Research Paper

Water, sanitation, and hygiene (WASH) conditions and prevalence of office visits due to anemia: a regional-level analysis from Peru

Benoit Mougenot, Elard Amaya and Percy Herrera-Añazco

ABSTRACT

In Peru, anemia affects around 30% of children under the age of four, making it one of the major public health problems of the country. The literature suggests that water, sanitation, and hygiene (WASH) conditions may reduce anemia prevalence; however, empirical evidence of this association remains scarce for the Peruvian context. The objective of this study was to analyze the association between WASH conditions and office visits due to anemia (OVA), at the regional level during the years 2010–2018. Using generalized estimating equation models (GEE), we find that the prevalence of OVA increases by 0.24/1,000 per one percentage point (PP) increase in the proportion of households with access to safe drinking water and decreases by 0.22/1,000 per one PP increase in the proportion of households with basic sanitation. Our results suggest that policymakers should not only ensure a better coverage of drinking water sources but also ensure adequate quality.

Key words | anemia, diarrhea, fresh water, parasitic, sanitation

Benoit Mougenot (corresponding author)
Facultad de Ciencias Empresariales, Universidad
 San Ignacio de Loyola,
Lima,
Peru
E-mail: *bmougenot@usil.edu.pe*

Benoit Mougenot
Elard Amaya
Centro de Excelencia en Investigaciones
 Económicas y Sociales en Salud, Vicerrectorado
 de Investigación, Universidad San Ignacio de
 Loyola,
Lima,
Peru

Percy Herrera-Añazco
Universidad Señor de Sipan,
Chiclayo,
Peru

HIGHLIGHTS

- Anemia in Peru is still one of the major public health problems.
- We analyze the association between WASH conditions and a specific health management indicator, office visits due to anemia (OVA).
- The prevalence of OVA increases in the proportion of households with access to safe drinking water and decreases in the proportion of households with basic sanitation.
- Policymakers should ensure adequate water quality.

INTRODUCTION

Anemia is a major public health problem, affecting around two billion people worldwide, mainly women and children (De Benoist *et al.* 2008; Kassebaum *et al.* 2014; Mujica-Coopman *et al.* 2015; World Health Organization 2015). Likewise, anemia results in severe health consequences in all stages of life, including high maternal mortality, stunting, inadequate cognitive development in children, and low labor performance in adults (Balarajan *et al.* 2011; Rahman *et al.* 2016; Larsen *et al.* 2017).

Anemia is caused mainly by malnutrition, including a deficiency in micronutrients, such as iron and vitamin B12 (Tsuyuoka *et al.* 1999; Oliveira *et al.* 2015; Ihejirika *et al.* 2019). In low- and middle-income countries, anemia is related to cultural, socio-economic, and environmental factors, such as poor water, sanitation, and hygiene (WASH) conditions (Ngui *et al.* 2012; Amarasinghe *et al.* 2017; Gonmei & Toteja 2018; Harding *et al.* 2018; Kawo *et al.* 2018). Consequently, in these countries, anemia is

disproportionately concentrated in the vulnerable population (Balarajan et al. 2011). In Peru, anemia affects around 30% of children under the age of four (Mujica-Coopman et al. 2015).

WASH conditions can influence the anemia prevalence for many reasons. First, the lack of access to basic sanitation increases the probability of having parasitic diseases, which can generate iron-deficiency. Some parasites, such as Ascaris lumbricoides or Giardia lamblia, cause a lack of appetite and malnutrition, decreasing the absorption of iron and other nutrients (Assandri et al. 2018). Second, other nutritional deficiencies such as a deficiency of folate, vitamin B12, vitamin A, and protein, among others, affect erythropoiesis which results in anemia. Third, households without either access to an improved drinking water source or basic sanitation may lead to an increase in malnutrition or inflammation and involve other types of anemia (Larsen et al. 2017; Kothari et al. 2019; United Nations Economic and Social Council 2019). However, improving WASH conditions does not necessarily lead to a decrease in anemia. In India, households using surface water have a protective effect to anemia (Kothari et al. 2019).

The most recent Sustainable Development Goals progress report showed that 785 million people still lack even basic drinking water services and 701 million people still practice open defecation worldwide (United Nations Economic and Social Council 2019). Peru has improved its WASH conditions, but there are several areas for improvement, for instance, only 2.2% of rural households have access to safe drinking water access and 24.6% have access to basic sanitation facilities (Ministry of Development and Social Inclusion 2018).

