Anemia and socioeconomic status among older adults in the Study on global AGEing and adult health (SAGE)

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Background: Research on anemia has primarily focused on young children and pregnant women, yet anemia also raises considerable health concerns for older adults. Anemia can often be easily identified and treated, yet it affects large populations in low- and middle-income countries (LMICs). The older adult population is rapidly growing in LMICs; therefore, not only is this population understudied but the impact of anemia within this population will become a larger global issue. Documenting anemia prevalence and identifying associated factors in different countries will help public health officials more effectively target this disorder.

Methods: Hemoglobin (Hb) levels and survey data from 14,848 adults 50 years and older in South Africa, China, and Mexico were obtained from Wave 1 of the World Health Organization (WHO)'s Study on global AGEing and adult health (SAGE). Data were analyzed to describe anemia prevalence and to test relationships among anemia, age, and socioeconomic status (SES) using binomial logistic regression.

Results: For Mexico, China, and South Africa the prevalence of anemia in older adults was found to be 24%, 28%, and 91%, respectively. An association between lower wealth and higher prevalence of anemia was present for only one group: men in China [prevalence ratio (PR) =0.40; 95% confidence interval (CI): 0.34–0.47; P=0.004]. Each year of age after 50 was associated with a 1% higher prevalence of anemia among women and men in Mexico and China. A large amount of variance (10% to 61%) in the prevalence of anemia was accounted for by community-level clustering.

Conclusions: These results highlight the enormous global burden of anemia in older adults. As the population size of older adults increases within LMICs, the health burden and economic impact of anemia in older adults in these countries will also increase. Additionally, this research documents variation in factors that are associated with anemia by group, highlighting the importance of specifying treatment for age and gender.

Keywords: Epidemiology; aging; biomarkers; chronic disease; hemoglobin (Hb)

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Introduction

Anemia—a condition caused by the lack of or dysfunctional red blood cells (RBCs) in the body, leading to reduced transportation of oxygen—is the most common blood disorder in the world, negatively affecting the health and socioeconomic well-being of millions of men, women, and children (1). Anemia can be caused by nutritional deficiencies, environmental factors, medications, blood loss as well as inflammation, malaria, hemoglobinopathies, enzymopathies, and some chronic diseases (2,3). Symptoms of anemia include fatigue, weakness, pale/yellow skin, irregular heartbeats, shortness of breath, dizziness, chest pain, cold extremities, and headaches; this can lead to increased mortality and morbidity in both children and adults (4,5). This condition can be caused by congenital conditions or developed later in life (6). While anemia is a serious global public health problem for many groups (7), research and interventions have typically focused on young children and pregnant women because of the impact and risks of anemia from growth and development, as well as reproduction (4,8,9). Despite the current global health focus, the prevalence of anemia within the older adult population is known to increase with age (10). Although the susceptibility to anemia in older adults is not well characterized, high rates of dietary and nutrient deficiency, renal deficiencies, chronic inflammation, and other chronic conditions have been associated with its presence (11,12). It is important to understand common chronic conditions of the older adult population given that they are increasing globally (13). The present study helps to address this need by investigating the prevalence and correlates of anemia among older adults in China, Mexico, and South Africa using data from the World Health Organization (WHO)'s Study on global AGEing and adult health (SAGE).

In the United States (12), anemia prevalence is approximately 20% in community-dwelling older adults and approximately 48–63% among nursing-home residents. A large systematic review in economically developed countries comprised of 45 studies, of which 34 studies used the criteria to define anemia as described by the WHO, found an estimated 12–47% of older adult populations will develop anemia depending on if they live in the community or nursing home (14,15). Previous studies provide prevalence of anemia for men, children, pregnant and non-pregnant women by national and subnational surveys distributed by the WHO to 192 member states (7). However, data are missing on how many older adults have anemia, how many of those with anemia have additional diseases, their socioeconomic status (SES), as well as the severity of their anemia (7). Older adults with multiple diseases typically experience mild anemia and remain unrecognized and untreated (13). However, there are serious health concerns related to anemia among older adults as it increases the likelihood of osteoporosis and other comorbidities (12). The relationship's cause and effect has not yet been established. High prevalence of anemia in older adults, and its association with decreased health and morbidity, make this a pressing public health issue.

