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RESEARCH ARTICLE

Water, sanitation and the risk of chronic diseases in old age: Results from the Ghana WHO SAGE 2 [version 1; peer review: awaiting peer review]

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Abstract

Background: The associations of water and sanitation with population health have been well-documented. However, the specific effects of water and sanitation on chronic diseases in old age are least explored. This study examines the associations between water, sanitation and chronic diseases among older people in Ghana and whether these associations are moderated by sex and spatial variation.

Methods: Data from the WHO-SAGE Wave 2 involving adults aged ≥ 50 years were analyzed. Chronic diseases were assessed based on the self-reported diagnosis by a healthcare professional. The exposures included water sources, type of toilet, and sharing of toilet facilities. Generalized logistic regression models estimated the effects of water and sanitation indicators on chronic diseases.

Results: Overall, 18.8% of the sample reported at least one chronic disease. Compared to men and those in rural areas, women and urban residents respectively were more likely to report chronic disease ($p < 0.001$). After full adjustments, logistic regressions showed that the use of unimproved sanitation (OR = 1.732, CI: 1.377–5.418) and sharing of sanitation facilities (OR = 1.624, CI: 1.095–1.320) were associated with higher odds of chronic diseases. However, the use of water did not reach significance ($p = 0.125$). We found a significant interaction effect for type of toilet $\times$ sex (OR = 3.498, CI: 1.744–16.442), source of water $\times$ residence (OR = 5.935, CI: 1.320–26.685), and type of toilet $\times$ spatial variation (OR = 1.998, CI: 1.462–8.642).

Conclusions: The use of unimproved sanitation facilities and the sharing of toilet facilities are associated with the occurrence of chronic diseases among older people. Policy and public health interventions targeted at improving the health and well-being of older people should conspicuously include better access and improved sanitation services.

Keywords

chronic conditions, sanitation, water, older people, public health

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Introduction

The Joint Monitoring Program (JMP) of the World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF) estimated in 2017 that 435 million people globally used water from unprotected wells and springs, and a further 144 million used untreated surface water.¹ With regard to sanitation, it has been estimated that 701 million people used unimproved sanitation facilities, and 673 million still practiced open defecation.¹ Inadequate water, sanitation, and hygiene (WASH) have been linked to increased morbidity and mortality rates from the WASH-related diseases, especially among vulnerable groups such as the poor and children under five.² Conversely, the provision of adequate WASH services has been related to saving the time spent fetching water and accessing sanitation facilities, health care savings, more time for women and girls in school, improved school attendance, and general socio-economic development.^{3–5}

Inclusive WASH service provision requires consideration of particular groups of people such as older adults and people living with disabilities. However, limited data is available on the effects of WASH among older people, although sparse evidence suggests the importance of increasing access through age-friendly technologies.^{6–8} WASH-related challenges among older people may be striking, particularly in low- and middle-income countries (LMICs) because these people largely rely on other demographic cohorts for safe WASH services.

The absolute numbers and the proportions of older people are generally increasing globally and in LMICs in particular due to increases in life expectancy driven by epidemiological transition.^{9–11} For instance, the WHO estimates that by 2020, the number of people aged 60 years and older will exceed the number of children under five and that by 2050, LMICs will be home to over 80% of global older people (WHO: ageing). Ghana for example, has one of the highest growth rates of the older population in sub-Saharan Africa (after South Africa) where the 60-plus cohort is projected to double from 6.0% in 2011 to approximately 12.0% in 2050.^{11,12}

More importantly, older populations in LMICs generally face various intractable socio-economic and health-related challenges, including poor access to services, decreased mobility and the occurrence of chronic diseases.^{9,13} Moreover, the Global Burden of Disease reports indicate an increase in the proportion of total Disability Adjusted Life Years (DALYs) that are attributable to chronic conditions (such as diabetes, cancers and cardiovascular diseases) from 18.6% to 29.8% of the total burden in sub-Saharan Africa.¹⁴ This increase suggests a huge shift in the disease burden from hitherto dominant communicable diseases to a double burden of communicable and noncommunicable diseases, largely due to increasing demographic ageing.