Office visits to a medical professional remain a fundamental part of the strategies for the management of diseases and have been used commonly as a proxy of medical treatment and prevalence, in studies which have evaluated the prescription of medications in obesity and anxiety disorders (Harman et al. 2002; Padwal 2005). In Peru, office visits due to anemia (OVA) is an indicator of health services utilization, and its increase, through a greater probability of diagnosis and treatment, may contribute to anemia prevalence reduction.

The objective of our study was to analyze the association between WASH conditions and prevalence of OVA in Peru.

METHODS

Design and data source

We conducted an ecological study with secondary data sources for the years 2010–2018. The sample size included each region-year (e.g. Lima-2016). The main information source was the National Record of Healthcare Visits provided by the Peruvian Ministry of Health (MINSA is the acronym in Spanish). This record contained all healthcare interventions (post-diagnosis) conducted by MINSA establishments, which cover around 60% of the total interventions in the Peruvian health system (Mezones-Holguín et al. 2019). In addition, we used the National Survey on Strategic Programs (ENAPRES is the acronym in Spanish) and the National Household Survey (ENAHO is the acronym in Spanish), which are both nationally representative surveys conducted by the National Institute of Statistics and Informatics of Peru. The ENAPRES included information on basic services coverage of different government programs, while the ENAHO collected information on several characteristics related to individuals/households welling.

For our analysis, the National Record of Healthcare Visits provided a record of the OVA for individuals +18 aged, the ENAPRES provided several indicators on household sanitation facilities and WASH conditions and the ENAHO provided information on health insurance coverage of the population.

Procedures

We requested the National Record of Healthcare Visits through MINSA Platform for Access to Public Information (http://www.minsa.gob.pe/portada/transparencia/solicitud/frmFormulario.asp). Both ENAPRES and ENAHO provide public data which can be downloaded from http://iinei.inei.gob.pe/microdatos/.

Variables

The outcome variable was the prevalence of OVA expressed per 1,000 patients for each region-year. This variable was

estimated as a ratio: annually healthcare visits due to anemia divided by the sum of population covered by the public health insurance program plus the uninsured population, serviced mainly in MINSA establishments. Public health insurance users and the uninsured population (i.e. individuals that reported not having any public or private health insurance) were estimated by the ENAHO. The prevalence of OVA was age-standardized following the approach proposed by the WHO (Ahmad *et al.* 2001).

The exposure variables were estimated for each region-year. We considered survey design and sampling weights to obtain population-based values. For WASH conditions-related variables, we estimated the proportion of households with access to an improved drinking water source, defined as a source that, by nature of its construction, adequately protects the water from outside contamination, in particular from fecal matter, such as piped household water connection, public standpipe, borehole, and protected dug well (WHO/UNICEF Joint Water Supply & Sanitation Monitoring Programme 2014). We included the proportion of households with access to basic sanitation, defined as the proportion of households using improved sanitation facilities (such as those with sewer connections, septic system connections, pour-flush latrines, ventilated improved pit latrines, and pit latrines with a slab or covered pit) (WHO/UNICEF Joint Water Supply & Sanitation Monitoring Programme 2014). We added the proportion of households using hand washing with soap (proportion of households using hand washing with soap over the total households with access to drinking water). All data were obtained from ENAPRES.

Healthcare visits due to parasitic disease, diarrheic disease, and binary variables related to time for the years were included in the analysis.

Statistical analyses

All analyses were performed in Stata 15.0® (StataCorp, College Station, Texas, USA) (StataCorp 2017). We described regional trends of OVA prevalence with linear graphs and linear regressions models. The OVA prevalence was the dependent variable, while year-related variable was the main explanatory variable. We corrected standard errors for robust variance and considered significant trends with a $p < 0.05$.

Additionally, we applied generalized estimating equation (GEE) models with longitudinal data to assess the association between WASH conditions and OVA prevalence. Further adjustments were made using the incidence of healthcare visits due to parasitic and diarrheic diseases, and variables related to time. We excluded the Callao region due to missing values in some variables. We considered an exchangeable correlation structure, standard errors corrected for robust variance, and significant association with a $p < 0.05$, as well as marginally significant with a $p < 0.1$.

Ethics statement

Our study employed secondary data sources, which were obtained through online requests or were downloaded from public domain websites. These data are anonymous, so they did not involve any direct risk of subject identification.

