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# Factors associated with child's comorbid diarrhea and pneumonia in rural Democratic Republic of the Congo

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**Diarrhea and pneumonia are leading killers of the world's youngest children. The toll is highly concentrated in the most disadvantaged children from 15 high-burden countries. The present research reports the factors associated with the comorbidity of the two killer diseases in the context of the Democratic Republic of the Congo (DRC), one of the 15 countries suffering the most from the blights. This analysis of data from a cross-sectional household survey found an association between child's comorbid diarrhea and pneumonia and the indicators of child's age, unimproved sanitation facilities, unsafe or indiscriminate disposal of children's feces, malnutrition and parents' education. It was concluded that improved child's environment and safe hygiene practice protect against a co-occurrence of the two conditions in rural DRC.**

**Key words:** Diarrhea, pneumonia, comorbidity, sub-Sahara, rural, fecal disposal, sanitation, Congo-Kinshasa.

## INTRODUCTION

Diarrhea and pneumonia remain the leading infectious causes of death in children younger than 5 years. These two common, yet largely preventable diseases were responsible for nearly one in every four under-5 deaths in 2016 (WHO and Maternal and Child Epidemiology Estimation Group, 2018a, b). Nearly 70% of mortality from diarrhea and from pneumonia is concentrated in 15 high-burden countries-including the Democratic Republic of the Congo (DRC), where around 82,000 children died of diarrhea or pneumonia in 2016 (IVAC, 2018). Given that comorbidity carries more risk on child mortality (Fenn et al., 2005), knowledge of the factors associated to the co-occurrence of the two conditions can help in the targeting of programmes designed to reduce mortality. This paper reports a number of variables associated with the prevalence of comorbid diarrhea and pneumonia among children aged 2-59 months in rural DRC.

## MATERIALS AND METHODS

### Data

The data for this research are drawn from the second Demographic and Health Survey (DHS), a nationally representative survey which took place from November 2013 to February 2014 under the acronym of DRC-DHS II.

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**Outcome variable**

Children were classified into four mutually exclusive categories as having experienced no diarrhea or pneumonia, diarrhea alone, pneumonia alone, and both diarrhea and pneumonia during the 14-day time span preceding the survey.

1. Pneumonia: Mothers reported whether their children had suffered from cough during the two weeks preceding the survey, and if so, if it had been accompanied by short, rapid breathing. “Pneumonia” was generated as a composite variable using the information on cough and difficulty in breathing according to the World Health Organization (WHO) definition of Pneumonia: Age 2-59 months with cough or difficult breathing and fast breathing and/or chest in-drawing (World Health Organisation, 2014).
2. Diarrhea: During the survey, mothers were asked if their children had diarrhea in the two weeks preceding the survey.

**Data analysis**

*Data were analyzed using R* (R Core Team, 2018).

A multinomial logistic regression of the four-category outcome variable defined above was fitted on the factors of interest taking “no diarrhea or pneumonia” as reference category for the dependent variable. As several of the factors we studied are related to each other at varying levels, we entered all of the independent variables into the models in order to identify those that contribute independently to the occurrence of diarrhea alone, pneumonia alone and their comorbidity. The antilogarithms of the estimates from the model were calculated to obtain the respective odds ratios (OR) and their 95% confidence intervals (95% CI). We limited the analysis to a complete dataset, where only records with valid values in all the variables of interest were retained and included in the analyses.

## RESULTS

The dataset used included 12019 children aged 2-59 months. The characteristics of the household in which the children lived are summarized in Table 1 restricted to 5651 (47%) children with valid data on age, sex and weight-for-age anthropometric status. The characteristics include child’s gender almost equally distributed (50% of boys and 50% of girls), child’s age, mother’s age (56% less than 30 years old), the gender of the household head (21% of households were female led), and weight-for-age Z-scores (26% were malnourished children with Z < -2SD). Children with and without data on weight-for-age Z-scores did not differ either in the household characteristics or diarrhea and pneumonia prevalence.