In Ghana, approximately 81% of the population had access to basic water services and only 4% used unimproved sources.¹ However, the country has experienced slow progress in improving access to sanitation. By 2017, for example, one-half of the Ghanaian population shared sanitation facilities, a whopping 82% lacked basic sanitation, 13% used unimproved sanitation facilities, and about 18% practiced open defecation.¹ These developments may present health and well-being challenges, particularly among vulnerable groups such as older people.

The increase in the burden of chronic conditions in sub-Saharan African countries such as Ghana is attributable to nutrition, environmental and lifestyle risk factors.¹⁴ Unfortunately, the role of WASH in the occurrence of chronic diseases, especially in later life, is less investigated and poorly understood. This paper, therefore, explores the associations of water and sanitation, with chronic diseases among older people in Ghana. It has been demonstrated that health stratification and social factors may differ by demographic circumstances.^{9,15} We, therefore, investigated the moderating roles of sex and spatial variation to assess whether there are between-sex and spatial heterogeneity in the associations of water and sanitation with chronic diseases among older people.

Methods

Data source

The study used data from the WHO Study on Global AGEing and adult health (SAGE). Wave 2 was a survey conducted in six LMICs, including China, Ghana, India, Mexico, Russian Federation, and South Africa.¹⁶ The nationally representative survey collects data through a stratified multistage cluster design to complement existing aging data sources and inform policy and programs. WHO and the University of Ghana Medical School through the Department of Community Health collaborated to implement SAGE Wave 2 in Ghana in 2014–2015. We used the GhanaINDDataW2 and GhanaHHDDataW2 datasets. The INDD data set comprised of individual questions targeted at the main respondent and the HHD data set comprised of questions concerning the household within which the primary respondent resided.

The primary sampling units were stratified by region and location of residence (urban/rural) with samples selected from 250 enumeration areas.¹³ In households identified as “older” for sampling purposes, all household members aged

50 years and older were invited to participate in the study. Individuals were interviewed regarding their chronic health conditions and health services coverage, subjective wellbeing and quality of life, health care utilization, risk factors, and preventive health behaviors, perceived health status, socio-demographic and work history, social cohesion, and household characteristics. Respondents further provided details about the use of water and sanitation facilities, including the source of water and type of toilet facility and whether these facilities were shared with others. Primary data management, checking and quality assurance was undertaken by country survey teams and coordinated centrally through WHO Geneva. The Ghana response rate was 83%. The data are publicly available via the WHO Multi-Country Studies Data Archive. Details about the data and further information can be found at <https://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/sage>. Weight was calculated to offset the sampling effect.¹⁷

Measures

Outcome variable

The main outcome variable of interest in this study was chronic diseases defined as the existence of one or more chronic conditions in an individual (ranging from 1 to 8). We included all available self-reported chronic conditions queried in the WHO-SAGE data, each prompted by the item “*Has a health care professional ever told you that you have ... hypertension, diabetes, chronic lung diseases, angina, asthma, tightness in the chest, stroke, and arthritis?*”. Individuals who indicated “yes” to these items were recorded as having a chronic disease. We dichotomized the outcome variable into 0 = no chronic disease when the respondent answered “no” to all the items and 1 = presence of chronic diseases when at least one response was affirmative.

Explanatory variables

Three independent variables were considered in this analysis: the source of water, type of toilet facility, and shared toilet facility. First, older adults were asked to indicate the main sources of drinking water. The responses were broadly categorized into 1 = piped private, 2 = piped to yard/plot, 3 = public tap/standpipe, 4 = tube well/borehole, 5 = protected dug well, 6 = unprotected dug well, 7 = protected spring, 8 = unprotected spring, 9 = rainwater collection, 10 = bottled water, 11 = small scale vendor, 12 = tanker-truck/lorry, 13 = surface water (river, lake, etc.).

Based on the Joint Monitoring Program’s classification of water and sanitation technologies,¹ we recoded these sources of water into “improved source” = 1 to include piped private, piped to yard/plot, public tap/standpipe, tube well/borehole, protected dug well, protected spring, bottled water, small scale vendor, tanker-truck/lorry, and “unimproved source” = 2 to include unprotected dug well, unprotected spring, and surface water.