RESULTS

Regional trends of OVA

The prevalence of OVA from MINSA establishments increased at a rate of 16/1,000 during the 2010–2018 period. Regions reporting a substantial increase in OVA prevalence during this period were Ayacucho (with a rate increased in 37.1/1,000), Madre de Dios (with a rate increased in 34.4/1,000), Ancash (with a rate increased in 29.3/1,000), and Tumbes (with a rate increased in 28.2/ 1,000) (Figure 1).

Moreover, regression analyses showed an increase in OVA prevalence trends for all regions during the period, with the highest growing trends being in Ayacucho ($\beta = 5.68$), Madre de Dios ($\beta = 5.47$), Ancash ($\beta = 4.59$), and Pasco ($\beta = 4.08$) (Table 1).

Descriptive statistics

For the years 2010–2018, the average OVA prevalence was 24/1,000 patients (95% CI: 22.02–25.64); the average proportion of WASH conditions and prevalence of office visits due to parasitic and diarrheic diseases are described in Table 2.
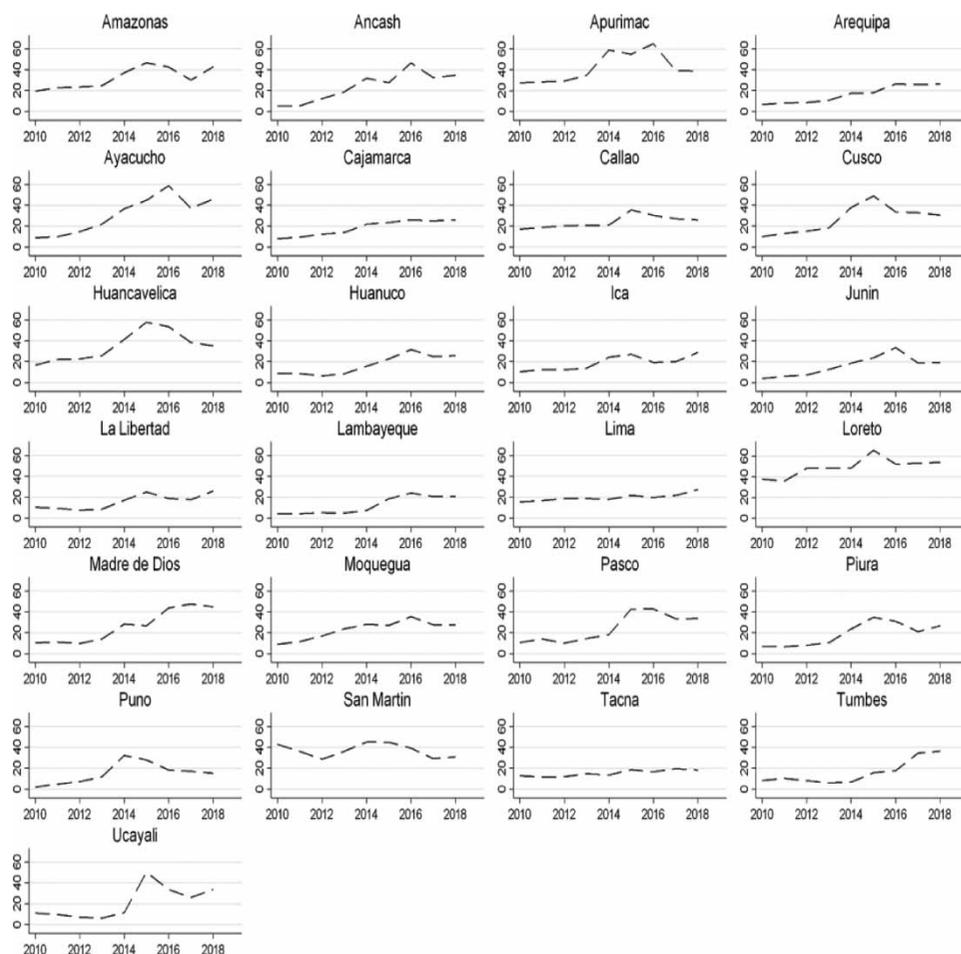
Figure 1 | Trends of OVA prevalence per 1,000 patients at the regional level.

Association between WASH conditions and OVA prevalence

GEE models showed that OVA prevalence increased by 0.24/1,000 per one percentage point (PP) increase in the proportion of households with access to an improved drinking water source and decreased by 0.22/1,000 per one PP increase in the proportion of households with basic sanitation (Table 3).

