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Prevalence and determinants of Acute Lower Respiratory Infections among children under-five years in sub-Saharan Africa: Evidence from demographic and health surveys

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ABSTRACT

Acute Lower Respiratory Infections (ALRIs) account for 5.8 million deaths globally and 50% of these deaths occur in sub-Saharan Africa. In this paper, we examined the prevalence and determinants of ALRIs among children under-five years in 28 sub-Saharan African countries. We used data from the most recent (2011–2016) Demographic and Health Surveys of the 28 countries. Women aged 15–49 (N = 13,495) with children under-five years participated in the study. Data were extracted and analysed using STATA version 14.2. Bivariate and multivariate analyses were done to establish associations between the outcome and explanatory variables. The prevalence of ALRI for all the countries was 25.3%. Congo (39.8%), Gabon (38.1%), Lesotho (35.2%), and Tanzania (35.2%) were the countries with the highest prevalence of ALRIs. The results from the multivariate analyses showed that children aged 24–59 months (AOR = 1.15; 95% CI = 1.04–1.28), and children who received intestinal parasite in the 6 months preceding the survey (AOR = 1.11; 95% CI = 1.02–1.22) had higher odds of developing ALRIs. However, children whose mothers were employed (AOR = 0.77; 95% CI = 0.64–0.94) and those whose households used improved toilet facilities (AOR = 0.72; 95% CI = 0.64–0.97) had lower odds of contracting ALRIs. Our findings underscore the need for stakeholders in health in the various sub-Saharan African countries, especially those worst affected by ALRIs to implement programmes and develop policies at different levels aimed at reducing infections among children under-five years. Such strategies should specifically focus on improving the administration of medications for intestinal worms, health education to mothers with children under five on ALRIs and improving the sanitation situations of households through the provision of improved toilet facilities.

1. Introduction

An infection of any part of the respiratory tract and related structures is termed an Acute Lower Respiratory Infection (ALRI). ALRIs are among the leading causes of morbidity and mortality among children under-five years worldwide (Accinelli, Leon-Abarca, & Gozal, 2017). Nearly all (97%) of ALRI cases occur in low and middle-income countries with about 70% occurring in South Asia and sub-Saharan Africa (UNICEF, 2016). In 2010, ALRIs accounted for approximately 5.8 million deaths globally (Chen, Williams, & Kirk, 2014) and about 50% of these deaths occurred in sub-Saharan Africa (UNICEF, 2016). Among children under-five, ALRIs contribute to about 4 million out of the 15

million under-five mortality cases recorded annually across the globe (Harerimana, Nyirazinyoye, Thomson, & Ntaganira, 2016). In low and middle-income countries, 6.9 million children died in 2011 and about one in five of these deaths were caused by an ALRI (Nair et al., 2013).

The symptoms of ALRIs are cough accompanied by short, rapid breathing that is chest-related, and is commonly linked to death through co-morbidities with other childhood illnesses such as pneumonia (Mirji, Shashank, Shrikant, Reddy & Naik, 2014). Pneumonia for instance, continues to be the leading infectious cause of mortality among children under-five, killing about 2,400 children a day (UNICEF, 2016). ALRIs are due to bacterial, fungal, or viral infections of the respiratory tract leading to breathing difficulties, fatigue, wheezing, pain

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on swallowing, fever, cough, nasal discharge, and sputum production (Banda, Mazaba, Mulenga, & Siziya, 2016). Some of these conditions further lead to complications in other parts of the body such as the ears and the membranes surrounding the brain and causing serious fatalities in both younger and older age-groups. Some health conditions such as; sore throat, ear infections, pink eye, breathing difficulties and their associated disabilities including deafness among children, can partly be explained by improperly treated episodes of ALRIs (Banda et al., 2016).

Organisms known to cause ALRI among children under-five include: bacteria such as *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pneumococci*, *Haemophilus influenzae* and *Klebsiella pneumoniae*. Viruses such as respiratory syncytial virus (RSV), parainfluenza type 3 virus (PF3), adenovirus (Adeno), influenza virus (FLU), and enterovirus are also the common etiological agents (Straliotto et al., 2002). Antibiotics are effective against a greater percentage of bacterial infections. Despite this, the diversity of microorganisms causing ALRI, and a diagnostic deficit of around 30% make the formulation of an effective universal treatment for these diseases very challenging (Shi et al., 2017). It is, therefore, prudent to identify the risk factors for ALRIs which are important for developing effective policies and strategies to interrupt transmission and improve health outcomes especially among children under-five years.

