THE LANCET
Global Health

Supplementary appendix

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Supplement to: Stevens GA, Beal T, Mbuya MNN, et al. Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys. *Lancet Glob Health* 2022; **10:** e1590–99.

Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys

Appendix

CONTENTS

1. Objective

We aimed to estimate the prevalence of at least one micronutrient deficiency in non-pregnant women of reproductive age (15-49 years) and preschool-aged children (6-59 months) during the period 2003-2019, globally and in seven epidemiologically relevant groups of countries (listed in Appendix Table 1 and referred to as regions in the text). Our analysis focused on non-pregnant women of reproductive age and pre-school aged children because data on micronutrient status are most often available for these population groups. Our analysis included the following seven steps:

1. Establish consensus on a set of sentinel micronutrients, and their biomarkers that should be included in the analysis;
2. Identify, review, access, and include population-based individual-level biomarker datasets containing at least two of the six sentinel micronutrients;
3. Adjust the micronutrient biomarker concentrations for inflammation, where applicable, using the Biomarkers Reflecting Inflammation and Nutritional Determinants of Anemia (BRINDA) approach and apply thresholds to identify individuals with deficiencies in each micronutrient;
4. Identify three core micronutrients for pre-school children and non-pregnant women, that is, micronutrients whose deficiencies often occur alone and which are more commonly measured;
5. Include in the global and regional analysis data sources identified in step 2 that measure at least two of the three core micronutrients identified in step 4;
6. Apply regression models to adjust the prevalence of deficiency for the unmeasured micronutrient when only two of the three core micronutrients were measured; and
7. Apply statistical models to estimate the global and regional prevalence and number of PSC and NPW with one or more core MNDs.

These estimates have been documented following the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) (1). The locations where GATHER reporting items are reported are given in Appendix Table 2.

Appendix Table 1. Countries/territories in each geographic region or analysis grouping.[1]

Region or analysis grouping	Countries/territories
East Asia & Pacific	Cambodia, China, Democratic People's Republic of Korea, Fiji, Indonesia, Kiribati, Lao People's Democratic Republic, Malaysia, Micronesia (Federated

[1] World Bank Group geographic regions are used, with countries classified by the World Bank as high-income countries in calendar year 2020 (22) grouped separately.

Region or analysis grouping	Countries/territories
	States of), Mongolia, Myanmar, Papua New Guinea, Philippines, Samoa, Solomon Islands, Thailand, Timor-Leste, Tonga, Vanuatu, Vietnam
Europe & Central Asia	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Georgia, Kazakhstan, Kyrgyzstan, Montenegro, Republic of Moldova, Republic of North Macedonia, Romania, Russian Federation, Serbia, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan
High Income	Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Brunei Darussalam, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Poland, Portugal, Puerto Rico, Qatar, Republic of Korea, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States of America, Uruguay
Latin America & Caribbean	Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Venezuela
Middle East & North Africa	Algeria, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Lebanon, Libya, Morocco, Occupied Palestinian Territory, Syrian Arab Republic, Tunisia, Yemen
South Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka
Sub-Saharan Africa	Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe

Appendix Table 2. Locations of GATHER reporting items for *Revealing the prevalence of "hidden hunger": global and regional estimates of micronutrient deficiencies among preschool-age children and non-pregnant women of reproductive age*.

Item #	Checklist item	Location reported
Objectives and funding		
1	Define the indicator(s), populations (including age, sex, and geographic entities), and time period(s) for which estimates were made.	Appendix section 1
2	List the funding sources for the work.	Abstract
Data Inputs		
For all data inputs from multiple sources that are synthesized as part of the study:		
3	Describe how the data were identified and how the data were accessed.	Appendix section 2
4	Specify the inclusion and exclusion criteria. Identify all ad-hoc exclusions.	Appendix sections 2 and 5
5	Provide information on all included data sources and their main characteristics. For each data source used, report reference information or contact name/institution, population represented, data collection method, year(s) of data collection, sex and age range, diagnostic criteria or measurement method, and sample size, as relevant.	Appendix section 5, https://github.com/GAINAlliance/hiddenhunger
6	Identify and describe any categories of input data that have potentially important biases (e.g., based on characteristics listed in item 5).	Appendix section 3
For data inputs that contribute to the analysis but were not synthesized as part of the study:		
7	Describe and give sources for any other data inputs.	Appendix sections 6-7
For all data inputs:		
8	Provide all data inputs in a file format from which data can be efficiently extracted (e.g., a spreadsheet rather than a PDF), including all relevant meta-data listed in item 5. For any data inputs that cannot be shared because of ethical or legal reasons, such as third-party ownership, provide a contact name or the name of the institution that retains the right to the data.	https://github.com/GAINAlliance/hiddenhunger
Data analysis		
9	Provide a conceptual overview of the data analysis method. A diagram may be helpful.	Appendix section 1
10	Provide a detailed description of all steps of the analysis, including mathematical formulae. This description should cover, as relevant, data	Appendix sections 3, 6, 7

