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Beyond High-Income Countries: Low Numeracy Is Associated with Older Adult Age around the World

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Abstract

Background. Numeracy, or the ability to understand and use numbers, has been associated with obtaining better health and financial outcomes. Studies in high-income countries suggest that low numeracy is associated with older age—perhaps especially among individuals with lower education. Here, we examined whether findings generalize to the rest of the world. **Methods.** Gallup surveyed >150,000 participants for the 2019 Lloyd's Register Foundation World Risk Poll, from 21 low-income, 34 lower-middle income, 42 upper-middle income, and 43 high-income countries. Low numeracy was operationalized as failing to correctly answer, "Is 10% bigger than 1 out of 10, smaller than 1 out of 10, or the same as 1 out of 10?" **Results.** Regressions controlling for participants' education, income, and other characteristics found that, worldwide, low numeracy was associated with older age, lower education, and their interaction. Findings held in each country-income category, although low numeracy was more common in low-income countries than in high-income countries. **Limitations.** Age differences may reflect cohort effects and life span–developmental changes. **Discussion.** Low numeracy is more common among people who are older and less educated. We discuss the need for education and interventions outside of the classroom.

Highlights

- We analyzed a global survey conducted in 21 low-income, 34 lower-middle income, 42 upper-middle income, and 43 high-income countries.
- Low numeracy was associated with older adult age, even after accounting for age differences in education.
- Low numeracy was more common in older people with lower education.

Keywords
number ability, cognitive ability, age-related decline

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Low numeracy, or low ability to understand and use numbers, is associated with worse health and financial outcomes, according to studies from the United States and the United Kingdom.[1–6] Numeracy has been measured with questions such as, "Is 10% bigger than 1 out of 10, smaller than 1 out of 10, or the same as 1 out of 10?"[7]

Older adult age is correlated with lower numeracy, according to cross-sectional studies in North America and Europe.[8–11] Although these correlations hold after accounting for age differences in education, they may

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partly be due to younger cohorts having received better math education than older cohorts. These correlations may also reflect age-related changes: an 11-y US-wide longitudinal study found age-related declines in numeracy starting around age 60 y.[12] Indeed, theories of cognitive aging[13] suggest that age-related declines in fluid cognitive abilities may hinder numerical operations.[14,15]

Low numeracy is also more common among adults with lower education, according to cross-sectional studies in high-income and upper-middle income countries.[10,16–19] An Austrian study found that the association between older age and low numeracy held only among adults with ≤ 12 y of education.[20] Longitudinal US-based analyses showed this pattern as well, but the low-education subsample was too small to draw confident conclusions.[12] Such longitudinal findings suggest that knowledge gained through education, or crystallized cognitive ability, may counteract age-related fluid cognitive decline.[13] Specifically, educated individuals may have learned numeric rules that they can apply to numerical problems well into older age, without relying much on fluid cognitive ability.

A main limitation of research on age differences in numeracy is its focus on high-income countries, thus largely ignoring the poorest countries in the world. Yet, low numeracy affects 76% of people in low-income countries compared to 32% in high-income countries.[7] The World Bank defines high-income countries as having Gross National Income (GNI) > $12,375, while low-income countries' GNI is < $1,026, lower-middle income countries' GNI is $1,026 to $3,995, and upper-middle income countries' GNI is $3,996 to $12,375.[21]

To address this gap, we report secondary analyses of the 2019 Lloyd's Register Foundation World Risk Poll, covering 140 countries across country-income categories. Our main research question is whether, worldwide and for each country-income category, older adult age was associated with low numeracy, despite accounting for education. In addition, we examine whether age differences in numeracy especially affect individuals with lower education.

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Methods

Sample

For the 2019 Lloyd's Register Foundation World Risk Poll, Gallup recruited national probability-based samples of about 1,000 participants aged 15 + y in 142 countries. Kuwait and Venezuela lacked, respectively, numeracy and income information. The remaining data set included 150,634 participants from 21 low-income, 34 lower-middle income, 42 upper-middle income, and 43 high-income countries. Table 1 shows participant characteristics.