The outcome variables analyzed are presented in Table 2. Diarrhea was present in 16.5% and pneumonia in 12.9% of children, but only 12.6% experienced diarrhea alone, and 9.0% pneumonia alone. The 14-day comorbidity of the two conditions was reported for 3.9% of children. This observed proportion of comorbid children exceeds 2.1 % that would have been expected by chance given the prevalence of the two conditions. The expected comorbidity represents the prevalence of both diseases co-occurring by chance alone in the absence of any association between the two conditions. In other terms, it is the probability of the occurrence of two independent events obtained by the product of their individual probabilities (the prevalence of each of the conditions). The prevalence of the two conditions by child’s age, the observed comorbidity and the expected comorbidity are shown in Table 3. The observed comorbidity was higher than the expected comorbidity. Figure 1 shows this relationship across the age groups.

**Model results**

The results from the model are shown in Table 4 for the diarrhea alone and pneumonia alone as compared to no diarrhea/no pneumonia and derived from the multinomial logistic regression and in Figure 2 for the comorbidity of the two conditions. Mother’s age, categorized as >= 30 years vs. <30 years, was the only factor statistically associated to both diarrhea (OR=0.77; 95% CI: 0.61 to 0.96) and pneumonia (OR=0.77; 95% CI: 0.60 to 0.99). However it did not make it into the list of factors statistically associated to the comorbidity of the two conditions.

Child’s age and sex: In terms of the comorbidity, the prevalence defined as experience of both conditions during the two weeks preceding the interview appeared to be impacted by the child’s age but not his/her gender. Using the youngest age group (2-5 months) as a reference, the risk peaked in children aged 12-23 months with nearly 4-fold increase (OR=3.52; 95% CI=1.94 to 6.38). A slightly lower odds ratio was observed in children aged 6-11 months (OR=2.55; 95% CI=1.35 to 4.84). The risk of comorbid diarrhea and pneumonia decreased constantly for older children.

Weight-for-age Z-score: Co-occurrence of the two conditions was lower in children with weight-for-age Z-scores greater or equal to -2 standard deviation (SD) compared to the malnourished with scores less than -2 SD (OR=0.6; 95% CI: 0.44 to 0.82). Improved sanitation was defined as toilet facility with one of the following characteristics: connection to a public sewer, connection to a septic system, pour-flush latrine, simple pit latrine with a slab, or ventilated, improved pit or composting toilet. This variable was associated to the 14-day comorbidity (improved/unimproved OR= 0.63; 95% CI: 0.45 to 0.90).

Disposal of child feces: Mothers were asked where they disposed of their children’s stools when they do not use any toilet facility. Disposal of child’s feces was considered as safe if the child used the toilet or latrine or if the excreta were put or rinsed into toilet or latrine. Safe fecal disposal showed a statistically significant association with the 14-day comorbidity (OR: 0.73; 95% CI: 0.55 to 0.98).

**Table 1.** Physical and socioeconomic characteristics of the households where the child lives.

| Characteristics | N | Categories | n (%) |
|---|---|---|---|
| Child sex | 5651 | Female | 2839 (50) |
| Child's Age (months) | 5651 | 2 to 5 | 540 (10) |
| | | 6 to 11 | 665 (12) |
| | | 12 to 23 | 1151 (20) |
| | | 24 to 35 | 1119 (20) |
| | | 36 to 47 | 1141 (20) |
| | | 48 to 59 | 1035 (18) |
| Wealth index Quintile | 5651 | Poorest | 1936 (34) |
| | | Poorer | 1690 (30) |
| | | Middle | 1379 (24) |
| | | Richer/Richest | 646 (11) |
| Household size | 5651 | 7 or more | 2659 (47) |
| Mother's Education | 5651 | None | 1583 (27) |
| | | Primary | 2820 (50) |
| | | Secondary + | 1248 (22) |
| Father's Education | 5443 | None | 632 (12) |
| | | Primary | 1661 (31) |
| | | Secondary + | 3150 (58) |
| Mother's parity | 5651 | >=5 | 2559 (45) |
| Mother's age | 5651 | >= 30 yrs | 2508 (44) |
| Household head | 5651 | Female | 1185 (21) |
| No. of Children under 5 | 5651 | <2 | 1073 (19) |
| | | 2 | 2667 (47) |
| | | >2 | 1911 (34) |
| Main floor | 5649 | Improved | 122 (2) |
| Main wall | 5651 | Improved | 471 (8) |
| Main roof | 5651 | Improved | 702 (12) |
| Water treated | 5651 | Yes | 52 (1) |
| Drinking water | 5650 | Improved | 2246 (40) |
| Cooking fuel | 5650 | Improved | 0 (0) |
| Sanitation | 5651 | Improved | 1762 (31) |
| Faecal disposal | 5637 | Safe | 3329 (59) |
| Weight-for-age Z-score | 5651 | >= -2 | 4170 (74) |
| Separate room as kitchen | 5651 | Yes | 954 (17) |
| Hand washing water | 5645 | Yes | 123 (2) |