Research has shown that even though several factors are associated with ALRIs, there are major variations in these factors from low and middle-income countries to high income countries. In the low and middle-income countries for instance, factors such as age of the child (Akinyemi & Morakinyo, 2018; Cardoso, Coimbra & Werneck, 2013), sex (Al-Sharbatti & AlJumaa, 2012), and immunisation status (Pore, Ghattargi & Rayate, 2010; Jackson et al., 2013) are all associated with ALRIs. Others have observed that parental factors such as age (Cardoso, Coimbra, & Werneck, 2013; Gebertsadik, Worku, & Berhane, 2015), employment status (Cardoso, Coimbra & Werneck, 2013; Gebertsadik et al., 2015) and educational levels (Al-Sharbatti & AlJumaa, 2012; Prajapati, Talsania, & Sonaliya, 2011) are found to be associated with ALRIs among children under-five. Evidence exists to show that factors including wealth status (Adesanya & Chiao, 2017; Akinyemi & Morakinyo, 2018; Cardoso et al., 2013), place of residence and household size (Adesanya & Chiao, 2017; Akinyemi & Morakinyo, 2018; Al-Sharbatti & AlJumaa, 2012), type of toilet facility and type of cooking fuel (Akinyemi & Morakinyo, 2018; Alemayehu, Alemu, Sharma, Gizaw, & Shibru, 2014) can also predict the risk of ALRIs.

In relation to ALRIs, some studies have been conducted in sub-Saharan African countries such as Nigeria (Adesanya & Chiao, 2017; Akinyemi & Morakinyo, 2018), Rwanda (Harerimana et al., 2016), Ethiopia (Alemayehu et al., 2014; Gebertsadik et al., 2015), Cameroun (Tazinya et al., 2018) and Ghana (Jones et al., 2016; Sumaila & Tabong, 2018). Some of these studies conducted in sub-Saharan and other settings on ALRIs have been at the micro level using smaller samples (see Chen et al., 2014; Ramani, Pattankar, & PuttAhonnAPPA, 2016; Cardoso, Coimbra & Werneck, 2013; Fekadu, Terefe, & Alemie, 2014; Alemayehu et al., 2014; Arun, Gupta, Sachan, & Srivsatava, 2014; Mirji, Shashank, & Shrikant, 2016; Prajapati, Talsania, Lala & Sonalia, 2012). The results of such studies may not be applicable to all children under-five due to the unrepresentative nature of samples used. The novelty of our research is, therefore, the use of recent nationally representative samples-DHS from 28 countries in sub-Saharan Africa to examine the prevalence and risk factors associated with ALRIs. This study, therefore, sought to answer the following research questions; what is the prevalence of ALRI among children under five in sub-Saharan Africa? and what are the determinants of ALRI among children under five in sub-Saharan Africa?

Table 1

Prevalence of ALRIs among children under-five years from 28 sub-Saharan African countries.

Country (year of most recent DHS)	Children in the study	Children suffering from ALRI	
	n	n	%
Benin (2011–2012)	304	58	18.2
Burundi (2011)	1,023	243	23.7
Congo DR (2013–2014)	979	206	21.0
Congo (2011–2012)	276	110	39.8
Cote d' Ivoire (2011–2012)	266	32	12.1
Cameroon (2011)	604	69	11.5
Ethiopia (2016)	735	201	27.3
Gabon (2012)	301	115	38.1
Ghana (2014)	158	40	24.2
Gambia (2013)	248	70	28.4
Guinea (2012)	393	74	18.8
Kenya (2014)	1,355	412	30.4
Comoros (2012)	169	33	19.6
Liberia (2013)	280	95	34.0
Lesotho (2014–2015)	45	15	35.2
Malawi (2015–2016)	353	94	26.5
Mozambique (2011)	388	103	26.5
Nigeria (2013)	985	281	28.5
Niger (2012)	366	89	24.7
Namibia (2013)	111	20	18.2
Rwanda (2014–2015)	409	105	25.7
Sierra Leone (2013)	534	125	23.4
Senegal (2016)	235	39	16.5
Chad (2014–2015)	1,113	355	31.9
Togo (2013–2014)	392	29	7.4
Tanzania (2016)	365	128	35.2
Zambia (2013–2014)	694	237	34.2
Zimbabwe (2015)	311	36	11.5
All countries	13,495	3,413	25.3