Item #	Checklist item	Location reported
	cleaning, data pre-processing, data adjustments and weighting of data sources, and mathematical or statistical model(s).	
11	Describe how candidate models were evaluated and how the final model(s) were selected.	Appendix sections 6-7
12	Provide the results of an evaluation of model performance, if done, as well as the results of any relevant sensitivity analysis.	Appendix sections 6-7
13	Describe methods for calculating uncertainty of the estimates. State which sources of uncertainty were, and were not, accounted for in the uncertainty analysis.	Appendix sections 6-7
14	State how analytic or statistical source code used to generate estimates can be accessed.	https://github.com/GAINAlliance/hiddenhunger
Results and Discussion		
15	Provide published estimates in a file format from which data can be efficiently extracted.	https://github.com/GAINAlliance/hiddenhunger
16	Report a quantitative measure of the uncertainty of the estimates (e.g. uncertainty intervals).	Table 4
17	Interpret results in light of existing evidence. If updating a previous set of estimates, describe the reasons for changes in estimates.	Paragraph 1 of discussion
18	Discuss limitations of the estimates. Include a discussion of any modelling assumptions or data limitations that affect interpretation of the estimates.	Paragraph 4 of discussion

2. Data identification, access and initial inclusion

Following advice from the Advisory Panel to USAID Advancing Nutrition, an initial set of sentinel micronutrients were selected for which: (1) biomarkers are commonly collected at the population level along with other micronutrient biomarkers within the same individuals, (2) the consequences of deficiency can be severe and long-term, and (3) prevalence of deficiency is high in many countries. Six micronutrients were selected as sentinel micronutrients: iron, vitamin A, zinc, vitamin B_{12}, folate, and vitamin D. Iodine was excluded because it is not typically measured along with other micronutrient status biomarkers within the same individuals. Population-level biomarker data are collected in population-based household surveys, in which blood samples are collected from a randomly selected sample of a population (hereafter called nutrition surveys). These nutrition surveys were the primary data source for this analysis.

The aim of this analysis was to determine the prevalence of at least one micronutrient deficiency, which requires information on the overlap among multiple micronutrient deficiencies at the individual level. Such data are not typically reported together with the results of nutrition surveys, which are generally limited to reporting the prevalence of each micronutrient deficiency separately. Therefore, our data search and access strategy was designed to obtain access to individual-level nutrition survey databases, while ensuring that the sources were representative of the population at the national level or at least three first-level administrative divisions within the country. Our primary source of data was datasets already compiled by the BRINDA collaboration[2], which were all assessed for inclusion. A supplemental search was conducted to identify additional datasets, particularly recent nationally representative datasets from countries with large populations. We searched "micronutrient deficiencies" and "country name" for the 50 most populous countries in Google and Google Scholar and reviewed the first 10 results from each search, sorted by relevance. We reviewed the Micronutrients Database of the WHO Vitamin and Mineral Nutrition Information System and reached out to our network of collaborators and the expert advisory group supporting this analysis for additional data sets. We requested access to all additional qualifying datasets identified from this supplemental search process.

We initially included data sources if:

- Plasma or serum (hereafter referred to as serum) concentrations of biomarkers of at least two of six sentinel micronutrients—serum ferritin, serum retinol or retinol-binding protein (RBP), serum zinc, serum folate or red blood cell (RBC) folate, serum vitamin B_{12}, and serum 25(OH)D—were measured in children aged 6-59 months or non-pregnant women aged 15-49 years;
- C-reactive protein (CRP) or α-1-acid-glycoprotein (AGP) was measured in the same population;
- a probabilistic sampling method with a defined sampling frame was used and data were representative of at least three first administrative units within a country;
- data were collected in or after 2005 (including surveys that commenced prior to 2005); and
- we were able to obtain anonymized individual-level data for reanalysis.

From the individual-level data, we included data on children aged 6 to 59 months and non-pregnant women aged 15 to 49 years. Measurement of biomarkers of micronutrient status in children younger than 6 months of age is not common in surveys because it requires a blood sample. For this reason, most data sources exclude infants younger than 6 months by design. Some surveys that were designed to capture children under 5 years of age included some children who were 60 months of age; we included the measurements on

[22] https://brinda-nutrition.org/about-us/brinda-countries/

60-month-old children. Some data sources did not cover the full target age range. We included these data as long as any children 6-59 months or non-pregnant women aged 15-49 years were included in the study/survey sample. Age ranges for each included data source are reported in Section 5. We included data collected in or after 2005 (including surveys that commenced earlier), in order to maximize inclusion of recent surveys in low-and-middle income countries, without including older data from high-income countries.

