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ORIGINAL ARTICLE

Clustering of multiple health risk factors among a sample of adolescents in Liberia: a latent class analysis

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Abstract

Aim Non-communicable diseases (NCDs) are associated with modifiable health risk factors. There is a lack of evidence regarding clusters of health-related behaviours among school-going adolescents from sub-Saharan Africa. This study was conducted to identify clustering patterns of health risk factors (i.e. smoking tobacco, inadequate fruit intake, inadequate vegetable intake, physical inactivity, sedentary behaviour, anxiety and depression) and association with sociodemographic factors among school-going adolescents in Liberia.

Subject and methods The 2017 Liberian Global School-based Student Health Survey on 2774 adolescents aged 11 years and above (52.5% females) sampled with a two-stage cluster sample design was used. Latent class analysis was used to generate the clusters and latent class regression assessed the associations between sociodemographic factors and the clusters.

Results We identified three clusters labelled as (1) 'low substance use, moderately active cluster' (34.8%); (2) 'inadequate fruit and vegetable cluster' (48.9%) and (3) 'risk taking cluster' (16.3%)'. Compared to cluster 1, adolescent boys [AOR = 1.71, 1.29–2.27, $p < 0.001$], and those in grade 10–12 [AOR = 1.51, 1.13–2.02, $p < 0.001$] were more likely to belong to cluster 2. Participants aged 15 years and above [AOR = 0.60, 0.39–0.91, $p = 0.018$] were less likely to belong to cluster 2. Compared to cluster 1, adolescents aged 15 years and above [AOR = 3.58, 1.33–9.62, $p = 0.011$] and those with low socio-economic status [AOR = 1.83, 1.22–2.73, $p = 0.003$] were more likely to belong to cluster 3.

Conclusion These results underscore the need for interventions that address adolescent multiple health risk factors, especially considering sociodemographic differences.

Keywords Cluster analysis · Multiple health risk factors · Adolescents · Liberia

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Introduction

Globally, non-communicable diseases (NCDs) are responsible for majority of deaths (World Health Organization 2018) and may have implications on the quality of life, social and economic development in low- and middle-income countries (World Health Organization 2014a). In Liberia, 31% of deaths were related to NCDs (World Health Organization 2018). In the same report, the common risk factors that contributed to these NCDs were tobacco use, harmful use of alcohol, physical inactivity, poor nutrition characterised by inadequate fruit and vegetable consumption and obesity (World Health Organization 2018). The above-mentioned report provides evidence for the existence of clustering effect of varying health risk behaviours among the adult population in Liberia. The existence of such pattern of clustering among school-going adolescents in the same country remains unexplored.

Engagement in these health risk behaviours usually commences during adolescence and is often carried and continued

into adulthood (Kwan et al. 2012; Wengreen and Moncur 2009; Winpenny et al. 2018). These health risk behaviours do not only occur in isolation, but they often co-occur or cluster with psychological distress (McAloney et al. 2013; Meader et al. 2016; Champion et al. 2018). The risk of chronic diseases and mortality is higher when one engages in multiple health risk behaviour compared to engaging in just a single health behaviour (Ding et al. 2015; Loef and Walach 2012).

There is an increasing number of studies that have examined the clustering patterns of health risk factors associated with NCDs. However, the majority of these studies were conducted among adults (e.g. Meader et al. 2016) and few among adolescents in developed countries (Leech et al. 2014). Some of these studies have reported the prevalence of health risk factors among adolescents in Liberia (Borba et al. 2016; Harris et al. 2012; Ogundare et al. 2020). For instance, the study by Harris and colleagues that examined substance use among secondary school students in Liberia reported the prevalence of alcohol use, marijuana use and cigarettes smoking to be 51%, 9% and 6.8%, respectively (Harris et al. 2012). A recent study has also revealed that adolescents who use alcohol were 2.4 times more likely to engage in other health risk behaviour, including tobacco smoking (Ogundare et al. 2020). However, none of these studies have examined the clustering patterns and socio-demographic characteristics associated with clusters.

