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Food insecurity, affected by socio-demographic factors, is associated with water insecurity? A cross-sectional analysis of sub-Saharan Africa

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Abstract

Worldwide, insufficient water and food are among the major natural resource challenges which are experienced by millions of people. Compared to other developing regions, Sub Saharan Africa (SSA) is the most affected part of the world by insufficient water. Moreover, according to the report from FAO, more than 300 million people in SSA are severely food insecure. The main objectives of this study are 1) to understand the association between water insecurity and food insecurity in sub-Saharan African countries, and 2) to explore the role of socio-demographic factors in food insecurity status. Data were used from the Round 6 of the "Afrobarometer" Surveys conducted in 2016. 32 Sub-Saharan African countries (n=49,137) were included in this analysis. Different statistical analyses such as descriptive, crosstabs and regressions form the basis of this study. In terms of the prevalence of water insecurity, 53% of respondents had access to water and more than half of the respondents were food secure (52%). Crosstabs analyses showed that there was a strong and significant association between water insecurity and food insecurity (0.485; $p<0.0001$). The findings from regression analyses indicate that the probability of being food secure increased among people who had enough clean water for home use (OR=39.17; 95% CI (33.40-45.93)). Water and income availability are strongly related to food insecurity in SSA. As a result, investments in water infrastructure is recommended, and findings from this study can be used by policy makers to influence governments' action.

Keywords: Water Insecurity; Food Insecurity, SSA; Socio-Demographic Factors

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1. Background

Worldwide, insufficient water and food are among the major natural resource challenges which are experienced by millions of people (Wutich and Brewis, 2014). In fact, 844 million people lack access to basic drinking water (Gomez et al., 2019). Water is concerning reality, especially for millions of people living in poor and developing countries (Hopewell and Graham, 2014). In 2010, the United Nations recognized the human right to water and sanitation, and this closely aligned with the Sustainable Development Goals (SDG) to improve sustainable access to drinking-water sources (UN, 2010). Consequently, water contributes to the progressive realization of both the right to adequate food in the context of national food security and the right to safe drinking water (Committee on Food Security (CFS), 2015). Compared to regions such as Caucasus, Central Asia, Northern Africa, and Oceania (Armah et al., 2018), Sub Saharan Africa (SSA) is the most affected by insufficient water and more population disproportionately live without access to clean water (Dos Santos et al., 2017). In fact, more than one-third of people living in SSA do not have enough access to improved water sources (Pierce, 2017). Like water, according to the report from FAO et al. (2018) more than 300 million people in SSA are severely food insecure. Regarding causes, many factors, such as climate change, farm productivity and access to soil amendments, labor availability, and family income influence food insecurity in SSA (Mendum and Njenga, 2018).

Food security is defined as the access by all people to enough food to live a healthy and productive life (Pinstrup-Andersen, 2009). Similar to food insecurity, household water insecurity is also defined as insecure access to adequate water for a healthy lifestyle (Stevenson et al., 2016). Water is essential to food security because crops and livestock require water to grow. In fact, agriculture needs large quantities of water for irrigation and of good quality for various production processes (UNWOMEN, 2014). Water is the key element for agricultural production. As such, irrigation has been crucial for global food security (Ringler and Zhu, 2015). Access to adequate food in many developing countries, therefore, depends heavily on access to water that is necessary to produce food (UNWOMEN, 2014). Use of water and food security are interconnected. In turn, lack of food security can lead to major challenges, such as famine and undernourishment, in areas where people depend on agriculture which is the source of food and income (FAOWATER, 2009). The relation between water and food availability may seem clear; however, the association between the two is fairly complex (Peterson, 2019). Therefore, further studies are required to study the mechanism of associations between water and food security. The main objectives of this study are 1) to understand the level of association between water insecurity and food insecurity in sub-Saharan African countries, and 2) to explore the role of socio-demographic factors in food insecurity status.

2. Methods

2.1. Data

Data were used from the Round 6 of the Afrobarometer Surveys conducted in 2016. 32 Sub-Saharan African countries (n=49,137) were included in this analysis (Table 1). Afrobarometer measures the social, political and economic atmosphere in more than 30 countries in Africa.