Procedure

Gallup conducted surveys in participants' language, face-to-face or by phone. Survey methodology and data are publicly available (http://doi.org/10.5255/UKDA-SN-8739-1). Ethical approval was obtained at Gallup.

Numeracy. Participants answered the following question: "Do you think that 10% is bigger than 1 out of 10, smaller than 1 out of 10, or the same as 1 out of 10?" Response options included "10% is bigger than 1 out of 10," "10% is smaller than 1 out of 10," "10% is the same as 1 out of 10," "I don't know," or no answer. Anything other than "10% is the same as 1 out of 10" was counted as incorrect and reflecting low numeracy. Single-item measures can provide valid assessments while reducing cost and respondent burden for large surveys.[22] Performance on similar single items is reliably correlated with multi-item numeracy assessments.[23] Moreover, across 37 countries, the percentage of low-numerate individuals among 16 to 65-y-olds as identified by the single-item World Risk Poll measure was significantly correlated with the average numeracy score among 16 to 65-y-olds as identified by the Organisation for Economic Co-operation and Development (OECD)'s multi-item numeracy measure ($r = -0.83$, $P < 0.001$).[19]

Demographics. Participants reported age, gender, education (in country-specific categories for up to elementary school, high school, and college), and monthly pretax income (in local currency) divided by Gallup into income quintiles reflecting whether participants were among the 20% poorest up to the 20% richest individuals in their country.

Table 1 Participant Characteristics

Weighted Statistics	World	Low-Income Countries	Lower-Middle Income Countries	Upper-Middle Income Countries	High-Income Countries
Low numeracy, %	60%	76%	73%	57%	32%
Up to elementary school, %	44%	73%	49%	52%	10%
High school, %	43%	25%	46%	35%	62%
College, %	12%	2%	6%	13%	28%
Female, %	50%	52%	49%	51%	51%
Each income quintile, %	20%	20%	20%	20%	20%
Mean (*s*) age, y	40.57 (17.35)	33.70 (15.42)	36.48 (15.84)	42.26 (17.05)	47.53 (18.54)
Unweighted *N*	150,634	22,172	37,788	47,238	43,439

Analyses

Our main research question asked whether, worldwide and in each country-income category, adult age was associated with low numeracy despite accounting for education. For the world and each country-income category, multilevel logistic regressions modeled low numeracy as a function of age (models 1-5A, Table 2). Age was divided by 10 to make odds ratios easier to interpret. We included dummy variables for elementary school and high school (v. college), female (v. not), participants' country-specific income quintiles (v. richest 20%), and country-income categories (v. high-income country). Models treated participants as nested within countries, with random intercepts for each country. We subsequently added relationships between quadratic age and low numeracy (model 1-5B, Table 2).

Our additional research question asked whether, worldwide and for each country-income category, age differences in numeracy were more pronounced among people with lower education. Models 1-5A examined the association of numeracy with having completed up to elementary school or high school (v. college). We added interactions of education with age (models 1-5C, Table 2) and age × age (models 1-5D, Table 2). We examined whether relationships of numeracy with age, education, and age × education interacted with whether participants lived in low-income, lower-middle income, and upper-middle income (v. high-income) countries (Supplementary Table S3). To facilitate the interpretation of age × education interactions, we examined the relationship between age and low numeracy separately for each education level (Supplementary Tables S4–S8).

Analyses were conducted in SPSS version 26, using Gallup's statistical projection weights to improve representativeness. Preliminary analyses were published elsewhere but did not include regressions examining age differences in numeracy by country-income category and education.[7,24] Our funder informed the design of the World Risk Poll, but not our analyses.