Type of toilet facility was collected on a 12-response scale including 1 = flush/pour to piped sewage system, 2 = flush/pour to septic tank, 3 = flush/pour to pit latrine, 4 = flush/pour to other locations, 5 = flush/pour to unknown, 6 = ventilation improved pit latrine, 7 = pit with slab, 8 = pit without slab/open, 9 = composting toilet, 10 = bucket, 11 = hanging toilet/latrine, 12 = no facilities (bush, field). These responses were transformed into 1 = “improved toilet facility” (flush/pour to the piped sewage system, flush/pour to a septic tank, flush/pour to pit latrine, flush/pour to other locations, flush/pour to unknown, ventilation improved pit latrine, a pit with slab, composting toilet), and 2 = “unimproved toilet facility” (pit without slab/open, bucket, hanging toilet/latrine, no facilities (bush, field). Finally, participants answered on a “no” = 1 or “yes” = 2 scale about whether a toilet facility was shared with others.

Covariates

Sociodemographic and health-related variables were assessed and included for adjustments and as moderators. These included age (years), sex (1 = male, 2 = female), location of residence (1 = urban, 2 = rural), and years of education. Marital status was collected using a four-level measure but collapsed and dichotomized into currently married/partnered = 1, and not currently married/partnered = 2. WHO-SAGE collected data on ethnic background on a 10-level scale but the variable was dichotomized into 1 = Akan, 2 = others due to the limited frequencies for specific categories and subsequent incidence of model over-fitting in the regression analysis. Respondents were asked to rate their own health, on a scale from 1 to 5 (very good, good, moderate, bad, very bad) with the item, “How would you rate your current health state?” A higher score indicated poor self-rated health and we recoded this variable into good (very good, good) = 1, moderate = 2, bad (bad/very bad) = 3 for analytic purposes.

Statistical analysis

Univariate descriptive analysis was first conducted to generally describe the characteristics of the sample. These statistics were reported as mean and standard deviation for continuous variables, or count and percentage for categorical variables.

Next, we performed bivariate analysis stratified by sex and location of residence to estimate the relationships between the study variables using non-parametric Pearson's χ^2 test for categorical variables and independent t-test for continuous variables. Kendall's tau-b correlations were run to determine the relationships of relevant exposure variables with the outcome variable. Accounting for the complex survey design, survey weights were used to estimate sex- and residential-specific prevalence of chronic conditions, and water and sanitation indicators.

Given the measurement level of the outcome variable, a series of generalized logistic regression models were conducted in which the presence of chronic diseases was regressed on the major independent variables (water, and sanitation) controlling for the potential confounders. Models 1, 2, and 3 regressed the presence of chronic diseases on the use of water, toilet facility type, and sharing of toilet facility respectively. These crude models estimated the variance explained by the three key independent variables. In addition, the presence of chronic diseases was regressed on the three key independent variables simultaneously in Model 4. Model 5 added the sociodemographic and health-related variables for full adjustment. In Model 6, we included the interaction terms (water/sanitation indicators $\times$ sex and water/sanitation indicators $\times$ residential status) to investigate the potential modifying roles of sex and location of residence in the associations. In a confirmatory analysis, we fitted separate models to estimate the specific effect of independent variables on each individual chronic disease. We checked for multicollinearity by computing the variance inflation factor (VIF) but none of the VIF scores exceeded the value of 1.5, indicating no challenges of multicollinearity. A p -value of less than 0.05 was considered statistically significant and all analyses were performed using **IBM SPSS Statistics v.21.0** (IBM, Armonk, NY) (RRID:SCR_019096) (An open-access alternative that can perform an equivalent function is the **R stats** package (R Project for Statistical Computing, RRID:SCR_001905)).

Ethical approval

SAGE was approved by the World Health Organization's Ethical Review Board (Reference number RPC149) and the Ethical and Protocol Review Committee, College of Health Sciences, University of Ghana, Accra, Ghana. Written informed consent was obtained from all study participants.

Results

Sample characteristics

The characteristics of the sample are presented in **Table 1**.¹⁸ Our study population consisted of 4735 adults aged 50 years or over. The average age was approximately 58 years and the majority of the respondents lived in rural areas (59%), were females (59%), and were married or partnered (57%). More than half of the respondents professed to other ethnic groups than the Akan. The mean years of education were 11 years, and the health status of the sample was generally good with 68% reporting "good" and only 8% rating their health as "bad". Approximately 19% reported at least one chronic condition. Hypertension was the most prevalent individual chronic condition (12%), followed by arthritis (8%), tightness in the chest (4.3%), and diabetes (3%). About 90% and 77% reported using improved water and toilet facility sources respectively, and 77% of the respondents shared their toilets.