2. Materials and methods

2.1. Data source

The study made use of pooled data from the most current Demographic and Health Surveys (DHS) conducted from 1st January 2010 to 31st December 2016 in 28 sub-Saharan African countries (See Table 1). DHS are nationwide surveys conducted every five years across low and middle-income countries. The surveys focus on maternal and child health by interviewing women of reproductive age (15–49 years). In addition, men aged 15–59 are also interviewed. DHS follow the same standard procedures—sampling, questionnaires, data collection, cleaning, coding and analysis which allows for cross-country comparisons and employ two-stage stratified sampling techniques. The first stage involves the selecting of points or clusters [enumeration areas (EAs)] while the second stage involves the systematic sampling of households listed in each cluster. All women in their reproductive age (15–49) who are usual residents of selected households or visitors who sleep in the households the night before the survey are interviewed. For the purpose of this study, only women who had children aged 0–59 months were used (N = 13,495). The women gave oral and written consent. Ethics review committees in the various countries and ICF International's institutional review board gave ethical approval for the DHS. Permission to use the data set was obtained from MEASURE DHS. Data set is freely available to the public at www.measuredhs.org.

2.2. Study variables

The outcome variable for the study was ALRI which resulted from the questions that asked if the child had experienced cough followed by short, rapid breath in the past two weeks preceding the survey which was posed as “When (NAME) had an illness with a cough, did he/she breathe faster than usual with short, rapid breaths or have difficulty

breathing?" This question was a follow up to an initial question which asked whether the child coughed within the two weeks preceding the survey. As evidenced in previous studies (Akinyemi & Morakinyo, 2018; Harerimana et al., 2016) the outcome variable was derived from the two questions. The response categories of these variables were: "Yes" and "No". The 'Yes' responses were coded '1' and the 'No' responses were coded '0'. An index was created with all the "Yes" and "No" answers with scores ranging from 0 to 2. The scores 0 and 1 were labelled as "No" and 2 as "Yes". A dummy variable was generated with '0' score being a child who had not experienced any short rapid breath nor any problem in the chest or child experienced only one of the problems; short rapid breaths or problems in the chest. '1' represented a child who experienced all the two conditions; short rapid breaths and problems in the chest.

Fifteen explanatory variables were used. These were: child's age, child's sex, child received Bacille, Calmette Guerin (BCG) in the last 6 months, child received Vitamin A in the last 6 months, child received intestinal parasite in the last 6 months, mother's age, mother's employment status, mother's education level, father's educational level, wealth status, residence, household size, source of drinking water, type of toilet facility, and type of cooking fuel. The variables were chosen based on their availability in the DHS dataset and previous studies (Gebertsadik et al., 2015, Jackson et al., 2013; Arun et al., 2014, Mirji et al., 2016; Prajapati, Talsania, Lala & Sonalia, 2012) which have found them as influential determinants of ALRIs among children.

2.3. Statistical analyses

Descriptive and inferential statistics were conducted. Descriptive figures were presented in percentages by country. Bivariate analyses were conducted using Pearson chi-square tests to check for the association between the explanatory variables and ALRIs. Using the explanatory variables which were significantly associated with ALRIs at the bivariate level. Two binary logistic regression models were conducted to establish the specific attributes of the significant explanatory variables which contributed to the prevalence of ALRIs among the children. Model I looked at a bivariate analysis of the countries and the outcome variable. Model II, however, looked at a complete model of all the explanatory variables and the outcome variable. All frequency distributions were weighted by applying the sample weight variable 'v005' divided by 1,000,000 using the 'gen' weight command to correct for non-responses and disproportionate sampling. In addition, the survey command (svy) in STATA version 14.2 was used to adjust for the complex sampling structure of the data in the logistic regression analyses. For each variable included in the logistic regression models, Odds Ratios (ORs) and Adjusted Odds Ratios (AORs) with 95% confidence intervals (95% CI) were calculated.

