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Access to improved water and sanitation in sub-Saharan Africa in a quarter century

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Abstract

The realization of the scale, magnitude, and complexity of the water and sanitation problem at the global level has compelled international agencies and national governments to increase their resolve to face the challenge. There is extensive evidence on the independent effects of urbanicity (rural-urban environment) and wealth status on access to water and sanitation services in sub-Saharan Africa. However, our understanding of the joint effect of urbanicity and wealth on access to water and sanitation services across spatio-temporal scales is nascent. In this study, a pooled regression analysis of the compositional and contextual factors that systematically vary with access to water and sanitation services over a 25-year time period in fifteen countries across sub-Saharan Africa (SSA) was carried out. On the whole, substantial improvements have been made in providing access to improved water sources in SSA from 1990 to 2015 unlike access to sanitation facilities over the same period. Households were 28.2 percent and 125.2 percent more likely to have access to improved water sources in 2000−2005 and 2010−2015 respectively, than in 1990−1995. Urban rich households were 329 percent more likely to have access to improved water

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sources compared with the urban poor. Although access to improved sanitation facilities increased from 69 percent in 1990–1995 and 74 percent in 2000–2005 it declined significantly to 53 percent in 2010–2015. Urban rich households were 227 percent more likely to have access to improved sanitation facilities compared with urban poor households. These results were mediated and attenuated by biosocial, socio-cultural and contextual factors and underscore the fact that the challenge of access to water and sanitation in sub-Saharan Africa is not merely scientific and technical but interwoven with environment, culture, economics and human behaviour necessitating the need for interdisciplinary research and policy interventions.

Keywords: Public health, Environmental science, Geography

1. Introduction

Access to improved water and sanitation are fundamental human rights and basic to the health of every person, nonetheless many people around the world do not have access to these basic needs (WHO/UNICEF, 2006). People who are deprived of access to improved water and sanitation services face diminished opportunities to realize their potential (Watkins, 2006). Unimproved drinking water and sanitation are the world's second biggest killer of children (Watkins, 2006). Approximately 10,000 people die every day from water- and sanitation-related diseases, and thousands more suffer from a range of debilitating illnesses (World Bank, 2003). Access to improved water sources and improved sanitation significantly reduce water-borne diseases (Armah, 2014; Pullan et al., 2014).

In 1976, the United Nations Conference on Human Settlements launched the International Drinking Water Supply and Sanitation Decade (1981–1990), which provided recommendations for urgent action on programmes to raise the quality and quantity of water supplies for urban and rural areas by 1990. This led to a commitment to improve water supply and sanitation coverage for the disadvantaged people lacking such services. A wide spectrum of low-cost water and sanitation options were applied in the course of the decade (Najlis and Edwards, 1991). Nonetheless by 2013, approximately 1.3 billion people in the developing world lacked access to adequate quantities of clean water, and nearly 3 billion people were without adequate sanitation services (Bosch et al., 2002).

As a sequel, the Millennium Development Goals (MDGs) ended in 2015 with significant progress in access to improved drinking water. The global target for drinking water was met in 2010 giving 91 percent of the global population access to improved drinking water as compared to 76 percent in 1990 (Mulenga et al., 2017). By 2015, the Progress Report on Drinking Water, Sanitation and Hygiene (2017) of the World

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Health Organization (WHO) and the United Nations Children's Fund (UNICEF) indicated that 71 percent of the global population representing 5.2 billion used a safely managed drinking water service; that is, one located on premises, available when needed and free from contamination. The report further indicates that one out of three people using safely managed drinking water services (1.9 billion) lived in rural areas.

The 2015 MDG assessment revealed that five developing regions met the target, but the Caucasus and Central Asia, Northern Africa, Oceania and sub-Saharan Africa (SSA) failed to meet the target (World Health Organization WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2015). Global coverage of access to basic sanitation services is lower as compared to safe drinking water. The MDG target for sanitation was not met with 68 percent of the global population currently using an improved sanitation facility which is an improvement over the 1990 figure of 54 percent (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2015). Even though there has been significant progress with regards to access to improved drinking water and sanitation, there are large disparities among countries, within countries and between gender (Osei et al., 2015; UNICEF, 2016).

In order to address the disparities in access to water and sanitation, the Sustainable Development Goal (SDG) 6 attempts to achieve universal and equitable access to improved drinking water and sanitation for all by 2030. It is important to track inequalities in access to drinking water and sanitation in order to assess progress with regards to universal coverage. The SDGs deal with inequalities, with Goal 10 aimed at reducing inequalities between and within countries. The Joint Monitoring Programme (JMP) annual reports continually highlight inequalities between rural and urban areas, between rich and poor and between other groups. The 2030 Agenda further commits Member States to 'leave no one behind' and states that SDG indicators should be disaggregated, where necessary, by income, sex, age, race, ethnicity, migratory status, disability and geographic location.

Sub Saharan Africa (SSA) is one of the regions with low levels of coverage (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2015). SSA, like other least developed regions, did not meet the MDG target but progressed during the MDG period, with 42% of its current population gaining access to improved drinking water since 1990 (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2015). The region achieved a 20 percentage point increase in the use of improved sources of drinking water (UN – UNICEF, 2015). The population of SSA doubled during the MDG period (1990–2015). However, access to improved sanitation facilities increased by only six percentage points during the same period (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2015).

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From a spatio-temporal perspective (across countries and over time), there is little empirical evidence on household level factors that systematically and jointly influence access to improved water and sanitation services and which of these factors transcend geopolitical boundaries. Overall, there is also incomplete understanding of how to incorporate initiatives at the household level into a wider planning and support framework in sub-Saharan Africa. Consolidating information on such factors would be relevant both nationally and regionally for policymaking. In this study, we conducted a pooled analysis of multi-country data to assist in the interpretation of complex, contradictory and quickly changing social contexts related to the water and sanitation problems in SSA. In particular, this study assessed household trends in access to improved water and sanitation for the past 25 years and evaluated the combined effect of relative residential well-being on access to improved water sources and sanitation facilities in sub Saharan Africa to inform policy and intervention design. Water and sanitation interventions can be strengthened or undermined by factors that assist or hinder access to safe water and adequate sanitation. Insight into factors that affect access to safe water and adequate sanitation can help various stakeholders to develop and implement solutions in SSA.

2. Materials and methods

2.1. Data source

This study uses nationally representative household survey data from Demographic and Health Surveys (DHS) for selected sub Saharan African (SSA) countries. DHS data are secondary data which provide several indicators for monitoring and impact assessment in the areas of population, health, and nutrition. DHS data are open source and can be accessed on DHS website (www.dhsprogram.com). The questionnaire of the DHS are standardized and pre-tested to ensure comparability across populations and over time. One important advantage of the DHS data is the vastness of data that are collected including demographic, social, wealth and health attributes and allow for in-depth analysis of the data, that goes beyond the count of prevalence and examine complex causal relationships or associations between social characteristics and health (Corsi et al., 2012). Water and sanitation data are collected at the household level in the DHS. The surveys are based on probability sampling using existing sampling frames primarily, population censuses. The selection criteria for including a country in this study were as follows: (i) the country should be found in SSA based on the United Nations regional groupings; (ii) should have DHS dataset with standardised questions on sources of drinking water and type of toilet facility at the household level; (iii) should have datasets in all the three-timeframes for the study (i.e. 1990−1995, 2000−2005, and 2010−2015) (iv) should contain data on size of population without access to improved water sources and sanitation facilities.

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2.2. Study countries

A total of 15 countries in SSA met the criteria (see Fig. 1). Where multiple datasets were available for one-time frame for the same country, the most recent survey was used (see Table 1). Table one gives detail information on countries included in this study and the year of available data.

