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Depressive symptoms among adolescents in six sub-Saharan African countries: A pooled analysis of associated factors

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ABSTRACT

There is a need to identify risk factors, including nutrition-related factors, for depressive disorders among sub-Saharan African (SSA) adolescents. We examined the association of multiple measures with depressive symptoms among adolescents living across six SSA countries. Building on previous analyses, we used data from a cross-sectional study conducted from 2015 to 2017 among adolescents aged 10–19 years in six SSA countries (N = 7512). Depressive symptoms were defined as highest tertile of the 6-item Kutcher Adolescent Depression Scale score. Using mixed-effects Poisson regression models, we pooled data across sites and examined the association of sociodemographic, nutrition, and other indices with depressive symptoms. We additionally assessed effect modification by sex, age, and school-going status. We observed higher risk of depressive symptoms among girls (adjusted risk ratio [RR]: 1.29, 95 % confidence interval [95 % CI]: 1.05–1.58, $P = 0.016$), older adolescents (RR for 18–19 years: 1.59, 95 % CI: 1.44–1.76, $P < 0.001$), and adolescents experiencing bullying (RR: 1.43, 95 % CI: 1.26–1.62, $P < 0.001$) or violence (RR: 1.34, 95 % CI: 1.24–1.45, $P < 0.001$). Adolescents experiencing food insecurity also had a higher risk of depressive symptoms (RR: 1.90, 95 % CI: 1.64–2.19, $P < 0.001$) along with those consuming $\geq$ 5 servings of fruit and vegetables per day (RR: 1.18, 95 % CI: 1.03–1.34, $P = 0.015$); conversely, those who consumed grains, roots and tubers in the past day were at decreased risk (RR: 0.73, 95 % CI: 0.69–0.77, $P < 0.001$). There was no strong evidence of effect modification of associations. This study reinforces the potential role of multiple sociodemographic and nutrition-related measures on risk of depressive symptoms in these populations.

1. Introduction

The burden of depressive disorders among adolescents is substantial. The global prevalence of elevated depressive symptoms among adolescents aged 10–19 years was recently estimated to be approximately 34 % (Shorey et al., 2022). Evidence from sub-Saharan Africa suggests that approximately 26.9 % of adolescents may have depressive disorders, with close to 30 % prevalence estimated among at-risk adolescent populations such as those who previously experienced trauma (Jörns-Presentati et al., 2021), and depressive disorders identified as the leading cause of years lived with disability among adolescents aged 15–19 in the region (Guthold et al., 2021). Depressive symptoms include low mood, decreased interest in activities, disrupted sleep and appetite, and fatigue (DSM, 2016). Depressive disorders among adolescents have

Abbreviations: SSA, Sub-Saharan Africa; KADS-6, 6-item Kutcher Adolescent Depression Scale; RR, Risk ratio; 95% CI, 95% confidence interval; GSHS, Global School-Based Health Survey; MDD-W, Minimum Dietary Diversity for Women of Reproductive Age.

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been linked to negative effects on school attainment (López-López et al., 2021), poor health behaviors (Pozuelo et al., 2021), and adverse concurrent health outcomes including increased risk of sexually transmitted infections and suicidal behavior (Acog, 2017). Depressive disorders in adolescence may additionally continue into adulthood and predict poor future mental health outcomes (Jonsson et al., 2011), and depressive symptoms have been associated with other adverse consequences such as cardiovascular disease (Rajan et al., 2020). As such, depressive disorders are among the top contributors to years lived with disability among adolescents globally (Guthold et al., 2021).

Depressive disorders among adolescents are understood to be influenced by multiple risk factors, including demographic and socioeconomic status, relationships with parents and peers, and other health-related habits such as sedentary behaviors (O'Neil et al., 2014; Stikkelbroek et al., 2016; Bohman et al., 2017; Orri et al., 2021; Mridha et al., 2021; Rock, 2016; Gautam et al., 2021; Arhin et al., 2019; Park et al., 2018; Oddy et al., 2009; Dziedzic et al., 2021; Danielsson et al., 2013; Gell-Redman et al., 2020). Importantly, while risk factors may be broadly similar across settings, population-specific evidence from regions such as SSA assessing a range of potential risk factors is key to informing the most suitable and effective strategies to address depressive disorders among adolescents. This includes assessing the contribution of aspects related to diet and nutrition, which are increasingly understood to influence depressive and related symptoms (O'Neil et al., 2014; Peltzer and Pengpid, 2010) – but for which evidence remains generally limited to adult populations in high-income countries (O'Neil et al., 2014; Khalid et al., 2016). Furthermore, a closer examination of the relative influence of potential risk factors across key adolescent population subgroups would enable a better understanding of the need for prioritization of targeted research and interventions. This includes assessing differences by age, sex and school-going status.

A clearer examination of influences on the risk of depressive disorders among adolescents is especially important in settings such as sub-Saharan Africa (SSA), where approximately one fifth of the world's adolescents reside, and where adolescents comprise the largest proportion of the population (Guthold et al., 2021; Adolescent Demographics, 2019). Comprehensive, SSA-specific evidence from general populations on potential determinants of depressive disorders remains limited, despite the notable burden of depressive disorders among adolescents identified in the region (Jörns-Presentati et al., 2021; Guthold et al., 2021). Here, we sought to examine indices associated with depressive symptoms among adolescents living in eight communities across six SSA countries. We built upon previous analyses using data from these communities which examined site-specific predictors of depressive symptoms among adolescents (Nyundo et al., 2020), pooling data to increase precision, assessing the effect of additional nutrition and other related factors, and examining potential effect modification of associations by age, sex and school-going status.