3. Results

Table 1 presents the prevalence of ALRIs among children under-five years from 28 sub-Saharan African countries. The overall prevalence of ALRI for all the countries was 25.3%. The five countries with the highest prevalence of ALRIs were Congo (39.8%), Gabon (38.1%), Lesotho (35.2%), Tanzania (35.2%) and Zambia (34.2%). The countries which recorded the least prevalence were Cameroon (11.5%) and Togo (7.4%).

Table 2 presents a bivariate analysis of the association between the explanatory variables and ALRIs among children under-five in sub-Saharan Africa. The highest proportion of ALRI (26.2%) was recorded among children whose mothers used unimproved toilet facility. This was followed closely by children who were 12–23 weeks (25.8%) old, those whose mothers were unemployed (25.4%), using unclean cooking fuel (25.3%) and children who were 24–59 weeks old (25.0%). The Chi-square test conducted showed that child's age ($X^2 = 9.43$, $p < 0.05$), child's receipt medicine for intestinal worms ($X^2 = 3.8$, $p < 0.05$),

Table 2

Bivariate analysis on the proportions of ALRIs among children under-five years in 28 sub-Saharan African countries.

Variables	Children in the study	Children suffering from ALRI	Chi-square (X^2)	p-value
	(n = 13, 495)	n		
Child factors				
<i>Child's age (In months)</i>				
0–11	3,485	830	23.8	9.43
12–23	3,586	926	25.8	
24–59	6,424	1,657	25.0	
<i>Child's sex</i>				
Male	6,966	1,730	24.8	0.001
Female	6,529	1,683	25.8	
<i>Child received BCG in the Last 6 Months</i>				
No	2,074	517	24.4	0.31
Yes	11,421	2,896	25.4	
<i>Child received Vitamin A in the Last 6 Months</i>				
No	4,996	1,277	25.6	0.121
Yes	8,499	2,136	25.1	
<i>Child received medicine for intestinal worms</i>				
No	7,632	1,854	24.3	3.75
Yes	5,863	1,559	26.6	
Parental factors				
<i>Mother's age</i>				
15–19	790	191	24.1	5.50
20–24	2,946	750	25.5	
25–29	3,736	913	24.4	
30–34	2,876	725	25.2	
35–39	1,970	510	25.9	
40–44	885	230	26.0	
45–49	292	95	32.0	
<i>Mother's employment status</i>				
Not employed	3,962	1,004	25.4	11.11
Employed	9,533	2,409	25.3	
<i>Mother's educational level</i>				
No education	5,256	1,311	24.9	2.34
Primary	5,129	1,296	25.3	
Secondary	2,781	708	25.6	
Higher	329	99	29.9	
<i>Father's educational level</i>				
No education	4,157	1,089	26.2	5.14
Primary	4,551	1,094	24.0	
Secondary	3,944	1,006	25.5	
Higher	843	225	26.7	
Household factors				
<i>Wealth status</i>				
Poorest	3,116	798	25.5	6.00
Poorer	3,052	779	25.5	
Middle	2,736	686	25.1	
Richer	2,495	632	25.4	
Richest	2,096	518	24.7	
<i>Residence</i>				
Urban	3,833	1,033	26.9	2.43
Rural	9,662	2,380	24.6	
<i>Household size</i>				
Less than 5	5,789	1,481	25.6	0.001
5 or more	7,706	1,932	25.1	
<i>Source of drinking water</i>				
Unimproved	4,932	1,220	24.8	0.16
Improved	8,563	2,183	25.6	
<i>Type of toilet facility</i>				
Unimproved	8,331	2,179	26.2	5.83
Improved	5,164	1,234	23.9	
<i>Type of cooking fuel</i>				
Not clean	10,093	2,552	25.3	3.84
Clean	3,402	860	25.2	

* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$.

mother's employment status ($X^2 = 11.1$, $p < 0.001$), type of toilet facility ($X^2 = 5.8$, $p < 0.05$), and type of cooking fuel ($X^2 = 3.8$, $p < 0.05$) were significantly associated with ALRIs among children under-five in sub-Saharan Africa.

Table 3
Logistic regression of ALRIs among children under-five in sub-Saharan Africa.