In high-income countries, anemia is generally easily identified and treated, showing that its negative consequences can be reduced. In contrast, anemia is a health problem that affects major portions of the population in many low- and middle-income countries (LMICs) (16). However, data on older adults in LMICs are sparse, which is unfortunate given the severity of impact that anemia has, along with the growing number of older adults in LMICs (16). It is estimated that by 2050, 80% of older people, aged 60 years and older, will live in LMICs (17) and while anemia affects roughly 33% of the world's population, LMICs account for 89% of anemia cases (9). Further characterizing anemia in LMICs is imperative for targeting this treatable disorder in older adults globally.

SES and anemia

SES is generally defined as the composite measure of a person's wealth, educational attainment, and employment status. One's ability to access care is often strongly shaped by their SES. Previous studies of anemia demonstrate that higher levels of wealth and education are generally associated with a lower prevalence of anemia in LMICs (18,19). These factors can cause anemia by influencing access to diverse food sources (quantity and quality), fortified food sources, health services and interventions, knowledge and education about anemia, clean water, sanitation, and insecticide-treated bed-nets (18). SES and anemia have been shown to be negative correlated in diverse settings, including primary school children in Vietnam (19), children under five in rural Nigeria (20), and adolescent girls in South Korea (21).

Older adults can struggle with income insecurity, leading to inadequate nutrition or inability to access health care; these can be particularly challenging issues in countries without social safety nets, as is common in LMICs. This population is vital to address because older adults are uniquely susceptible to changes in SES, which may contribute to the increased prevalence of anemia.

Ultimately, SES is often closely tied to healthy aging, with greater wealth producing a greater likelihood of better health among older adults (22). Low SES also contributes to a heavier disease burden (23). The present study examines the relationship between SES and anemia by focusing on the individual components of wealth (itself a composite variable) and education rather than creating a composite variable of SES.

Current study and hypotheses

The purpose of the present study is to use Wave 1 data (collected 2007–2010) from the WHO's SAGE to: (I) describe prevalence of anemia for 14,848 adults 50 years and older in three middle-income countries (South Africa, China, and Mexico); and (II) investigate associations among anemia, age, and components of SES in the three countries. Our hypotheses are: (I) lower individual wealth will be associated with greater anemia; and (II) lower education levels will be associated with greater anemia. We present the following article in accordance with the STROBE reporting checklist (available at https://jphe.amegroups.com/article/view/10.21037/jphe-22-29/rc).

Methods

SAGE

SAGE is a comprehensive longitudinal study of the health and well-being of older adults (50 years of age and older) and the aging process in six middle-income countries: China, Ghana, India, Mexico, the Russian Federation, and South Africa (24). For the SAGE study, households were randomly selected from population census data to create nationally representative samples using a stratified multistage cluster sampling design. Not all SAGE participants had hemoglobin (Hb) biomarker values; a convenience sample of dried blood spots for biomarker analysis have been run as a preliminary analysis. The present paper concentrates only on the SAGE countries for which biomarker data were available: Mexico, South Africa, and China. Comparative samples of younger adults (aged 18 to 49 years old) were also obtained from each country but were not included in the present analysis. All samples were collected during Wave 1 (2007 through 2010).

Ethical statement

The WHO's Ethical Review Committee, as well as review bodies within each country, approved the study (24). All participants signed an informed consent document before participation in the study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Participants

The subset of older adult individuals who had biomarker values from the SAGE study in the three countries were included in this study (n=14,848). Participants' ages ranged from 50 to 99 years (*Table 1*). It was assumed that women over 50 would be menopausal, and therefore the survey did not ask about pregnancy status. Missingness on all variables was less than 5% except for education and alcohol in South Africa which had 15% and 7% missingness respectively.