All biomarker data were converted to SI units. To identify possible error codes or other data quality issues, discrete histograms of biomarker or inflammation marker values were visually inspected. Based on these inspections, we excluded the following data:

- serum folate data, Pakistan 2011 non-pregnant women: 40% of observations were at the lower (1.42) or upper (45.3) bounds of the distribution.
- serum B_{12} data, Ethiopia 2015 pre-school aged children: the serum B_{12} distribution was bimodal (which is atypical) and the data were not included in the survey's final report.

In other survey-biomarker pairs, up to 10% of observations were assigned a plausible low or high value, which were presumed to be values that were below or above the analytical limit of detection. These data were included, as is appropriate when computing prevalence estimates.

Exclusion of biologically implausible values is recommended when analysing nutrition survey data, however, standard plausible ranges are not currently well defined (2). Implausible values may bias regression coefficients. In contrast, infrequent implausible values have a limited effect on prevalence values. Visual inspection of discrete histograms (described above) revealed few apparent implausible values in the included datasets. Because apparent outliers were infrequent, the main motivation for removing implausible values is to avoid biasing regression coefficients. Therefore, outliers were identified considering the distribution of logged values of biomarkers included in adjustment regressions (described in Section 3). Outliers were identified based on all individual-level data included from the BRINDA collaboration, which represents a wide range of populations and nutritional statuses. Conservative outlier thresholds were chosen: six median absolute deviations (MADs) above and below the median log value. Any observation falling outside the range defined by the outlier thresholds was removed for all subsequent analyses, including adjustment regressions and computation of prevalence of deficiency (described in Section 3). Outlier thresholds are shown in Appendix Table 3.

Appendix Table 3. Thresholds for excluding outliers prior to fitting regressions to adjust for inflammation.

	Pre-school aged children (6-59 months)		Non-pregnant women of reproductive age (15-49 years)	
Biomarker	**Lower exclusion threshold**	**Upper exclusion threshold**	**Lower exclusion threshold**	**Upper exclusion threshold**
Serum ferritin (µg/l)	0.11	6412	0.094	12978
Serum zinc (µmol/L)	1.6	62	not adjusted for inflammation	
Retinol binding protein (µmol/L)	0.15	5.7		
Serum retinol (µmol/L)	0.082	8.4		
AGP (g/L)	0.098	8.0	0.12	5.2
CRP (mg/L)	0	48291	0	4064

3. Adjustment for inflammation and application of thresholds for deficiency

Concentrations of some micronutrient biomarkers are affected by inflammation, including inflammation caused by acute infection (3). These may lead to under- or over-estimates of the prevalence of micronutrient deficiency. Several analytic approaches have been proposed to adjust for inflammation prior to computing prevalence of deficiency (3). We applied the BRINDA regression adjustments for inflammation, which are described elsewhere (3–5). Briefly, separate regressions relating each log micronutrient biomarker concentration to one or two markers of inflammation are fit. The basic ordinary-least-squares regression takes the following form:

$$\ln(MB) \sim \alpha + \beta_1 \ln(CRP) + \beta_2 \ln(AGP)$$

Where MB is the serum micronutrient biomarker concentration, CRP is C-reactive protein, and AGP is α-1-acid-glycoprotein. The regression is modified if CRP or AGP is not measured in the survey dataset. Individual serum micronutrient biomarker concentrations are then counterfactually adjusted to a reference level of AGP and/or CRP, as specified by the BRINDA regression approach (3–5). For some included surveys, the BRINDA reference level of CRP—0.10 mg/L in pre-school aged children and 0.16 mg/L in non-pregnant women—were below the survey's level of detection for CRP. In those cases, the BRINDA approach is to modify the regressions to counterfactually adjust serum micronutrient biomarker concentration to the

specific survey's lower level of detection, to avoid adjusting serum micronutrient biomarker values in individuals without inflammation. Included surveys with CRP limits of detection above the BRINDA thresholds are as follows:

- Ecuador 2012, 1.9 mg/L
- Bangladesh 2012, 0.3 mg/L
- United Kingdom 2008-19 and Georgia 2008: 1.0 mg/L
- India 2016-18, level of detection varied with a maximum of 3.3 mg/L

The specific micronutrient-population groups on which this adjustment was carried out are summarized in Appendix Table 4.