2. Methods

2.1. Study population

We used data from the ARISE Network Adolescent Health Study, a cross-sectional community-based survey of adolescents aged 10–19, undertaken between July 2015 and December 2017 in nine communities across seven SSA countries (Darling et al., 2020). Previously published analyses based on these data by Nyundo et al. highlighted a notable burden of depressive symptoms and associated factors across sites (Nyundo et al., 2020). The current analysis aimed to extend this work in three ways: (i) pooling data across sites to estimate associations with increased power, (ii) more closely examining the potential influence of nutrition and other related factors, and (iii) assessing interaction between potential predictors and age, sex, and school-going status. Data for the analysis were from eight communities across six countries (Dar es Salaam, Tanzania [urban]; Dodoma, Tanzania [rural]; Ningo Prampram, Ghana [rural]; Harar, Ethiopia [urban]; Kersa, Ethiopia [rural]; Ibadan, Nigeria [urban]; Nouna, Burkina Faso [rural]; Iganga and Mayuge, Uganda [rural]), with the ninth site (Lubombo/Manzini, eSwatini [rural]) not included due to differences in the study tools used.

The methods for the ARISE Network Adolescent Health study have been previously described elsewhere and are outlined briefly in the Supplementary Methods (Darling et al., 2020). Ethical approval for the study was obtained from the Nouna Health Research Center (Burkina Faso), the University of Heidelberg (Germany), Haramaya University (Ethiopia), the University of Ghana (Ghana), the University of Ibadan (Nigeria), the University of Swaziland (Eswatini), Muhimbili University of Health and Allied Sciences (Tanzania), University of Dodoma (Tanzania), Makerere University (Uganda) and the Harvard T.H. Chan School of Public Health (USA) (Darling et al., 2020).

2.2. Measures of interest and variable transformation

Depressive symptoms were measured using the 6-item Kutcher Adolescent Depression Scale (KADS-6), consisting of six questions probing the frequency of depressive symptoms experienced in the last week, rated on a five point scale (hardly ever to always) (LeBlanc et al., 2002). Based on a Canadian population of school-based adolescents, KADS-6 score $\geq$6 has been suggested as a reasonably sensitive and specific cutoff indicative of a major depressive episode (LeBlanc et al., 2002). As KADS-6 was not validated in the study sites, being in the site-specific highest tertile of the KADS-6 score (versus being in the lower two tertiles) was considered indicative of having depressive symptoms, as has been done previously (Nyundo et al., 2020). Specific cutoffs for highest tertile of KADS-6 score were >2 in Dar es Salaam (Tanzania), Dodoma (Tanzania), Harar (Ethiopia), Kersa (Ethiopia) and Ningo Prampram (Ghana), >5 in Ibadan (Nigeria), >0 in Nouna (Burkina Faso), and >3 in Iganga and Mayuge (Uganda) (Supplementary Table 1). Due to positively skewed distributions and clumping of scores around these cutoffs, the total proportion of adolescents in the highest tertile of KADS-6 score was less than one third.

We examined a range of factors across multiple domains, which were also examined in the analysis by Nyundo et al. (Nyundo et al., 2020) and have been examined in other previous analyses exploring potential risk factors for depressive disorders in adolescents globally (see Supplementary Methods for details) (O'Neil et al., 2014; Stikkelbroek et al., 2016; Bohman et al., 2017; Orri et al., 2021; Mridha et al., 2021; Rock, 2016; Gautam et al., 2021; Arhin et al., 2019; Park et al., 2018; Oddy et al., 2009; Dziedzic et al., 2021; Danielsson et al., 2013; Gell-Redman et al., 2020). In the current analysis, we also examined the following additional nutrition, physical activity and social indices: highest site-specific quartile of time spent watching television in a day, highest site-specific quartile of time spent using the internet in a day, participating in physical education $\geq$4 days per week, and dietary diversity measures. Dietary diversity was assessed based on a 24-hour recall, using a modified version of the Minimum Dietary Diversity for Women of Reproductive Age (MDD-W) indicator (Supplementary Methods) (USAID, FAO. Minimum Dietary Diversity for Women- A Guide to Measurement. Rome: : Food and Agriculture Organization, 2016). As the primary aim of the current analysis was to consider and quantify the specific effect of each factor separately as a potential determinant of depressive symptoms, we did not apply data reduction techniques to reduce the number of variables.

2.3. Statistical analysis

Following initial assessment of the distribution of participants (overall and by sex) by site, we summarized and examined variables grouped broadly in terms of their position on the hypothesized pathway to depressive symptoms, from more distal to more proximal. These groups were (i) sociodemographic indices; and (ii) nutrition, physical activity, social and healthcare indices (with multiple food groups

included singly or instead as a combined MDD-W score). For each group, we examined the distribution of participant characteristics overall and across tertiles of KADS-6 score (lower two versus highest). Differences in proportions across groups were assessed using Pearson's Chi squared tests. We also checked univariable associations between each variable and the risk of being in the highest KADS-6 score tertile, using mixed-effects Poisson regression models with robust standard errors adjusted for clustering at the site level.

For each group, we then built fully-adjusted mixed-effects Poisson regression models, to examine associations between each variable and the risk of being in the highest KADS-6 score tertile. Models examining variables in the sociodemographic indices group were adjusted for all other variables within the same group. Models examining variables in the nutrition, physical activity, social and healthcare indices group were adjusted for all variables within this group and for sociodemographic indices. For this group, we examined adjusted associations for supportive school and participating in physical education $\geq$4 times per week in models restricted to in-school participants only. Also, for this group, we ran two separate models: one including combined MDD-W score $\geq$5 as a binary variable, and another instead assessing all the singular food groups comprising the MDD-W score. The missing indicator method was used to handle missingness in variables of interest. All models used robust standard errors, and were adjusted for clustering at the site level.