Parents' education: Comorbidity was associated with father's education but not mother's. Children of fathers with primary education were less exposed to comorbidity compared to those from fathers with no education (OR =0.64; 95%CI: 0.42 to 1:00). Similarly children of fathers educated to secondary level and above experienced less comorbidity of the two conditions (OR= 0.68; 95%CI: 0.44 to 1.04).

Household wealth Index: Children from the wealthiest household experienced less comorbidity compared to the lowest wealth index quintile (OR=0.45; 95% CI: 0.21 to 0.95). Type of dwelling: Of the three indices of housing quality examined (main material of wall, floor and roof), only the type of roof suggested an association with the

**Table 2.** Prevalence of diarrhea, pneumonia and their comorbidity.

| Characteristics | N | Category | n (%) |
|---|---|---|---|
| Comorbidity | 5631 | None | 4193 (74.45) |
| | | Diarrhea alone | 712 (12.64) |
| | | Pneumonia alone | 508 ( 9.02) |
| | | Comorbidity | 218 ( 3.87) |
| Diarrhea in last 2 weeks | 5636 | No | 4706 (83.50) |
| | | Yes | 930 (16.50) |
| Pneumonia in last 2 weeks | 5631 | No | 4905 (87.11) |
| | | Yes | 726 (12.89) |

**Table 3.** Observed and Expected comorbidity by age (%).

| Age (months) | Diarrhea | Pneumonia | Observed comorbidity | Expected comorbidity[i] |
|---|---|---|---|---|
| 6 -11 | 24.8 | 10.8 | 7.7 | 2.7 |
| 12-23 | 28.0 | 12.2 | 10.1 | 3.4 |
| 24-35 | 17.1 | 11.2 | 5.5 | 1.9 |
| 36-47 | 9.2 | 8.5 | 2.0 | 0.8 |
| 48-59 | 8.1 | 7.7 | 2.0 | 0.6 |
| **Age adjusted[ii]** | **16.6** | **10.6** | **5.1** | **1.8** |