2.1.1. Sample selection

The survey is based on face-to-face interviews with a randomly selected sample of 1,200 or 2,400 people in each country.[1] The sample is designed as a representative cross-section of all citizens of voting age in a given country. Every adult citizen was given an equal and known chance of selection for interview. In sum, the sample is a clustered, stratified, multi-stage, and area probability (Afrobarometer, 2017). To increase the precision of the estimates, the sample was stratified by key social characteristics in the population, typically sub-national area (usually the first-order administrative division within the country, e.g., region or province) and residential locality (urban or rural). Stratification reduces the likelihood that distinctive types of people (e.g., those living in the regions, belonging to particular ethnic or language groups, or living in the city or countryside) are left out of the sample. The proportion of the sample allocated to each stratum should be the same as its proportion in the national population as indicated by the updated census figures (Afrobarometer, 2017).

2.2. Study variables

2.2.1. Dependent variable

This question, as a proxy measure, was used from survey to measure food insecurity: "Over the past year, how often, if ever, have you or anyone in your family gone without enough food to eat? Values of this question are: 0= Never, 1= Less than once a year, 2= At least once a year, 3= At least every six months, 4= At least every three months, and 5= At least once a month".

2.2.2. Independent and control variables

Water insecurity is the principal independent variable in this study and the following question was used as the proxy measure: "Over the past year, how often, if ever, have you or anyone in your family: Gone without enough clean water for home use?". Values of this question are: 0= Never, 1= Less than once a year, 2= At least once a year, 3= At least every six months, 4= At least every three months, and 5= At least once a month". To control the role of socio-demographic factors, the following variables were used: sex, age, employment, education, area of residence, asset ownership and income availability. To measure income availability, this question was used in the survey: "Over the past year, how often, if ever, have you or anyone in your family: Gone without a cash income? (Values of this question are: 0= Never, 1= Less than once a year, 2= At least once a year, 3= At least every six months, 4= At least every three months, and 5= At least once a month)". Asset ownership was creased using the following questions: "Do you own radio, television, motor vehicle, car or motorcycle and mobile phone?". The new created variable ranges from zero to four.

1. A randomly selected sample of n=1200 cases allows inferences to national adult populations with a margin of sampling error of no more than +/-2.8% with a confidence level of 95 percent. With a sample size of n=2400, the margin of error decreases to +/-2.0% at 95 percent confidence level [17].

2.3. Statistical analysis

Statistical analyses were performed using IBM SPSS version 24. The analysis procedure included three steps: analyses of quantitative data (i) to identify the frequencies of dependent, independent and control variables, (ii) to explore the associations between dependent, independent and control variables through running crosstabs analyses (bivariate), and (iii) to assess whether the dependent variable is influenced by water insecurity. This investigation relies on odds ratios to assess whether a change in the value of independent variable (water insecurity) is associated with the change in the odds of dependent variable (food insecurity). In this analysis, two adjusted and unadjusted multinomial logistic regressions were carried out. To check the presence of multicollinearity, the method of pairwise correlation was used. The levels of Chi-Square significance for all analyses are 0.001, 0.01 and 0.05.

Table 1. Sample size of studied countries in SSA (n= 49,137)

GPD PPP (4,000 and more $)	Cape Verde	1200
	Mauritius	1200
	South Africa	2390
	Botswana	1200
	Namibia	1200
	Gabon	1198
	Zambia	1199
	Ghana	2400
	Nigeria	2400
GDP PPP (2,000 to 3,999 $)	Swaziland	1200
	Senegal	1200
	Tanzania	2386
	Guinea	1200
	Ivory Coast	1199
	Zimbabwe	2400
	Kenya	2397
	Cameroon	1182
	Benin	1200
	Lesotho	1200
	Mali	1200
	Sudan	1200
GDP PPP (1,500 to 1,999 $)	Burkina Faso	1200
	Togo	1200
	Sierra Leon	1191
	Uganda	2400
	Madagascar	1200
GDP PPP (Less than 1,500$)	Niger	1200
	Mozambique	2400
	Malawi	2400
	São Tomé and Príncipe	1196
	Liberia	1199
	Burundi	1200