Survey measures

Trained WHO interviewers performed face-to-face computer-assisted personal interviews (CAPI) for half of the interviews in China while the other half used paper and pencil. Mexico and South Africa conducted their interviews via pencil and paper (25). The interviews took place from 2007 to 2008 in South Africa, from 2008 to 2010 in China, and from 2009 to 2010 in Mexico. The interviews were conducted in the participants' homes and lasted approximately 1.5 hours on average (24). Detailed information about the collection of included variables is described elsewhere (24).

Wealth

The wealth variable is a composite of a 21-item self-report survey that asked about items owned by the household and household characteristics. Questions asked about various aspects of SES such as income (wages, earnings from selling products, and income from rental property, pension, interest, and other) assets (land/property, jewelry, books, art, and other valuable items), and housing characteristics (e.g., washing machine, hot running water, a refrigerator, internet access, household employees) and were adapted to each country. The responses were modeled as independent observations of wealth then combined using item response theory. This variable was used to assess wealth separate from

Table 1 Participant descriptive statistics by country and gender

Variable	China		Mexico		South Africa	
	Women	Men	Women	Men	Women	Men
Age (years), M (SD)	62.98 (9.35)	63.06 (9.25)	68.26 (9.37)	68.00 (9.31)	63.57 (9.99)	62.70 (9.35)
Education (years), M (SD)	4.51 (4.45)	6.40 (4.25)	4.18 (4.02)	4.80 (4.31)	4.91 (4.24)	5.85 (4.82)
Health, M (SD)	2.92 (0.82)	2.79 (0.81)	2.79 (0.71)	2.66 (0.72)	2.86 (0.81)	2.76 (0.92)
Gender, n [%]	5,539 [52]	5,072 [48]	1,253 [62]	774 [38]	1,287 [58]	923 [42]
Location, n [%]						
Urban	2,706 [49]	2,166 [43]	924 [74]	542 [70]	809 [63]	567 [61]
Rural	2,833 [51]	2,906 [57]	329 [26]	232 [30]	477 [37]	355 [39]
Marriage, n [%]						
Never married	101 [1]	186 [3]	186 [11]	64 [6]	453 [19]	199 [11]
Currently married	6,315 [79]	6,178 [88]	804 [49]	738 [74]	780 [33]	1,185 [67]
Cohabiting	14 [0]	13 [0]	68 [4]	60 [6]	94 [4]	141 [8]
Separated/divorced	133 [2]	134 [2]	116 [7]	42 [4]	170 [7]	91 [5]
Widowed	1,443 [18]	478 [7]	451 [28]	100 [10]	876 [37]	159 [9]
Smoking, n [%]						
Yes						
Daily	178 [3]	2,503 [50]	83 [7]	162 [21]	278 [22]	279 [31]
But not daily	28 [1]	228 [5]	42 [3]	74 [10]	66 [5]	51 [6]
No						
Not currently	51 [1]	589 [12]	144 [12]	254 [34]	68 [5]	109 [12]
Never	5,249 [95]	1,692 [34]	943 [78]	266 [35]	828 [67]	454 [51]

Inconsistencies in the totals listed with the populations of the subgroups are due to missingness. M, mean; SD, standard deviation.

employment status since participants may have retired from the workforce.

Education

The survey asked, "*Have you ever been to school?*" and if participants answered "*Yes*" they were asked "*How many years of school including higher education have you completed?*" and it indicated for the interviewer to write the number of years. A "*No*" answer for "*Have you ever been to school?*" was converted into 0 years of school to make a continuous years of school variable.

Age

The individual survey asked, "*How old are you now?*" and it indicated for the interviewer to write the age in years.

Covariates

Covariates included self-rated health, cigarette smoking frequency, frequency of alcohol consumption, average number of servings of fruit in a day, and average number of servings of vegetables in a day. Participants were shown serving sizes of locally available fruits and vegetables for reference. More detailed information about these variables can be found online (25).