Results

Age Differences in Low Numeracy

Descriptive statistics showed that low numeracy was associated with older age in each country-income category (Figure 1A), although numeracy was more common in low-income countries than in high-income countries (Table 1).[7] Adults aged 70 + y were more likely to be low-numerate than 15- to 19-y-olds in 124 of 140 countries, with the largest difference (+ 62%) emerging in Singapore (Supplementary Table S1). Globally, low numeracy affected 58% of teens, 57% of 20-somethings, 58% of 30-somethings, 59% of 40-somethings, 61% of 50-somethings, 66% of 60-somethings, and 64% of participants aged 70 + y.

Multilevel logistic regressions accounting for education found that, around the world, a 10-y increase in age was associated with having 1.16 times the odds of low numeracy (models 1A, Table 2). The relationship between older age and low numeracy was significant for each country-income category, with odds ratios varying from 1.09 for lower-middle income countries to 1.24 for upper-middle income countries (model 2-5A, Table 2). Although low numeracy varied by country-income categories, the relationship between older age and low numeracy did not differ significantly between high-income countries and lower country-income categories (Table S3). Quadratic age was not significantly associatied with low numeracy in global analyses (model 1-5B, Table 2). Quadratic age reached significance only in lower-middle and upper-middle income countries, but effects were in opposite directions. As seen in Figure 1, lower-middle income countries showed a U-shaped relationship between age and low numeracy with teens and 30-somethings being more likely to have low numeracy than 20-somethings and an increase in low numeracy being observed across subsequent age groups. For upper-middle income countries, Figure 1 shows an inverted U-shaped relationship

Table 2 Odds Ratios (95% Confidence Interval) from Multilevel Logistic Regressions Predicting Low Numeracy

	Model 1: World	Model 2: Low-Income Countries	Model 3: Lower-Middle Income Countries	Model 4: Upper-Middle Income Countries	Model 5: High-Income Countries
Model version A					
Age (divided by 10)	1.16*** (1.08, 1.25)	1.14*** (1.08, 1.20)	1.09*** (1.05, 1.14)	1.24*** (1.12, 1.36)	1.12*** (1.09, 1.15)
Up to elementary school (v. college)	3.51*** (2.91, 4.25)	2.96*** (1.65, 5.30)	3.35*** (2.48, 4.52)	3.21*** (2.42, 4.26)	3.76*** (2.99, 4.74)
High school (v. college)	1.92*** (1.58, 2.35)	1.46 (.96, 2.22)	1.81*** (1.58, 2.07)	1.75*** (1.24, 2.48)	2.14*** (1.53, 2.99)
Model version B					
Quadratic age	1.01 (1.00, 1.03)	0.99 (0.98, 1.01)	0.99* (0.98, 1.00)	1.03*** (1.02, 1.05)	1.01 (0.99, 1.03)
Model version C					
Age (divided by 10) × up to elementary school (v. college)	1.17*** (1.03, 1.33)	1.55*** (1.15, 2.08)	1.07 (0.96, 1.19)	1.29*** (1.15, 1.44)	1.06 (.90, 1.24)
Age (divided by 10) × high school (v. college)	1.06* (1.00, 1.12)	1.44* (1.05, 1.99)	1.08 (1.00, 1.18)	1.07 (0.98, 1.18)	1.00 (0.91, 1.11)
Model version D					
Quadratic age × up to elementary school (v. college)	0.97 (0.94, 1.00)	0.87 (0.76, 1.00)	0.95 (0.90, 1.00)	0.98 (0.93, 1.04)	0.98 (0.95, 1.01)
Quadratic age × high school (v. college)	0.99 (0.96, 1.22)	0.85* (0.74, 0.98)	0.98 (0.94, 1.03)	1.02 (0.96, 1.08)	1.00 (0.96, 1.03)

Full main effects models with control variables (models 1-5A) appear in Supplementary Table S2. Variables in Models B, C, and D, were consecutively added to associated Model A. Multilevel models treated participants as nested in countries, used random intercepts for each country, and controlled for female gender (v. not) and whether or not participants' income fell into 1 of the 4 lowest quintiles (v. richest 20%). Worldwide analyses also controlled for whether participants lived in a low-income country, lower-middle income country, or upper-middle income country (v. high-income country). Quadratic age reflects age × age, with age divided by 10. Main effects were controlled for when interactions were included. Weights were used in these analyses.
***$P < 0.001$; $P < 0.05$.

between age and low numeracy, with low numeracy being lowest in teens and highest in 60-somethings, but individuals aged 70 + y outperforming 60-somethings.