Variable	Model I OR (CI)	Model II AOR (CI)
<i>Country</i>		
Benin	Ref	Ref
Burundi	1.16 (0.85–1.60)	1.21 (0.88–1.67)
Congo DR	0.93 (0.68–1.29)	0.96 (0.69–1.33)
Congo	1.97*** (1.35–2.78)	1.96*** (1.36–2.81)
Cote d'Ivoire	0.56** (0.35–0.90)	0.58** (0.36–0.92)
Cameroon	0.60** (0.41–0.87)	0.61** (0.42–0.88)
Ethiopia	2.05*** (1.47–2.86)	2.15*** (1.54–3.02)
Gabon	1.90*** (1.33–2.72)	1.86** (1.30–2.67)
Ghana	1.38 (0.88–2.17)	1.47* (0.93–2.30)
Gambia	1.76** (1.20–2.58)	1.88** (1.28–2.67)
Guinea	0.90 (0.62–1.31)	0.97 (0.66–1.41)
Kenya	2.12*** (1.57–2.89)	2.19*** (1.62–2.97)
Comoros	1.14 (0.72–1.83)	1.14 (0.72–1.83)
Liberia	1.75** (1.23–2.49)	1.77** (1.24–2.53)
Lesotho	1.93 (0.92–4.05)	2.17** (1.03–4.58)
Malawi	1.59** (1.10–2.28)	1.73** (1.20–2.50)
Mozambique	1.37 (0.96–1.96)	1.38 (0.96–1.98)
Nigeria	1.65** (1.21–2.53)	1.75** (1.27–2.39)
Niger	1.35 (0.93–1.96)	1.40 (0.96–2.04)
Namibia	1.03 (0.62–1.73)	1.03 (0.62–1.73)
Rwanda	1.43** (1.02–2.04)	1.48** (1.03–2.12)
Sierra Leone	1.37 (0.97–1.92)	1.43** (1.02–2.02)
Senegal	0.77 (0.50–1.18)	0.78 (0.51–1.21)
Chad	1.75*** (1.29–2.39)	1.78*** (1.31–2.44)
Togo	0.36*** (0.23–0.57)	0.37*** (0.24–0.59)
Tanzania	2.42*** (1.69–3.46)	2.59*** (1.81–3.71)
Zambia	1.83*** (1.33–2.53)	1.85*** (1.34–2.56)
Zimbabwe	0.57** (0.36–0.89)	0.62** (0.39–0.96)
<i>Mothers' employment</i>		
Not employed		Ref
Employed		0.77** (0.64–0.94)
<i>Child's age</i>		
0–11		Ref
12–23		1.13** (1.01–1.26)
24–59		1.15** (1.04–1.28)
<i>Child received medicine for intestinal worms</i>		
No		Ref
Yes	–	1.11** (1.02–1.22)
<i>Type of toilet facility</i>		
Unimproved		Ref
Improved	–	0.72** (0.64–0.97)
<i>Type of cooking fuel</i>		
Unclean		Ref
Clean	–	1.00 (0.90–1.11)
Pseudo R ²	0.0267	0.0283

*p < 0.05, **p < 0.01, ***p < 0.001 Ref = Reference category CI = Confidence Interval.

OR = Odds Ratio, Adjusted Odds Ratio.

3.1. Multivariate analysis

Table 3 presents the results of the logistic regression analysis on the factors associated with ALRIs among children under-five in sub-Saharan Africa. It was found that children from Tanzania (AOR = 2.59, 95% CI = 1.81–3.71), Kenya (AOR = 2.19, 95% CI = 1.62–2.97), Lesotho (AOR = 2.17, 95% CI = 1.03–4.58) and Ethiopia (AOR = 2.15, 95% CI = 1.54–3.02) had higher odds of contracting ALRI compared to children in Benin. With employment, children with mothers who were employed had lower odds of contracting ALRI (AOR = 0.77, 95% CI = 0.64–0.94) compared to those whose parents were unemployed. It was also shown that children aged 12–23 (AOR = 1.13, 95% CI = 1.01–1.26) and 24–59 (AOR = 1.15, 95% CI = 1.04–1.28) months had higher odds of developing ALRI than those aged 0–11 months. Children who received medicine for intestinal worms 6 months preceding the survey had higher odds of developing ALRI (AOR = 1.11, 95% CI = 1.02–1.22) compared to those who did not. In addition, children whose mothers used improved toilet facilities (AOR = 0.77, 95% CI = 0.64–0.94), however, had lower odds of contracting ALRIs.