Bivariate associations

Table 1 shows the bivariate associations stratified by sex and location of residence. Compared to females and urban dwellers, males and those in rural areas respectively were more likely to be older ($p < 0.05$).¹⁸ Similarly, males and urban residents were more likely to report higher levels of education than their respective females and rural dwellers ($p < 0.001$). More males were married compared with females (74% vs 45%, $p < 0.001$) but the majority of the married lived in rural areas compared to urban areas (61% vs 52%; $p < 0.001$). Males self-rated their health better compared to females and also in terms of chronic conditions (16% vs 21%; $p < 0.001$). Whilst the difference in health status was statistically insignificant between urban and rural residents, the former reported more co-morbidity (23% vs 16%, $p < 0.001$). The tendencies to use improved sources of water and toilet facilities were significantly higher for females and urban dwellers compared to male and rural dwellers respectively. Kendall's tau-b correlations are depicted in **Table 2**.¹⁸ Co-morbidity was significantly associated with water source ($\tau_b = -.033$, $p < .005$), type of toilet facility ($\tau_b = -.080$, $p < .001$), shared toilet facility ($\tau_b = -.044$, $p < .001$), age ($\tau_b = .199$, $p < .001$), sex ($\tau_b = .054$, $p < .001$), residence ($\tau_b = -.083$, $p < .001$), years of education ($\tau_b = .046$, $p < .001$), marital status ($\tau_b = -.117$, $p < .001$), and self-rated health ($\tau_b = .201$, $p < .001$).

Main regression results

Table 3 depicts the results of the associations of water and sanitation with co-morbidity estimated by generalized logistic models of the pooled sample.¹⁸ In the unadjusted models (Models 1, 2, and 3), those who used unimproved water (OR = 1.350, CI: 1.037–1.757), toilet facility (OR = 1.716, CI: 1.413–2.083), and shared toilet facility (OR = 1.287, 1.077–1.539) were significantly more likely to report co-morbidity. Accounting for water and sanitation variables in Model 4, the associations in Model 3 persisted but the effect sizes were negligibly attenuated by 0.12, 0.10, and 0.02 respectively. After adjusting for potential confounders (Model 5), the odds of reporting chronic conditions significantly increased for

Table 1. Descriptive distribution and bivariate associations of water, sanitation, demographic and health-related characteristics by sex and location of residence (N = 4735).

	Total		Sex		Location of residence						Rao Scott χ^2	Rural	Rao Scott χ^2	p-value	
	N	%	Male	%	Female		Urban		Rural						
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
Potential confounders															
Age (in years) ⁶	57.59	±16.74	58.41	±17.19	57.02	±16.39			56.24	±17.19	58.55	±16.35			0.004
Sex															
Male	1948	(41.1)	-	-	-	-			692	(35.2)	1256	(45.3)			<0.001
Female	2787	(58.9)	-	-	-	-			1273	(64.8)	1514	(54.7)			
Residential status															
Urban	1965	(41.5)	692	(35.5)	1273	(45.7)			-	-	-	-			-
Rural	2770	(58.5)	1256	(64.5)	1514	(54.3)			-	-	-	-			
Years of education ⁶	10.53	±5.45	11.45	±5.35	9.72	±5.40			11.43	±5.27	9.64	±5.47			<0.001
Marital relations															
Not partnered	2042	(43.1)	506	(26.0)	1536	(55.1)			952	(48.4)	1090	(39.4)			<0.001
Partnered	2693	(56.9)	1442	(74.0)	1251	(44.9)			1013	(51.6)	1680	(60.6)			
Ethnicity															
Akan	2296	(48.5)	848	(43.5)	1448	(52.0)			1043	(53.1)	1253	(45.2)			<0.001
Others	2439	(51.5)	1100	(56.5)	1339	(48.0)			922	(46.9)	1517	(54.8)			
Self-rated health (SRH)															
Good	3192	(68.0)	1385	(71.6)	1807	(65.4)			1342	(69.2)	1850	(67.1)			0.225
Medium	1114	(23.7)	401	(20.7)	713	(25.8)			449	(23.2)	665	(24.1)			
Bad	390	(8.3)	148	(7.7)	242	(8.8)			148	(7.6)	242	(8.8)			
Outcome variables															