Biomarker analysis of Hb

The biomarker collection and lab methods used to measure Hb differed by country, as the specific analysis was determined by in-country lab teams in collaboration with SAGE leadership. In China and South Africa, dried

Table 2 Hb cutoffs used to diagnose anemia at sea level

Population	Non-anemia (g/dL)	Mild (g/dL)	Moderate (g/dL)	Severe (g/dL)
Non-pregnant women (15 years of age and above)	≥12.0	11.0–11.9	8.0–10.9	<8.0
Men (15 years of age and above)	≥13.0	11.0–12.9	8.0–10.9	<8.0

Hb in grams per deciliter. Hb, hemoglobin.

Table 3 Hb levels and anemia rates by country and gender

Country	Hb (g/dL)				Anemia			
	Women, M (SD)	Men, M (SD)	PR	95% CI	Women, %	Men, %	PR	95% CI
China	13.01 (2.64)	14.12 (2.85)	0.27***	0.21–0.33	29	28	0.50	0.47–0.53
Mexico	13.31 (1.90)	14.69 (2.09)	0.20***	0.13–0.30	25	22	0.55	0.49–0.60
South Africa	9.26 (2.21)	9.95 (2.47)	0.37**	0.29–0.45	92	90	0.53	0.45–0.62

**, P<0.01; ***, P<0.001. Hb, hemoglobin; M, mean; SD, standard deviation; PR, prevalence ratio; CI, confidence interval.

blood spot samples were collected using finger-prick capillary blood spotted onto standard filter paper, following established procedures (25). In Mexico, the values were obtained through dried blood spots collected by spotting whole blood collected by venipuncture onto standard filter paper (26). For all countries, the biomarkers were analyzed using enzyme-linked immunosorbent assays.

Anemia cut-offs were classified based on Hb levels, determined by gender, as defined by the WHO in 2011 [(17); *Table 2*]. Although normal (Hb)-specific laboratory cut-offs will differ slightly, the WHO has created general thresholds to classify individuals by age and gender at sea level as anemic. Hb values were adjusted for smoking however altitude data was not available (17).

Statistical analysis

Statistical analyses were performed in R (v. 4.1.2). All statistical assumptions were checked before analysis, and the marriage variable was dichotomized into married (married, cohabiting) and not married (never married, separated/divorced, widowed) to meet normality parameters. Clustering due to the complex sampling design was controlled by including the community-level sampling units as a random intercept. Sampling weights could not be used to create representative samples in these analyses since biomarker analyses were only performed on a convenience sample of the overall study cohorts. In China the community-level sampling units were villages and neighborhoods, in Mexico communities were defined by the National Institute of Statics' (INEGIs) Basic Geo-Statistical Areas (AGEB), and in South Africa they were defined by the Human Sciences Research Council's population enumeration areas (27). Both descriptive and inferential statistics were run on women and men separately since they often have different rates of anemia and different anemia etiologies. To explore this relationship in older adults, Hb levels and anemia rates were compared between women and men in each of the three countries (China, Mexico, and South Africa). Six mixed effect binomial logistic regressions using maximum likelihood estimation were used to predict the presence of anemia, modeling women and men separately for each of the three countries. The predictors of interest in these models were SES, wealth, and education, and covariates included health, cigarette smoking, alcohol use, servings of fruit and servings of vegetables. Pairwise deletion was used to accommodate missing data.

Results

The prevalence of anemia was 28% [95% confidence interval (CI): 27–29%], 24% (95% CI: 22–25%), and 91% (95% CI: 90–93%) in China, Mexico, and South Africa, respectively. The average level of Hb was lower for women in all three countries; however, rates of anemia between women and men were similar (*Table 3*).

Wealth

Mixed effect binomial logistic regression analysis showed low wealth was associated with the presence of anemia for

Table 4 Mixed methods logistic regression prevalence ratios predicting anemia and model fit statistics