We additionally explored the influence of personal perceptions (satisfied with health, satisfied with life, lonely in the last year, and so worried that could not sleep in the last year) on the risk of having a high KADS-6 score – exploring these variables as correlates or symptoms rather than potential risk factors for depressive symptoms. Analyses followed the steps described above, and multivariable models were adjusted for all variables within this group, and for all sociodemographic, and nutrition, physical activity, social and healthcare indices

Table 1
Pooled distribution of sociodemographic indices by lower tertiles versus highest tertile of 6-item Kutcher Adolescent Depression Scale (KADS-6) score, and association between indices and risk of being in the highest KADS-6 score tertile, among adolescents in six countries in Sub-Saharan Africa in 2015–2017.

	n (%)			*P*	Adjusted risk ratio (95 % confidence interval)	*P*
	Overall	Lower tertiles	Highest tertile			
Overall	7512 (100.0)	5521 (73.5)	1991 (26.5)			
Sex						
Boys	3754 (50.0)	2864 (76.3)	890 (23.7)		1.00	
Girls	3758 (50.0)	2657 (70.7)	1101 (29.3)	<0.001	1.29 (1.05–1.58)	0.016
Age (years)						
10–14	3947 (52.5)	3077 (78.0)	870 (22.0)		1.00	
15–17	2377 (31.6)	1679 (70.6)	698 (29.4)		1.35 (1.18–1.54)	<0.001
18–19	1188 (15.8)	765 (64.4)	423 (35.6)	<0.001	1.59 (1.44–1.76)	<0.001
Both parents alive						
No	989 (13.2)	673 (68.0)	316 (32.0)		1.00	
Yes	6499 (86.5)	4824 (74.2)	1675 (25.8)	<0.001	0.99 (0.83–1.18)	0.888
Missing	24 (0.3)	24 (100.0)	0 (0.0)			
Live with both parents						
No	2614 (34.8)	1812 (69.3)	802 (30.7)		1.00	
Yes	4870 (64.8)	3687 (75.7)	1183 (24.3)	<0.001	0.93 (0.76–1.13)	0.458
Missing	28 (0.4)	22 (78.6)	6 (21.4)			
Wealth quintile						
Lowest	1764 (23.5)	1278 (72.4)	486 (27.6)		1.00	
Lower-middle	1371 (18.3)	1026 (74.8)	345 (25.2)		0.92 (0.80–1.07)	0.287
Middle	1448 (19.3)	1048 (72.4)	400 (27.6)		1.00 (0.87–1.15)	0.993
Upper-middle	1454 (19.4)	1084 (74.6)	370 (25.4)		0.93 (0.80–1.08)	0.344
Highest	1458 (19.4)	1071 (73.5)	387 (26.5)	0.403	0.99 (0.85–1.15)	0.890
Missing	17 (0.2)	14 (82.4)	3 (17.6)			
Father's education						
Less than primary	2108 (28.1)	1536 (72.9)	572 (27.1)		1.00	
Primary	1620 (21.6)	1194 (73.7)	426 (26.3)		1.03 (0.92–1.16)	0.598
Secondary +	1240 (16.5)	984 (79.4)	256 (20.6)	<0.001	0.91 (0.80–1.03)	0.133
Missing	2544 (33.9)	1807 (71.0)	737 (29.0)			
Father farmer						
No	2690 (35.8)	2042 (75.9)	648 (24.1)		1.00	
Yes	2915 (38.8)	2135 (73.2)	780 (26.8)	0.022	0.98 (0.85–1.12)	0.744
Missing	1907 (25.4)	1344 (70.5)	563 (29.5)			
Mother's education						
Less than primary	2981 (39.7)	2143 (71.9)	838 (28.1)		1.00	
Primary	1928 (25.7)	1431 (74.2)	497 (25.8)		0.97 (0.88–1.07)	0.519
Secondary +	1175 (15.6)	928 (79.0)	247 (21.0)	<0.001	0.91 (0.81–1.02)	0.092
Missing	1428 (19.0)	1019 (71.4)	409 (28.6)			
Mother farmer						
No	3854 (51.3)	2910 (75.5)	944 (24.5)		1.00	
Yes	3006 (40.0)	2185 (72.7)	821 (27.3)	0.008	1.11 (0.91–1.35)	0.296
Missing	652 (8.7)	426 (65.3)	226 (34.7)			
In school						
No	2190 (29.2)	1511 (69.0)	679 (31.0)		1.00	
Yes	5300 (70.6)	3991 (75.3)	1309 (24.7)	<0.001	0.96 (0.87–1.06)	0.390
Missing	22 (0.3)	19 (86.4)	3 (13.6)			
Money earning activity past year						
No	4946 (65.8)	3731 (75.4)	1215 (24.6)		1.00	
Yes	2535 (33.7)	1769 (69.8)	766 (30.2)	<0.001	1.18 (0.93–1.50)	0.165
Missing	31 (0.4)	21 (67.7)	10 (32.3)			

P for differences across distributions calculated using Pearson's Chi squared test.Risk ratios based on mixed-effects Poisson regression models adjusted for all variables shown, and for clustering at site level.

(including MDD-W but not singular food groups, and excluding supportive school and physical education).

We then examined potential effect modification of observed associations by sex, age, and school-going status, in two ways. First, for each variable of interest, we compared fully adjusted models with models that additionally included an interaction term between each variable of interest and each potential effect modifier (sex, age, or school-going status), using likelihood ratio tests. Additionally, we visually examined differences in associations across sex, age, and school-going status in stratified models.