Analysis of demographic variables with clustering of health risk factors among adolescents is important as it allows policy makers to know which sub-groups of individuals are more likely to be at risk for immediate and long-term health outcomes. However, within sub-Saharan Africa, there is sparse literature regarding which cluster of health behaviours are present in which sociodemographic groups. Even though Western literature shows that that age, sex and social class (Leech et al. 2014; Watts et al. 2016; Matias et al. 2018; Meader et al. 2016) are implicated in clustering of health risk factors, they may not be applicable to the African context as cluster patterns may be unique to specific cultures and context (Leech et al. 2014; Iannotti and Wang 2013).

The aims of this study are twofold: (1) to identify the clustering patterns of health risk factors among adolescents in Liberia and (2) to identify which socio-demographic characteristics are associated with the identified clusters. An examination of the clustering pattern and factors associated with the identified clusters among adolescents in Liberia could provide evidence-based information to guide the design and delivery of interventions. Furthermore, it is important to examine the clustering pattern of health risk factors among adolescents given that engagement in these health risk factors commence during adolescence and it is also a stage in life where many of them will transition out of school to work or further their education.

Methods

Data

Several studies have previously reported the details about the Global School-based Student Health Survey (GSHS) (World Health Organization 2014b). Briefly, the Global School-based Student Health Survey (GSHS) is a youth health and risk behaviour study conducted in low- and middle-income countries worldwide by national ministries of health and/or education with technical support from the World Health Organization (WHO) and the U.S. Center for Disease Control and Prevention (CDC). Each country's GSHS questionnaire includes validated survey items examining the behavioural risk factors and protective factors in several domains of functioning among school-going adolescents. Data for the GSHS are collected from a nationally representative sample of secondary school students after ethical approval and other permissions are granted by the relevant authorities. Students who voluntarily consent to complete the survey record their own answers on a computer scannable form distributed by trained staff during one standard class period. No individually identifiable information is collected. Approximately two years after the data are gathered, clean data files are made freely available to the public and they do not contain any individual- or school-level identifiers.

Sampling

The data used for this study was obtained from the 2017 cross-sectional Global School-based Student Health Survey (World Health Organization 2014b). For all GSHS-participating countries, a two-stage approach is used to generate a nationally representative sample of school children in the grades that educate the most students who are in the target age ranges. In the first stage of the cluster sampling design, schools are randomly sampled from a list of all schools in the country using a probability proportionate to size (PPS) method. This method ensures that the participants represent the geographic diversity of the country. In the second stage of the sampling process in each country, several classrooms that include high proportions of students from the targeted age groups are sampled for inclusion from within each of the participating schools. This allowed every student to have an equal chance of being selected for the study. Participants for this study were grades 7–12 students sampled from selected schools in Liberia. Numerical weights were applied to each student record to enable generalization of results to the eligible population. A total of 2744 students participated in this study.

Measures

Data for this study was collected using closed ended questionnaires that asked questions about their socio-demographic

characteristics and a range of health risk behaviours (World Health Organization 2014b). Variables used for this study are described below:

Smoking Tobacco

Smoking tobacco was assessed by asking 'During the past 30 days, on how many days did you use any tobacco products other than cigarettes, such as snuff?' (World Health Organization 2014b). Participants who chose '0 days' were classified as non-smokers and those who chose '1 to 2 days', '3 to 5 days', '6 to 9 days', '10 to 19 days', '20 to 29 days' and 'all 30 days' were classified as current smokers (Oppong Asante and Kugbey 2019).

Vegetable consumption

Vegetable consumption was measured by asking 'During the past 30 days, how many times per day did you usually eat vegetables such as water greens, potato greens, pumpkin, bitter bove, kittily, or watermelon?' (World Health Organization 2014a). Participants who chose 'I did not eat vegetables during the past 30 days' to '4 times per day' were categorised as not eating adequate vegetables (Teh et al. 2019). Those who selected '5 or more times per day' were classified as adequate consumers of vegetables (Teh et al. 2019).