Table 1. Continued

	Total		Sex		Location of residence				Rao Scott χ^2	p-value	Rao Scott χ^2	p-value
	N	%	Male	Female	Urban	Rural	N	%				
	N	%	N	%	N	%	N	%				
Chronic disease												
Hypertension	378	(11.8)	114	(8.1)	264	(14.8)	252	(17.9)			126	(7.1)
Diabetes	99	(3.1)	39	(2.8)	60	(3.4)	67	(4.8)			32	(1.8)
Chronic lung disease	21	(0.4)	10	(.5)	11	(.4)	11	(0.6)			10	(.4)
Angina	65	(2.0)	20	(1.4)	45	(2.5)	29	(2.1)			36	(2.0)
Asthma	102	(2.2)	41	(2.1)	61	(2.2)	49	(2.5)			53	(1.9)
Tightness in chest	200	(4.3)	79	(4.1)	121	(4.4)	62	(3.2)			138	(5.0)
Stroke	55	(1.7)	22	(1.6)	33	(1.9)	31	(2.2)			24	(1.3)
Arthritis	266	(8.3)	90	(6.4)	176	(9.9)	114	(8.1)			152	(8.5)
Multimorbidity												
None	3847	(81.2)	1632	(83.8)	2215	(79.5)	1521	(77.4)			2326	(84.0)
At least one	888	(18.8)	316	(16.2)	572	(20.5)	444	(22.6)			444	(16.0)
<i>Exposure variables</i>												
Sources of water												
Improved	4260	(90.0)	1723	(88.4)	2537	(91.0)	1900	(96.7)			2360	(85.2)
Unimproved	475	(10.0)	225	(11.6)	250	(9.0)	65	(3.3)			410	(14.8)
Toilet facility												
Improved	3646	(77.0)	1449	(74.4)	2197	(78.8)	1805	(91.9)			1841	(66.5)
Unimproved	1089	(23.0)	499	(25.6)	590	(21.2)	160	(8.1)			929	(33.5)
Shared toilet facility												
No	917	(23.3)	390	(24.9)	527	(22.3)	458	(24.4)			459	(22.4)
Yes	3015	(76.7)	1174	(75.1)	1841	(77.7)	1421	(75.6)			1594	(77.6)

Mean ($\pm$ SD);*** $p < 0.001$;** $p < 0.005$;* $p < 0.05$.

Table 2. Kendall's tau-b correlation matrix for study variables.

	1	2	3	4	5	6	7	8	9	10
1. Multimorbidity	1									
2. Source of water	-.033**	1								
3. Type of toilet facility	-.080***	.310***	1							
4. Shared toilet facility	-.044***	-.018	.070***	1						
5. Age	.199***	.003	.021	-.086***	1					
6. Sex	.054***	-.042***	-.052***	.031	-.045***	1				
7. Residence	-.083***	.189***	.297***	.024	.055***	-.101***	1			
8. Years of schooling	.046***	-.057***	-.083***	-.131***	.000	-.164***	-.183***	1		
9. Marital status	-.117***	.093***	.077***	-.037**	-.100***	-.290***	.091***	.038	1	
10. Ethnic background	-.016	.045***	.189***	-.038**	.017	-.083***	.077***	.027	.106***	1
11. Self-rated health	.201***	.031**	.012	.010	.321***	0.061***	.023	-.054***	-.141***	-.033**

*** $p < 0.001$;** $p < 0.05$;

those using unimproved toilet facilities (OR = 1.732, CI: 1.377–5.418), and shared toilet facilities (OR = 1.624, 1.095–1.320). However, the use of unimproved water sources lost its robustness although it had a higher odds of chronic disease risk than the use of improved water sources (OR = 1.552, 95% CI: 0.792–3.042) suggesting the potential role of sociodemographic and health-related factors in predicting co-morbidity risks in later life.