***Reference**: Micro data analysis of Afrobarometer's data in 2016; World Bank, 2018.*

3. Results

3.1. Descriptive findings

Basic descriptive statistics for water insecurity, food insecurity and socio-demographic characteristics are presented in Table 2. In terms of the prevalence of water insecurity, 53% of respondents had access to water and more than 50% of the respondents were food secure (52%). Men (50.3%) and women (49.7%) were equally distributed across the sample and 30% were between 26 to 35 years of age. Results from this study showed that unemployment was very common (61%), and 15% of respondents were post-secondary.

Table 2. Characteristics of sample of SSA countries (n= 49,137).

		n=	%
Area of residence	Rural	29,312	60.4
	Urban	19,225	39.6
Sex	Female	24,736	50.3
	Male	24,401	49.7
Age groups	18-25	11944	24.5
	26-35	14876	30.5
	36-45	9885	20.2
	46-55	6023	12.3
	56-65	3708	7.6
	66 and over	2414	4.9
Education	No formal education	9223	18.8
	Primary	14403	29.4
	Secondary	18323	37.4
	Post-secondary	7057	14.4
Employment status	Unemployed	30045	61.4
	Employed part-time	5898	12.1
	Employed full-time	12966	26.5
Income availability	Always	7416	15.1
	Many times	13028	26.5
	Several times	11485	23.4

	Just once or twice	5823	11.9
	Never	11176	22.7
Asset ownership (Accumulated score)	0	5544	11.3
	1	10073	20.5
	2	12949	26.4
	3	13896	28.3
	4	6654	13.5
Electricity	No	18662	38.0
	Yes	30459	62.0
Water insecurity	Always	4127	8.4
	Many times	5592	11.4
	Several times	7872	16.1
	Just once or twice	5523	11.3
	Never	25929	52.9
Food insecurity	Always	1290	2.6
	Many times	5552	11.3
	Several times	9313	19.0
	Just once or twice	7249	14.8
	Never	25630	52.3

***Reference**: Micro data analysis of Afrobarometer's data in 2016.*

3.2. Crosstabs findings

Results of bivariate analyses are presented in Table 3. Crosstabs analyses showed that strong and significant association between water insecurity and food insecurity was found (0.485; $p<0.0001$). All socio-demographic factors were found significantly related to food insecurity; however, income availability (0.581; $p<0.0001$), asset ownership (-0.334; $p<0.0001$), employment (-0.233; water), education (-0.283; water), and area of residence (0.137; $p<0.0001$) were observed to be strongly associated with food insecurity. Further, results from bivariate analyses indicated that even though food security status was found significantly related to gender (0.027; $p<0.0001$), the strength of association was weak. For instance, females were more food insecure than their male counterparts.