Definitions of deficiency are summarized in Appendix Table 4. Included surveys used a variety of folate assays (Appendix Table 8), which may affect folate measurements. Rogers and colleagues have recommended that assay-adjusted folate cutoffs should be used (6). We applied assay factors to adjust the WHO folate thresholds listed in Appendix Table 4. These survey-specific factors were obtained from Rogers and colleagues (6) if available, or if not, were provided by the US CDC (personal communications, Christine Pfeiffer, 11 November 2021 and 16 November 2021). The WHO thresholds were derived from measurements obtained by radioimmunoassay and in that context indicate metabolic folate insufficiency where homocysteine concentrations start to rise, which is indicative of increased risk of neural tube defects. However, when these thresholds are applied to measurements obtained by or adjusted to the microbiologic assay, as in our study, they are closer to the thresholds indicating risk of megaloblastic anaemia (<7 nmol/L for serum folate and <305 nmol/L for RBC folate (7)). We chose to use these thresholds because they reflect what is more commonly considered folate deficiency. However, we recognize that our estimates of folate deficiency will be lower than estimates of folate insufficiency and there is thus a need to reach global consensus on how to assess folate status for public health significance. Zinc thresholds were selected based on survey protocols, including time of day of blood collection and fasting/non-fasting blood collection (see Appendix Table 4). Survey-specific thresholds for zinc and folate are shown in Appendix Tables 6 and 7.

Appendix Table 4. Definition of deficiency and adjustment for inflammation for each included biomarker.

Micronutrient	Biomarker	Definition of deficiency	Population	Adjust for inflammation?
Vitamin B_{12}	Serum B_{12}	< 150 pmol/L (8)	All	No (9)
Folate[1]	RBC folate	< 340 nmol/L (8)	All	No (9)
Folate[1]	Serum folate	< 10 nmol/L (8)	All	No (9)
Vitamin A[2]	Serum retinol	< 0.7 µmol/L (10)	All	Pre-school children only (4)
Vitamin A[2]	Retinol-binding protein	< 0.7 µmol/L (11,12)	All	Pre-school children only (4)
Zinc[3]	Serum zinc	< 9.9 µmol/L (13)	Children < 10 years (morning, non-fasting)	Yes, provided conditions are met (5)
Zinc[3]	Serum zinc	< 8.7 µmol/L) (13)	Children < 10 years (afternoon, non-fasting)	Yes, provided conditions are met (5)
Zinc[3]	Serum zinc	< 10.7 µmol/L (13)	Females ≥ 10 years (morning, fasting)	No (5)
Zinc[3]	Serum zinc	< 10.1 µmol/L (13)	Females ≥ 10 years (morning, non-fasting)	No (5)
Zinc[3]	Serum zinc	< 9.0 µmol/L (13)	Females ≥ 10 years (afternoon, non-fasting)	No (5)
Iron	Serum ferritin	< 12 µg/l (14)	Children < 5 years	Yes (3)
Iron	Serum ferritin	< 15 µg/l (14)	Individuals ≥ 5 years	Yes (3)
Vitamin D	Serum 25-hydroxyvitamin D	< 25 nmol/L (15)	All	No

1. When both RBC folate and serum folate are measured in a survey, RBC folate data were used. Folate thresholds were adjusted for survey assay (see text and Appendix Tables 6 and 7).
2. When both serum retinol and RBP are measured in a survey, serum retinol was used provided that it was available for the full biological measurement sample. If serum retinol was only available for a subsample, RBP data were used.
3. For surveys with blood collection throughout the day or if the blood collection protocol was not reported, the average of the morning non-fasting and afternoon non-fasting cutoffs was used (i.e., < 9.3 µmol/L for children and < 9.55 µmol/L for women). Specific thresholds used for each survey are listed in Section 5.

