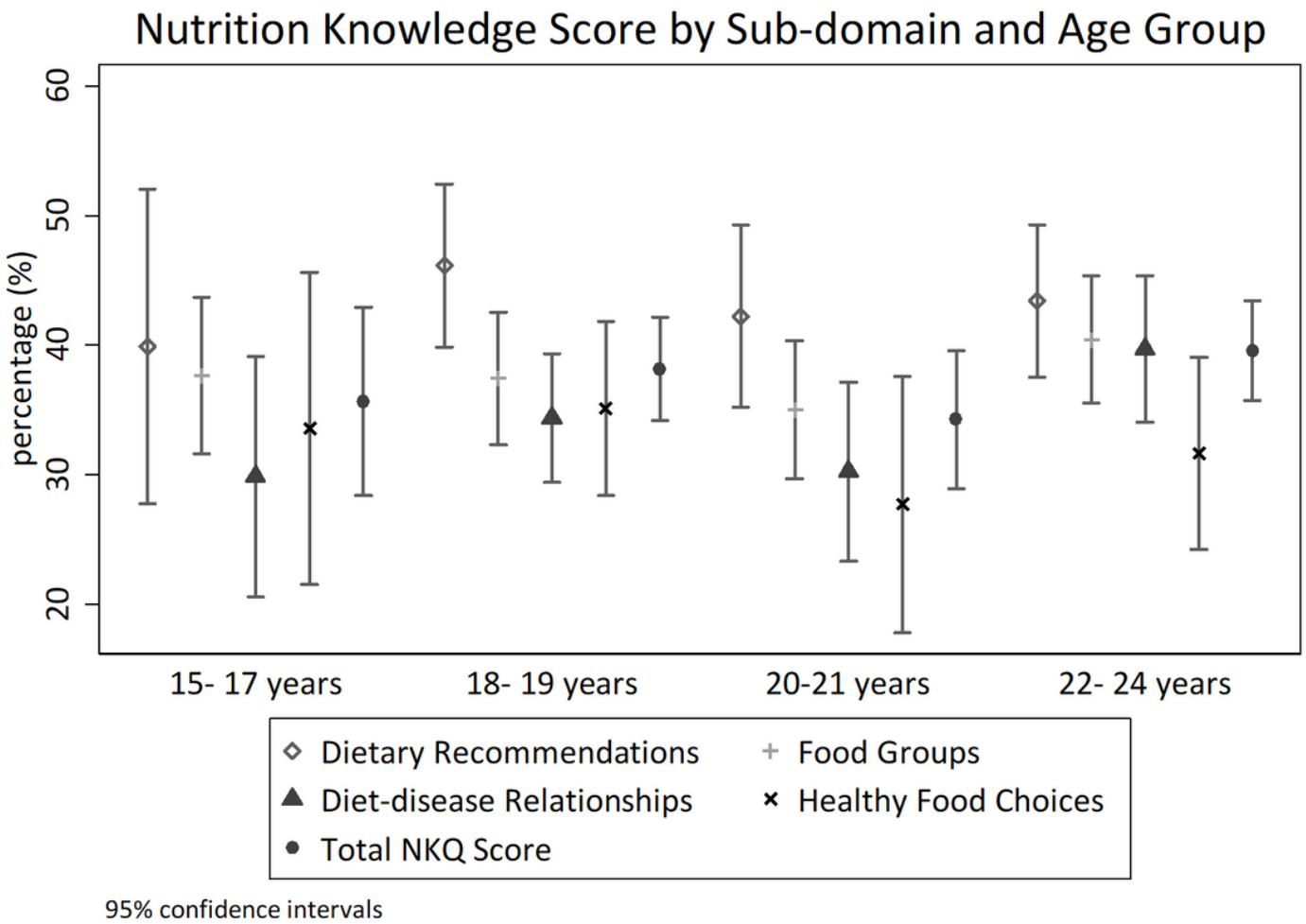

Figure 2

Nutrition Knowledge Score by Sub-domain and Age Group