Age Differences in Low Numeracy by Education

Worldwide, 80% of participants aged 60 to 69 y with up to elementary school education were low numerate, while 24% of college-educated participants aged 60 to 69 y were low numerate (Figure 1B). Similar patterns emerged in each country-income category (Figure S1A–D). Multilevel logistic regressions accounting for other characteristics found that, for the world and each country-income category, participants with up to elementary school education had about 3 times the odds of low numeracy, and participants with a high school education had about twice the odds of low numeracy, compared with college-educated participants (model 1-5A, Table 2). These relationships did not significantly differ between high-income countries and lower country-income categories (Supplementary Table S3).

The relationship between age and low numeracy appeared strongest among adults with up to an elementary school education (Table 3). Indeed, interactions of age with having completed up to elementary school (Table 2) or high school (v. college) reached significance across the world and in low-income countries. The interaction between age and having completed up to elementary school (v. college) was also significant for upper-middle income countries. Yet, these interactions were similar for each country-income category, as compared with high-income countries (Supplementary Table S3). The one exception was the interaction between age and having completed elementary school (Supplementary Table S3), which was stronger for upper-middle than for high-income countries (Table 3).

Discussion

Worldwide and in each country-income category, we find that older age is associated with low numeracy, even after accounting for education. Thus, previous findings hold beyond traditionally studied high-income countries. Globally, age differences in low numeracy were slightly more pronounced among individuals with lower education.

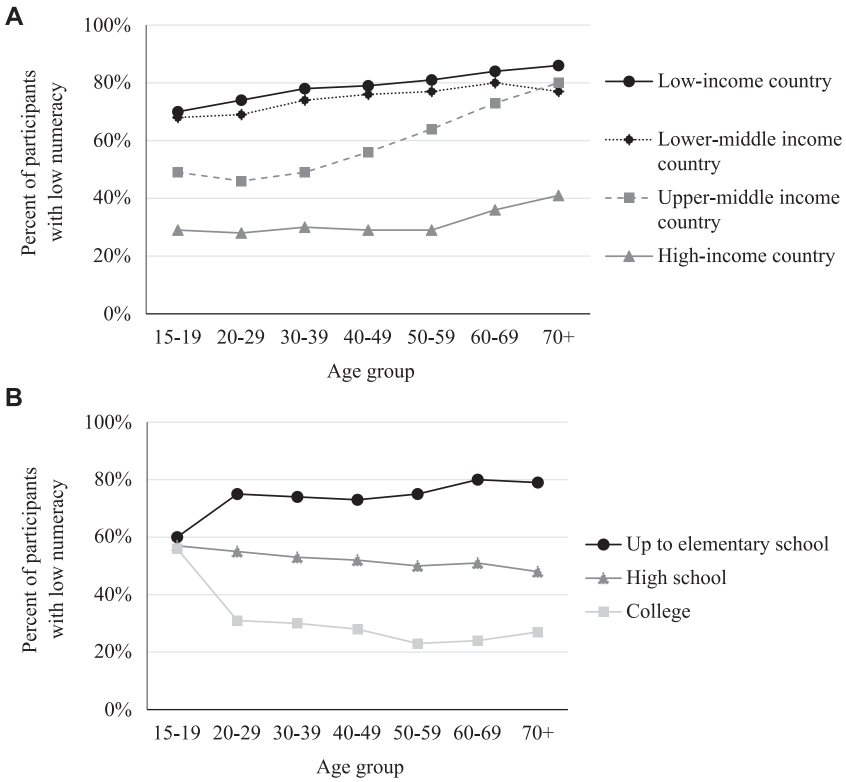

Figure 1 Percentage of participants with low numeracy by age group (A) in each country-income category and (B) by education across the world.