Moreover, we found significant interactions between toilet facilities and sex (Model 6). Compared to males, females who used unimproved toilet facilities were 3.5 times more likely to report chronic conditions (OR = 3.498, CI: 1.744–16.442). Also, the results revealed a moderation effect of residential status on the association between water and sanitation, and co-morbidity: First, using unimproved water sources in rural areas significantly increased the risk of chronic diseases compared to living in urban areas (OR = 5.935, CI: 1.320–26.685). Second, rural residents who used unimproved toilet facilities were twice as likely to have a chronic disease compared with their urban counterparts (OR = 1.998, CI: 1.462–8.642).¹⁸

Additional models

A sensitivity CC-specific estimation showed mixed effects of water and sanitation on CCs (Table 4).¹⁸ The use of unimproved water and unimproved toilet facilities was associated with an increased likelihood of reporting hypertension, diabetes, and chronic angina diseases. Moreover, the shared toilet facilities significantly increased the odds of hypertension and arthritis among older people.

Discussion

Chronic conditions (CCs) are highly reported public health problems for older people and continue to increase in prevalence and severity.¹⁹ To our knowledge, this is the first study examining the association of water and sanitation with the occurrence of chronic diseases among community-dwelling older people and the first study specifically on this topic from LMICs. The findings suggest that more older people use improved water sources compared to improved sanitation facilities and that a large proportion of older people use unimproved and shared sanitation facilities. The occurrence of CCs in Ghana is generally low, with approximately 19% of older persons reporting at least one CC. Interestingly, the occurrence of CCs is higher among females and those living in rural areas as well as those using unimproved and shared sanitation facilities.

Our study highlights a less researched area on the relationship between water and sanitation and the occurrence of chronic conditions among older people. As earlier alluded to in our introduction, the public health effects of inadequate water and sanitation have always been described among children under the age of five, mainly because they are most susceptible to inadequate and poor-quality services particularly in their formative years.² As humans grow older, the health challenges slowly shift focus from communicable to a double burden of communicable and non-communicable diseases, whose occurrence especially in sub-Saharan Africa has mainly been linked to environmental, nutritional, and lifestyle factors.¹⁴ As such, the role of water and sanitation in well-being, especially among older people, fades away. These findings bring back the almost invisible role of water and sanitation in the health and well-being of older people, particularly in LMICs.

Our study did not investigate the pathways through which sanitation relates to physical chronic diseases. However, in an attempt to identify the linkages and the etiology of sanitation and chronic conditions, some hypotheses are composed. Healthy

Table 3. Unadjusted and adjusted (multivariate) associations of WASH with diagnosed NCDs: Generalized logit regression.

Variable	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Model 3 OR (95%CI)	Model 4 OR (95%CI)	Model 5 OR (95%CI)	Model 6 OR (95%CI)
Source of water (ref: improved)						
Unimproved	1.350 (1.037–1.757)*			1.232 (1.028–1.774)*	1.552 (0.792–3.042)	1.572 (0.784–3.152)
Source of toilet facility (ref: improved)						
Unimproved		1.716 (1.413–2.083)***		1.616 (1.135–2.301)**	2.732 (1.377–5.418)**	2.929 (1.404–6.113)**
Shared toilet facility (ref: No)						
Yes			1.287 (1.077–1.539)***	1.267 (1.060–1.516)**	1.624 (1.095–1.320)*	1.031 (0.799–1.329)
Age (in years)						
					1.052 (1.043–1.062)***	1.052 (1.042–1.062)***
Sex (ref: males)						
Female					1.364 (1.058–1.759)*	0.767 (0.289–2.034)
Residence (ref urban)						
Rural					0.585 (0.462–0.742)***	0.5820.459–0.738)
Years of education						
					1.018 (0.998–1.038)	1.018 (0.998–1.038)
Marital relations (ref: with no partner)						
With partner					0.847 (0.664–1.081)	0.849 (0.665–1.083)
Ethnicity (ref: Akan)						
Others					1.246 (0.989–1.570)	1.2480.990–1.572)
Self-rated health (ref: good)						
Medium						
					1.669 (1.276–2.183)***	1.677 (1.282–2.194)***
Bad						
					2.547 (1.732–3.747)***	2.543 (1.729–3.741)***