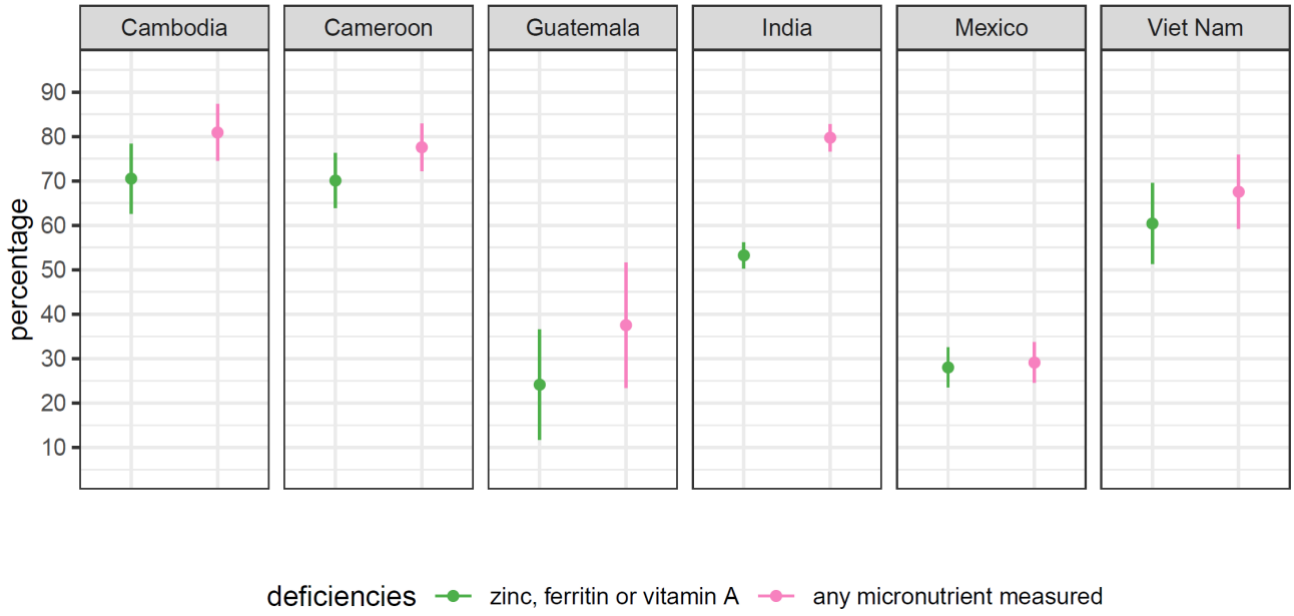
4. Selection of core micronutrients

Few datasets measuring all six sentinel micronutrients in the same individuals were identified (4 in non-pregnant women, 2 in pre-school aged children). Estimation of the prevalence of any of the six deficiencies would require extrapolation from these studies to all populations worldwide. Therefore, we sought to

simplify the analysis by reducing the number of micronutrients included in the global and regional analysis. Our aim was to identify a maximum of three core micronutrients that could be used to identify the majority of individuals with any micronutrient deficiency. Limiting the analysis to three micronutrient deficiencies reduced the number of assumptions and modelling steps that were required. Two factors were considered: (1) micronutrient deficiencies that have a higher prevalence and/or often occur alone and are, therefore, needed to capture a large proportion of individuals with any deficiency, and (2) micronutrients that are more frequently measured in the datasets initially included. Figures 1 and 2 (main paper) show the prevalence of any deficiency, by deficiency type, in surveys that measured at least 5 of the sentinel micronutrients. In these surveys, which were carried out in a variety of settings, iron deficiency and zinc deficiency frequently occurred alone for both pre-school children and non-pregnant women. These micronutrients also had the highest median prevalence of deficiency in the initially included datasets. For non-pregnant women, folate deficiency also had a higher median prevalence of deficiency than the other sentinel micronutrients, and frequently occurred alone (main paper Figure 2). For non-pregnant women, we selected zinc, iron and folate as core micronutrients. For children, the range of prevalence of vitamin D deficiency (IQR 2.9%-13.9%), vitamin A deficiency (IQR 4.3%-15.4%), and folate deficiency (IQR 4.2%-17.9%) were similar in the initially included datasets, while vitamin B_{12} deficiency had a lower prevalence range. Vitamin A deficiency was measured in all but two datasets (US continuous NHANES and Mexico 2006), while vitamin D deficiency was measured in just 8 of 23 initially included datasets and folate deficiency was measured in just 10 of 23 initially included surveys. Therefore, for children, we selected zinc, iron and vitamin A as core micronutrients.