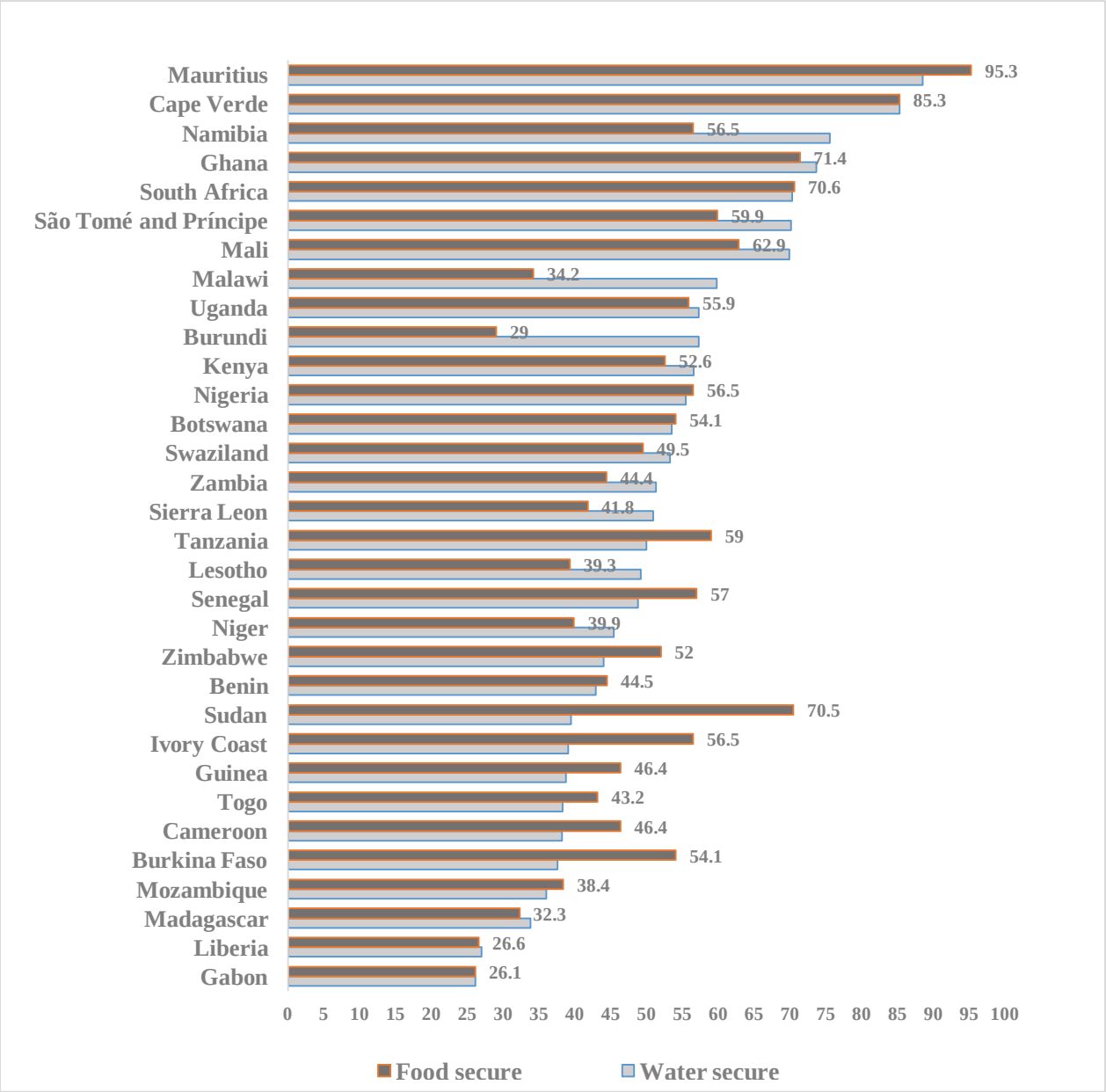

Figure 1. Water secure (nevere gone) and food secure (nevere gone) in SSA 2016 (Reference: Micro data analysis of Afrobarometer's data in 2016.)

Figure 1. illustrates the association between water security and food security. Notably, people living in countries with access to water were more likely to be food secure. Moreover, the probability of water and food security are shown to be significantly high within countries with high GDP per capita (i.e., Mauritius, South Africa, Namibia, etc.).[1]

[1]. (Refer to table 1 to see a list of Sub Saharan African (SSA) countries by Gross Domestic Product (GDP).

Table 3. Crosstabs tables between food insecurity, water insecurity and socio-economic factors in SSA countries (n=49,137).

	Strength	Sig level
Water insecurity	0.485	0.000
Gender	0.027	0.000
Age group	0.071	0.000
Area of residence	0.137	0.000
Education	-0.283	0.000
Employment	-0.233	0.000
Income availability	0.581	0.000
Asset ownership	-0.334	0.000

***Reference**: Micro data analysis of Afrobarometer's open data in 2016*

Table 4. Unadjusted multinomial logistic regression analyses between Food Insecurity and Water Insecurity by controlling socio-demographic factors in sub-Saharan Africa (n=49,137)