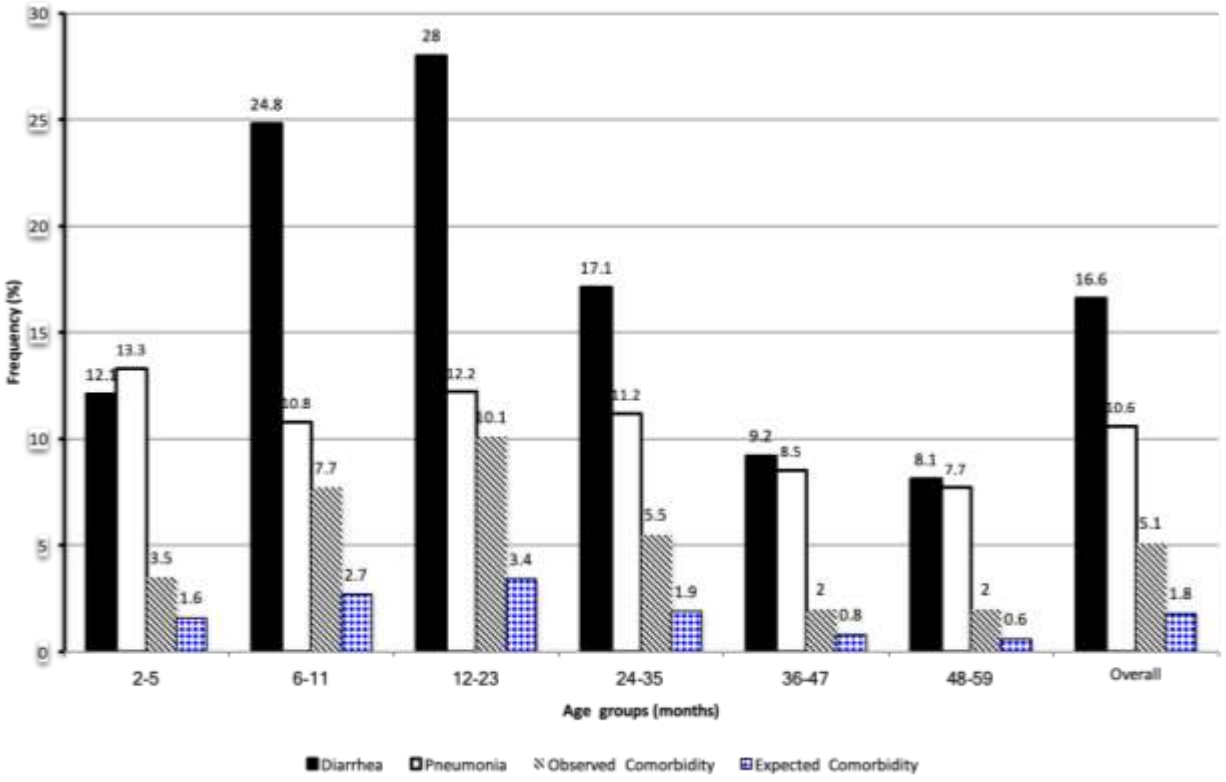


**Figure 1.** Prevalence of diarrhea, pneumonia and their co-morbidity by age.

**Table 4.** Odds ratios and 95% confidence intervals from the multinomial logistic regression model of diarrhea alone and pneumonia compared to no diarrhea and no pneumonia.

| Predictors | Diarrhea alone | | | Pneumonia alone | | |
|---|---|---|---|---|---|---|
| | Odds ratios | CI | p | Odds ratios | CI | p |
| Child's sex: Female | 0.93 | 0.79 - 1.11 | 0.434 | 1.05 | 0.87 – 1.27 | 0.613 |
| **Child's age (months)** | | | | | | |
| 6-11 | 2.46 | 1.70 - 3.55 | <0.001 | 0.75 | 0.50 - 1.11 | 0.152 |
| 12-23 | 3.07 | 2.17 - 4.33 | <0.001 | 0.96 | 0.68 - 1.36 | 0.836 |
| 24-35 | 1.51 | 1.05 - 2.16 | 0.025 | 0.86 | 0.61 - 1.21 | 0.374 |
| 36-47 | 0.76 | 0.52 - 1.11 | 0.157 | 0.65 | 0.46 - 0.92 | 0.016 |
| 48-59 | 0.63 | 0.42 - 0.95 | 0.027 | 0.59 | 0.41 - 0.86 | 0.006 |
| Mother's age: ≥ 30 years | 0.76 | 0.61 - 0.95 | 0.015 | 0.77 | 0.60 - 0.99 | 0.039 |
| Weight-for-age Z-score : ≥-2 | 0.72 | 0.60 - 0.87 | 0.001 | 1.12 | 0.89 - 1.40 | 0.34 |
| Household head: Female | 0.94 | 0.76 - 1.17 | 0.591 | 0.83 | 0.64 - 1.08 | 0.163 |
| Wealth index quintile: Poorer | 0.88 | 0.71 - 1.09 | 0.254 | 0.89 | 0.70 - 1.14 | 0.36 |
| Middle | 1.01 | 0.80 - 1.29 | 0.906 | 0.96 | 0.73 - 1.25 | 0.757 |