Finally, in sensitivity analyses, we examined associations between each variable of interest and continuous KADS-6 score in mixed-effects linear regression models, adjusted as described above. Analyses were performed using Stata 16 (StataCorp, Texas).

3. Results

3.1. Distribution by site, sex and KADS-6 score tertile

Analyses covered a total of 7512 participants of whom 50.0 % (N = 3758) were girls (Table 1). Participants were distributed variably across sites, with the greatest proportion of participants from Nouna, Burkina Faso (21.5 %) and the smallest from Iganga and Mayuge, Uganda (7.5 %). The proportion of girls across sites ranged from 41.8 % (Nouna, Burkina Faso) to 55.3 % (Dodoma, Tanzania and Ibadan, Nigeria) (Supplementary Table 1). Overall, approximately one quarter of all participants (26.5 %) were categorized in the highest site-specific tertile of KADS-6 score (Table 1).

3.2. Sociodemographic indices

We first examined the distribution of sociodemographic indices and their potential influence on being in the highest tertile of KADS-6 score (Table 1). Approximately half of participants were aged 10–14 years and about one third were aged 15–17 years, with over 80 % having both parents alive and over 60 % living with both parents. About 30–50 % had parents with less than primary education or parents whose occupation was farming. Just over one quarter of participants were out-of-school, with approximately one third undertaking some money-earning activity in the past year (Table 1).

In the multivariable adjusted model, only sex and age were associated with the risk of being in the highest KADS-6 score tertile, with girls having higher risk versus boys (adjusted risk ratio [RR]: 1.29, 95 % confidence interval [95 % CI]: 1.05–1.58, $P = 0.016$), and older adolescents having progressively increased risk compared with 10–14 year old adolescents (RR for 15–17 years: 1.35, 95 % CI: 1.18–1.54, $P < 0.001$; for 18–19 years: 1.59, 95 % CI: 1.44–1.76, $P < 0.001$) (Table 1).

3.3. Nutrition, physical activity, social and healthcare indices

We then examined nutritional, physical activity, social and healthcare indices (Table 2). In multivariable adjusted analyses, ever being bullied or experiencing violence was associated with increased risk of being in the highest KADS-6 score tertile (RR for ever being bullied: 1.43, 95 % CI: 1.26–1.62, $P < 0.001$; RR for experiencing violence: 1.34, 95 % CI: 1.24–1.45, $P < 0.001$). Food insecure participants had almost twice as high risk of being in the highest KADS-6 score tertile compared with those who were not food insecure (RR: 1.90, 95 % CI: 1.64–2.19, $P < 0.001$), and those who consumed ≥5 servings of fruit and vegetables per day were also at marginally higher risk (RR: 1.18, 95 % CI: 1.03–1.34, $P = 0.015$). We also observed some evidence of increased risk among participants who reported having physical education ≥4 times per week (RR: 1.28, 95 % CI: 1.03–1.60, $P = 0.024$) and those having a supportive school environment (RR: 1.11, 95 % CI: 1.02–1.21, P = 0.022) (Table 2).

As use of a combined dietary diversity score may not be reflective of associations of individual food groups with depressive symptoms, we also considered the potential contribution of the individual food groups separately (Table 3). Decreased risk of being in the highest KADS-6 score tertile was observed for participants consuming grains, white roots and tubers in the past day in multivariable adjusted models (RR: 0.73, 95 % CI: 0.69–0.77, $P < 0.001$) (Table 3).

3.4. Additional analyses examining personal perceptions

In additional analyses, we examined personal perceptions as potential correlates of depressive symptoms (Table 4). In adjusted analyses, participants satisfied with their health and life had a lower risk of being in the highest KADS-6 score tertile (RR for health satisfaction: 0.63, 95 % CI: 0.52–0.77, $P < 0.001$; RR for life satisfaction: 0.84, 95 % CI: 0.72–0.99, $P = 0.036$), while those who were lonely or so worried they couldn't sleep in the past year had a substantially increased risk (RR for lonely: 1.75, 95 % CI: 1.67–1.85, $P < 0.001$; RR for worried: 1.85, 95 % CI: 1.64–2.08, $P < 0.001$).

3.5. Effect modification

Following this, we explored potential effect modification by sex, age, and school-going status (Table 5). Likelihood ratio tests indicated some evidence of interaction between sex and father's education, mother's education, and mother's occupation as farmer, and experiencing violence ($P < 0.05$ for all); between age and having a supportive home ($P = 0.047$) or being lonely in the last year ($P = 0.001$); and between school-going status and being in the highest site-specific quartile of internet use ($P = 0.020$) (Table 5). However, associations were not noticeably different when stratifying models, except in the case of experiencing violence: boys who reported experiencing violence had a noticeably higher risk of being in a higher KADS-6 score tertile (RR for boys: 1.53, 95 % CI: 1.38–1.70, $P < 0.001$; for girls: 1.20, 95 % CI: 1.04–1.38, $P = 0.012$) (data not shown).

3.6. Sensitivity analyses

Finally, we explored consistency in patterns of associations when examining mixed-effects linear regression analyses using KADS-6 score as a continuous outcome (data not shown). Patterns and directions of associations remained consistent with trends in main analyses.

4. Discussion

There is a need to identify risk factors for depressive disorders among adolescents, particularly in SSA. In the current analysis, building on previous cross-sectional analyses based in six countries across SSA (Nyundo et al., 2020), we pooled data across sites to examine the influence of a range of indices on depressive symptoms, defined as being in the highest KADS-6 score tertile, in adolescents aged 10–19 years. Consistent with the previous analyses (Nyundo et al., 2020), we observed a higher risk of depressive symptoms across demographic, social and nutrition-related factors, with generally no clear evidence for effect modification by sex, age or school-going status, apart from for experiencing violence. Our findings extend previous analyses based on these and other data, providing additional insight regarding diet-related influences on depressive symptoms and subgroup-specific differences in associations.