2.3. Definitions of improved and unimproved water sources and sanitation facilities

The WHO/UNICEF Joint Monitoring Programme (JMP) 2017 report has reviewed the definition of improved and unimproved water sources and sanitation facilities and has established additional criteria relating to service levels. For drinking water, improved sources are those that have the potential to deliver safe water by nature of their design and construction. According to the report, an improved source should meet these three criteria: (i) it should be accessible on premises (ii) water should be available when needed (iii) the water supplied should be free from contamination. Packaged water (bottled water and sachets of water) and delivered water are now classified as improved but these were previously considered as unimproved as a result of lack of data on accessibility, availability and quality.

For sanitation, improved facilities are those designed to hygienically separate excreta from human contact. The three main criteria for having a safely managed sanitation

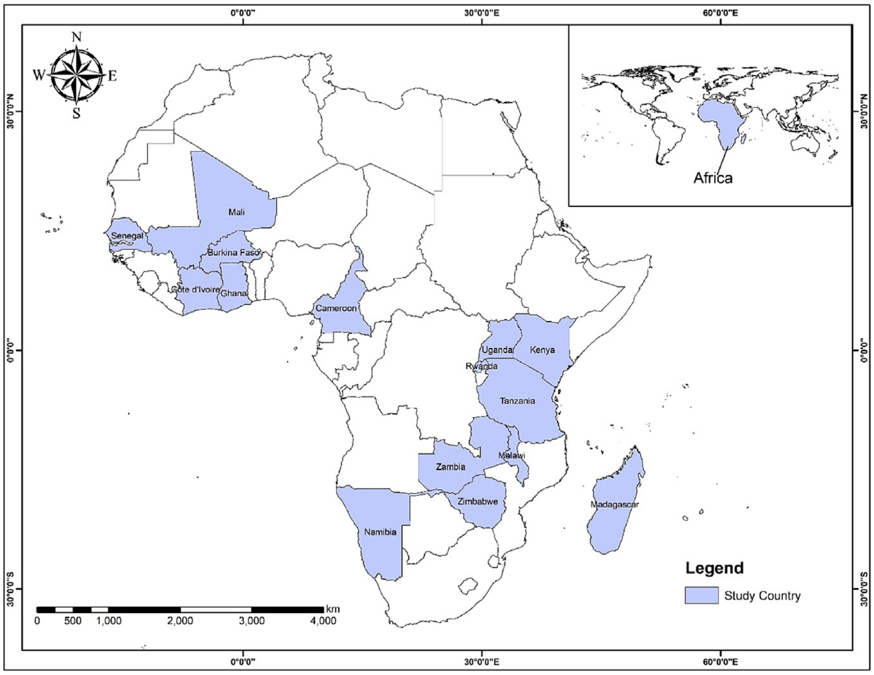

Fig. 1. The selected study countries in sub-Saharan Africa.

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Table 1. Study country and available dataset.

Country	Available Dataset
Senegal	1992–1993, 2005, 2010–2011
Cote d'Ivoire	1994, 2005, 2011–2012
Cameroon	1991, 2004, 2011
Ghana	1993, 2003, 2014
Kenya	1993, 2003, 2014
Madagascar	1992, 2003–2004, 2011
Mali	1995, 2001, 2012–2013
Malawi	1992, 2004, 2015
Namibia	1992, 2000, 2013
Rwanda	1992, 2000, 2014–2015
Burkina Faso	1993, 2003, 2010
Tanzania	1992–1993, 2004–2005, 2010
Uganda	1995, 2000–2001, 2011
Zambia	1992, 2001–2002, 2013–2014
Zimbabwe	1994, 2005, 2015

service are: (i) treated and disposed of in situ (ii) stored temporarily and then emptied, transported and treated off-site (iii) transported through a sewer with wastewater and then treated off-site. Some examples of improved water sources and sanitation facilities from WHO/UNICEF Joint Monitoring Programme (JMP) 2017 report are shown in Table 2.

2.4. Measures

2.4.1. Response variable

The response/dependent or outcome variables considered in this study were improved drinking water sources and improved sanitation facilities. Improved and

Table 2. Definition of improved and unimproved facilities (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2017).

Service	Improved	Unimproved
Drinking water sources	Piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater, and packaged or delivered water.	Unprotected dug well, unprotected spring, river, dam, lake, pond, stream, canal and irrigation canal
Sanitation facilities	Flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs.	Pit latrines without a slab or platform, hanging latrines or bucket latrines and open defecation.

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unimproved water sources or sanitation facilities were represented as dichotomous variables, with'1' representing 'improved' and '0' representing 'unimproved', respectively for both water sources and sanitation.

2.4.2. Key predictor variable

The predictor or independent variable was selected based on literature review, parsimony, practical significance and theoretical relevance. The predictor variable was derived from type of residence (rural–urban) and wealth status (poorer, poor, middle, rich and richer). The wealth index is a composite measure of a household's cumulative living standard. The wealth index was calculated from data collected on ownership of durable assets, housing characteristics and access to services (Howe et al., 2009). Principal components analysis (PCA) was used to assign the indicator weights. The wealth index places individual households on a continuous scale of relative wealth. The DHS separates all interviewed households into five wealth quintiles to compare the influence of wealth on various populations. For parsimony, the observations under poorer and poor were combined and recoded as 'poor'. Observations under richer and rich were also combined and recoded as 'rich'. This produced the predictor variable called urbanicity wealth status with six mutually exclusive groups: the urban poor (poor households in urban areas), urban middle (middle quintile households in urban areas), urban rich (rich quintile households in urban areas), rural poor (poor households in rural areas), rural middle (middle quintile households in rural areas) and rural rich (rich households in rural areas).

2.4.3. Compositional and contextual factors

Compositional factors refer to variables relating to the socio-demographic characteristics of individuals (Collins et al., 2017; Pol and Thomas, 2000). Compositional factors comprise biosocial and socio-cultural factors. Biosocial characteristics are factors with an underlying biological or physical component which are characteristics present at birth and not amenable to change (Pol and Thomas, 2000). Socio-cultural factors are customs, beliefs, lifestyles and values. In this study, the compositional factors included gender of household head (male or female), age of household (young adult: below 35years, middle-age adult: 35–55 years, old age adult: above 55 years), household size (small: 1–5, medium: 6–10, large: above 10), level of education of household head (no education/preschool, primary, secondary, higher). Contextual factors are defined as the broader neighbourhood attributes or location-specific opportunities in a region, such as availability of and access to services (Collins et al., 2017; Ross and Mirowsky, 2008). In this study, the contextual factors considered were country and year (1990–1995, 2000–2005, 2010–2015).

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2.4.4. Data analysis

All statistical analyses were performed in STATA 13 MP (StataCorp, College Station, TX, USA). Descriptive analysis was carried out to describe the status and trend of access to improved water sources and sanitation facilities over 25 year period in the study countries and the type of residence (urban/rural). Inferential and multivariate techniques were used to assess associations between the access to improved water and sanitation and residential wellbeing (urbanicity wealth) status of households while controlling for theoretically relevant compositional factors (biosocial, socio-cultural) and contextual factors (year, country).

2.4.5. Univariate analysis

Univariate analysis of predictors of access to improved water and sanitation was carried out using Pearson chi-square and Cramer's V statistic. Pearson chi-square was used to estimate associations between categorical variables. The chi-square test of independence is a nonparametric statistical test that is used to determine if two or more groups of samples are independent or not.