Variable	China				Mexico				South Africa			
	Men		Women		Men		Women		Men		Women	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Age	0.51***	0.50–0.51	0.51***	0.50–0.51	0.51***	0.51–0.52	0.51*	0.50–0.51	0.51	0.50–0.51	0.50	0.49–0.50
Marriage	0.45	0.39–0.51	0.51	0.46–0.55	0.56	0.44–0.68	0.48	0.40–0.56	0.59	0.45–0.71	0.45*	0.41–0.50
Wealth	0.40**	0.34–0.47	0.46	0.40–0.53	0.39	0.27–0.52	0.39	0.30–0.50	0.42	0.27–0.59	0.36	0.22–0.53
Education	0.50	0.49–0.50	0.51	0.50–0.51	0.50	0.49–0.51	0.50	0.49–0.51	0.51	0.49–0.52	0.50	0.48–0.52
Health	0.53*	0.51–0.56	0.52	0.49–0.55	0.54	0.47–0.60	0.50	0.45–0.56	0.56	0.47–0.64	0.36	0.40–0.58
Smoking	0.49	0.46–0.51	0.51	0.45–0.57	0.51	0.48–0.55	0.54*	0.50–0.57	0.47	0.40–0.54	0.44	0.37–0.52
Alcohol	0.48*	0.46–0.50	0.51	0.48–0.54	0.48	0.43–0.54	0.43	0.35–0.52	0.53	0.47–0.59	0.48	0.40–0.55
Fruits	0.50	0.49–0.51	0.50	0.49–0.51	0.53	0.48–0.57	0.49	0.45–0.53	0.52	0.44–0.59	0.47	0.40–0.54
Vegetables	0.50	0.49–0.51	0.49**	0.48–0.50	0.48	0.43–0.53	0.47	0.42–0.51	0.53	0.47–0.60	0.52	0.45–0.59
ICC	0.56		0.61		0.10		0.20		0.25		0.46	
Fixed effect R^2	0.03		0.01		0.10		0.04		0.05		0.03	
Model R^2	0.57		0.62		0.18		0.23		0.29		0.47	

*, P<0.05; **, P<0.01; ***, P<0.001. PR, prevalence ratio; CI, confidence interval; ICC, intraclass correlation.

men in China (*Table 4*).

Education

Education was not associated with the presence of anemia.

Age

Older age was closely associated with the presence of anemia. There was an association between age and anemia in men and women from China and Mexico. Both women and men from China and women and men from Mexico had a 1% increase in the odds of anemia for every year people were older after age.

Covariates

Marriage was associated with lower odds of anemia for women in South Africa. Health was associated with anemia for men in China, such that for every one-point increase in self-rated health (on a 5-point scale) there was a 3% lower chance of having anemia. More frequent smoking was associated with 4% higher odds of anemia for women in Mexico and one less serving of vegetables per day on average was associated with 1% higher odds of having anemia for women in China.

Random effects

Much of the variance in the presence of anemia was accounted for by community-level clustering (adjusted intraclass correlations (ICCs) =0.10 to 0.61). China had the most community-level clustering of anemia, with 56% and 61% of the variance in anemia prevalence in men and women respectively accounted for by the community. In Mexico, 10% and 20% of the variance in anemia prevalence in men and women respectively was accounted for by the community, and in South Africa, 25% and 46% of the variance in anemia prevalence in men and women respectively was accounted for by community-level clustering. In addition, age was highly correlated with community level clustering (r=0.76 to 0.86).

Discussion

We used the SAGE to assess the relationship between anemia prevalence and components of SES for older adults in Mexico, China, and South Africa. The results show the prevalence of anemia in older adults in China, Mexico, and South Africa are a moderate to high public health significance (17). The public health significance of anemia in South Africa is extremely high, which is similar to hypertension and diabetes, rates in this sample (28,29). The current study also shows how anemia prevalence is higher with increasing age. The public health concern of anemia identified in this large cross-national study demonstrates the necessity of health policy related to anemia for older adult populations.