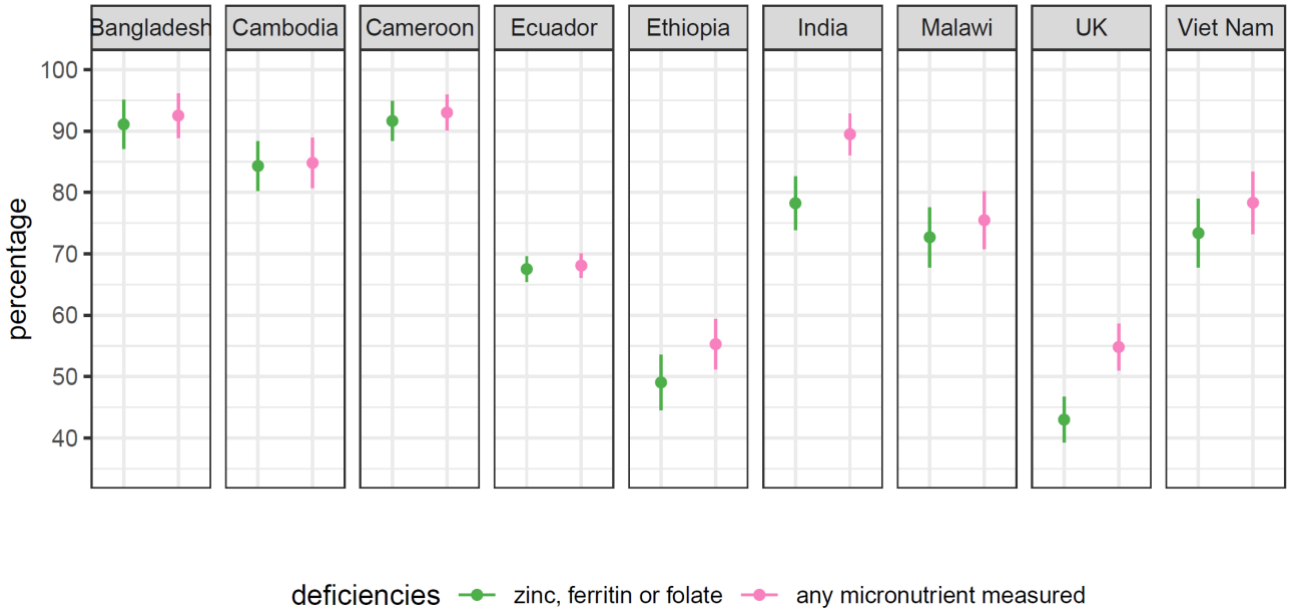
Appendix Figures 1 and 2 compare the prevalence of deficiency of any of the three core micronutrients to the prevalence of deficiencies of any of 5 or 6 sentinel micronutrients in the datasets that measured at least 5 sentinel micronutrients. For most surveys, the prevalence of any of the three core micronutrients was similar to that of any of the measured micronutrients.

Appendix Figure 1. Prevalence of any of three core micronutrient deficiencies and of any measured deficiencies, children 6-59 months. Surveys that measure at least 5 of 6 sentinel micronutrients, including all three core micronutrients, are shown.



Note: Surveys in Mexico and Guatemala did not measure folate, the survey in Cameroon did not measure vitamin D, and Vietnam did not measure vitamin B12. Surveys in India and Cambodia measured all six sentinel micronutrients. Age ranges varied by survey and are specified in Appendix Table 6. For comparison, prevalence of any of three core deficiencies was computed for the same individuals who had measurements for other sentinel micronutrients and prevalence values therefore may not match values in Table 2.

Appendix Figure 2. Prevalence of any of three core micronutrient deficiencies and of any measured deficiencies, nonpregnant women 15-49 years. Surveys that measure at least 5 of 6 sentinel micronutrients and all three core micronutrients are shown.