Previous site-specific analyses by Nyundo et al. using these data highlighted associations between multiple indices and depressive symptoms (Nyundo et al., 2020), indicating a potentially important role across sites of age, sex, food insecurity, and experiencing bullying or violence. Evidence of association for other measures was inconsistent across sites, possibly at least partly due to the relatively small site-specific sample sizes (Nyundo et al., 2020). In the current analysis, pooling data across these sites enabled us to investigate potential

Table 2
Pooled distribution of nutrition, physical activity, social and health indices by lower tertiles versus highest tertile of 6-item Kutcher Adolescent Depression Scale (KADS-6) score, and association between indices and risk of being in the highest KADS-6 score tertile, among adolescents in six countries in Sub-Saharan Africa in 2015–2017.

	n (%)			*P*	Adjusted risk ratio (95 % confidence interval)	*P*
	Overall	Lower tertiles	Highest tertile			
Overall	7512 (100.0)	5521 (73.5)	1991 (26.5)			
Supportive home						
No	1788 (23.8)	1304 (72.9)	484 (27.1)		1.00	
Yes	5481 (73.0)	4058 (74.0)	1423 (26.0)	0.356	0.95 (0.86–1.04)	0.278
Missing	243 (3.2)	159 (65.4)	84 (34.6)			
Supportive school						
No	1938 (25.8)	1497 (77.2)	441 (22.8)		1.00	
Yes	3315 (44.1)	2461 (74.2)	854 (25.8)	0.015	1.11 (1.02–1.21)	0.022
Missing	2259 (30.1)	1563 (69.2)	696 (30.8)			
Ever bullied						
No	5367 (71.4)	4127 (76.9)	1240 (23.1)		1.00	
Yes	2081 (27.7)	1348 (64.8)	733 (35.2)	<0.001	1.43 (1.26–1.62)	<0.001
Missing	64 (0.9)	46 (71.9)	18 (28.1)			
Close friends						
No	201 (2.7)	137 (68.2)	64 (31.8)		1.00	
Yes	7255 (96.6)	5343 (73.6)	1912 (26.4)	0.082	0.86 (0.72–1.03)	0.106
Missing	56 (0.7)	41 (73.2)	15 (26.8)			
Experienced violence						
No	4620 (61.5)	3527 (76.3)	1093 (23.7)		1.00	
Yes	2798 (37.2)	1917 (68.5)	881 (31.5)	<0.001	1.34 (1.24–1.45)	<0.001
Missing	94 (1.3)	77 (81.9)	17 (18.1)			
TV watching highest quartile						
No	5551 (73.9)	4055 (73.0)	1496 (27.0)		1.00	
Yes	1053 (14.0)	770 (73.1)	283 (26.9)	0.960	1.01 (0.89–1.15)	0.886
Missing	908 (12.1)	696 (76.7)	212 (23.3)			
Internet use highest quartile						
No	5238 (69.7)	3849 (73.5)	1389 (26.5)		1.00	
Yes	566 (7.5)	405 (71.6)	161 (28.4)	0.325	1.00 (0.80–1.24)	0.965
Missing	1708 (22.7)	1267 (74.2)	441 (25.8)			
Physically active ≥ 1hr/day						
No	6309 (84.0)	4623 (73.3)	1686 (26.7)		1.00	
Yes	1189 (15.8)	887 (74.6)	302 (25.4)	0.343	0.94 (0.82–1.08)	0.413
Missing	14 (0.2)	11 (78.6)	3 (21.4)			
Physical education ≥ 4 days/week						
No	4921 (65.5)	3734 (75.9)	1187 (24.1)		1.00	
Yes	312 (4.2)	215 (68.9)	97 (31.1)	0.006	1.28 (1.03–1.60)	0.024
Missing	2279 (30.3)	1572 (69.0)	707 (31.0)			
Food insecure						
No	6699 (89.2)	5072 (75.7)	1627 (24.3)		1.00	
Yes	804 (10.7)	440 (54.7)	364 (45.3)	<0.001	1.90 (1.64–2.19)	<0.001
Missing	9 (0.1)	9 (100.0)	(0.0)			
Fruit or veg ≥ 5 servings/day						
No	6699 (89.2)	4954 (74.0)	1745 (26.0)		1.00	
Yes	804 (10.7)	558 (69.4)	246 (30.6)	0.006	1.18 (1.03–1.34)	0.015
Missing	9 (0.1)	9 (100.0)	0 (0.0)			
Fast food ≥ 1/week						
No	5059 (67.3)	3749 (74.1)	1310 (25.9)		1.00	
Yes	2434 (32.4)	1755 (72.1)	679 (27.9)	0.066	1.05 (0.99–1.13)	0.113
Missing	19 (0.3)	17 (89.5)	2 (10.5)			
Soda ≥ 1/day						
No	5519 (73.5)	4122 (74.7)	1397 (25.3)		1.00	
Yes	1986 (26.4)	1393 (70.1)	593 (29.9)	<0.001	1.13 (0.90–1.41)	0.295
Missing	7 (0.1)	6 (85.7)	1 (14.3)			
Dietary diversity score ≥ 5						
No	4190 (55.8)	3078 (73.5)	1112 (26.5)		1.00	
Yes	3284 (43.7)	2417 (73.6)	867 (26.4)	0.893	1.06 (0.98–1.15)	0.170
Missing	38 (0.5)	26 (68.4)	12 (31.6)			
Poor healthcare access						
No	4010 (53.4)	3064 (76.4)	946 (23.6)		1.00	
Yes	3455 (46.0)	2422 (70.1)	1033 (29.9)	<0.001	1.26 (1.00–1.59)	0.050
Missing	47 (0.6)	35 (74.5)	12 (25.5)			

P for differences across distributions calculated using Pearson's Chi squared test. Risk ratios based on mixed-effects Poisson regression models adjusted for all variables shown and variables in Table 1, and for clustering at site level. Models for supportive school and physical education were based only among in-school children (N = 5300).
TV: television.