Table 3. Continued

Variable	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Model 3 OR (95%CI)	Model 4 OR (95%CI)	Model 5 OR (95%CI)	Model 6 OR (95%CI)
<u>Interaction terms</u>						
Source of water × sex						
Toilet facility × sex						1.185 (0.271–5.180)
Shared toilet facility × sex						3.498 (1.744–16.442)**
Source of water × location of residence						0.837 (0.505–1.386)
Toilet facility × location of residence						5.935 (1.320–26.685)*
Shared toilet facility × location of residence						1.998 (1.462–8.642)**
						0.791 (0.467–1.340)
2 Log likelihood	-4565.277	-4538.216	-3918.212	-3908.165	-1931.614	-1921.312
Nagelkerke Pseudo-R²	0.002	0.011	0.003	0.007	0.194	0.200
Hosmer-Lemeshow	0.000(.000)	0.000(.000)	0.000(.000)	0.188(.910)	6.834(.555)	6.800(.558)
N	4735	4735	4735	4735	4735	4735

OR = Odds Ratio; CI = Confidence Interval in parenthesis; NCDs = noncommunicable diseases; WASH = water, sanitation and hygiene. Models 1, 2 and 3 are unadjusted (crude) models. Model 4 included WASH variables only (sources of drinking water, toilet facility and sharing of toilet facility). Model 5 included Model 4 and adjusted for age, sex, residential status, years of education, marital status, ethnicity, and self-rated health. Model 6 included Model 5 plus interaction terms (WASH variables × sex and WASH variables × residential status); *** $p < 0.001$;

** $p < 0.005$;

* $p < 0.05$.

Table 4. Adjusted associations of WASH with specific diagnosed NCDs: Generalized logit regression.

Variable	Hypertension	Diabetes	Angina	Asthma	Tightness in chest	Stroke	Arthritis
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Source of water (ref: improved)	1.901***	1.841**	1.676**	0.636	1.415	1.4	2.683
Unimproved	(1.230–4.951)	(1.245–2.887)	(1.219–12.805)	(0.190–2.137)	(0.331–6.045)	(0.725–4.361)	(0.627–11.468)
Toilet facility (ref: improved)	2.553*	2.783**	1.724*	1.4	2.062	1.434	2.971
Unimproved	(1.896–7.278)	(1.370–20.948)	(0.226–13.134)	(1.148–3.810)	(0.488–8.719)	(0.188–10.943)	(0.682–12.943)
Shared toilet facility (ref: No)	1.153**	1.327	0.897	1.250	0.787	1.008	1.604*
Yes	(1.024–1.612)	(0.772–2.284)	(0.402–2.003)	(0.687–2.273)	(0.445–1.392)	(0.463–2.195)	(1.039–2.476)
2 Log likelihood	-1146.968	-492.591	-309.955	-485.392	-551.978	-302.868	-691.174
Nagelkerke Pseudo-R²	0.186	0.125	0.067	0.041	0.111	0.091	0.173
Hosmer-Lemeshow	7.822(.451)	5.717(.679)	8.057(.428)	11.988(.152)	6.558(.585)	5.418(.712)	9.198(.326)
N	4735	4735	4735	4735	4735	4735	4735

OR = Odds Ratio; CI = Confidence Interval; NCDs = noncommunicable diseases; WASH = water, sanitation and hygiene. All models were adjusted for age, sex, residential status, years of education, marital status, ethnicity, and self-rated health. *** $p < 0.001$;

** $p < 0.005$;

* $p < 0.05$.

aging is not only influenced by biological and psychosocial factors, but by environmental and socio-economic factors.⁹ Studies from high-income countries have highlighted that improved sanitation contributes to the longevity of older persons and increases their probability of becoming centenarians.²⁰ However, in many LMICs, older people increasingly face acute difficulties in accessing improved sanitation facilities. For example, due to the lack of technologically appropriate sanitation facilities, older people – especially those with daily activity limitations – using pit latrines are forced to touch the walls or toilet slabs (often shared toilets).²¹ Such conditions may expose these vulnerable older people to sanitation-related communicable diseases. Morbidity as a result of poor environmental health conditions weakens the already existing chronic conditions among older persons and reduces their quality of life and longevity.²⁰

Notably, though, the above-mentioned study by Kim & Kim²⁰ was conducted in high-income countries with the certainty of having improved sanitation facilities for the majority of the population. In Ghana and most part of sub-Saharan Africa, access to sanitation facilities especially in rural areas is wanting.¹ The country still has to make huge strides in increasing access to sanitation. It is estimated that poor sanitation costs the Ghanaian economy approximately US\$290 million, and a 1.6% loss of the GDP annually.²² These costs are mainly felt by the poor, who are often more likely to have poor sanitation and to pay more for the effects of poor sanitation.²² Poverty is often linked to poor health through poor nutrition and poor access to services.²³