2.4.6. Multivariate regression

A complementary log-log regression model was fitted to the data at the multivariate level. The link function of this model is apt for binary outcomes that are symmetrical unlike the logit or probit models that are appropriate for modeling symmetrical binary outcomes (see Ajibade et al., 2014). The complementary log-log transformation is expressed as

$$\eta_i = \log(-\log(1-\pi_i)), \tag{1}$$

which is the inverse of the cumulative distribution function of the extreme value (or log-Weibull) distribution, with cumulative distribution:

$$F(\eta_i) = 1 - e^{-e\eta i} \tag{2}$$

For small values of π_i, the complementary log-log transformation is close to the logit. As the probability increases, the transformation approaches infinity more slowly that either the probit or logit. Although the complementary log-log link differs from the probit and logit, one would need extremely large sample sizes, as in this study, to be able to discriminate empirically between these links.

In Eqs. (1) and (2), the contributory role of urbanicity wealth status in determining access to improved water sources and sanitation facilities was estimated using a complementary log-log model and reported as exponentiated coefficients or odds ratios (OR). An OR of 1 means that predictor does not affect odds of access to

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improved water sources or improved sanitation facilities; OR > 1 means that predictor is associated with higher odds of access to improved water sources or improved sanitation facilities; and OR < 1 means that predictor is associated with lower odds of access to improved water sources or improved sanitation facilities. The study accounted for clustering of observations in units of household, and robust estimates of variance was used to correct for this and any statistical outliers in the estimation of standard errors. The study employed 95% confidence interval (CI) and the level of statistical significance was set at 0.05. Some compositional (sex of household head, age of household head, household size, level of education of household head) and contextual (year, country) variables that are known in literature to affect household access to improved water sources and sanitation facilities were controlled for in the models. The model was run separately for access to improved water sources and improved sanitation facilities. Three models namely urbanicity wealth of household head and biosocial (model 1), socio-cultural (model 2), and contextual (model 3) were ran. The analyses were performed separately for improved water sources and improved sanitation facilities. Selection of reference groups for the independent variables in the models was based on theory, literature and parsimony. Urban poor was chosen as the reference group for the key predictor, urbanicity wealth status. Urban poor are considered as vulnerable, marginalized and dwell in slums as well as lack access to improved water and sanitation (Armah et al., 2017a, 2017b; Hawkins et al., 2013). The reference group selected for the sex was "male". Studies have shown that male in households are relatively less concerned about water and sanitation issues (Mulenga et al., 2017). The young adult group was chosen as the reference group as they are usually in transition and may not be able to afford improved water and sanitations services. Lack of formal education was chosen as the reference category since it has a direct influence on affordability and decision-making capacity of households regarding access to water and sanitation services. The reference period "1990−1995" was selected as baseline for temporal assessment on inequality in access to water and sanitation services. The reference country selected for country variable was "Senegal". The water, sanitation and hygiene (WASH) performance index report, 2015 ranked Senegal above all the other 14 countries included in this study (Cronk et al., 2015).

2.5. Ethical statement

The data used in this study was obtained using procedures and questionnaires that have been reviewed and approved by ICF Institutional Review Board (IRB). Besides, ICF IRB ensures that the survey complies with the United States Department of Health and Human Services regulations for the protection of human subjects CFR 46. The survey protocols for countries also complied with various host country laws.

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3. Results

The study countries made significant progress in terms of access to improved water sources. Namibia had the highest (91%) access to improved water sources in 2010−2015 and Madagascar had the lowest access of 47 percent. Rwanda recorded the highest increase in access by 45 percent from 1990-1995 to 2010−2015. With regards to access to improved sanitation facilities, Zimbabwe was the only country which increased continuously from 1990-1995 to 2010−2015. All the remaining fourteen countries studied increased in access from 1990-1995 to 2000−2005 but declined in 2010−2015.

Among the studied countries, Malawi had the highest (83%) access in 2010−2015 and Madagascar recorded the lowest of 15 percent. Details of the trend in access to improved water sources and sanitation facilities are shown in Figs. 2 and 3 respectively.

On aggregate, access to improved water sources by urban dwellers increased from 86 percent in 1990−1995 to 92 percent in 2010−2015 (Fig. 4). Access to improved water sources in rural areas also increased from 31.57 percent in 1990−1995 to 63.79 percent in 2010−2015. However, access to unimproved water sources remains high in rural areas.

Access to improved sanitation increased for both urban and rural populations between 1990-1995 and 2000−2005, but declined significantly in 2010−2015 for both urban and rural populations, respectively (Fig. 5).

Pearson chi-square and Cramer's V statistic were used to determine whether the observed differences in access to improved water sources and sanitation facilities, urbanicity wealth as well as the compositional factors and contextual factors were independent. The contingency tables (Tables 3 and 4) show the detailed results.

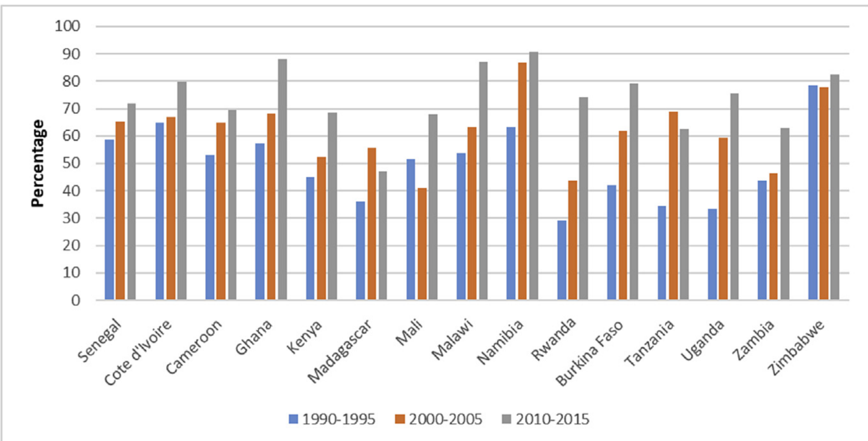

Fig. 2. Access to improved water sources for study countries in 2010−2015.

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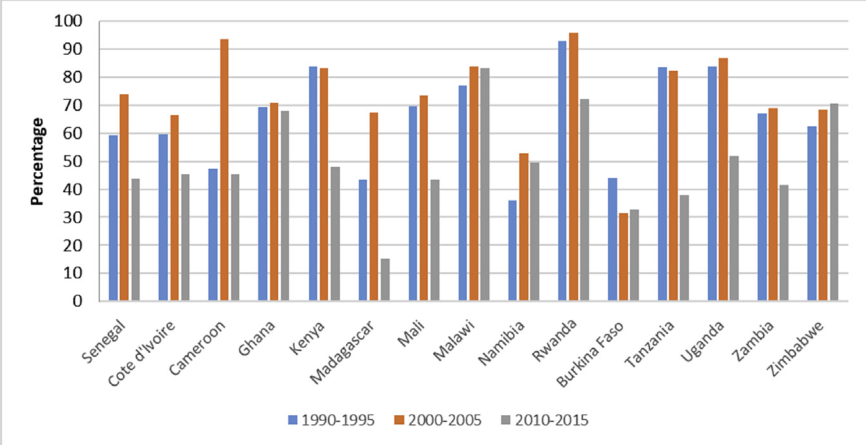

Fig. 3. Access to improved sanitation facilities for study countries in 2010−2015.