4. Discussion

Using the recent nationally representative samples of children under-five from 28 countries in sub-Saharan Africa, the study sought to examine the prevalence and risk factors for ALRIs. The overall prevalence of ALRI for all the countries was 25.3%. Congo (39.8%), Gabon (38.1%), Lesotho (35.2%), Tanzania (35.2%) and Zambia (34.2%) were the five countries with the highest prevalence of ALRIs among children under-five. The overall prevalence recorded is higher than what has been reported in other parts of the world (Williams, Gouws, Bosch-Pinto, Bryce, & Dye, 2002) and confirm UNICEF's observation that the majority of ALRI cases and deaths recorded from such infections among children, are in sub-Saharan Africa (UNICEF, 2016). Apart from Togo (7.4%), the prevalence of ALRI was higher in all the countries studied, than what Cunha, Margolis, and Wing (2003) reported in a Brazilian study (10.2%).

The high prevalence of ALRIs in the sub-Saharan African countries could be attributed to the frequent outbreak of disease epidemics in the countries (Ekaza et al., 2014). Taking the country with the highest prevalence (Congo) for instance, the International Federation of Red Cross and Red Crescent (IFRC) Disaster Relief Emergency Fund (DREF) cited in Prajapati et al. (2011) noted that “The heavy downpour of 17 and 18 Nov 2012 caused widespread destruction of the drainage system, overflowed wells and latrines as well as stagnant water in Pointe Noire, the second largest city in the Republic of Congo. A few weeks after the flooding, the first cholera case was recorded, and the numbers of cases and deaths continued to increase. As of 6 April 2013, 15 deaths and 656 cases had been registered”. This could partly explain the phenomenon as the current DHS in Congo was conducted from August 2013 to February 2014.

The World Health Organisation (WHO) (2015) contends that Vitamin A is crucial for the effective functioning of the body's immune system and the healthy growth and development of children. The WHO (2015) also argues that provision of vitamin A supplementation every four to six months is a quick, effective, and an inexpensive strategy to enhance the vitamin A status of children and reduce childhood morbidity as well as mortality. It is, therefore, not surprising that in our analysis, children who did not receive Vitamin A supplementation in the six months preceding data collection for the DHS recorded higher proportions of ALRI compared with those who received the supplements.

It was found in our study that children whose mothers were employed had lower odds of contracting ALRI. The finding is consistent with previous studies done in other parts of the world. For example, an Ethiopian study showed that mothers working in a professional/technical occupation were less likely to have their children suffering from ALRI (Geberetsadik, Worku & Berhane, 2015). Similarly, the results are in line with studies done in Brazil (Cardoso et al., 2013), India (Bhat & Manjunath, 2013) and Ethiopia (Alemayehu et al., 2014). Again, those who are employed are more likely to afford the basic necessities in life for themselves and their children including access to healthcare. This could serve as protective factors for reducing the occurrence of ALRI in children under five years.

Children from poor households recorded the highest prevalence of ALRI while those from the richest households recorded the least. This finding points to the role of wealth status as an important determinant of health service utilisation and the health outcomes of people, particularly children. While rich households in sub-Saharan Africa are usually able to afford the cost of healthcare out-of-pocket, the reverse happens among those in poor wealth quintiles who can even hardly afford what to eat much more to talk of health care utilisation out-of-pocket, especially for the prevention of ALRIs among children under-five (Nicholas, Edward, & Bernardin, 2016). Even though social health interventions implemented by many of the countries in the sub-region are pro-poor and meant to bridge the gap in access to and utilisation of health care including immunisation for children between the rich and poor (Haile, Ololo, & Megersa, 2014), studies have shown that it is

rather the rich who end up benefiting from such interventions to the detriment of the poor (Hammer-Fomuki, Okwen, Ranft, Gardemann, & Schikowski, 2016).