Anemia and SES components

Our hypothesis that SES would be related to anemia was only supported in certain groups. Low wealth predicted the presence of anemia in men in China, and high education levels were not associated with the presence of anemia. High proportions of the variance in anemia prevalence were accounted for by the community in which individuals live, which could potentially be helpful in targeting anemia in older adults. Only a lack of marriage in women was associated with higher odds of anemia in South Africa, warranting the further study of anemia in this population. The present results are somewhat different from previous studies that show low wealth is consistently associated with anemia; however, previous studies did not focus on older adults in LMICs or control for community. In India, a study showed low SES was associated with higher prevalence of anemia levels among men. They also documented marked differences in anemia prevalence by region (30). A similar result was found for young adult women in India (31). This paper highlighted the multifactorial effects of SES by showing that education, water sources, sanitization facilities, undernourishment, use of fertilizers, birthrates, and wealth were associated with the presence of anemia (31). One study in Mexico found that high wealth was associated with anemia, alongside obesity. The paper also demonstrated regional differences with rural areas being associated with higher anemia prevalence (32). Therefore, it is likely that SES and community play overlapping roles in the etiology of anemia.

The role of education tied to anemia prevalence has been previously studied in children, but studies in older adults are lacking. A study published in 2011 from China, found that lower educational attainment of parents led to higher anemia prevalence in children (33). However, there is a lack of research on the impact of education and anemia prevalence in older adults in LMICs specifically. The current study, however, found this relationship was mostly not present. One reason for this could be because the study population is older adults in middle-income countries with little variation in educational attainment. Further, there is overlap between community and educational attainment in older adults in LMICs. This diversity in results shows the need for the comprehensive evaluation of factors associated with anemia in individual populations.

Limitations

Since the publicly available dataset used in this study was de-identified, the locations and altitudes for participants were not known to us. Therefore, the Hb rates for anemia were not adjusted for altitude. This could lead to an underestimate of anemia prevalence, as Hb values would be 0.2 to 4.5 mg/dL lower with high altitude adjustments for 1,000 and 4,500 m respectively (17). Although the overall SAGE study used multi-step complex random sampling, the subset of participants for which biomarker values are available used a convenience sample. Additionally, biomarker analyses were conducted in separate labs with different lab techniques in each country to expand the laboratory capability of participating countries, therefore the data may not be accurately comparable across countries. Recent studies have found the relationship between Hb to be well correlated between dried blood spots and venous methods (25,34). Dried blood spot collection was conducted because of the easy collection process, the convenience for participants, and the less-invasive nature of this technique that does not require a clinic. Furthermore, one possible reason for the increased anemia prevalence in South Africa is the prevalence of the human immunodeficiency virus. Roughly 1.8 million people were newly infected with HIV in Africa in 2010, accounting for 69% of new infections worldwide (35). In the present study we did not have data on HIV status.

Conclusions

Overall, this study highlights the enormous burden of anemia in older adults in these three middle-income countries. Global demographic trends are leading to an increased older adult population in LMICs, which means the burden of anemia in older adults in these countries will increase. Anemia prevention efforts have generally concentrated on women and children, who are at the highest risk for anemia. However, with demographic trends more attention should be paid to the burden from and prevention of anemia in older adults. Additionally, this study documents that the characteristics associated with anemia vary by country, and that there is a high level of community clustering of anemia in older adults. Understanding how to better identify and target communities with high prevalence of anemia is important for lowering the burden of anemia globally.

Previous research has characterized the numerous reasons for gender differences in anemia. One paper focused on the role of women in India specifically within the caste system emphasized the effect of how unequal gender norms exacerbate anemia risk among women (31). Women often lack time to prioritize health visits and tests, nor do they have the ability to regularly obtain iron supplements for their anemia. This study in India therefore is specifically looking into an iron deficiency anemia which requires iron supplements for treatment. On top of this, women are expected to prioritize the health of the family over their own health, thus affecting their health care status. The autonomy of women in this setting is also limited outside of the home, which can make travel and accessibility difficult (31). However, it is important to keep in mind that gender is not the main explanatory variable in the present study. Furthermore, various nutritional and lifestyle factors that can affect anemia are shaped by gender in diverse ways that vary culturally and generationally.

The present study emphasizes the importance of wealth and education on anemia. However, other personal characteristics such as education, age, gender, urban/rural location, and poor health all significantly affected the anemia prevalence of the older adult population in this study. The significance of variables predicting anemia prevalence differs depending on the gender and country.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The WHO's Ethical Review Committee, as well as review bodies within each country, approved the study. All participants signed an informed consent before participation.

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