DISCUSSION

Our results showed increased trends of OVA prevalence for all regions. The OVA prevalence at regional level had a positive association with households that had access to an improved drinking water source and a marginal negative association with households that had a basic sanitation facility. The positive association between OVA prevalence and households with access to an improved drinking water source is given in a context where water access does not necessarily guarantee a safe quality of drinking water (George *et al.* 2014; Villena Chávez 2018). Indeed, during the years 2008–2016, the improved drinking water source access rate increased by 13.5 percentage points (National Institute of Statistics and Informatics – INEI 2016), but the quality of drinking water still presented serious issues. For instance, the metal concentration in drinking water due to mining activities, mainly present in the Ayacucho region, exceeds the World Health Organization's recommendations. In 2014, more than 86% of samples analyzed in 12 districts showed arsenic concentrations in drinking

Table 1 | Trend effects of OVA prevalence by linear regression models

Regions	Coeff	95% CI	p
Amazonas	2.92	[1.27, 4.57]	**0.004**
Ancash	4.59	[2.53, 6.65]	**0.001**
Apurímac	2.82	[−0.75, 6.38]	0.104
Arequipa	2.92	[2.28, 3.56]	**0.000**
Ayacucho	5.68	[3.06, 8.31]	**0.001**
Cajamarca	2.61	[1.98, 3.23]	**0.000**
Callao	1.59	[0.59, 2.59]	**0.007**
Cusco	3.49	[1.25, 5.73]	**0.008**
Huancavelica	3.60	[0.47, 6.73]	**0.030**
Huánuco	3.03	[1.74, 4.33]	**0.001**
Ica	2.07	[1.17, 2.97]	**0.001**
Junín	2.71	[0.78, 4.65]	**0.013**
La Libertad	2.10	[1.08, 3.13]	**0.002**
Lambayeque	2.82	[1.87, 3.76]	**0.000**
Lima	1.12	[0.50, 1.74]	**0.004**
Loreto	2.36	[0.84, 3.88]	**0.008**
Madre de Dios	5.47	[3.82, 7.11]	**0.000**
Moquegua	2.71	[1.14, 4.27]	**0.005**
Pasco	4.08	[2.17, 5.99]	**0.001**
Piura	3.21	[1.57, 4.86]	**0.002**
Puno	2.15	[0.13, 4.16]	**0.040**
San Martín	− 0.65	[−2.24, 0.95]	0.369
Tacna	1.00	[0.60, 1.41]	**0.001**
Tumbes	3.57	[1.44, 5.70]	**0.005**
Ucayali	3.95	[1.90, 5.99]	**0.003**

Note: All regressions include robust standard errors.
Bold corresponds to p < 0.05.
Coeff: Estimated coefficients; CI: Confidence Interval; p: p-value of linear regressions.

water exceeding the level of standard controls (George et al. 2014; Villena Chávez 2018). Our finding is contrary to those found in a systematic review which showed a negative association between anemia prevalence and fresh water access (Cardona-Arias 2018); however, this is not exactly comparable because we used a proxy for disease prevalence (the prevalence of OVA).

The association between OVA prevalence and access to an improved drinking water source may be conditioned by the higher likelihood of reporting a diagnosis of anemia. The health insurance coverage in Peru improved from 61% in 2009 to 76% in 2017 (Lazo-Gonzales et al. 2016; Mezones-Holguín et al. 2019) with possible positive effects in the prevalence of office visit (Benites-Zapata et al. 2017). This increase in health insurance coverage (2010–2018) has been significantly higher in Ancash (19 PP), Madre de Dios (17 PP), or Pasco (22 PP) regions, where we have found an increase in OVA prevalence (Mezones-Holguín et al. 2019).