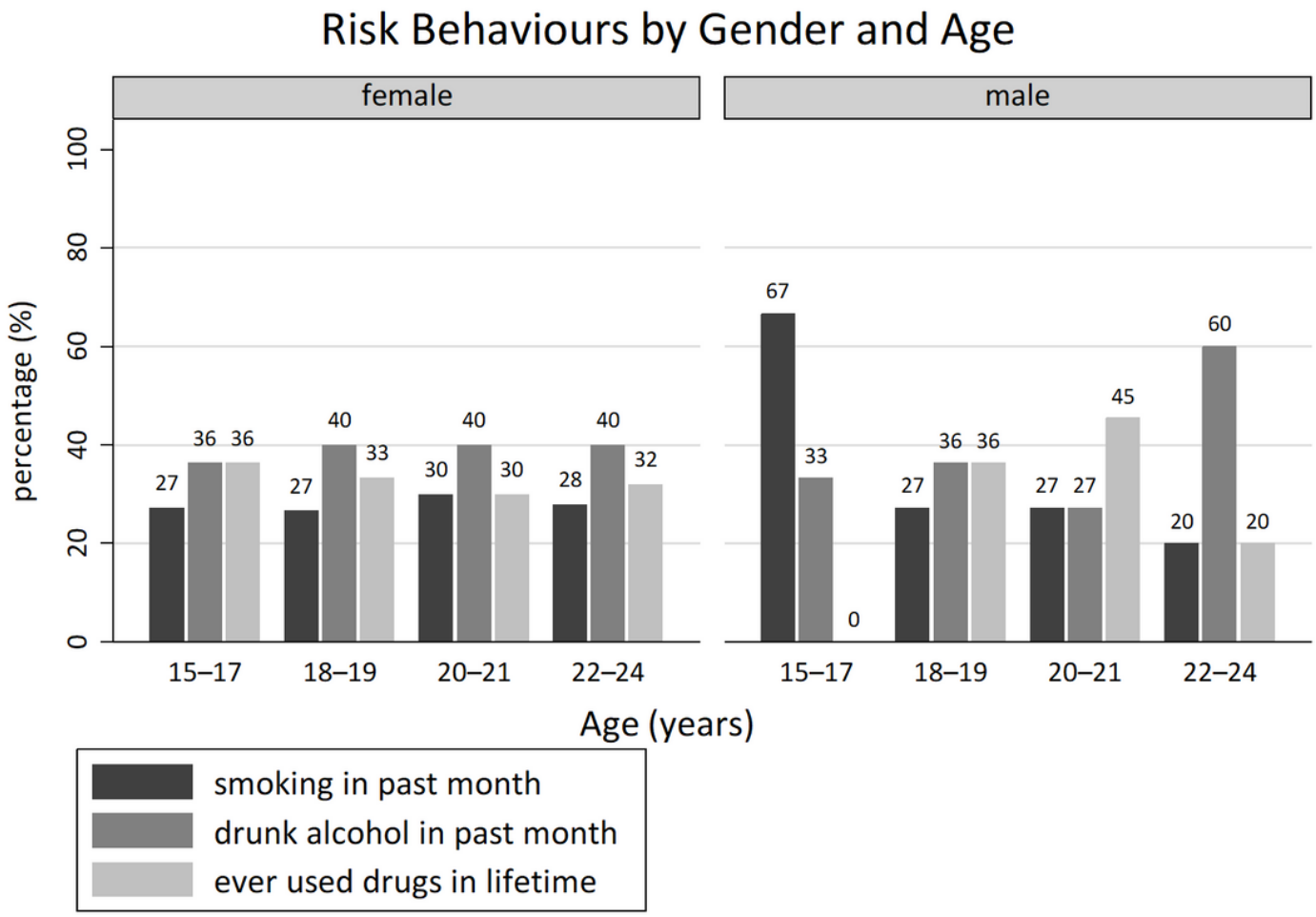

Figure 3

Current smoking, alcohol consumption, and lifetime substance use by Gender and Age Group