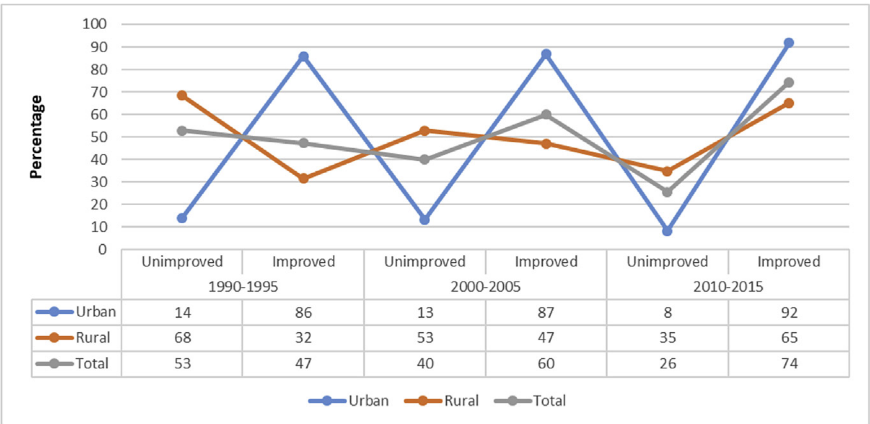

Fig. 4. Residential inequalities in access to water sources for study countries.

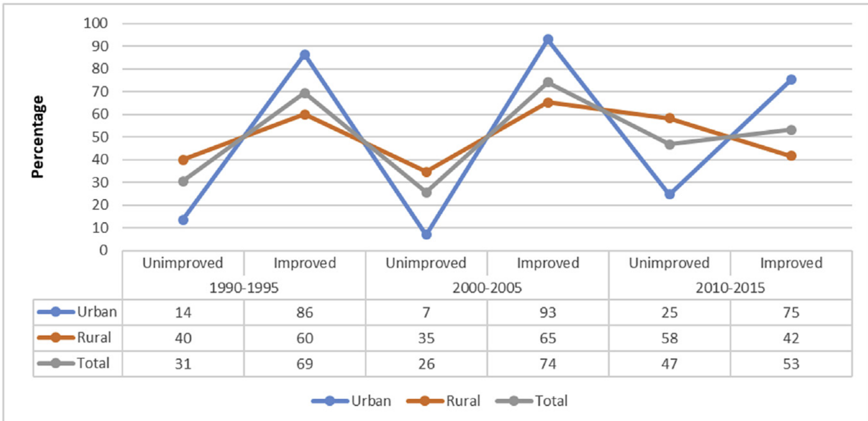

Fig. 5. Residential inequalities in access to sanitation facilities for study countries.

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Table 3. Percentage distribution of access to water sources by predictor variables.

Variable	1990–1995		N = 75842	2000–2005		N = 107452	2010–2015		N = 186073
	Unimproved (%)	Improved (%)	Inferential Statistics	Unimproved (%)	Improved (%)	Inferential Statistics	Unimproved (%)	Improved (%)	Inferential Statistics
Urbanicity Wealth									
Urban Poor	34	66	Pearson chi2 = 3.6e+04	55	45	Pearson chi2 = 2.3e+04	34	66	Pearson chi2 = 2.3e+04
Rural Poor	93	7	P value = 0.000 Cramér's V = 0.6856	64	36	P value = 0.000 Cramér's V = 0.4654	41	59	P value = 0.000 Cramér's V = 0.3525
Urban Middle	30	70		36	64		10	90	
Rural Middle	45	55		53	47		28	72	
Urban Rich	6	94		7	93		3	97	
Rural Rich	33	67		33	67		18	82	
Sex of household head									
Male	52	48	Pearson chi2 = 15.4561	41	59	Pearson chi2 = 166.1230	26	74	Pearson chi2 = 90.3536
Female	50	50	P value = 0.000 Cramér's V = 0.0133	37	63	P value = 0.000 Cramér's V = 0.0368	24	76	P value = 0.000 Cramér's V = 0.0210
Age of household head									
Young Adult (Below 35yrs)	48	52	Pearson chi2 = 842.2819 P value = 0.000	38	62	Pearson chi2 = 285.5426 P value = 0.000	24	76	Pearson chi2 = 432.7012 P value = 0.000
Middle-aged Adult (35–55yrs)	50	50	Cramér's V = 0.0979	39	61	Cramér's V = 0.0483	25	75	Cramér's V = 0.0460
Older-aged Adult (Above 55yrs)	60	40		40	60		29	71	
Household size									
Small (1–5 members)	51	49	Pearson chi2 = 86.2787	39	61	Pearson chi2 = 171.0617	23	77	Pearson chi2 = 985.6094
Medium (6–10 members)	53	47	P value = 0.000 Cramér's V = 0.0313	43	57	P value = 0.000	30	70	P value = 0.000
Large (Above 10 members)	48	52		39	61	Cramér's V = 0.0374	30	70	Cramér's V = 0.0694

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Table 3. (*Continued*)

Variable	1990−1995		N = 75842	2000−2005		N = 107452	2010−2015		N = 186073
	Unimproved (%)	Improved (%)	Inferential Statistics	Unimproved (%)	Improved (%)	Inferential Statistics	Unimproved (%)	Improved (%)	Inferential Statistics
Highest education level of household head									
No education/ Preschool	60	40	Pearson chi2 = 6.2e+03 P value = 0.000 Cramér's V = 0.2661	51	49	Pearson chi2 = 8.4e+03 P value = 0.000 Cramér's V = 0.2622	32	68	Pearson chi2 = 8.7e+03 P value = 0.000 Cramér's V = 0.1997
Primary	54	46		44	56		29	71	
Secondary	26	74		21	79		14	86	
Higher	9	91		9	91		5	95	
Country									
Senegal	42	58	Pearson chi2 = 6.2e+03 P value = 0.000 Cramér's V = 0.2659	35	65	Pearson chi2 = 7.4e+03 P value = 0.000 Cramér's V = 0.2457	28	72	Pearson chi2 = 1.1e+04 P value = 0.000 Cramér's V = 0.2365
Cote d'Ivoire	35	65		33	67		20	80	
Cameroon	47	53		35	65		30	70	
Ghana	43	57		32	68		12	88	
Kenya	55	45		48	52		31	69	
Madagascar	64	36		44	56		53	47	
Mali	48	52		59	41		32	68	
Malawi	46	54		37	63		13	87	
Namibia	37	63		13	87		9	91	
Rwanda	71	29		56	44		26	74	
Burkina Faso	58	42		38	62		21	79	
Tanzania	66	34		31	69		38	62	
Uganda	66	34		41	59		24	76	
Zambia	56	44		54	46		37	63	
Zimbabwe	22	78		22	78		18	82	

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Table 4. Percentage distribution of access to sanitation facilities by predictor variables.

Variable	1990–1995		N = 75842	2000–2005		N = 107452	2010–2015		N = 186073
	Unimproved (%)	Improved (%)	Inferential Statistics (%)	Unimproved (%)	Improved (%)	Inferential Statistics (%)	Unimproved (%)	Improved (%)	Inferential Statistics (%)
Urbanicity Wealth									
Urban Poor	12	88	Pearson chi2 = 6.9e+03	41	59	Pearson chi2 = 1.9e+04	68	32	Pearson chi2 = 3.9e+04
Rural Poor	45	55	P value = 0.000 Cramér's V = 0.3015	46	54	P value = 0.000 Cramér's V = 0.4217	70	30	P value = 0.000 Cramér's V = 0.4559
Urban Middle	25	75		15	85		30	70	
Rural Middle	37	63		25	75		49	51	
Urban Rich	10	90		3	97		15	85	
Rural Rich	24	76		10	90		30	70	
Sex of household head									
Male	31	69	Pearson chi2 = 22.6812	26	74	Pearson chi2 = 10.2874	47	53	Pearson chi2 = 103.3761
Female	33	67	P value = 0.000 Cramér's V = -0.0161	25	75	P value = 0.001 Cramér's V = 0.0092	45	55	P value = 0.000 Cramér's V = 0.0225
Age of household head									
Young Adult (Below 35yrs)	28	72	Pearson chi2 = 842.2819	23	77	Pearson chi2 = 586.9827	44	56	Pearson chi2 = 880.1444
Middle-aged Adult (35–55yrs)	31	69	P value = 0.000 Cramér's V = 0.0979	25	75	P value = 0.000 Cramér's V = 0.0693	46	54	P value = 0.000 Cramér's V = 0.0656
Older-aged Adult (Above 55yrs)	38	62		31	69		52	48	
Household size									
Small (1–5 members)	31	69	Pearson chi2 = 57.8144	24	76	Pearson chi2 = 222.0830	44	56	Pearson chi2 = 1.3e+03
Medium (6–10 members)	32	68	P value = 0.000 Cramér's V = 0.0256	27	73	P value = 0.000 Cramér's V = 0.0426	51	49	P vale = 0.000 Cramér's V = 0.0805
Large (Above 10 members)	36	64		31	69		56	44	
Highest education level of household head									
No education/Preschool	43	57	Pearson chi2 = 4.5e+03	40	60	Pearson chi2 = 9.4e+03	64	37	Pearson chi2(3) = 1.9e+04
Primary	27	73	P value = 0.000 Cramér's V = 0.2256	22	78	P value = 0.000 Cramér's V = 0.2781	47	53	P value = 0.000 Cramér's V = 0.3089
Secondary	17	83		11	89		30	70	
Higher	6	94		2	98		13	87	