| Richer/Richest | 0.85 | 0.55 - 1.32 | 0.467 | 0.6 | 0.36 - 1.00 | 0.05 |
| **Mother's education** | | | | | | |
| Primary | 1.14 | 0.93 - 1.40 | 0.209 | 1.07 | 0.85 - 1.35 | 0.578 |
| Secondary + | 0.88 | 0.67 - 1.16 | 0.361 | 0.95 | 0.70 - 1.28 | 0.718 |
| **Father's education** | | | | | | |
| Primary | 0.97 | 0.72 - 1.32 | 0.859 | 1.25 | 0.89 - 1.75 | 0.196 |
| Secondary + | 1.11 | 0.83 - 1.48 | 0.5 | 1.08 | 0.77 - 1.51 | 0.666 |
| Water source: Improved | 1.04 | 0.87 - 1.24 | 0.645 | 1.09 | 0.89 - 1.32 | 0.419 |
| Sanitation: Improved | 0.87 | 0.72 - 1.05 | 0.144 | 0.85 | 0.68 - 1.05 | 0.135 |
| Faecal disposal: Safe | 0.66 | 0.56 - 0.79 | <0.001 | 0.91 | 0.75 - 1.11 | 0.345 |
| Household size: >= 7 | 0.9 | 0.73 - 1.11 | 0.33 | 1.13 | 0.89 - 1.43 | 0.329 |
| Main floor: Improved | 1.62 | 0.89 - 2.98 | 0.117 | 0.92 | 0.37 - 2.30 | 0.854 |
| Wall: Improved | 0.82 | 0.58 - 1.17 | 0.278 | 0.66 | 0.42 - 1.04 | 0.073 |
| Roof: Improved: | 1.13 | 0.78 - 1.63 | 0.526 | 1.34 | 0.89 - 2.01 | 0.162 |
| Mother's parity: ≥5 | 1.31 | 1.04 - 1.66 | 0.024 | 1.12 | 0.86 - 1.47 | 0.404 |
| **No. of children under 5:** | | | | | | |
| 2 | 0.91 | 0.72 - 1.14 | 0.413 | 0.85 | 0.65 - 1.10 | 0.205 |
| >2 | 0.93 | 0.72 - 1.20 | 0.567 | 0.83 | 0.62 - 1.11 | 0.209 |
| Hand washing water: Yes | 1.37 | 0.78 - 2.42 | 0.271 | 1.84 | 1.06 - 3.20 | 0.032 |
| Observations | | 4727 | | | 4741 | |