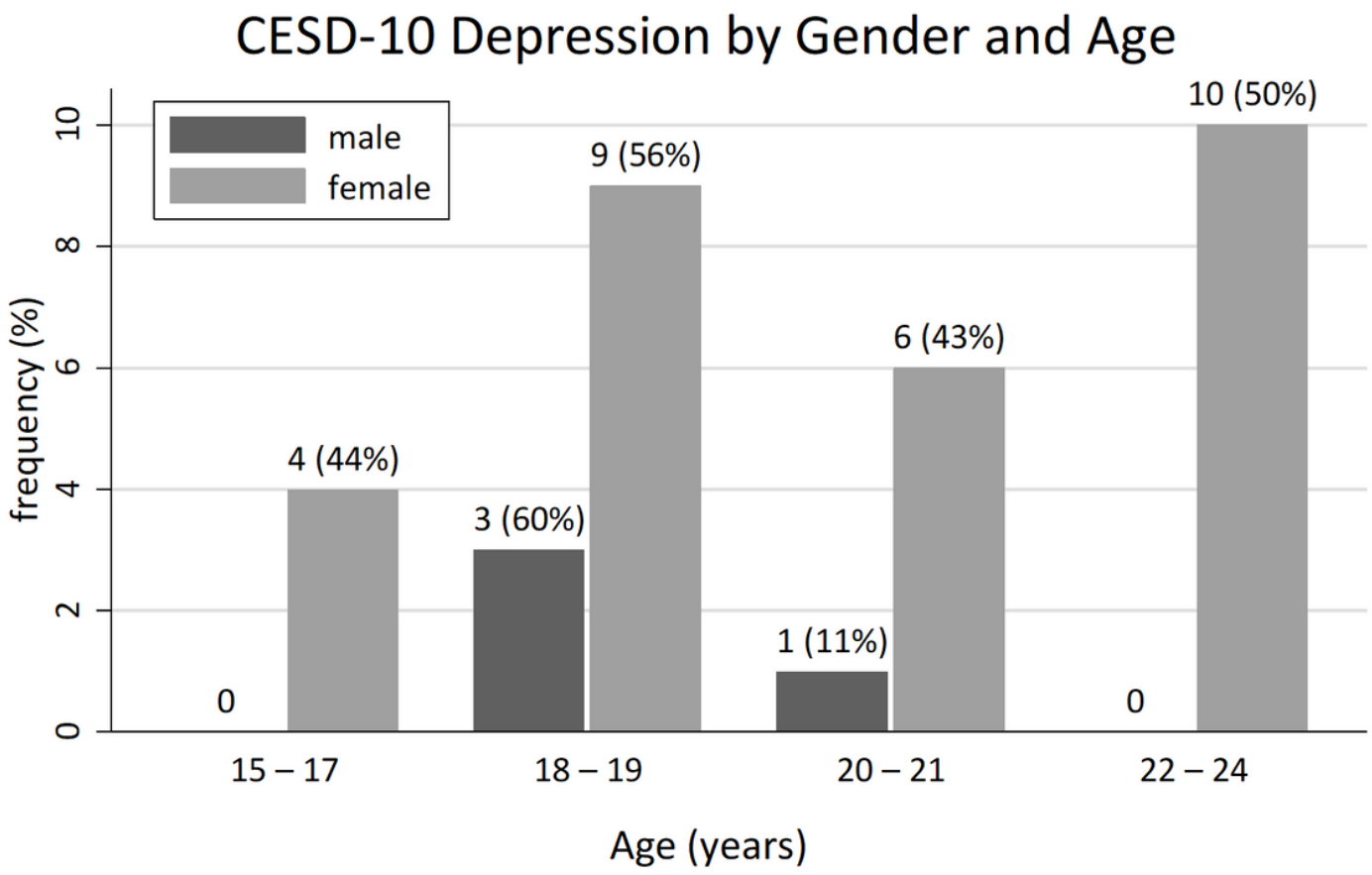

Figure 4

Mental Health Status by Gender and Age Group Bar represents proportion (%) with significant depression (CESD score ≥10) by gender in each age group.