Fruit consumption

Participants were asked 'During the past 30 days, how many times per day did you usually eat fruit, such as pawpaw, orange, plum, lemon, grapefruit, or apple?' (World Health Organization 2014b). Those who selected 'I did not eat fruit during the past 30 days' to '1 time per day' were classified as *inadequate fruit consumers* and those who selected '2 times per day' and above were classified as *adequate fruit consumers* (Teh et al. 2019).

Alcohol consumption

Alcohol consumption was assessed by asking 'During the past 30 days, on how many days did you have at least one drink containing alcohol?' (World Health Organization 2014b). Non-drinkers were those who selected '0 days' and current drinkers were those who selected '1 to 2 days', '3 to 5 days', '6 to 9 days', '10 to 19 days', '20 to 29 days' and 'All 30 days'.

Physical inactivity

Participants were asked 'During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?' (World Health Organization 2014b). Those who selected '0 days' were classified as physically inactive and those who selected '1 day' and above were classified as physically active (World Health Organization 2010).

Sedentary behaviour

Sedentary behaviour was measured by asking 'How much time do you spend during a typical or usual day sitting and watching television, playing computer games, talking with friends, or doing other sitting activities such as ludo, check-up, tag, cards, marbor, or scramble?' (World Health Organization 2014b). Respondents who selected 'Less than 1 hour per day' and '1 to 2 hours per day' were classified as non-sedentary. Those who selected '3 to 4 hours per day', '5 to 6 hours per day', '7 to 8 hours per day' and 'more than 8 hours per day' were classified as sedentary (Teh et al. 2019).

Depression

Participants were asked 'During the past 12 months, how often have you felt lonely?' (World Health Organization 2014b). All those who selected 'never', 'rarely' and 'sometimes' were categorised as not having a symptom of depression and those who selected 'most of the times' and 'always' were considered to have a symptom of depression (Oppong Asante and Kugbey 2019).

Anxiety

Participants were asked 'During the past 12 months, how often have you been worried about something so that you could not sleep at night?' (World Health Organization 2014b). All those who selected 'never', 'rarely' and 'sometimes' were categorised as not having a symptom of anxiety and those who selected 'most of the times' and 'always' were considered to have a symptom of anxiety (Oppong Asante and Kugbey 2019).

Socio-demographic characteristics

The following socio-demographic characteristics were collected: age, gender, grade and socio-economic status (SES). Hunger status was used as a proxy for measuring SES. Participants were asked 'During the past 30 days, how often did you go hungry because there was not enough food in your home? (World Health Organization 2014b). Those who selected 'never' and 'rarely' were those from high SES background and participants who selected 'sometimes', 'most of the time' and 'always' were classified as participants from low SES background (Glozah et al. 2018).

Statistical analysis

All eight health risk factors were dichotomised (1 = presence of risk, 0 = no risk) and the scores were added to generate a

total risk score ranging from 0 to 8. Descriptive statistics were used to describe the socio-demographic characteristics and prevalence of each of the health risk factors.

We used Latent Class Analysis (LCA) to generate clusters of health risk factors among the participants. Latent class analysis is used to identify homogeneous, mutually exclusive classes in a heterogeneous population (Laska et al. 2009). This clustering analysis helps to identify subgroups of individuals in a population who have similar health risk factors, as indicated by their responses to a set of observed categorical variables (Collins and Lanza 2009). The subgroups are unobserved and are referred to as latent classes. The observed categorical variables that make up the latent classes in this analysis was the eight health risk factors. The latent regression model allows covariates to be included and this helps to identify how these covariates are associated with the latent clusters (Linzer and Lewis 2011). To fit the LCA model, we first of all specified the number of latent classes we wanted and using maximum likelihood, the procedure found the best class solution, estimated the response probability for each class and the probability of each participant in the study belonging to each class. The LCA model was fit over four classes, the Bayesian information criterion (BIC) and Akaike information criterion (AIC) were generated for each (Lanza et al. 2007). The class with the smallest BIC and AIC was considered a good fit (Lanza et al. 2007). We were guided by the following to interpret the model: classes should be different from each other based on the item response probabilities, classses should not be trivial in size, and the ability to give meaningful names to each class (Lanza et al. 2007). The three class model was selected because it had the smallest AIC (20,568.229) and BIC (20,722.0745).