		Never	Just once or twice a month	Several times	Many times
		95% CI for EXP (B)	95% CI for EXP (B)	95% CI for EXP (B)	95% CI for EXP (B)
Water insecurity	Never	39.17 (33.40-45.93)	12.99 (10.91-15.47)	7.90 (6.70-9.31)	4.609 (3.89-5.45)
	Just once or twice	16.57 (12.82-21.40)	27.82 (21.63-36.25)	10.50 (8.09-13.62)	3.609 (2.74-474)
	Several times	11.24 (9.16-13.79)	13.79 (11.11-17.13)	13.46 (10.95-16.54)	5.424 (4.38-6.71)
	Many times	3.494 (2.949-4.13)	3.62 (3.00-4.37)	4.023 (3.38-4.77)	4.520 (1.06-5.72)
	Always (Ref)				
Gender	Female	0.828 (0.740-0.926)	0.891 (0.791-1.003)	0.880 (0.783-0.989)	0.956 (0.846-1.079)
	Male (Ref)				
Age groups	18-25	2.191 (1.716-2.798)	2.266 (1.737-2.956)	1.515 (1.174-1.956)	1.328 (1.017-1.734)
	26-35	1.716 (1.358-2.167)	1.942 (1.504-2.507)	1.392 (1.091-1.777)	1.246 (0.956-1.608)
	36-45	1.400 (1.101-1.781)	1.583 (1.217-2.059)	1.276 (0.992-1.640)	1.202 (0.924-1.563)
	46-55	1.533 (1.179-1.992)	1.599 (1.202-2.127)	1.313 (0.999-1.726)	1.450 (1.091-1.927)
	56-65	1.328 (1.000-1.796)	1.451 (1.066-1.974)	1.137 (0.846-1.529)	1.430 (1.053-1.943)
	66 and over (Ref)				
Area of residence	Rural	0.457 (0.403-0.518)	0.630 (0.552-0.719)	0.756 (0.663-0.861)	0.984 (0.858-1.127)
	Urban (Ref)				
Employment	Unemployed	0.303 (0.257-0.357)	0.438 (0.370-0.520)	0.636 (0.537-0.753)	0.762 (0.639-0.908)
	Employed full-time	0.538 (0.424-0.682)	0.880 (0.688-1.125)	0.903 (0.706-1.154)	0.653 (0.739-1.231)
	Employed part-time (Ref)				
Income availability	Always	83.95 (63.89-110.3)	8.24 (6.18-11.00)	2.76 (2.07-3.70)	1.218 (0.890-1.668)
	Many times	44.2 (31.9-	34.7 (24.9-48.3)	4.83 (3.45-677)	1.724 (1.201-

		61.31)						2.474)	
	Several times	23.8 (19.4-29.1)		16.5 (13.4-20.3)		10.2 (8.38-12.58)		2.446 (1.974-3.032)	
	Just once or twice	9.22 (7.88-10.7)		7.55 (6.40-8.9)		6.88 (5.88-.04)		5.350 (4.568-6.266)	
	Never (Ref)								
Asset ownership	0	0.065 (0.050-0.085)		0.208 (0.157-0.276)		0.398 (0.301-0.526)		0.873 (0.651-1.170)	
	1	0.168 (0.129-0.220)		0.425 (0.322-0.562)		0.729 (0.552-0.963)		1.171 (0.873-1.5690	
	2	0.270 (0.207-0.354)		0.677 (0.512-0.896)		0.927 (0.701-1.122)		1.113 (0.828-1.496)	
	3	0.490 (0.372-0.645)		0.807 (0.606-1.074)		0.895 (0.672-1.192)		0.921 (0.680-1.249)	
	4 (Ref)								
Education	No formal education	0.141 (0.111-0.179)		0.250 (0.194-0.322)		0.510 (0.397-654)		0.975 (0.749-1.269)	
	Primary	0.238 (0.187-0.302)		0.515 (0.402-0.660)		0.722 (0.563-0.925)		1.113 (0.856-1.447)	
	Secondary	0.536 (0.420-0.685)		0.847 (0.657-1.092)		0.985 (0.764-1.270)		1.083 (0.827-1.419)	
	Post-secondary (Ref)								