(*continued on next page*)

Table 4. (*Continued*)

Variable	1990–1995		N = 75842	2000–2005		N = 107452	2010–2015		N = 186073
	Unimproved (%)	Improved (%)	Inferential Statistics (%)	Unimproved (%)	Improved (%)	Inferential Statistics (%)	Unimproved (%)	Improved (%)	Inferential Statistics (%)
Country									
Senegal	41	59	Pearson chi2 = 1.0e+04 P value = 0.000 Cramér's V = 0.3424	26	74	Pearson chi2 = 1.7e+04 P value = 0.000 Cramér's V = 0.3713	56	44	Pearson chi2 = 2.4e+04 P value = 0.000 Cramér's V = 0.3418
Cote d'Ivoire	41	59		33	67		55	45	
Cameroon	53	47		6	94		44	56	
Ghana	31	69		29	71		32	68	
Kenya	16	84		17	83		52	48	
Madagascar	56	44		33	67		85	15	
Mali	30	70		26	74		57	44	
Malawi	23	77		16	84		17	83	
Namibia	64	36		47	53		50	50	
Rwanda	7	93		4	96		28	72	
Burkina Faso	56	44		69	31		67	33	
Tanzania	17	83		18	82		62	38	
Uganda	16	84		13	87		48	52	
Zambia	33	67		31	69		58	42	
Zimbabwe	38	62		32	68		30	70	

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The Pearson chi-squared statistic result rejected the hypotheses that access to improved water sources and sanitation facilities are independent of the urbanicity wealth of household, compositional and contextual factors. This means that urbanicity wealth status influences access to improved water sources and sanitation facilities. Besides, the probability values indicate that figures obtained for improved water sources and sanitation facilities were not by chance and that if the analyses were repeatedly ran same results will be obtained. The Cramer's V statistic indicated strong association between access to improved water sources and urbanicity wealth of household for the 25 year period, same association was observed for access to improved sanitation facilities and urbanicity wealth of household. Cramer's V statistic for contextual factors (country) indicated strong associations, however, that of the compositional factors showed very weak associations.

3.1. Urbanicity wealth status and access to improved water sources

Table 5 shows the odds ratios, robust standard errors, probability values and confidence intervals associated with urbanicity wealth status of households, as well as compositional and contextual factors. Model 1 shows that rural poor ($OR = 0.540$, $P < 0.0001$) and rural middle ($OR = 0.974$, $P < 0.0001$) households were less likely to have access to improved water sources compared to poor urban households. The urban middle ($OR = 1.759$, $P < 0.0001$), urban rich ($OR = 3.105$, $P < 0.0001$) and rural rich ($OR = 1.410$, $P < 0.0001$) households were more likely to have access to improved water sources than urban poor households. Female-headed households were 17.6 percent more likely to have access to improved water sources compared to male-headed households. Model 1 revealed that households with middle-aged adult ($OR = 0.977$, $P < 0.0001$) and older-aged adult ($OR = 0.973$, $P < 0.0001$) heads were less likely to have access to improved water sources than households with young adult heads.

The results from model 2, in which socio-cultural factors were controlled for, show that rural poor households were 42.5 percent less likely to have access to improved water sources compared to urban poor households. Again, urban middle ($OR = 1.707$, $P < 0.0001$), urban rich ($OR = 2.877$, $P < 0.0001$) and rural rich ($OR = 1.422$, $P < 0.0001$) households were more likely to have access to improved water sources than urban poor households. Model 2 also shows that female-headed households were 18.1 percent more likely to have access to improved water sources compared to male-headed households. It was revealed in model 2 that households with middle-aged adult ($OR = 1.035$, $P < 0.0001$) and older-aged adult ($OR = 1.074$, $P < 0.0001$) heads were now slightly more likely to have access to improved water sources than households with young adult heads.

Medium- ($OR = 0.902$, $P < 0.0001$) and large- ($OR = 0.891$, $P < 0.0001$) size households were less likely to have access to improved water source compared to

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Table 5. Complementary log-log regression model showing the relationship between access to improved water sources and household characteristics.

Variable	Urbanicity wealth + Bisocial factors					+ Socio-cultural factors					+ Contextual factors				
	OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval	
	Model 1					Model 2					Model 3				
Urbanicity wealth (ref: Urban poor)															
Rural Poor	0.540	0.006	**0.000**	0.529	0.553	0.575	0.007	**0.000**	0.563	0.589	0.708	0.009	**0.000**	0.690	0.726
Urban Middle	1.759	0.024	**0.000**	1.712	1.808	1.707	0.024	**0.000**	1.661	1.754	1.887	0.029	**0.000**	1.831	1.944
Rural Middle	0.974	0.012	**0.029**	0.952	0.997	1.010	0.012	0.413	0.986	1.034	1.291	0.017	**0.000**	1.258	1.326
Urban Rich	3.105	0.036	**0.000**	3.035	3.177	2.877	0.034	**0.000**	2.811	2.944	4.294	0.061	**0.000**	4.177	4.415
Rural Rich	1.410	0.017	**0.000**	1.378	1.443	1.422	0.017	**0.000**	1.389	1.455	1.916	0.026	**0.000**	1.866	1.968
Sex of household head (ref: Male)															
Female	1.176	0.006	**0.000**	1.164	1.189	1.181	0.007	**0.000**	1.169	1.194	1.106	0.007	**0.000**	1.093	1.120
Age group of household head (ref: Young adult)															
Middle-aged Adult	0.977	0.005	**0.000**	0.966	0.987	1.035	0.006	**0.000**	1.024	1.047	1.005	0.006	0.396	0.993	1.018
Older-aged Adult	0.973	0.006	**0.000**	0.961	0.985	1.074	0.007	**0.000**	1.060	1.088	1.002	0.007	0.782	0.988	1.016
Household size (ref: Small)															
Medium						0.902	0.005	**0.000**	0.892	0.911	0.938	0.005	**0.000**	0.927	0.949
Large						0.891	0.009	**0.000**	0.874	0.909	0.916	0.010	**0.000**	0.897	0.937
Education level of household head (ref: No education)															
Primary						1.069	0.006	**0.000**	1.057	1.081	1.024	0.007	**0.001**	1.010	1.038
Secondary						1.400	0.010	**0.000**	1.381	1.420	1.168	0.010	**0.000**	1.148	1.188
Higher						1.685	0.022	**0.000**	1.642	1.729	1.398	0.022	**0.000**	1.355	1.442
Year (ref: 1990−1995)															
2000−2005											1.282	0.009	**0.000**	1.264	1.300
2010−2015											2.252	0.015	**0.000**	2.223	2.282
Country (ref: Senegal)															
Cote d'Ivoire											1.025	0.017	0.137	0.992	1.060
Cameroon											0.711	0.011	**0.000**	0.690	0.732
Ghana											1.134	0.018	**0.000**	1.098	1.170