Given that the LCA model allows for covariates to be included, we then added the socio-demographic characteristics to determine which socio-demographic characteristics are associated with class membership. The latent regression model generated the adjusted odds ratios, 95% confidence interval, standard error of the mean and significance values for two classes relative to the reference class. All analysis was performed using STATA 15 (Stata Corporation, College Station, TX, USA).

Results

Characteristics of sample

A total of 2744 adolescents participated in the survey. Table 1 below is a summary of the sample characteristics. A little above half were females (52.5%), were in grade 7 to 9 (56.4%). The majority (85.3%) were in the 15 years and above age category and in the low socio-economic status (65.5%).

Table 1 Socio-demographic characteristic of adolescents ($n = 2774$)

Variables	Frequency [a]	Percentage
Gender		
Male	1253	47.6%
Female	1382	52.5%
Grade		
7 to 9	1523	56.4%
10 to 12	1177	43.6%
Age in years		
11–14 years	392	14.7%
15 years and above	2269	85.3%
Socio-economic status		
Low	1731	65.5%
High	910	34.5%

[a] Missing numbers

Prevalence of health risk factors

Prevalence of each health risk factor are presented in Table 2. Approximately 79.1% reported inadequate fruit consumption and 72.5% reported inadequate vegetable intake. Prevalence of tobacco smoking and alcohol intake was 12.8% and 24.9%, respectively. Approximately one out of five students (20%) engaged in sedentary behaviour, while 34.8% of the students reported inadequate physical activity. The prevalence of depression and anxiety among the students was 13.9% and 20.5%, respectively.

Cluster profiles

Clusters identified were labelled based on the analytic strategy and on the interpretability of the clusters. These clusters were labelled cluster 1: 'low substance use and moderately active cluster'; cluster 2: 'inadequate fruit intake and inadequate vegetable intake cluster' and cluster 3: 'risk taking cluster'. The conditional probabilities of the risk factors are shown in Fig. 1.

Cluster 1, 'low substance use, and moderately active' cluster comprised 34.8% (95% CI: 25–46%) of the sample. This cluster had the lowest probability of smoking and drinking alcohol. Adolescents in this cluster were more likely to eat adequate fruit, vegetable and moderately engage in physical activity compared to the other clusters. They also reported low probabilities of anxiety and depression. Cluster 2 labelled 'inadequate fruit and vegetable consumption' had the highest prevalence poor nutrition characterised by inadequate fruit intake and inadequate vegetable intake. The same cluster had low prevalence of alcohol intake, tobacco smokers and physical inactivity. Furthermore, low prevalence of sedentary activities, anxiety and depression were found to be associated with this cluster. This cluster comprised 48.9% (95% CI: 39–

Table 2 Prevalence of health risk factors and psychological distress among adolescents

Health risk factors	Frequency [a]	Percentage (%)
Smoking Tobacco		
No	2324	87.5%
Yes	331	12.8%
Inadequate fruit intake for the past 30 days		
No	556	20.9%
Yes	2110	79.1%
Inadequate vegetable intake for the past 30 days		
No	720	27.5%
Yes	1902	72.5%
Alcohol use for the past 30 days		
Yes	618	24.9%
No	1866	75.1%
Physical inactivity for the past 7 days for ≥ 60 min		
Yes	854	34.8%
No	1597	65.2%
Sedentary behaviour		
No	1962	80%
Yes	490	20%
Psychological distress		
Depression		
Yes	367	13.9%
No	2267	86.1%
Anxiety		
Yes	540	20.5%
No	2098	79.5%

[a] Missing numbers

59%) of the sample. Cluster 3 labelled 'risk taking' had adolescents with high probabilities of tobacco smoking and alcohol consumption compared to clusters 1 and 2. This cluster also had poor nutrition characterised by high probabilities of inadequate fruit and vegetable intake although not as high in cluster 2. However, they had low probabilities of physical inactivity and sedentary activities. Compared to the other clusters, they had high prevalence of anxiety and depression. This cluster comprised 16.3% (95% CI: 12–22%) of the sample.