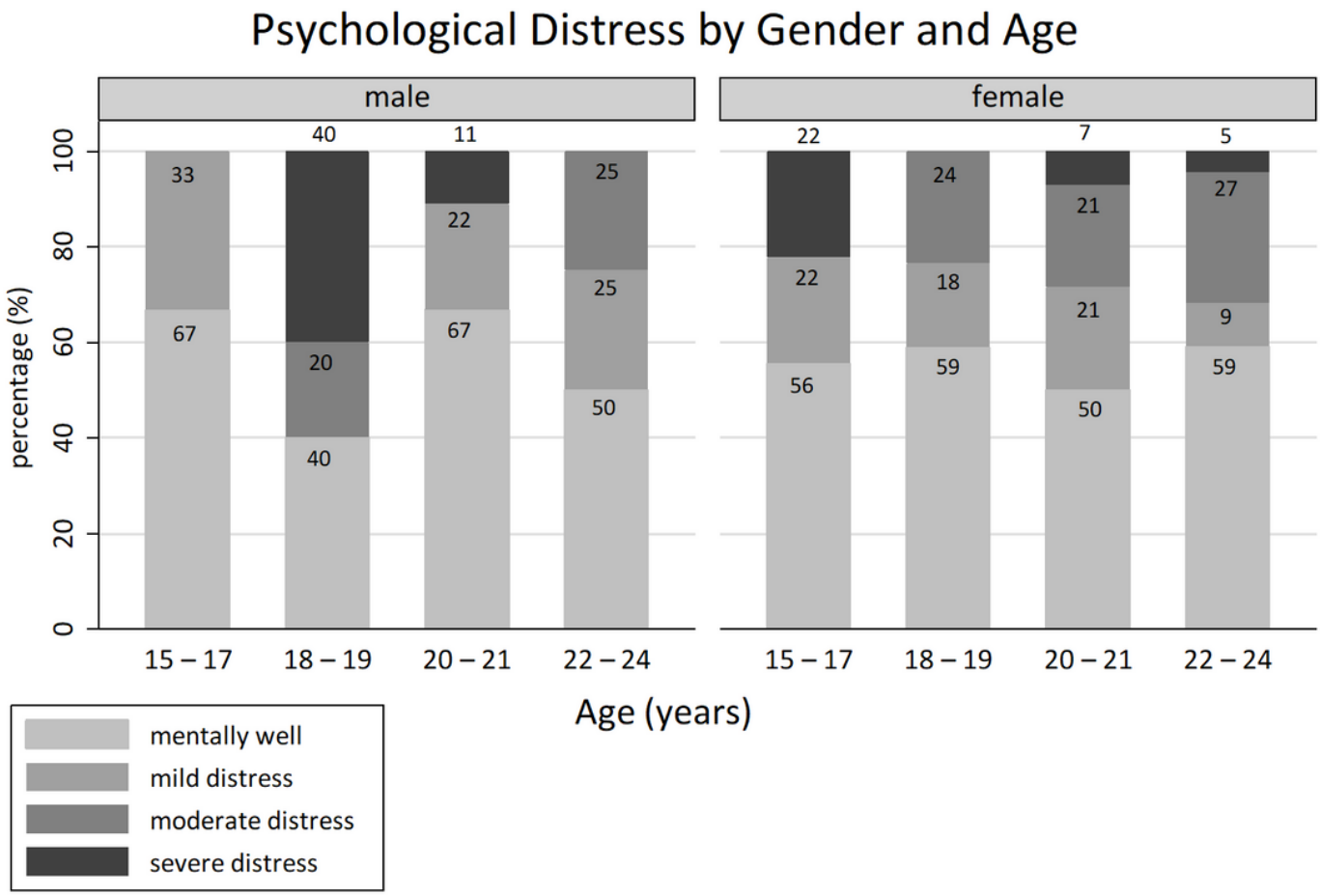

Figure 5

Severity of Psychological Distress by Gender and Age Group Psychological distress according to Kessler (K10) Distress Scale. Bars represent severity of distress (%) by gender and age group