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Table 5. (*Continued*)

Variable	Urbanicity wealth + Bisocial factors					+ Socio-cultural factors					+ Contextual factors				
	OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval	
	Model 1					Model 2					Model 3				
Kenya											0.630	0.009	**0.000**	0.612	0.648
Madagascar											0.491	0.009	**0.000**	0.473	0.510
Mali											0.682	0.010	**0.000**	0.662	0.702
Malawi											1.177	0.017	**0.000**	1.144	1.211
Namibia											1.574	0.026	**0.000**	1.523	1.627
Rwanda											0.649	0.010	**0.000**	0.630	0.669
Burkina Faso											0.856	0.013	**0.000**	0.832	0.882
Tanzania											0.604	0.009	**0.000**	0.586	0.623
Uganda											0.608	0.010	**0.000**	0.589	0.629
Zambia											0.657	0.012	**0.000**	0.634	0.680
Zimbabwe											1.274	0.022	**0.000**	1.232	1.318
N					**379000**					**369732**					**369732**

Bold font represents statistically significant relationships.

small-size households. Regarding level of education, households with heads that have primary level (OR = 1.069, P < 0.0001), secondary level (OR = 1.400, P < 0.0001) and higher education (OR = 1.685, P < 0.0001) were more likely to have access to improved water sources than households with uneducated heads.

In model 3, we considered some contextual factors that can influence access to improved water sources. The year and the country where the households are located were controlled for in the model. These contextual factors mediated the relationship between the main predictor and access to improved water sources. Observations under rural middle households were not statistically significant in model 1 and 2 but became significant when the contextual variables were added in model 3. Conversely, year and country variables attenuated the effect of age group of household head on access to improved water sources. Age group of household head variable was statistically significant in model 1 and 2 but ceased to be significant when the two contextual factors were considered in model 3. The results show rural poor households (OR = 0.708, P < 0.0001) were still less likely to have access to improved water sources compared to poor households. We found that urban middle (OR = 1.887, P < 0.0001), rural middle (OR = 1.291, P < 0.0001), urban rich (OR = 4.294, P < 0.0001) and rural rich (OR = 1.916, P < 0.0001) households were more likely to have access to improved water sources than urban poor households. Model 3 also shows that people in female-headed households were still 10.6 percent more likely to have access to improved water sources than male-headed households. With regards to household size, medium (OR = 0.938, P < 0.0001) and large (OR = 0.916, P < 0.0001) size households were still less likely to have access to improved water sources as compared to those in small size households. It was also observed that households with heads that have primary level (OR = 1.024, P < 0.0001), secondary level (OR = 1.168, P < 0.0001) and higher education (OR = 1.398, P < 0.0001) were more likely to have access to improved water sources than households with heads who have no education. Temporally, households were 28.2 percent and 125.2 percent more likely to have access to improved water sources in 2000−2005 and 2010−2015 respectively, than in 1990−1995. In terms of country, households in the following countries: Cameroon (OR = 0.711, P < 0.0001), Kenya (OR = 0.630, P < 0.0001), Madagascar (OR = 0.491, P < 0.0001), Mali (OR = 0.682, P < 0.0001), Rwanda (OR = 0.649, P < 0.0001), Burkina Faso (OR = 0.856, P < 0.0001), Tanzania (OR = 0.604, P < 0.0001), Uganda (OR = 0.608, P < 0.0001), Zambia (OR = 0.657, P < 0.0001) were less likely to have access to improved water sources compared to those in Senegal. Households in countries such as Ghana (OR = 1.134, P < 0.0001), Malawi (OR = 1.177, P < 0.0001), Namibia (OR = 1.574, P < 0.0001), Zimbabwe (OR = 1.274, P < 0.0001) were more likely to have access to improve water sources compared with those in Senegal.

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3.2. Urbanicity wealth status and access to improved sanitation facilities

Table 6 shows the three results for the multivariate analyses that were ran for access to improved sanitation facilities. Model 1 indicates that rural poor households (OR = 0.847, P < 0.0001) were less likely to have access to improved sanitation facilities compared to urban poor households. We observed that urban middle (OR = 2.023, P < 0.0001), rural middle (OR = 1.444, P < 0.0001) urban rich (OR = 3.389, P < 0.0001) and rural rich (OR = 2.254, P < 0.0001) households were more likely to have access to improved sanitation facilities than urban poor households. It was also observed that female-headed households (OR = 1.047, P < 0.0001) were slightly more likely to have access to improved sanitation facilities than male-headed households. Model 1 shows that households with middle-aged adult (OR = 1.059, P < 0.0001) and older-aged adult (OR = 1.128, P < 0.0001) heads were more likely to have access to improved sanitation facilities than households with young adult heads.

After controlling for the socio-cultural factors in model 2, the results show that rural poor households were 6.6 percent less likely to have access to improved sanitation facilities compared to urban poor households. We found out that urban middle (OR = 2.003, P < 0.0001), rural middle (OR = 1.524, P < 0.0001) urban rich (OR = 3.305, P < 0.0001) and rural rich (OR = 2.370, P < 0.0001) households were more likely to have access to improved sanitation facilities than urban poor households. Female-headed households were 6.5 percent marginally more likely to have access to improved sanitation facilities compared to male-headed households. Households with middle-aged adult (OR = 1.017, P < 0.003) and older-aged adult (OR = 1.060, P < 0.0001) heads were more likely to have access to improved sanitation facilities than households with young adult heads. Medium (OR = 0.988 P < 0.020) and large (OR = 0.933, P < 0.0001) size households were less likely to have access to improved sanitation facilities than small size households. With regards to level of education of household head, we observed that households with heads that have primary level (OR = 1.419, P < 0.0001), secondary level (OR = 1.509, P < 0.0001) and higher education (OR = 1.814, P < 0.0001) education were more likely to have access to improved sanitation facilities than those who reside in households with heads that have no education.

Contextual factors (year and country) were controlled for in model 3. We observed that rural poor households (OR = 0.745, P < 0.0001) were still less likely to have access to improved sanitation facilities compared to urban poor households. The model 3 shows that urban middle (OR = 2.091, P < 0.0001), rural middle (OR = 1.255, P < 0.0001), urban rich (OR = 3.266, P < 0.0001) and rural rich (OR = 1.915, P < 0.0001) households were more likely to have access to improved sanitation facilities than urban poor households. Female-headed households were 5

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Table 6. Complementary log-log regression model showing the relationship between access to improved sanitation facilities and household characteristics.