Reference: Micro data analysis of Afrobarometer's data in 2016

3.3 Regression findings (Unadjusted)

The results from unadjusted multinomial logistic regression analyses are presented in Table 4. The findings from table 4 indicate that the probability of having no food issues increased among people who had enough clean water for home use (OR=39.17; 95% CI (33.40-45.93)). In terms of socio-demographic factors, the probability of food insecurity increased among females (OR=0.828; 95% CI (0.740-0.926)) who were unemployed (OR=0.303; 95% CI (0.257-0.357)), had no formal education (OR=0.141; 95% CI (0.111-0.179)), were living in rural areas (OR=0.457; 95% CI (0.403-0.518)) and had no asset ownership (OR=0.065; 95% CI (0.050-0.085)). Surprisingly, income availability (OR= 83.95; 95% CI (63.89-11.03)) was found strongly associated to food insecurity compared to the others socio-demographic factors.

3.3. Regression findings (Adjusted)

The results from adjusted multinomial logistic regression analyses are presented in Table 5. Findings showed that water insecurity remained significant with food insecurity with strong association (OR=34.08; 95% CI (28.96-40.11)). For instance, individuals with access to water (water secure people) were 34 times more likely to experience food security. With regards to socio-demographic factors control, age groups between 18 and 25 (OR=2.161; 95% CI (1.660-2.814)) had low food insecurity compared to other age groups. However, gender (OR=0.845; 95% CI (0.749-0.953), area of residence (OR=0.697; 95% CI (0.610-0.796), and unemployment (OR=0.376; 95% CI (0.316-0.446) remained negatively related to food security.

Table 5. Adjusted multinomial logistic regression analyses between water insecurity and food insecurity by controlling factors[1] in sub-Saharan Africa (n=49,137)

		Never	Just once or twice a month	Several times	Many times
		95% CI for EXP (B)	95% CI for EXP (B)	95% CI for EXP (B)	95% CI for EXP (B)
Water insecurity	Never	34.08 (28.96-40.11)	12.06 (10.09-14.41)	7.648 (6.467-9.043)	4.555 (3.836-5.409)
	Just once or twice	14.90 (11.47-19.34)	26.05 (19.90-34.9)	10.275 (7.886-13.8)	3.509 (2.654-4.638)
	Several times	10.51 (8.51-12.98)	13.41 (10.73-16.76)	13.60 (11.00-16.81)	5.611 (4.50-6.981)
	Many times	3.351 (2.81-3.994)	3.625 (2.987-4.399)	4.093 (3.430-4.884)	5.024 (4.210-5.996)
	Always (Ref)				
Gender	Female	0.845 (0.749-0.953)	0.891 (0.785-1.011)	0.874 (0.772-0.989)	0.961 (0.846-1.092)
	Male (Ref)				
Age groups	18-25	2.161 (1.660-2.814)	2.202 (1.660-2.920)	1.521 (1.161-1.992)	1.343 (1.016-1.776)
	26-35	1.501 (1.164-1.936)	1.721 (1.310-2.262)	1.346 (1.037-1.746)	1.225 (0.936-1.603)
	36-45	1.168 (0.899-1.517)	1.359 (1.026-1.799)	1.223 (0.936-1.598)	1.180 (0.895-1.555)
	46-55	1.375 (1.035-1.726)	1.484 (1.095-2.011)	1.347 (1.007-1.800)	1.511 (1.112-2.036)
	56-65	1.209 (0.892-1.369)	1.360 (0.983-1.883)	1.130 (0.828-1.542)	1.434 (1.043-1.972)
	66 and over (Ref)				
Area of residence	Rural	0.697 (0.610-0.796)	0.886 (0.771-1.018)	0.983 (0.858-1.127)	1.190 (1.033-1.371)
	Urban (Ref)				
Employment	Unemployed	0.376 (0.316-0.446)	0.502 (0.419-0.600)	0.783 (0.618-0.881)	0.835 (0.695-1.003)
	Employed full-time	0.627 (0.490-0.802)	0.915 (0.710-1.179)	0.959 (0.745-1.234)	1.008 (0.777-1.309)
	Employed part-time (Ref)				