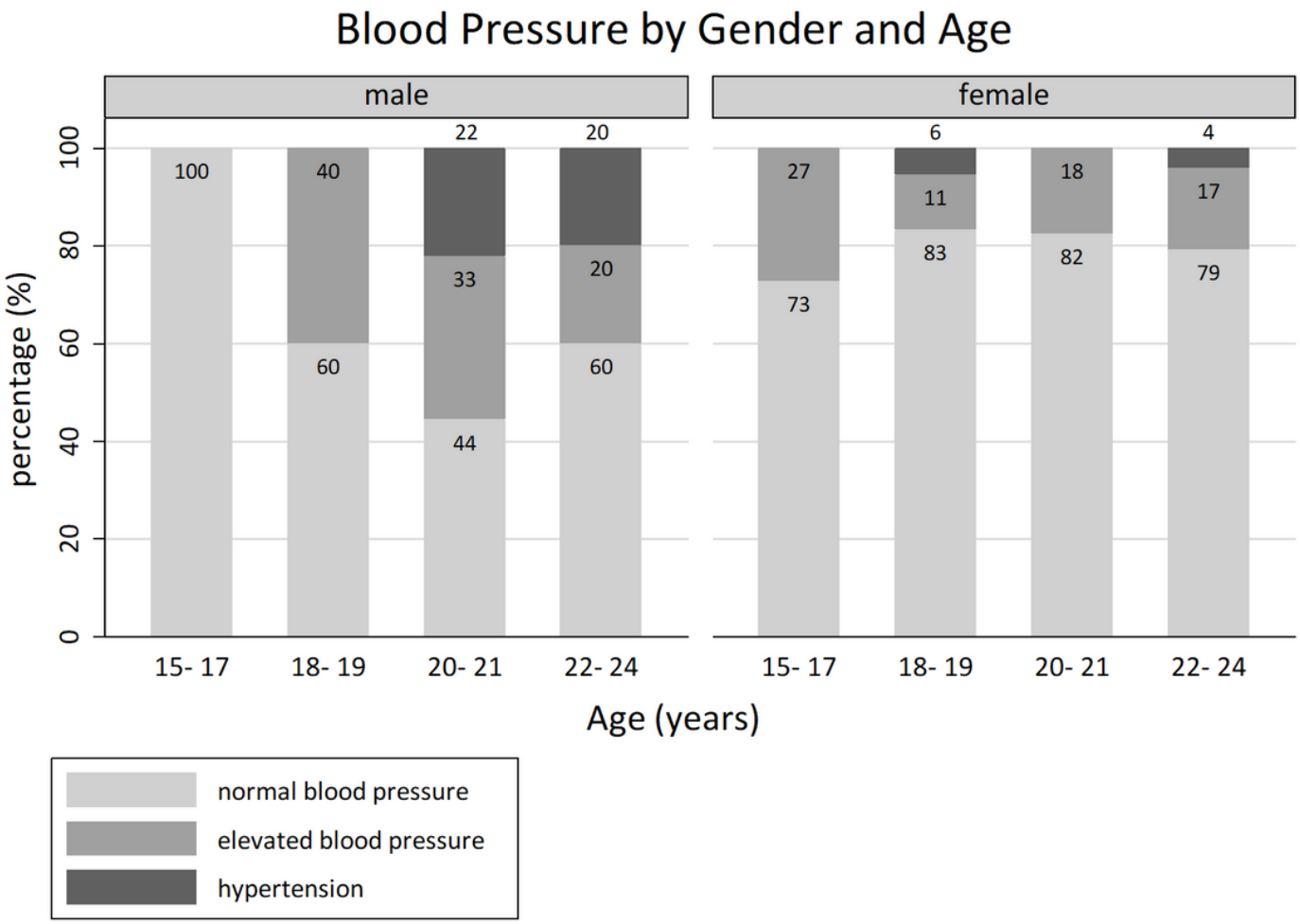

Figure 6

Blood Pressure Category by Gender and Age Group