Table 3
Pooled distribution of food groups consumed in the past day by lower tertiles versus highest tertile of 6-item Kutcher Adolescent Depression Scale (KADS-6) score, and association between food group consumption and risk of being in the highest KADS-6 score tertile, among adolescents in six countries in Sub-Saharan Africa in 2015–2017.

	n (%)			*P*	Adjusted risk ratio (95 % confidence interval)	*P*
	Overall	Lower tertiles	Highest tertile			
Overall	7512 (100.0)	5521 (73.5)	1991 (26.5)			
Grains, white roots and tubers						
No	216 (2.9)	141 (65.3)	75 (34.7)		1.00	
Yes	7295 (97.1)	5380 (73.7)	1915 (26.3)	0.005	0.73 (0.69–0.77)	<0.001
Missing	1 (0.0)	(0.0)	1 (100.0)			
Pulses, nuts and seeds						
No	3505 (46.7)	2618 (74.7)	887 (25.3)		1.00	
Yes	4001 (53.3)	2898 (72.4)	1103 (27.6)	0.027	1.11 (0.91–1.35)	0.309
Missing	6 (0.1)	5 (83.3)	1 (16.7)			
Dairy						
No	4953 (65.9)	3663 (74.0)	1290 (26.0)		1.00	
Yes	2552 (34.0)	1852 (72.6)	700 (27.4)	0.198	1.05 (0.96–1.16)	0.295
Missing	7 (0.1)	6 (85.7)	1 (14.3)			
Meat, poultry and fish						
No	3499 (46.6)	2531 (72.3)	968 (27.7)		1.00	
Yes	4007 (53.3)	2985 (74.5)	1022 (25.5)	0.034	0.95 (0.87–1.04)	0.269
Missing	6 (0.1)	5 (83.3)	1 (16.7)			
Eggs						
No	5911 (78.7)	4314 (73.0)	1597 (27.0)		1.00	
Yes	1596 (21.2)	1203 (75.4)	393 (24.6)	0.055	0.94 (0.76–1.15)	0.517
Missing	5 (0.1)	4 (80.0)	1 (20.0)			
Dark leafy green veg						
No	4043 (53.8)	2973 (73.5)	1070 (26.5)		1.00	
Yes	3464 (46.1)	2545 (73.5)	919 (26.5)	0.950	1.04 (0.93–1.16)	0.520
Missing	5 (0.1)	3 (60.0)	2 (40.0)			
Other Vit A rich fruit/veg						
No	4578 (60.9)	3363 (73.5)	1215 (26.5)		1.00	
Yes	2929 (39.0)	2154 (73.5)	775 (26.5)	0.939	1.02 (0.95–1.09)	0.614
Missing	5 (0.1)	4 (80.0)	1 (20.0)			
Other veg						
No	2534 (33.7)	1861 (73.4)	673 (26.6)		1.00	
Yes	4965 (66.1)	3651 (73.5)	1314 (26.5)	0.931	0.98 (0.81–1.20)	0.868
Missing	13 (0.2)	9 (69.2)	4 (30.8)			
Other fruit						
No	6288 (83.7)	4633 (73.7)	1655 (26.3)		1.00	
Yes	1216 (16.2)	881 (72.5)	335 (27.5)	0.374	1.08 (0.94–1.25)	0.268
Missing	8 (0.1)	7 (87.5)	1 (12.5)			

P for differences across distributions calculated using Pearson's Chi squared test.
Risk ratios based on mixed-effects Poisson regression models adjusted for all variables shown and variables in Tables 1 and 2 (with the exception of the MDD-W category, supportive school and physical education) and for clustering at site level. Veg: vegetables.

Table 4
Pooled distribution of personal perceptions by lower tertiles versus highest tertile of 6-item Kutcher Adolescent Depression Scale (KADS-6) score, and association between personal perceptions and risk of being in the highest KADS-6 score tertile, among adolescents in six countries in Sub-Saharan Africa in 2015–2017.

	n (%)			*P*	Adjusted risk ratio (95 % confidence interval)	*P*
	Overall	Lower tertiles	Highest tertile			
Overall	7512 (100.0)	5521 (73.5)	1991 (26.5)			
Satisfied with health						
No	86 (1.1)	31 (36.0)	55 (64.0)		1.00	
Yes	7418 (98.7)	5484 (73.9)	1934 (26.1)	<0.001	0.63 (0.52–0.77)	<0.001
Missing	8 (0.1)	6 (75.0)	2 (25.0)			
Satisfied with life						
No	987 (13.1)	598 (60.6)	389 (39.4)		1.00	
Yes	6489 (86.4)	4899 (75.5)	1590 (24.5)	<0.001	0.84 (0.72–0.99)	0.036
Missing	36 (0.5)	24 (66.7)	12 (33.3)			
Lonely last year						
No	6404 (85.3)	4975 (77.7)	1429 (22.3)		1.00	
Yes	1085 (14.4)	529 (48.8)	556 (51.2)	<0.001	1.75 (1.67–1.85)	<0.001
Missing	23 (0.3)	17 (73.9)	6 (26.1)			
No sleep due to worry last year						
No	6597 (87.8)	5121 (77.6)	1476 (22.4)		1.00	
Yes	904 (12.0)	390 (43.1)	514 (56.9)	<0.001	1.85 (1.64–2.08)	<0.001
Missing	11 (0.1)	10 (90.9)	1 (9.1)			

P for differences across distributions calculated using Pearson's Chi squared test.Risk ratios based on mixed-effects Poisson regression models adjusted for all variables shown and sociodemographic, nutritional, physical activity, social and healthcare variables shown in Tables 1 and 2 (with the exception of supportive school and physical education), and for clustering at site level.