comorbidity.

However, this was in a way that seems counterintuitive. Improved roofing had more than double comorbidity compared to non-improved roofing (OR=2.57; 95% CI: 1.45 to 4.54).

## DISCUSSION

Our results from the community survey add significantly to works reported on co-morbidity and clinical overlap between diarrhea and pneumonia (Fischer-Walker and Black, 2009; Mulholland, 2005; Fischer-Walker et al., 2013; Chisti et al., 2008, 2011). Given that comorbidity carries more risk on child mortality (Fenn et al., 2005; Fischer-Walker et al., 2013) our findings could be handy in the fight against child mortality. From these analyses comorbid diarrhea and pneumonia is more than would have been expected by chance. While being age-dependent, it peaks at ages between 12 and 23 and is high but slightly lower for the group of children aged between 6 and 11 months.

Other factors statistically associated to comorbid diarrhea and pneumonia included malnutrition, parents' education, unsafe fecal disposal and unimproved sanitation. Reduction of the burden of acute and chronic malnutrition can have a substantial impact on child morbidity and mortality from diarrhea (Rice et al., 2000;

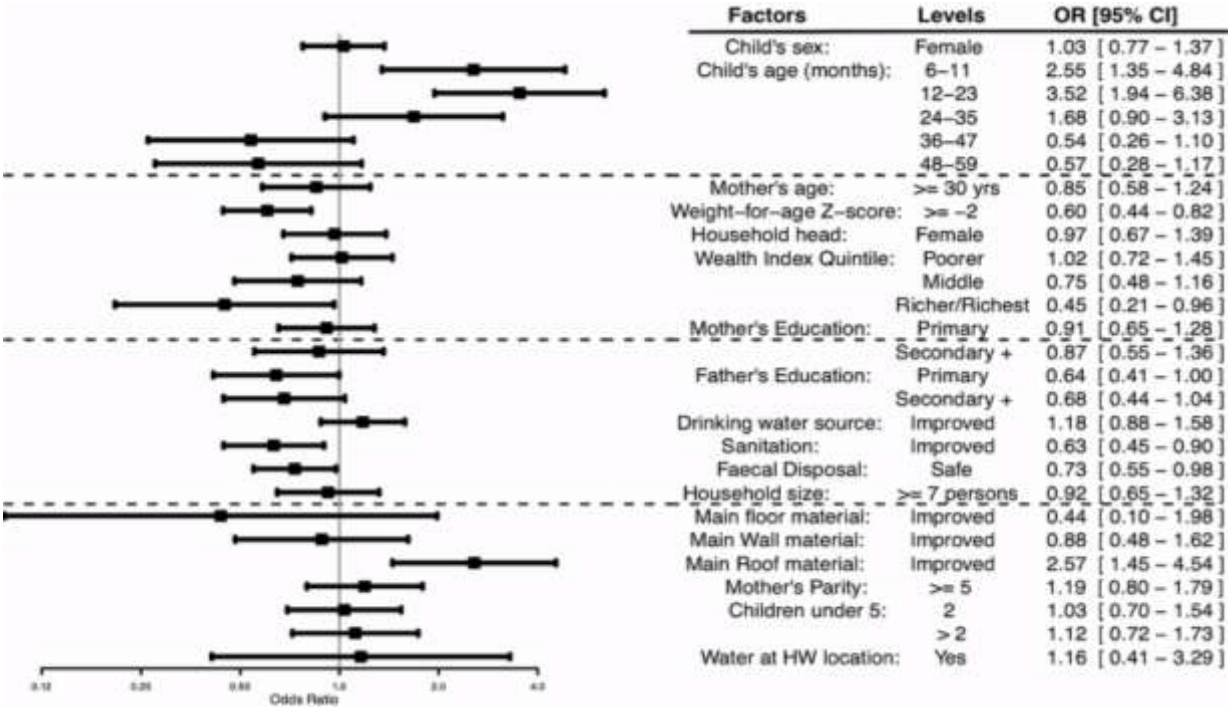


**Figure 2.** Odds ratios and 95% confidence intervals from the multinomial logistic regression model.

Caulfield et al., 2004) and pneumonia (Fonseca et al., 1996). Finding an association between this factor and the 14-day occurrence of the two conditions is particularly important.

We found increased risks of comorbidity for unsafe disposal of feces and its associated factor namely the quality of the household's sanitation facility. The safe disposal of children's feces has been identified as critical for children's health, and several studies have reported the effects of poor sanitation on childhood diarrhea in sub-Saharan Africa and elsewhere (Clasen et al., 2010; Bhutta et al., 2013; Cairncross et al., 2010; Jinadu et al., 2004; Tumwine et al., 2002; Manun'Ebo et al., 1994; Bauza et al., 2019; Messou et al., 1995; Oyejide et al., 1994; Pokhrel and Viraraghavan, 2004; Traoré et al., 1994; Schmidt et al., 2011; Cronin et al., 2016). Sanitation prevents contamination of the environment by excreta and therefore imposes a barrier to the transmission of pathogens coming from feces of an infected person (Brown et al., 2013). On the other hand, if feces are not properly disposed, they remain a source of contamination in the environment. Due to limited use of potties and diapers in most households in rural settings where young children are often allowed to defecate in the yard or land surrounding the household, a lower risk of diarrheal disease has been associated with safe disposal (Yeager et al., 1999). But finding this practice as related to lower risk of comorbidity could have implications in the targeting of policies designed to reduce child's mortality.

At the exception of the child's age, none of the factors associated to the comorbidity was identified as risk factor shared between the two conditions. This echoes findings from elsewhere. In a study of risk factors of diarrhea and Acute Respiratory Infection (ARI), Siziya et al. (2009) found no shared factors except child's age. Our findings linking malnutrition, unimproved sanitation facility and unsafe excreta disposal to the co-occurrence of childhood diarrhea and pneumonia seem not to support the suggestion that diarrhea and pneumonia occurring in the same individual at the same time could be caused by risk factors the two conditions share (Kahabuka et al., 2012). The above associations to comorbidity known for diarrhea suggest that the co-occurrence of the two conditions is perhaps influenced by the occurrence of diarrhea with a particular level of severity. It is unlikely that there is any shared risk factor playing a leading role. We believe that the co-occurrence of the two conditions is mediated through a weakened immune system or a loss of protective nutrients; we found malnourished children to be at great risk of co-occurring diarrhea and pneumonia.

In addition, the three factors linked strongly to diarrhea as documented in the literature and not as much to pneumonia would suggest rather that comorbidity could be a reflection of diarrhea leading to pneumonia. This tends to support findings reported elsewhere among young children in low-income settings and in the case of concomitant infection with diarrhea and pneumonia

(Fischer-Walker et al., 2013; Chisti et al., 2008; Schmidt et al., 2009).