Variable	Urbanicity wealth + Biosocial factors					+ Socio-cultural factors					+ Contextual factors				
	OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval	
	Model 1					Model 2					Model 3				
Urbanicity wealth (ref: Urban poor)															
Rural Poor	0.847	0.010	**0.000**	0.827	0.868	0.934	0.012	**0.001**	0.912	0.958	0.745	0.010	**0.000**	0.726	0.764
Urban Middle	2.023	0.030	**0.000**	1.966	2.082	2.003	0.030	**0.000**	1.946	2.063	2.091	0.032	**0.000**	2.030	2.154
Rural Middle	1.444	0.019	**0.000**	1.408	1.481	1.524	0.020	**0.000**	1.485	1.563	1.255	0.017	**0.000**	1.222	1.289
Urban Rich	3.389	0.042	**0.000**	3.308	3.473	3.305	0.042	**0.000**	3.224	3.389	3.266	0.045	**0.000**	3.180	3.355
Rural Rich	2.254	0.029	**0.000**	2.199	2.311	2.370	0.031	**0.000**	2.311	2.431	1.915	0.027	**0.000**	1.864	1.968
Sex of household head (ref: Male)															
Female	1.047	0.005	**0.000**	1.036	1.057	1.065	0.006	**0.000**	1.054	1.076	1.050	0.006	**0.000**	1.038	1.062
Age group of household head (ref: Young adult)															
Middle-aged Adult	0.967	0.005	**0.000**	0.957	0.977	1.017	0.006	**0.003**	1.006	1.028	1.059	0.006	**0.000**	1.047	1.072
Older-aged Adult	0.929	0.006	**0.000**	0.918	0.939	1.060	0.007	**0.000**	1.047	1.073	1.128	0.008	**0.000**	1.113	1.144
Household size (ref: Small)															
Medium						0.988	0.005	**0.020**	0.978	0.998	0.992	0.006	0.152	0.981	1.003
Large						0.933	0.009	**0.000**	0.915	0.950	1.020	0.011	0.074	0.998	1.041
Highest education level of household head (ref: No education)															
Primary						1.419	0.008	**0.000**	1.404	1.434	1.269	0.008	**0.000**	1.252	1.285
Secondary						1.509	0.010	**0.000**	1.489	1.530	1.637	0.014	**0.000**	1.610	1.665
Higher						1.814	0.021	**0.000**	1.774	1.856	2.129	0.031	**0.000**	2.069	2.190
Year (ref: 1990−1995)															
2000−2005											1.273	1.273	**0.000**	1.254	1.291
2010−2015											0.552	0.552	**0.000**	0.544	0.559
Country (ref: Senegal)															
Cote d'Ivoire											0.794	0.012	**0.000**	0.771	0.818
Cameroon											0.986	0.015	0.335	0.958	1.015

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Table 6. (*Continued*)

Variable	Urbanicity wealth + Bisocial factors					+ Socio-cultural factors					+ Contextual factors				
	OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval		OR	SE	P value	Conf. Interval	
	Model 1					Model 2					Model 3				
Ghana											0.983	0.015	0.266	0.953	1.013
Kenya											0.967	0.013	**0.000**	0.942	0.992
Madagascar											0.510	0.009	**0.000**	0.492	0.528
Mali											1.168	0.016	**0.000**	1.137	1.199
Malawi											2.068	0.029	**0.000**	2.012	2.126
Namibia											0.522	0.008	**0.000**	0.506	0.538
Rwanda											2.400	0.036	**0.000**	2.330	2.471
Burkina Faso											0.428	0.006	**0.000**	0.416	0.440
Tanzania											1.299	0.018	**0.000**	1.263	1.336
Uganda											1.114	0.017	**0.000**	1.081	1.149
Zambia											0.895	0.015	**0.000**	0.866	0.926
Zimbabwe											1.276	0.021	**0.000**	1.236	1.318
N					**379000**					**369732**					**369732**

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percent more likely to have access to improved sanitation facilities compared to male-headed households. Model 3 indicates that households with middle-aged adult (OR = 1.059, $P < 0.0001$) and older-aged adult (1.128, $P < 0.0001$) heads were slightly more likely to have access to improved sanitation facilities than households with young adult heads. Regarding education, households with heads that have primary level (OR = 1.269, $P < 0.0001$), secondary level (OR = 1.637, $P < 0.0001$) and higher (OR = 2.129, $P < 0.0001$) education were more likely to have access to improved sanitation facilities than households with heads that have no education. Even though household size was statistically significant in model 2, contextual factors attenuated its effect in model 3. Considering the year in which the surveys were carried out, households in 2000–2005 (OR = 1.273, $P < 0.0001$) were more likely to have access to improved sanitation facilities compared to those in 1990–1995. On the other hand, households in 2010–2015 (OR = 0.552, $P < 0.0001$) were less likely to have access to improved sanitation facilities than those in 1990–1995. When countries were controlled for, it was observed that households in the following countries: Cote d'Ivoire (OR = 0.771, $P < 0.0001$), Kenya (OR = 0.939, $P < 0.011$), Madagascar (OR = 0.510, $P < 0.0001$), Namibia (OR = 0.522, $P < 0.0001$), Burkina Faso (OR = 0.428, $P < 0.0001$) and Zambia (OR = 0.895, $P < 0.0001$) were less likely to have access to improved sanitation facilities compared to those in Senegal. Households in countries such as Mali (OR = 1.168, $P < 0.0001$), Malawi (OR = 2.013, $P < 0.0001$), Rwanda (OR = 2.400, $P < 0.0001$), Tanzania (OR = 1.299, $P < 0.0001$), Uganda (OR = 1.114, $P < 0.0001$) and Zimbabwe (OR = 1.276, $P < 0.0001$) were more likely to have access to improved sanitation facilities compared to those in Senegal.

4. Discussion

Comparative analyses on access to water and sanitation facilities in developing countries is fundamentally about using comparison across different units of analysis to delineate the mechanisms that explain variation among environmental, social, economic and health outcomes in those units and beyond them. The greater ease of acquiring comparable quantitative indicators, and the potential for exploiting both temporal and spatial variation through regression techniques that use pooled cross sectional time series, are technological advances that give credence to the value of multi-country studies. Both national comparisons and advanced statistical techniques using such data have moved knowledge forward in a variety of fields of inquiry within water and sanitation. We conducted a pooled analysis of data to assess the household level factors that determine access to water and sanitation services in fifteen countries across sub-Saharan Africa. Unlike previous studies which assessed the effect of rural-urban location and wealth on access to improved water sources and sanitation separately (see Roche et al., 2017; Tuyet-Hanh et al., 2016; Osei et al.,

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2015; Pullan et al., 2014), the current study examined the joint effect of relative residential well-being (urbanicity and wealth status) on access to improved water sources and sanitation facilities in selected SSA countries.

Based on our findings, great improvements have been made in providing access to improved water sources in SSA from 1990 to 2015. The results show a consistent increase in access to improved water sources over the 25-year period, thus the odds of having access to improved water sources increased over the 25-year period as indicated in the multivariate analyses. It was observed that 74 percent of the population of the SSA countries studied had access to improved water sources in 2010−2015 which is higher than the MDG 2015 figure of 68 percent (UN, 2015). The difference may be attributed to the time periods considered and the number of countries included in this study. On the contrary, same cannot be said about sanitation. Access to improved sanitation facilities increased from 69 percent in 1990−1995 to 74 percent in 2000−2005 however, it declined significantly to 53 percent in 2010−2015. The decline can be attributed to high population growth and urbanization in SSA without complementary expansion in sanitation facilities during the MDG period (1990−2015). The 2015 JMP report indicated that the population of SSA doubled during the MDG period (1990−2015). However, access to improved sanitation facilities increased by only six percentage points during the same period (World Health Organization WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, 2015). Africa's urban population was projected to reach 1.2 billion by 2050, with an urbanization rate of 58 percent (UNDESA, 2014) but, in SSA, urbanization is not accompanied by the level of per capita economic growth or housing investment as seen in global trends (World Bank Group, 2015). This, in combination with poorly planned human settlements, put many urban poor in SSA into slums. The slum population is growing at 4.5 percent annually, and expected to double in 15 years (Marx, Stoker and Suri, 2013). A study by Ndikumana and Pickbourn (2015), has also shown that foreign aid to the water and sanitation sector has a non-linear effect on the percentage of the rural population that has access to improved sanitation. Generally, access to improved sanitation facilities increased with increase in foreign aid to a threshold beyond which further increases in aid are associated with declining access to sanitation. As shown by the results, both the urban and rural poor households are least likely to have access to improved water and sanitation facilities. This raises two fundamental issues– economic access and spatial access. Economically, the poor cannot afford the initial high cost of both water and sanitation facilities, regardless of whether they are in urban or rural areas. Spatially, the urban poor, especially, are often confined to slums or areas without municipal services. And even if they can afford, they might be quite a distance away from improved facilities, resulting in additional high transaction cost. The urban rich, on the other hand, regardless of their locations, can have both economic and spatial access to improved facilities as they might have better access to transportation.