Table 3 Odds Ratios (95% Confidence Interval) for Age, from Multilevel Logistic Regressions Predicting Low Numeracy, by Educational Attainment[a]

	Model 1: World	Model 2: Low-Income Countries	Model 3: Lower-Middle Income Countries	Model 4: Upper-Middle Income Countries	Model 5: High-Income Countries
Age (divided by 10), among participants with up to elementary school education	1.24*** (1.11, 1.38)	1.16*** (1.10, 1.22)	1.10*** (1.05, 1.16)	1.34*** (1.23, 1.46)	1.15** (1.05, 1.27)
Age (divided by 10), among participants with high school education	1.11*** (1.08, 1.15)	1.09 (0.99, 1.20)	1.10*** (1.05, 1.14)	1.13** (1.05, 1.22)	1.11*** (1.08, 1.14)
Age (divided by 10), among participants with college education	1.09*** (1.03, 1.16)	0.82** (0.72, 0.95)	1.06 (0.99, 1.13)	1.08*** (1.05, 1.12)	1.13*** (1.00, 1.28)

[a]Full models with control variables appear in Supplementary Tables S4 to S8 for the world and each country-income category. Multilevel models treated participants as nested in countries, used random intercepts for each country, and controlled for female gender (v. not) and whether or not participants' income fell into the 1 of the 4 lowest quintiles (v. richest 20%). Weights were used in these analyses.
***$P < 0.001$; **$P < 0.01$.

Yet, many college-educated adults aged < 60 y were unable to answer whether 10% is the same as 1 in 10. Even educated health care professionals may struggle to understand probabilities.[25] Whether education promotes better numeracy may depend on how much and how well math is taught.

One limitation of our cross-sectional analyses is the confounding of cohort and aging effects. Findings may reflect older cohorts' limited training in numeracy, as well as age-related declines in fluid cognition. Because we did not follow individuals over time, leaving it unclear whether younger cohorts may be better able than older cohorts to preserve their numeracy skills into older age. Second, we analyzed a single-item numeracy assessment, although country-level observations did reliably correlate with OECD's 37-country multi-item numeracy assessments.[19] Third, education may not be comparable across country-income categories: in 2018–2019, high-income countries spent 4.7% of GNI on education, while upper-middle and lower-middle income countries spent 4.3% and low-income countries spent 3.5%.[26] Fourth, we had no measures of fluid or crystallized cognitive abilities. Fifth, we had no information about employment, even though an Australian study showed that numeracy may be learned on the job.[27]

Investments in education should help to reduce low numeracy in countries. For example, Singapore's efforts to reduce dropouts and improve math education likely increased younger cohorts' numeracy, which may benefit them into older adult age.[28] Interventions outside the classroom also show promise for improving students' numeracy, including text messages encouraging caregivers to engage children in numerical tasks.[29]

In addition, low-numerate adults may be best reached through interventions that teach numeracy within specific contexts of relevance to them.[30] In various European countries, family-based and workplace programs have been launched to target low-numerate adults.[30] A digital financial education intervention in Colombia improved numeracy among adults in poor rural communities in the context of financial decisions.[31] However, such digital interventions may work less well for older adults with low numeracy, who may lack the skills and confidence to use computers.[30] Studies in high-income countries have found that low-numerate adults may understand health risk information better when health risks are visualized in icon graphs or explained through narratives that explain what the numbers mean.[32–34] The Agency for Healthcare Research and Quality has created a Health Literacy Universal Precautions Toolkit, which aims to help primary care practices to make health communications more understandable for patients at all skill levels.[35] Such interventions should be developed to help adults with low numeracy around the world to understand and use numbers in the context of important life decisions.

Ethical Approval

Ethical approval was obtained at Gallup (2018-10-01).

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Supplemental Material

Supplementary material for this article is available on the *MDM Policy & Practice* Web site at https://journals.sagepub.com/home/mpp.

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