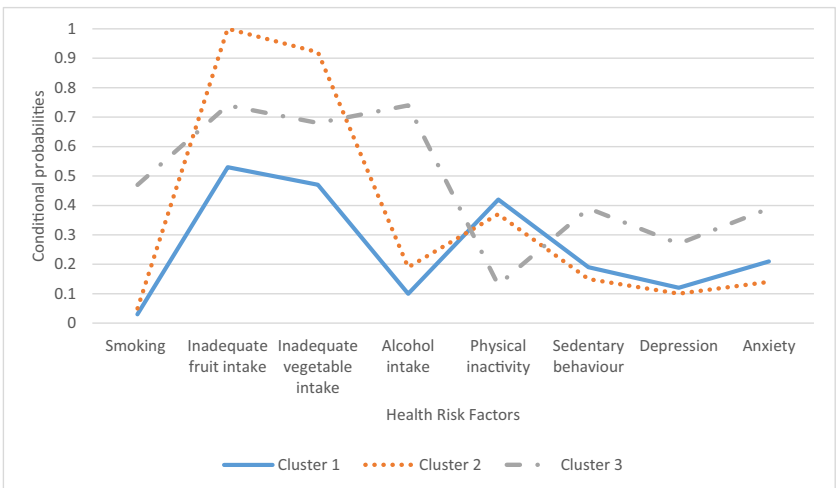

Fig. 1 Conditional probabilities of health risk behaviours

Sociodemographic characteristics associated with cluster profiles

From Table 3 below, compared to the low substance use and moderately active cluster, boys [AOR = 1.71, 1.29–2.27, $p < 0.001$] and adolescents in upper high school grades (10–12) [AOR = 1.51, 1.13–2.02, $p = 0.005$] were also more likely be in the inadequate fruit and vegetable consumption cluster. However, school-going adolescents aged 15 years and above [AOR = 0.60, 0.39–0.91, $p = 0.018$] were less likely to belong to the inadequate fruit and vegetable consumption cluster. We also observed that compared to the low substance use and inactive cluster, school-going adolescents aged 15 years and above [AOR = 3.58, 1.33–9.62, $p = 0.011$] and those from low socio-economic status background [AOR = 1.83, 1.22–2.73, $p = 0.003$] were more likely be in the risk taking cluster.

Discussion

This study examined the clustering patterns of health risk factors and their association with sociodemographic factors among a national population-based sample of Liberian school-going adolescents. Our analysis revealed three important findings: (1) high prevalence of health risk factors with approximately 79% and 73% of the participants reporting inadequate fruit and vegetable consumption, respectively; (2) three clusters were identified and were labelled as 'low substance use and moderately active'; 'inadequate fruit and vegetable consumption' and 'risk taking'; and (3) our latent class regression analysis showed that specific sociodemographic characteristics such as age, gender, grade and socioeconomic status were associated with different cluster profiles.

Our findings recognised cluster 1 as the healthiest cluster, characterised by lowest probability of smoking and drinking alcohol coupled with moderate consumption of fruits and vegetables with moderate engagement in physical activities. The other two clusters are characterised by moderate to high levels of unhealthy health risk factors (i.e. low physical activity, inadequate consumption of fruits and vegetables, tobacco smoking¸ and alcohol consumption). It is noteworthy that identification of clusters of health risk factors in young adults is important as it helps provide evidence-based information to guide the design and delivery of interventions. Each of these three identified clusters gives an indication of the presence of behavioural risk factors among the study sample, as two of these clusters consist of at least one unhealthy behaviour. This therefore confirms the existence of co-occurrence of health-related behaviour among school-going adolescents in Liberia; similar to what has been reported in developed countries (e.g. Watts et al. 2016; Matias et al. 2018; Meader et al. 2016). Our findings also reinforce the need for multiple health risk interventions that target multiple health risk factors concurrently instead of in isolation. This is based on the concept of 'transfer theory/effect', where skills or knowledge learnt in changing our health behaviour can be applied to change other health behaviours (Lippke et al. 2012).