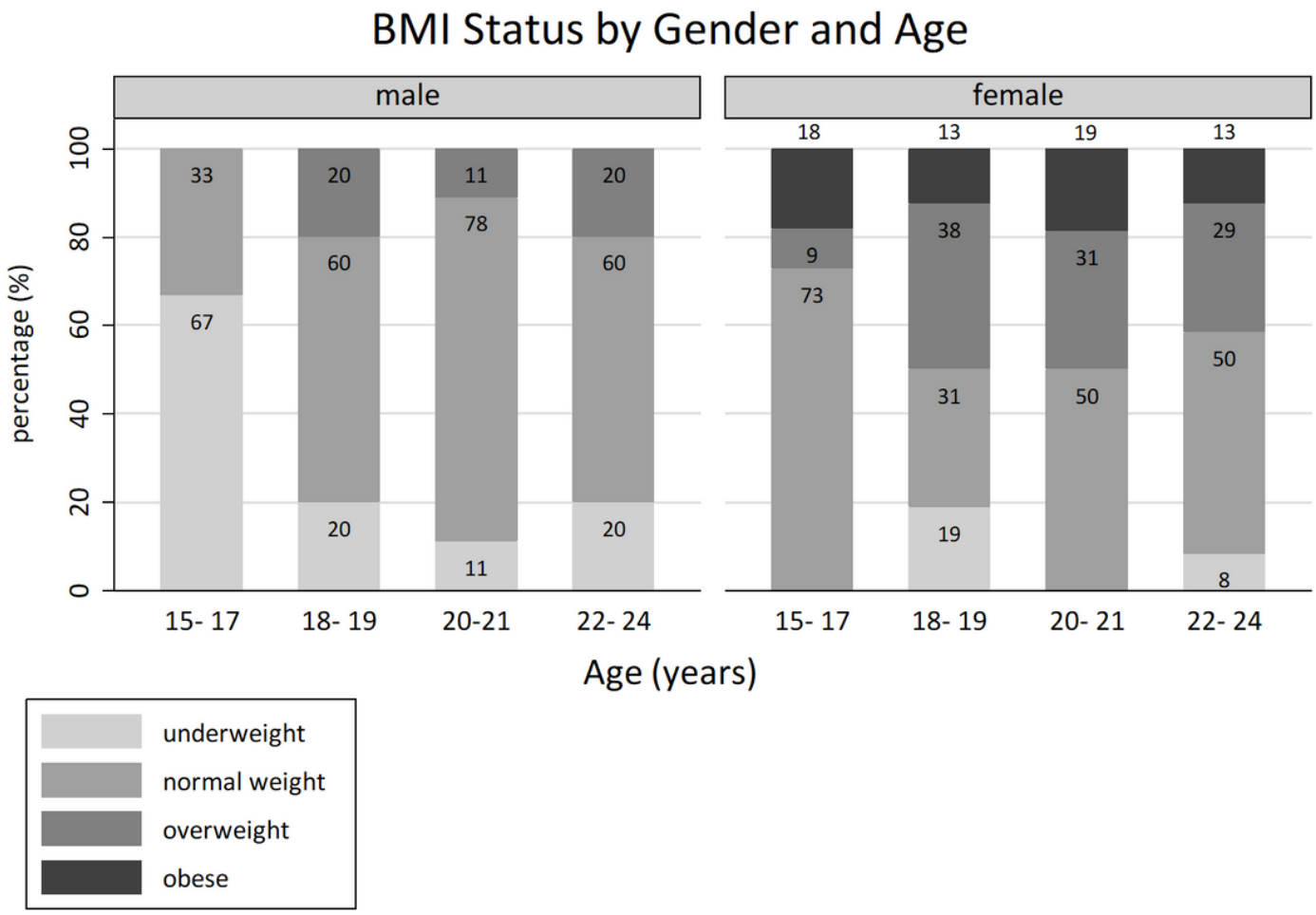

Figure 7

Weight Status by Gender and Age Group