Model fitting Criteria -2 Log Likelihood=6362.673; Chi-sq=11520.316; df=52; Sig=0.000
Pseudo R-Square= Cox and Snell= 0.214; Nagelkerke= 0.232; McFadden= 0.094
***Reference**: Micro data analysis of Afrobarometer's data in 2016*

4. Discussion

The main purpose of the present study was to explore the association between water insecurity and food insecurity in sub-Saharan Africa. However, due to the importance of socio-demographic factors, their association with water insecurity was also studied. We first assumed that water unavailability would be positively correlated with food insecurity. Indeed, the findings from this study showed very strong

[1]. Due to collinearity, only gender, age groups, area of residence and employment remained in the model.

association between water insecurity and food insecurity. It is also consistent with available studies (White et al., 2007). Water access through agriculture contributes positively to food security. Moreover, climate change may affect agriculture and food security by altering the distribution of rainfall and the availability of water. Consequently, increasing water scarcity has implications for food security, hunger, and poverty (Hanjra and Qureshi, 2010). The Food and Agricultural Organization (FAO) connected the concept of water security to food security. According to the FAO, water security means enough water supplies for people living in the drier areas to meet agricultural production needs (Cook and Bakker, 2012). Evidence from many developing countries showed that water insecurity, besides having economic impacts, also has social and environmental implications. As a result, poverty and social unrest are both consequences of lack of water security (Grey and Sadoff, 2007).

Although water insecurity was found significantly associated with food insecurity, socio-demographic factors were also among the determinants of food insecurity. Surprisingly, findings from crosstabs as well as regression analyses showed income availability contributed strongly to food insecurity. Findings from our study showed that people with no water issue were 84 times more likely to be food secure. Notably, the odds of being food secure was 40 times higher for people who have no water issues. Income is clearly one of the most important determinants of food insecurity and hunger (Rose, 1999). Notably, income is essential to ensure that enough food can be obtained to meet the requirements of a household (Walsh and Van Rooyen, 2015). A study by Tarasuk et al., (2019) revealed (Tarasuk, Germain and Mitchell, 2019), more specifically, that every $1000 increase in household income was associated with 2% lower odds of marginal food insecurity, 4% lower odds of moderate food insecurity, and 5% lower odds of severe food insecurity.

Further, gender was observed to be significantly related to food insecurity. Findings from our study revealed that females were more food insecure compared to their male counterparts. These findings were coherent with a study by Payne et al., (2016) which also showed that females are more food insecure than males (Payne et al., 2016). The difference may be caused by having less job opportunities, low education levels and less empowerments. Specifically, “the food security of adult male household members over female household members can be explained by the discrepancy in the returns to labor, women limited educational and employment opportunities, and limited bargaining power within the household” (Broussard, 2019). However, this still needs to be studied.

Apart from gender, findings from this study showed that area of residence was significantly associated with food insecurity. People in rural areas were more likely to be food insecure. In fact, Akanbiemu, Fatiregun and Adejugbagbe (2016) have explained that people in rural areas have lower level of education and low status in terms of wealth index. Therefore, in comparison to urban areas, rural areas are more likely to be food insecure.

In terms of limitation of our study, due to its cross-sectional nature, additional work on this topic for future research could utilize a longitudinal approach to better understand the causal relationships between food and water security. More importantly, this study lacked the validated index for water insecurity as well as food insecurity. Therefore, using waster insecurity, and food security indices is suggested for next studies.

5. Conclusions

This study found that water insecurity was strongly associated with food insecurity in context of sub-Saharan Africa. However, we also observed that the roles of socio-demographic factors were affecting food security status. Notably, this study demonstrated that even though water is among the main determinants of food security, other factors, such as income, contributed strongly to food security. The results from this study suggest that more efforts should be made to increase the access to water in SSA. Considering these findings, investments in water infrastructure is recommended.

Competing interests

The author declares no conflict of interest.

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Authors' contributions

DA lead study design, data analysis and interpretation, and manuscript writing.

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