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We observed that urbanicity wealth status of households had a strong association with access to improved water and sanitation facilities. Urban rich households were 329 percent more likely to have access to improved water sources and 227 percent more likely to have access to improved sanitation facilities compared to urban poor households. This means that access to improved water sources and sanitation is more concentrated in the rich households compared to the poor ones and this finding is in agreement with several studies (Mulenga et al., 2017; Tuyet-Hanh et al., 2016; Yang et al., 2013; Lawrence and Meigh, 2003). The reason is that having wealth increases the ability to pay for municipal services, such as water and sanitation, even when the local authority or government is not providing these services. Rural poor households were found to be 29 percent less likely to have access to improved water sources and 25 percent less likely to have access to improved sanitation facilities compared to urban poor households. This suggests that the urban poor might be spatially closer to facilities or services but might not be able to afford, compared to their rural counterpart who might not have these services or facilities at all. This clearly shows the disparities between rural-urban population in terms of access to improved water and sanitation facilities. This is in consonance with literature which suggest that urban households stand a better chance of having access to improved water sources and sanitation facilities (Tuyet-Hanh et al., 2016; Yang et al., 2013; WHO and UNICEF, 2014; UN, 2015).

The results show that gender of household head has association with access to improved water sources and sanitation facilities. Female-headed households had higher odds of access to improved water sources and sanitation. In many homes in SSA, women have the responsibility of managing water, sanitation and hygiene (WASH), cooking and other household chores. This direct connection with water and sanitation suggests that women could pay more attention to such issues than their male counterparts, and especially when women are the household heads. This finding is consistent with Mulenga et al. (2017) and Osei et al. (2015).

Age of household head had no association with access to improved water sources but had a weak association with improved sanitation facilities. Households with middle-aged and older-aged adult heads were more likely to have access to improved sanitation facilities than young adult headed households. Older people were able afford basic services as compared to young ones possibly because of their higher economic status.

The number of household members is one of the socio-cultural factors that were assessed in the multivariate analyses. Households with smaller size were observed to have higher odds of having access to improved water sources and sanitation facilities. This is in agreement with a study carried out by Armand and Fotu (2013) in Cameroon where they observed that increasing the size of a household decreases the likelihood of using improved water sources. The authors suggested that household wealth decreases with increasing size.

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Furthermore, households with more educated heads were more likely to have access to improved water sources and sanitation facilities compared to households with less educated heads and this is consistent with previous studies (see Abubakar, 2017; Prasetyoputra and Irianti, 2013; Ordinioha and Owhondah, 2013; Okurut et al., 2015). It may be attributed to the fact that educated people appreciate the respective benefits and cost of using improved and unimproved water sources or sanitation facilities. Therefore, awareness increases the likelihood of having access to improved sanitation facilities (Kema et al., 2012).

The strong association between country and access to improved water sources and sanitation facilities suggests that geographical inequalities surpass rural-urban disparities and can be likened to urbanicity wealth inequalities (Pullan et al., 2014). The large inter-country disparities in coverage of improved water sources and sanitation facilities in SSA has been reported (UNICEF/WHO, 2013). Our results suggest that there are substantial geographical inequalities in access of improved water sources and sanitation facilities across SSA that exceed simple urban-rural disparities and are of similar magnitude to the large socio-economic inequalities highlighted in a number of national studies (e.g. Pullan et al., 2014; Fehr et al., 2013; WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2011; Khan et al., 2011). The differences in coverage among countries can be attributed to difference in economic growth, infrastructure development, housing investment, government and nongovernmental organizations interventions etc. Studies show that unless governments and relevant stakeholders deliberately adopt strategies that target deprived areas and population groups, it is unlikely that countries will achieve universal coverage (Pullan et al., 2014; Taylor-Robinson et al., 2012; Murray et al., 2012; Laxminarayan et al., 2006).

4.1. Limitations of the study

The study limitations may result in under-estimation of inequality in access to improved water sources and sanitation facilities. The DHS records type of drinking water and type of toilet facility by households instead of individuals. This presupposes that our analyses does not pay attention to inequality in access to improved water sources and sanitation facilities among members in the same household (intra-household) and therefore may underestimate inequality. With regards to wealth index, the assets recorded in the DHS were not intended to measure economic status of households but were included for other purposes. Some studies have stated that such asset-based measures have weak association with other measures such as consumption (Howe et al., 2009). Even though, the criteria used in classifying improved drinking water sources and sanitation facilities in the Joint Monitoring

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Programme of the WHO/UNICEF are backed by empirical data, it is likely to overestimate or underestimate compliance.

Almost all data collected in DHS are subject to reporting and recall biases. This may affect some variables (age group of household heads, household size, and level of education) used in this study. However, detailed evaluation of DHS data has shown that these data are reasonably well reported (Boerma and Sommerfeltb, 1993). DHS are conducted on an ongoing basis and independently within countries, meaning that the majority of participating countries are not measured at the same time, limiting the contemporaneous cross-national comparisons.

5. Conclusion

Access to improved water sources has increased over the last 25 years in the SSA countries studied. Access to improved sanitation facilities also increased from 1990-1995 to 2000−2005 however, it declined significantly in the 2010−2015 period. The study shows that the improvement observed in access to improved sanitation facilities is gradually being eroded. The region has experienced a high population growth rate and urbanization which were not accompanied by economic growth and investment in housing, water and sanitation infrastructure. This has resulted in mushrooming of slum communities which lack basic amenities and social services. Access to improved water sources was not affected because of the growing use of packaged and delivered water. The combined effect of residential wellbeing (urbanicity wealth status) had magnified effect on access to improved water sources and sanitation facilities. Compositional factors such as sex, age and level of education of household head as well as the size of household are strong and significantly contribute to the magnified disparities in access to improved water sources and sanitation facilities in SSA. This suggests that concerted policy initiatives are required to increase access to improved water sources and sanitation facilities in the households giving special attention to the underserved populations. Extensive inequalities in coverage of improved water sources and sanitation facilities among countries in the region are discernible from the results of this study. International bodies and policy makers responsible for water and sanitation programmes should take note that a common intervention approach will not be favourable for all countries in sub-Saharan Africa rather; interventions should be designed to meet the peculiar needs of specific countries. On the whole, compositional and contextual factors mediated or attenuated the magnitude and direction of the relationship between residential wealth status and access to improved water sources and sanitation facilities indicating that access to water and sanitation facilities in SSA is a complex and multifaceted issue that needs to be tackled holistically taking into consideration interdisciplinary research and policy interventions covering environment, culture, economics and human behaviour.

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Declarations

Author contribution statement

Frederick A. Armah, Bernard Ekumah: Conceived and designed the analysis; Analyzed and interpreted the data; Contributed analysis tools or data; Wrote the paper.

David O. Yawson, Justice O. Odoi: Analyzed and interpreted the data; Contributed analysis tools or data; Wrote the paper.

Abdul-Rahaman Afitiri, Florence E. Nyieku: Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

Data associated with this study is available at https://dhsprogram.com/data/available-datasets.cfm.

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