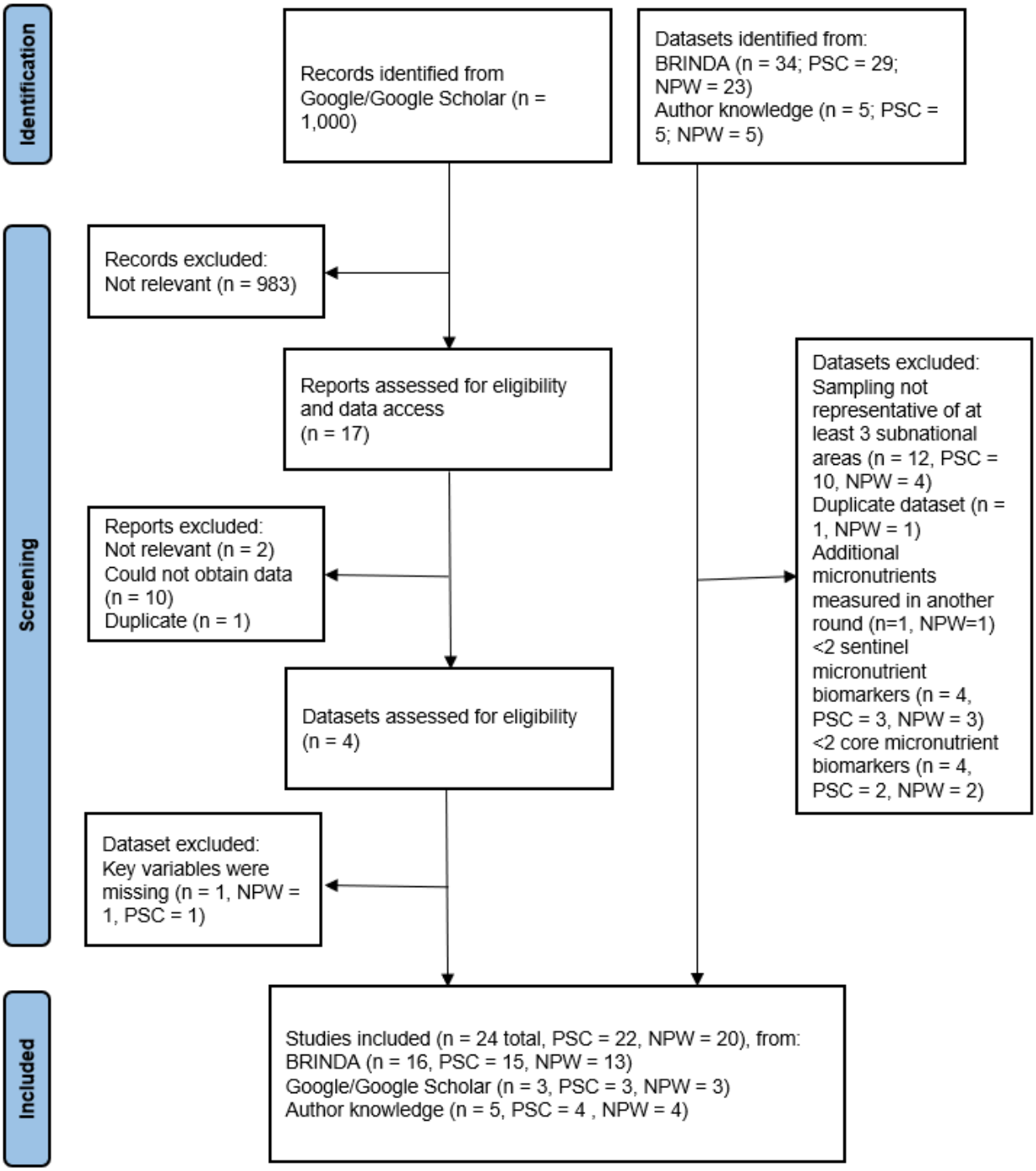


Notes: The following surveys did not measure vitamin D status: Bangladesh, Cameroon, Ecuador, Ethiopia, and Malawi; Ecuador data include ages 20-49 because vitamin A status was not available for women 15-19 years; India age range is 15-19 years. For comparison, prevalence of any of three core deficiencies was computed for the same individuals who had measurements for other sentinel micronutrients and prevalence values therefore may not match values in Table 3.

5. Inclusion of data sources in the global and regional analysis

Not all datasets identified in section 3 measured all three core micronutrients. We included datasets that measured at least two of three core micronutrients, with the third imputed if needed as described in section 6. This resulted in exclusion of two datasets for nonpregnant women (Colombia ENSIN 2010 and Liberia National Micronutrient Survey 2011) and two datasets for pre-school aged children (two rounds of US continuous NHANES). For continuous survey programs, we excluded cycles in which two of three micronutrients were measured, provided that cycles measuring all three core micronutrients were available. This resulted in exclusion of most cycles of the US NHANES (women) and Guatemala SIVESNU (both populations). This resulted in a total of 22 datasets covering pre-school aged children and 20 datasets covering nonpregnant women of reproductive age. These datasets, together with key characteristics, are listed in Appendix Tables 6 and 7, and the full data identification, access, and inclusion process is summarized in Appendix Figure 3.

Appendix Figure 3. Data identification, access and inclusion.



For each included dataset, the quantities listed in Appendix Table 5 were computed, as permitted by the biomarkers measured by the survey. If appropriate for the survey's design, prevalence of deficiency was computed using sample weights that reflect differential probability of selection into the sample. To reflect

the true availability of information, we estimated effective sample sizes based on the "*estat effects*" command of the Stata version 16.1 svy suite of commands (StataCorp, 2019).

Appendix Table 5. Types of prevalence computed for each survey and population as inputs to the calculation of the number of non-pregnant women aged 15-49 years and children aged 6-59 months with any core deficiency, as described in Section 6 and Section 7.