Sex and location of residence were found to moderate the positive effects of unimproved sanitation use on the occurrence of chronic conditions in later life. Thus, among females and rural dwellers, exposure to unimproved sanitation was even related to more reports on chronic diseases, possibly suggesting that demographic circumstances and disparities can facilitate some degree of etiology of chronic diseases. This finding is in line with the *male-female health survival paradox*, the phenomenon observed in modern human societies in which women experience greater longevity and yet higher rates of disability and poor health including chronic conditions than men.^{24,25} Therefore, females are more likely to report chronic conditions compared to their male counterparts in the context of using unimproved sanitation facilities. Moreover, individuals in rural areas are more likely to experience a lack of basic services and also utilize unimproved sanitation facilities compared to those in urban areas chiefly due to the lopsided nature of economic development in sub-Saharan African countries including Ghana.

The co-occurrence of chronic conditions and unimproved sanitation facilities highlights the lack of services in rural areas where older people are more likely to live. This finding seems to support the assertion that poor communities in Ghana face a

double burden of infectious and chronic diseases.^{26–28} These results are particularly important for older individuals as they may be more vulnerable compared to the younger population while being at greater risk of experiencing co-morbidity and poorer health.¹⁴ Furthermore, the findings highlight the importance of service provision in underserved areas, especially in African countries. Using the SAGE data, for example, Ralston²⁹ similarly reported that older people in areas that lack social and economic services in South Africa generally showed poor quality of life. The study further showed a decreasing gap in well-being between those with chronic conditions and those without, with an increase in resource provision.²⁹ It is critical to note that the occurrence of chronic conditions among the older population is indirectly related to service provision, therefore, calling on equitable service provision across Ghana and in sub-Saharan Africa in general.

These results should be interpreted in light of several limitations. First, our measures were entirely based on retrospectively reported cross-sectional data. This prevented us from establishing temporal and thus potentially causal relationships of water and sanitation use and the occurrence of chronic conditions in later life. Our conclusions are, therefore, limited to empirical associations. We propose that further studies should attempt longitudinal analyses of these relationships. A second limitation relates to the measurement of sanitation facilities regarding the retrospective reports on the use of these facilities within the past year. A shorter time frame might have been able to detect stronger and more immediate implications of the use of the services. The self-report might have resulted in recall bias which could inundate the veracity of the findings. Despite these limitations, the current study nevertheless adds to the literature by demonstrating the moderating roles of sex and residential status against the occurrence of chronic diseases due to the use of sanitation facilities in older age.

Conclusions

This study has highlighted the associations between water, sanitation, and the presence of chronic diseases among older persons in Ghana in the context of sex and spatial variation. The results suggest that the presence of chronic diseases among older people is a socio-economic proxy indicator of the lack of service provision, especially among those living in rural areas. Policymakers and practitioners should be well-informed about the implications of sanitation on chronic diseases and the overall health outcomes in old age. Effort is needed in increasing access to improved sanitation for older people with sex and residential lenses.

Data availability

Underlying data

Zenodo: Underlying data for 'Water, sanitation and the risk of chronic conditions in old age: Results from the Ghana WHO SAGE 2'. <https://doi.org/10.5281/zenodo.5829346>

This project contains the following underlying data:

- Data file 1: Table 1. Descriptive distribution and bivariate associations of water, sanitation, demographic and health-related characteristics by sex and residential status ($N = 4735$)
- Data file 2: Table 2. Kendall's tau-b correlation matrix for study variables
- Data file 3: Table 3. Unadjusted and adjusted (multivariate) associations of WASH with diagnosed NCDs: Generalized logit regression
- Data file 4: Table 4. Adjusted associations of WASH with specific diagnosed NCDs: Generalized logit regression

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

The WHO SAGE Wave 2 dataset will shortly be freely available online. Further details can be found at: <https://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/sage>

Researchers interested in using the data used in this study in the meantime should contact the corresponding author, Dr Razak Gyasi (rgyasi.research@gmail.com), for further information.

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