A finding of an improved type of roofing associated to higher prevalence of comorbidity is surprising. We would not speculate on possible explanations because it could be a chance effect. Manun'Ebo et al. (1994) reported similar unexpected results with diarrheal incidence and duration associated to the walling of the house in the wrong direction.

We carried out a second hand analysis of the data previously reported by the national DHS project team; this has some limitations as the data wouldn't fit exactly what we intended to do. The survey data may not be the most appropriate source of data for the study of this question, but this representative dataset covering the entire country allows comparison to other countries and regions of the world. We recognize the inability of a 14-day recall dataset to ascertain the simultaneous occurrence of the two conditions, or the order in which they occur in children. A longitudinal study mapping the days during which the conditions occur would be necessary to answer that question.

## Conclusion

Child's age, malnutrition, unsafe disposal of human feces, unimproved sanitation facility, father's lack of education (not mother's) emerged from the present study as factors associated to comorbid diarrhea and pneumonia in children under 5 years of age in rural DRC. The appearance of fecal disposal and related sanitation quality as factors associated to comorbid diarrhea and pneumonia in rural area is a significant finding.

Despite the limitation of the cross-sectional data source to ascertain whether any of the conditions leads to one another, the results presented here do bring some light in this area. Further studies using calendar records on the occurrence of each of the diseases over a period of 14 to 28 days would usefully qualify whether diarrhea leads to pneumonia in the comorbidity with these two conditions.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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## REFERENCES

Bauza V, Reese H, Routray P, Clasen T (2019). Child defection and Feces disposal practices and determinants among households after a combined household-level piped water and sanitation intervention in rural Odisha, India. The American journal of Tropical Medicine and Hygiene 100(4):1013-1021.

Bhutta ZA, Walker N, Rizvi A, Campbell H, Rudan I, Black RE (2013). Interventions to address deaths from childhood diarrhea and pneumonia equitably: what works and at what cost? Lancet 381(9875):1417-1429. BMC Infectious Diseases 12(1):219

Brown J, Cairncross, Ensink JHJ (2013). Water, sanitation, hygiene and enteric infections in children. Archives of Disease in Childhood 98(8):629-634.

Cairncross S, Hunt C, Boisson S, Bostoen K, Curtis V, Fung ICH, Schmidt WP (2010). Water sanitation and hygiene for the prevention of diarrhea. International Journal of Epidemiology 39 (Suppl 1):193-205

Caulfield LE, Onis M, Blössner M, Black RE (2004). Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. The American Journal of Clinical Nutrition 80(1):193-198.

Chisti MJ, Duke T, Robertson CF, Ahmed T, Faruque AS, Bardhan PK, La Vincente S, Salam MA (2011). Co morbidity: Exploring the clinical overlap between diarrhea and pneumonia in a hospital in Dhaka, Bangladesh. Annals of Tropical Paediatrics 31(4):311-319.

Chisti MJ, Huq S, Das SK, Malek MA, Ahmed T, Faruque AS, Salam MA (2008). Predictors of severe illness in children under age five with concomitant infection with diarrhea and pneumonia at a large hospital in Dhaka, Bangladesh. Southeast Asian Journal of Tropical Medicine and Public Health 39(4):719.

Clasen TF, Bostoen K, Schmidt WP, Boisson S, Fung IC, Jenkins MW, Scott B, Sugden S, Cairncross S (2010). Interventions to improve disposal of human excreta for preventing diarrhea. Cochrane Database of Systematic Reviews (6):CD007180.

Cronin AA, Sebayang SK, Torlesse and Nandy R (2016). Association of Safe Disposal of Child Feces and Reported Diarrhea in Indonesia: Need for Stronger Focus on a Neglected Risk. International Journal of Environmental Research and Public Health 13(3):310

Fenn B, Morris SS, Black RE (2005).Comorbidity in childhood in northern Ghana: Magnitude, associated factors, and impact on mortality. International Journal of Epidemiology 34(2):368-375.

Fischer-Walker CL, Black RE (2009). Commentary: What is the role of co-morbidity in child mortality? International Journal of Epidemiology 38(3):772-774.

Fischer-Walker CL, Perin J, Liu JL, Katz J, Tielsch JMM, Black R (2013). Does comorbidity increase the risk of mortality among children under 3 years of age? BMJ Open 3(8).