Table 5
P values for interaction between potential predictors for being in the highest tertile of 6-item Kutcher Adolescent Depression Scale (KADS-6) score and sex, age and school-going status among adolescents in six countries in Sub-Saharan Africa in 2015–2017.

Model	Predictor	*P* (sex)	*P* (age)	*P* (in school)
Sociodemographic indices				
Model 1	Sex	–	0.065	0.147
Model 1	Age	0.065	–	0.167
Model 1	In school	0.147	0.167	–
Model 1	Both parents alive	0.478	0.997	0.747
Model 1	Live with both parents	0.450	0.478	0.268
Model 1	Wealth quintile	0.990	0.822	0.416
Model 1	Father's education	0.012	0.253	0.152*
Model 1	Father farmer	0.257	0.679	0.783
Model 1	Mother's education	0.011	0.517	0.152*
Model 1	Mother farmer	0.020	0.910	0.799
Model 1	Money earning in past 12 months	0.417	0.955	0.448
Nutrition, physical activity and social indices				
Model 2	Supportive home	0.439	0.047	0.362
Model 2	Supportive school	0.182	0.358	–
Model 2	Ever bullied	0.853	0.799	0.853
Model 2	Close friends	0.339	0.932	1.000*
Model 2	Experienced violence	0.017	0.654	0.595
Model 2	TV watching highest quartile	0.569	0.171	0.132
Model 2	Internet use highest quartile	0.224	0.080	0.020
Model 2	Physically active $\geq$ 1hr/day	0.898	0.633	0.869
Model 2	Physical education $\geq$ 4 days/week	0.086	0.391	–
Model 2	Food insecure	0.995	0.392	0.913
Model 2	Fruit or veg $\geq$ 5 servings/day	0.281	0.886	0.160
Model 2	Fast food $\geq$ 1/week	0.054	0.637	0.868
Model 2	Soda $\geq$ 1/day	0.286	0.591	0.320
Model 2	Dietary diversity score $\geq$ 5	0.745	0.902	0.175
Model 2	Poor healthcare access	0.825	0.999	0.307
Diet - singular food group consumption				
Model 3	Grains, white roots and tubers	0.114	0.469	0.966*
Model 3	Pulses, nuts and seeds	0.447	0.634	0.478
Model 3	Dairy	0.375	0.475	1.000*
Model 3	Meat, poultry and fish	0.789	0.641	1.000*
Model 3	Eggs	0.584	0.075	1.000*
Model 3	Dark leafy green veg	1.000*	1.000*	1.000*
Model 3	Other Vit A rich fruit/veg	0.073	0.455	1.000*
Model 3	Other veg	0.476	0.243	0.245
Model 3	Other fruit	0.287	0.803	0.507
Personal perceptions				
Model 4	Satisfied with health	0.319	0.403	0.891
Model 4	Satisfied with life	0.389	0.577	0.465
Model 4	Lonely last year	0.534	0.001	0.103
Model 4	No sleep due to worry last year	0.505	0.126	0.667

Estimates of *P* for interaction based on mixed-effects Poisson regression models, adjusted for clustering by site. Model 1 was adjusted for all Model 1 variables. Model 2 was adjusted for all Model 1 variables, and all Model 2 variables (except supportive school and physical education (P values for these were based on models additional adjusted for these variables and restricted to school-going participants only). Model 3 was adjusted for all variables in Models 1, 2 and 3 (with the exception of supportive school and physical education). Model 4 was adjusted for all variables shown and sociodemographic, nutritional, physical activity, social and healthcare variables shown in Models 1 and 2 (with the exception of supportive school and physical education).*Models with interaction terms did not fully converge.
TV: television.

associations with greater power, including for a wider range of nutrition and related measures. Additional to confirming previously-reported trends (Nyundo et al., 2020), we also observed associations between other aspects of food intake and depressive symptoms. Furthermore, we were able to examine in greater detail potential effect modification by sociodemographic factors.

Associations observed in this analysis are also generally consistent with earlier studies, though SSA-specific evidence remains limited. The effect of adolescent age on depressive disorders is thought to reflect biological processes linked to pubertal development, and responses to changing societal roles and expectations (Mridha et al., 2021; Frey et al., 2020). The increased risk among girls is understood to be driven by biological mechanisms including endocrine influences, and sociocultural pathways impacting physical and emotional wellbeing (Mridha et al., 2021; Frey et al., 2020). Increased stress associated with violence and bullying is understood to promote the development of depressive disorders through cognitive and affective pathways, which are also thought to be interrelated with biological mechanisms such as inflammation and structural changes in the brain (Arhin et al., 2019; du Plessis et al., 2015; Logie et al., 2022; Slavich and Irwin, 2014; Weissman et al., 2020). On the other hand, in this population, we did not observe associations between other factors that have been linked to depressive symptoms in adolescents, including television viewing time or having close friends (Mridha et al., 2021; Gautam et al., 2021). Differences compared with previous research may be due to multiple factors, including population-specific differences in the contribution of such aspects, or study-specific differences in adjustment of other explanatory factors (Gautam et al., 2021).