Cluster 1 and 2 appears to be a 'healthy' cluster in our study. These clusters were characterised by low to moderate prevalence for most of the risk factors. It is therefore not surprising that these clusters had low prevalence of anxiety and depression compared to the risk taking cluster. Previous

Table 3 Cluster's profile and their association with sociodemographic characteristics

Variable	Inadequate fruit and vegetable intake cluster				Risk taking cluster			
	AOR	SE	95% CI	*p value*	AOR	SE	95% CI	*p value*
Sex								
Female	1				1			
Male	1.71	.143	1.29–2.27	**< 0.001**	1.35	.191	.93–1.96	0.119
Age								
11–14 years	1				1			
≥ 15 years	0.60	.219	0.39–0.91	**0.018**	3.58	.505	1.33–9.62	**0.011**
SES								
High	1				1			
Low	1.22	.146	0.92–1.63	0.171	1.83	.205	1.22–2.73	**0.003**
Grade								
7 to 9	1				**1**			
10–12	1.51	.148	1.13–2.02	**0.005**	1.21	.190	0.84–1.76	0.308

Reference cluster = cluster 1: Low substance use and inactive

AOR – Adjusted odds ratio; 95% CI – Confidence interval; SE – Standard error

Models adjusted for sex, age. Socioeconomic status (SES) and level of education (grade)

Bolded *p* values are statistically significant ($p < 0.05$)

studies have reported co-occurrence of health risk behaviours with either depression and/or anxiety symptoms (Hayward et al. 2016; Nguyen et al. 2017). Health interventions targeting multiple health risk behaviours among adolescents in Liberia should also consider addressing mental health problems as well.

We found in this study that different sociodemographic characteristics such as age, gender, grade and socioeconomic status correlated with different cluster profiles. For example, our findings that boys were also more likely be in the inadequate fruit and vegetable consumption cluster is not surprising as several studies have shown that active clusters were predominantly composed of boys (Leech et al. 2014; Rasmussen et al. 2006; Watts et al. 2016). A recent study that explored consumption of fruits and vegetables among individuals 15 years and older in 28 low- and middle-income countries also found Liberia to be one of the countries where adolescents were likely to consume lower amounts of fruits and vegetables than the recommended amount by the WHO (Frank et al. 2019). On the contrary, this finding contrast with other studies that have generally suggested that girls consume more fruits and vegetables than boys (Matias et al. 2018; Darfour-Oduro et al. 2018). However, the fact that Liberian boys were more likely be in the inadequate fruit and vegetable consumption cluster calls attention to the urgent need for health promotion targeting this population. It may also be plausible that in Liberia, gender-specific social roles may explain the differences because both boys and girls may have been socialized in different ways and tend to have different encouragements in pursuit of a healthy lifestyle.

In this study, we observed that age was negatively associated with the inadequate fruit and vegetable consumption cluster but at the same time positively associated with the risk taking cluster. In other words, younger adolescents were more likely to have inadequate fruit and vegetable consumption whilst older adolescents were more likely to engage in risk taking behaviours. The negative relationship between age and inadequate fruit and vegetable consumption contradicts previous findings that have found increases in age to be associated with high fruit and vegetable consumption (Cuenca-García et al. 2013; Leech et al. 2014; Matias et al. 2018) but consistent with the findings by Winpenny et al. that reported that fruit and vegetable intake decreases as an individual ages (Winpenny et al. 2018). The positive relationship between age and the risk taking cluster (particularly high probabilities of tobacco smoking and alcohol consumption) is not surprising as adolescence at the developmental stage is troubled with experimentations of several risky behaviours, including substance use (Kugbey et al. 2018; World Health Organization, 2014)), and within sub-Saharan Africa, existing studies on alcohol consumption and tobacco smoking among school-going adolescents suggest that heavy episodic drinking is higher among adolescents than adults (World Health Organization 2014c; Doku et al. 2012; Peltzer et al. 2016). This observed relationship could be explained in two ways: post conflict nature of Liberia and peer influence. For example, a recent review of the literature has reported that in West African countries, including Liberia, alcohol and other unconventional substances are commonly misused by young people (Lange et al. 2018), and in Liberia, peer influence has also been implicated for alcohol and substance use among school-going adolescents (Olurishe 2019).