This study found that children living in households with improved toilet facility are less likely to suffer from ALRI compared with children living in households with unimproved toilet facilities. Globally, poor living conditions present as risk factors for illness and are associated with inadequate utilisation of primary health care (Astale & Chenault, 2015). In Ghana, there are several measures adopted to overcome barriers to proper housing conditions such as affordable housing projects (Boamah, 2014) and measures to improve healthcare accessibility among the poor through a national health insurance scheme (Duku, Nketiah-Amponsah, Janssens, & Pradhan, 2018) and community-based case management of childhood illness targeting children under five years. Our findings in relation to the role of toilet facility in the development of ALRIs among children in sub-Saharan Africa clearly establish the fact that household living conditions, especially sanitation is essential in determining the contraction of infections among children under-five including ALRIs (Sultana, 2016).

We realised that the probability of developing ALRI among children under-five in sub-Saharan Africa increased with age. Specifically, the chances of ALRI was greatest in children aged 12–23 months and 24–59 months. The results are similar to what was found in a Nigerian study (Akinyemi & Morakinyo, 2018); an Ethiopian study (Harerimana et al., 2016), a Ghanaian study (Cough) (Amugsi et al., 2015) and a Nepalese study (Acharya, Mishra, & Berg-Beckhoff, 2015) that used DHS to estimate the likelihood of ALRI among children under five. They all found that the likelihood of a child presenting ALRI was high among children aged 12–23 months. As explained in previous studies (Aborigo et al., 2012; Amugsi et al., 2015) the high risk of morbidity in the 12–23 months age brackets could be due to loss of innate immunity and/or exposure to different types of infections from eating contaminated food prepared with unclean water and in an unhealthy environment. This could be due to the fact that the older the children get, the more exposed they are to the ALRI as at that age some of the children begin to walk and for that matter get exposed to outdoor air pollutants (Amugsi et al., 2015). Thus, with increasing age, the exposure to polluted air including smoke emanating from unclean sources of cooking fuel (which we found to be significantly related to the development of ALRI in our chi-square analysis) like biomass (dung, wood, and crop residues) and coal (for cooking and heating). However, contrary results were found by Nair et al. (2013) who indicated that ALRI incidence was highest in neonates aged 0–27 days and infants aged 0–11 months. The possible reasons for the variation in study findings could be the times the studies were conducted, the estimation techniques used and the source of data for the studies.

4.1. Strength and limitations of the study

The outcome variable was derived by categorising children under-five as having ALRI or otherwise based only on the occurrence of signs and symptoms of ALRI as reported by the mothers of the children without any medical validation (Adesanya & Chiao, 2017; Akinyemi & Morakinyo, 2018). Since participants were asked about events which occurred in the past, potential effects of recall bias on the side of the mothers, on our results can, therefore, not be overlooked (Adesanya & Chiao, 2017). In addition, due to the cross-sectional nature of the data, it is impossible to draw a cause-effect relationship in this study (Adesanya & Chiao, 2017; Harerimana et al., 2016). Also, some of the differences in the occurrence of ALRIs maybe very well explained by country specific conditions. In addition, we could not explore the effect of other possible variables that were not captured in the DHS such as flooding/environmental disasters. More research is thus needed to identify the effect of these other variables on ALRIs. Although statistically significant, very small differences existed in some of the proportions in the prevalence of ALRIs due to the high numbers involved in

our analysis. Despite these limitations, this study is by far the first study to look at the prevalence and determinants of ALRI among children under-five in sub-Saharan Africa using national representative survey data whose method of collection has been through a validated process and its outcome generalizable. Also, variables in the DHS in different countries are defined alike thus allowing for results to be comparable across countries (Akinyemi & Morakinyo, 2018).

5. Conclusion and policy implications

We realised that ALRI is associated with mothers' employment status; child's age, child receiving intestinal parasite in the last 6 months preceding the survey and type of toilet facility in the household. These findings underscore the need for stakeholders of health in the various sub-Saharan African countries, especially those worst affected (Congo, Gabon, Lesotho, Tanzania, Zambia, Liberia, Lesotho, Chad, and Kenya) to implement strategic plans at different levels aimed at reducing ALRIs among children under-five years. Such strategic plans should specifically focus on improvement in the administration of medicine for intestinal worms, more health education to mothers with children under five on ALRIs, poverty alleviation, and improving the sanitation situations of households through the provision of improved toilet facilities.

Ethics approval and consent to participate

The women gave oral and written consent. Ethics review committees in the various countries and ICF International's institutional review board gave ethical approval for the DHS. Permission to use the data set was obtained from MEASURE DHS. Data set is freely available to the public at www.measuredhs.org.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2019.100443>.

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