Our findings reinforce the link between food insecurity and depressive symptoms, and additionally suggest an influence of intake of fruits and vegetables and starchy foods. Much data have previously highlighted a link between food insecurity and depressive symptomatology in global populations (Elgar et al., 2002), with growing evidence from adolescent populations globally (Mridha et al., 2021; Logie et al., 2022). Food insecurity is considered a proxy of low socioeconomic status, which has been associated with increased risk of common mental disorders (Elgar et al., 2002), and is understood to contribute to the development of depressive disorders through directly increasing psychological stress related to the ability to secure food, and through hunger (Elgar et al., 2002; Allen et al., 2018). Food insecurity may also affect depressive symptoms through influences on diet and nutritional status (Myers, 2020). In the current analysis, food insecurity was one of a few key factors strongly associated with increased risk of depressive symptoms, reinforcing its importance in this population. Importantly, approximately one tenth of the population was food insecure. Within the context of previous research, our data suggest that addressing food insecurity may contribute to reducing the burden of depressive symptoms in this and similar populations.

Evidence is increasing regarding the contribution of diet and nutritional status to depressive disorders, including among adolescents (O'Neil et al., 2014; Khalid et al., 2016). However, the overall the quality of evidence is understood to be low, with comparatively less representation from LMICs including SSA (O'Neil et al., 2014; Khalid et al., 2016). Available data point towards a complex role of nutrients in the promotion and prevention of such disorders. Specific micro- and macronutrients are understood to contribute to depressive disorders through distinct and interacting pathways, including immunological and inflammatory, endocrine and neurological mechanisms (Ortega et al., 2022). In the current analysis, we observed decreased risk of depressive symptoms associated with consumption of grains, white roots and tubers in the past day, and increased risk associated with a higher daily intake of fruits and vegetables. Notably, intake of these food groups was higher among adolescents from lower socioeconomic backgrounds (data not shown). Given this, and previous research indicating either no effect or protective effects of fruit and vegetable intake on depressive disorders among adolescents (Khalid et al., 2016), the opposite trends observed here may be more broadly reflective of effects of food insecurity rather than the actual foods. Also within this context, the promotion of satiety by carbohydrate consumption may at least partly explain the inverse associations observed for consumption of grains, white roots and tubers, alongside the possible contribution of other known mechanisms such as increased brain serotonin levels (Allen et al., 2018; Wurtman and Wurtman, 1995).

Although previous research has suggested the importance of other dimensions of diet on depressive disorders, we did not observe strong

associations for any other nutritional factors examined. This includes consumption of fast foods and soda (Khalid et al., 2016), or intake of other specific food groups such as beans, pulses, nuts and seeds in the past day. One reason for this may be the specific measures used, particularly for the singular food groups comprising the MDD-W, which simply asked whether the participant had consumed a particular food group in the past day and may have resulted in an imprecise measure of intake. Additionally, the consumption of certain foods such as fast foods was relatively infrequent in this population. This, along with other possibly important context-specific factors such as general level of physical activity, may have led to low and unstable estimates of effect.

The current analysis highlights key avenues for further research and considerations for the design and testing of interventions to address depressive symptoms among adolescents in this population. The range of associated factors indicates the potential need for strategies encompassing multiple domains. The strong associations between personal perceptions suggest opportunities to use such symptoms to identify adolescents at higher risk of having depressive symptoms. The absence of effect modification by age, sex or school-going status, suggests that population-wide approaches may be suitable. Nonetheless, there is a need to ensure that interventions are designed and delivered appropriately to maximize uptake and effectiveness. Within this context, detailed examination of the joint distribution of associated factors identified here may help to further inform the design of such interventions. Most previous SSA-based studies have targeted specific risk factors only and often among high risk adolescents (Mabrouk et al., 2022). However, our findings reinforce the potential opportunity to examine more integrated approaches to achieve greater impact in terms of mental health but also overall health among all adolescents.

The current analysis has multiple strengths. We pooled data from a multi-country cross-sectional study on adolescent health, with data collection methods harmonized across sites and a large pooled sample, enabling increased precision of estimates. The large sample size allowed for increased power when examining associations overall, and when examining effect modification in stratified models. Furthermore, we were able to explore the relative influence of a number of factors across multiple domains, including those related to nutrition and food intake. This analysis was based in both in-school and out-of-school adolescents across eight rural and urban sites (in six countries) in SSA, suggesting some generalizability of key findings to these settings. Limitations of this analysis include its cross-sectional nature, preventing the establishment of the temporal nature of the associations and thereby limiting inferences. This includes more clearly characterizing associations which may be bidirectional in nature, such as those with physical activity and diet (Kracht et al., 2023). Since KADS-6 has not been validated in these populations, measures of depressive symptoms are indicative. Research further exploring and validating this and other measures in adolescent populations in SSA will be key. Furthermore, given the number of hypotheses tested in this analysis, the likelihood of observing false positive associations increases. Although we did not correct for multiple hypothesis testing, we interpret associations with caution and recognize the need for further evidence to corroborate our findings. As such, our results provide a strong basis for further longitudinal research into depressive symptoms among adolescents in sub-Saharan Africa, highlighting potentially important associated factors.

In all, in this analysis, we observed strong associations between several factors across demographic, social, and nutrition-related domains and the risk of depressive symptoms in a multi-country population of adolescents based in sub-Saharan Africa. Our observations highlight the need for further research investigating the causes and potential interventions to address depressive disorders among adolescents in this and similar populations.

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CRediT authorship contribution statement

Uttara Partap: Formal analysis, Writing – original draft, Writing – review & editing. **Azan Nyundo:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Adom Manu:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Mathilda Regan:** Methodology, Investigation, Writing – review & editing. **Abbas Ismail:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Angela Chukwu:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Yadeta Dessie:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Tasiana Njau:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Sylvia F. Kaaya:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Wafaie W. Fawzi:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102499.

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