Our results also showed that school-going adolescents with low socio-economic status were more likely to be in the risk taking cluster (i.e. high probabilities of tobacco smoking alcohol consumption and other health risk factors). This finding confirms a previous study that indicated that alcohol and substances are widely available for Liberian adolescents, particularly in neighbourhoods afflicted by poverty (Petruzzi et al. 2018) coupled with the fact that alcohol is one the most common substances used among school-going adolescents in Liberia (Harris et al. 2012). However, this finding challenges the existing notion that low-income groups are more likely to abstain from alcohol (Blakely et al. 2005; World Health Organization 2014c) and the assertion that socioeconomic status is positively associated with healthy lifestyle patterns (Matias et al. 2018). The findings that adolescents from low socio-economic status were more likely to be in the risk taking cluster is exceedingly complex and may be moderated by a host of individual and environmental factors. It is, however, possible that interpersonal level risk factors within the school environment may have played a role in this association, as indicated by previous studies (Hodder et al. 2017; Obradors-Rial et al. 2020). We further found that adolescents in upper high school grades (10–12) were also more likely be in the inadequate fruit and vegetable consumption cluster. This finding may be attributed to the fact that fruit and vegetable intake tends to change with age across childhood and adolescence. In a recent study, it was revealed that fruit intake started to decrease from late childhood and reached its lowest level during adolescence (Albani et al. 2017).

Strengths and limitations of this study

This is one of the first cross-sectional studies to have used nationally representative data to explore clustering of health-related behaviours among school-going adolescents from sub-Saharan Africa. This enabled us to explore which health risk factors co-exist among Liberian adolescents. Despite this strength, some limitations of the study should be noted. The cross-sectional design of this study prevents us from making inferences about the causal directions of the associations reported. For example, it is not clear whether clustered risk behaviours are adopted simultaneously or whether the adoption of one risk behaviour subsequently leads to the adoption

of further risk behaviours. Our analysis from this study was based on self-report measures which may be confounded by systematic and social desirability biases.

Conclusion

This study was conducted to identify clustering patterns of health risk factors and association with sociodemographic factors among school-going adolescents in Liberia. We identified three clusters, namely low substance use and moderately active cluster, inadequate fruit and inadequate vegetable consumption cluster and risk taking cluster consisting of 34.8%, 48.9% and 16.3% of the sample, respectively. We also observed association between the various clusters and sociodemographic characteristics of these adolescents. These associations underscore the need for the development of interventions that address adolescent multiple health risk behaviours which should be tailored to specific adolescent groups, especially considering sociodemographic differences. This study, thus, provides some critical information to our understanding of which adolescents may need more attention when addressing the health and wellbeing of this population.

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Authors' contributions Prince Atorkey conceptualised the study and the design. Statistical analysis was performed by Prince Atorkey. The first draft of the introduction, methodology and results were written by Prince Atorkey with input from Kwaku Oppong Asante. Discussion was written by Kwaku Oppong Asante. All authors critically reviewed the manuscript and approved the final version.

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Data availability Data for this study was obtained from the World Health Organisation (WHO) website and is freely available online.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were done in accordance with the ethical standards of the Ethics Committee of the Liberia Ministry of Education and the WHO and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written approval was obtained from Liberia Ministry of Education, the schools that participated, and teachers.

Informed consent Written informed consent was obtained from students and additional parental consent from parents of participants who were below 18 years.

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