Fonseca W, Kirkwood BR, Victora CG, Fuchs SR, Flores JA, Misago C (1996). Risk factors for childhood pneumonia among the urban poor in Fortaleza, Brazil: A case-control study. Bulletin of the World Health Organization 74 (2):199-208

IVAC at Johns Hopkins Bloomberg School of Public Health (2018). Pneumonia and Diarrhea Progress Report.

Jinadu MK, Esmai OA, Adegbenro CA (2004). Disposal of children's faeces and implications for the control of childhood diarrhea. The Journal of the Royal Society for the Promotion of Health 124(6):

276-279.
Kahabuka C, Kavle G, Hinderaker SG (2012). Factors associated with severe disease from malaria, diarrhea and pneumonia among children in rural Tanzania - A hospital-based cross-sectional study.
Manun'Ebo MN, Haggerty P, Kalengaie M, Ashworth A, Kirkwood B (1994). Influence of demographic, socioeconomic and environmental variables on childhood diarrhea in rural Zaire. Journal of Tropical Medicine and Hygiene 97(1):31-38.
Messou E, Sangare SV, Josseran R, Guelain J (1995). Water supply, excrement disposal and diarrheal diseases in rural zones of Ivory Coast. Medecine Tropicale: Revue du Corps de Sante Colonial 55(3):225-230.
Mulholland K (2005).Commentary: Comorbidity as a factor in child health and child survival in developing countries. International Journal of Epidemiology 34(2):375-377.
Oyejide O, Oladepo D, Oke E (1994). Hygiene behaviour practises as discriminants for the occurrence of childhood diarrhea. African Journal of Medicine and Medical Sciences 23(3):207-213.
Pokhrel D, and Viraraghavan T(2004). Diarrheal diseases in Nepal vis-à-vis water supply and sanitation status. Journal of Water and Health 2(2):71-81.
R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/. Accessed 8 June 2018
Rice AL, Sacco L, Hyder A, Black RE (2000).Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. Bulletin of the World Health Organization 78:1207-1221.
Schmidt WP, Arnold BF, Boisson S, Genser B, Luby SP, Barreto ML, Clasen T, Cairncross S (2011). Epidemiological methods in diarrhea studies - An update. International Journal of Epidemiology 40(6):1678-1692.
Schmidt WP, Cairncross, BML, Clasen T, Genser B (2009). Recent diarrheal illness and risk of lower respiratory infections in children under the age of 5 years. International Journal of Epidemiology 38(3):766-772.
Siziya S, Muula AS, Rudatsikira E (2009). Diarrhea and acute respiratory infections prevalence and risk factors among under-five children in Iraq in 2000. Italian Journal of Pediatrics 35(1):8.
Traoré E, Cousens S, Curtis V, Mertens T, Tall F, Traoré A, Kanji B, Diallo I, Rochereau A, Chiron JP (1994).Child defecation behaviour, stool disposal practices, and childhood diarrhea in Burkina Faso: Results from a case control study. Journal of Epidemiology and Community Health 48(3):270-275
Tumwine JK, Thompson J, Katua Katua M, Mujwajuzi M, Johnstone N, Porras I (2002). Diarrhea and effects of different water sources, sanitation and hygiene behaviour in East Africa. Tropical Medicine and International Health 7(9):750-756
WHO and Maternal and Child Epidemiology Estimation Group (2018a). Estimates of child cause of death, diarrhea.
WHO and Maternal and Child Epidemiology Estimation Group (2018b). Estimates of child cause of death, acute respiratory infection.
World Health Organisation (2014). Revised WHO classification and treatment of childhood pneumonia at health facilities - Evidence Summaries. Geneva: World Health Organisation. World Health Organisation website; Available from http://www.who.int/maternal_child_adolescent/documents/child-pneumonia-treatment/en/ Accessed 12 Sept 2018
Yeager BA, Huttly SRA, DIAZ J, Bartolini R, Rojas M, Lanata CF (1999). Defecation practices of young childrens in a Peruvian shanty town. Social Science and Medicine 49(4):531-541.

[i] Obtained from the product of the prevalence of diarrhea alone and the prevalence of pneumonia alone
[ii] Average of the column