As mentioned earlier, despite improvements in drinking water source access, a positive association with OVA prevalence is possibly related to a lack of access to safe drinking water. The association between a poor quality of drinking water and OVA prevalence is possibly related to the presence of diarrheal diseases (Larsen et al. 2017; Mshida Kassim Mpolya & Kimanya 2018) and most especially parasitic diseases, as suggested by several studies worldwide (Ngui et al. 2012; Cabada et al. 2015; Oliveira et al. 2015; Yanola et al. 2018; Humphrey et al. 2019; Ihejirika et al. 2019). A study in Paucartambo, Peru, showed a high prevalence of intestinal parasites among children with anemia (Cabada et al. 2015). However, these results are not

Table 2 | Descriptive statistics

	Sample size	Mean	95% CI
OVA (per 1,000 habitants)	225	23.83	[22.02, 25.64]
Cases of diarrhea (per 1,000 habitants)	225	38.20	[35.73, 40.66]
Cases of parasitic infections (per 1,000 habitants)	225	21.56	[19.5, 23.62]
Household with improved drinking water (%)	225	80.60	[78.77, 82.43]
Household using hand washing soap (%)	216	62.10	[60.17, 64.03]
Household with basic sanitation (%)	225	58.05	[55.64, 60.47]

Note: Sample size represents each region-year.
CI: Confidence Interval.

Table 3 | Association between WASH conditions and OVA prevalence

Variables	GEE model – outcome: OVA prevalence		
	Coeff	95% CI	p
Cases of diarrhea	0.01	[−0.15, 0.17]	0.925
Cases of parasitic infections	0.16	[−0.05, 0.37]	0.131
Household with improved drinking water (%)	0.24	[0.06, 0.43]	0.011
Household using hand washing soap (%)	0.07	[−0.05, 0.19]	0.281
Household with basic sanitation (%)	−0.22	[−0.46, 0.02]	0.071
Sample size	216		

Note: Sample size represents each region-year. Regression includes time fixed-effects and robust standard errors.
Coeff: Estimated coefficients; CI: Confidence Interval; *p*: *p*-value of linear regressions.

universal. A study among children of Aracaju, Brazil, did not show an association between parasites and anemia (Tsuyuoka *et al.* 1999). The difference among results could be explained by the different parasite and anemia types (Ngui *et al.* 2012). Iron-deficiency anemia is commonly associated with parasites (Ngure *et al.* 2014; Fraenkel 2017), but the interactions observed in WASH conditions could induce inflammation, a cause of anemia not related to iron-deficiency (Fraenkel 2017).

Our study found a negative association between public sanitation and OVA prevalence, similar to anemic prevalence studies worldwide (Larsen *et al.* 2017; Kothari *et al.* 2019). This association could be related to improvements in social conditions related to the lack of public sewerage. Therefore, public sanitation access must be a surrogate of health social determinants such as higher scholarship, balanced nutrition, or living in urban areas (Cardona-Arias 2018). In Peru, although the proportion of the population with basic sanitation access increased from 72.6 to 79.1% during the 2008–2016 period, we observed a decrease to 74.9% in 2019, being higher in rural areas (INEI 2016, 2019). Coincidentally, in 2016, the departments of Ayacucho, Madre de Dios, Ancash, and Pasco which showed an increased OVA trend, had lower public sanitation coverage than average (INEI 2016). Therefore, policies to improve access to public sanitation in rural zones should continue.

Our study has some limitations. First, we built the variables related to WASH with available information. The analysis units were the OVA and not individual patients and our findings must be carefully interpreted, for instance, we could not account for repeated visits from the same individuals. Moreover, when a physician recorded a diagnosis of anemia during a medical visit, we could not observe whether the treatment is mainly related to anemia. Second, we did not provide a disaggregated analysis by age as some variables were available only for the total population. Third, both incidence of healthcare visits due to parasitic and diarrheic diseases were not stratified by parasite type. Moreover, we did not know whether a diarrheic disease visit was infectious or not. Finally, we could not differentiate among anemia types and severity levels.

CONCLUSION

Our study showed evidence of the association between the OVA prevalence and WASH conditions in an epidemiologic transition country. Despite Peru having improved some aspects related to WASH conditions, it requires reinforcing investment in infrastructure in order to reduce regional gaps in health provision. We found a positive association between the OVA prevalence and the proportion of households with access to improved drinking water, a negative association with the proportion of households with basic sanitation and a positive but non-significant relation with households using hand washing soap. The main strength of our study was that it is the first study using a health management indicator, such as the OVA, instead of anemia prevalence. Therefore, we provided a complementary approach to evaluate the association to WASH conditions (Curioso Vílchez *et al.* 2013).

In view of our findings, policymakers should not only ensure better coverage of improved drinking water sources but should also ensure adequate quality. Future research should focus on verifying if the improvement in quality of water is related to a decrease in OVA, as a way to achieve a minimized health expenditure.

FUNDING

CONFLICT OF INTEREST STATEMENT

All the authors confirm that there are no conflicts of interests associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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