Metric	Numerator	Denominator
Preschool aged children aged 6-59 months		
Prevalence of any core micronutrient deficiency	Any child who is iron deficient, vitamin A deficient, or zinc deficient	All children with valid measurements of serum ferritin, vitamin A status, and serum zinc
Prevalence of either iron or vitamin A deficiency	Any child who is iron deficient or vitamin A deficient	All children with valid measurements of serum ferritin and vitamin A status
Prevalence of either iron or zinc deficiency	Any child who is iron deficient or zinc deficient	All children with valid measurements of serum ferritin and serum zinc
p(zinc deficiency|no vitamin A deficiency, no iron deficiency)	Any child who is zinc deficient	All children who are not iron or vitamin A deficient, and who have valid measurements of serum ferritin, vitamin A status, and serum zinc
p(vitamin A deficiency|no zinc deficiency, no iron deficiency)	Any child who is vitamin A deficient	All children who are not zinc or iron deficient, and who have valid measurements of serum ferritin, vitamin A status, and serum zinc
Non-pregnant women aged 15-49		
Prevalence of any core micronutrient deficiency	Any woman who is iron deficient, folate deficient, or zinc deficient	All women with valid measurements for serum ferritin, folate status, and serum zinc

Metric	Numerator	Denominator
Prevalence of either iron or folate deficiency	Any woman who is iron deficient or folate deficient	All women with valid measurements of serum ferritin and folate status
Prevalence of either iron or zinc deficiency	Any woman who is iron deficient or zinc deficient	All women with valid measurements of serum ferritin and serum zinc
p(zinc deficiency|no folate deficiency, no iron deficiency)	Any woman who is zinc deficient	All women who are not iron or folate deficient, and who have valid measurements of serum ferritin, folate status, and serum zinc
p(folate deficiency|no zinc deficiency, no iron deficiency)	Any woman who is folate deficient	All women who are not zinc or iron deficient, and who have valid measurements for serum ferritin, folate status, and serum zinc

Notes: Biomarkers were adjusted for inflammation if indicated, as described in Appendix section 3. Surveys which did not measure AGP or CRP were excluded. However, if an individual had a valid micronutrient biomarker value but an invalid or missing marker of inflammation, the individual was included without adjusting biomarker values for inflammation. It was not necessary to compute the prevalence of iron deficiency alone because it was measured in all included datasets.

Appendix Table 6. Included data sources and their characteristics (children 6-59 months). All data sources are nationally representative household surveys that measured at least one measure of inflammation (either AGP or CRP). Surveys are categorized as having measured iron deficiency if serum ferritin has been measured, as having measured vitamin A if serum retinol or RBP has been measured, and zinc if serum zinc is measured. Sample size noted here refers to the sample size for the core deficiencies measured in the survey. Cutoffs for zinc deficiency and folate deficiency are shown here because they vary by survey; cutoffs for all other deficiencies are shown in Appendix Table 4.

Country	Years	Age range (months)	Sample size	Core deficiencies measured	Zinc deficiency cutoff (µmol/l)	Serum folate cutoff (nmol/l)	RBC folate cutoff (nmol/l)	Data source
Afghanistan	2013	6-60	651	iron, vitamin A, zinc	9.3			National Nutrition Survey
Azerbaijan	2013	6-59	1019	iron, vitamin A, zinc	9.3			Azerbaijan Nutrition Survey
Bangladesh	2011	6-59	302	iron, vitamin A, zinc	9.3			National Micronutrients Status Survey 2011-12
Cambodia	2014	6-60	534	iron, vitamin A, zinc	9.9	15.9		Cambodia Demographic and Health Survey 2014
Cameroon	2009	12-60	776	iron, vitamin A, zinc	9.3	13.4		Engle-Stone, R., Ndjebayi, A. O., Nankap, M., & Brown, K. H. (2012). Consumption of potentially fortifiable foods by women and young children varies by ecological zone and socio-economic status in Cameroon. The Journal of Nutrition, 142(3), 555-565.
Colombia	2010	12-59	4091	iron, vitamin A, zinc	9.3			Encuesta Nacional de la Situación Nutricional (ENSIN)
Côte d'Ivoire	2007	6-59	746	iron, vitamin A				Rohner, F., Tschannen, A. B., Northrop-Clewes, C., Kouassi-Gohou, V., Bosso, P. E., & Mascie-Taylor, C. N. (2012). Comparison of a possession score and a poverty index in predicting anaemia and undernutrition in pre-school children and women of reproductive age in rural and urban Cote d'Ivoire. Public Health Nutrition, 15(9), 1620-1629.
Ecuador	2012	6-59	2017	iron, vitamin A, zinc	9.9	10.3	551	Encuesta Nacional de Salud y Nutrición (ENSANUT-2012)
Ethiopia	2015	6-59	1116	iron, vitamin A, zinc	9.3			Ethiopian National Micronutrient Survey
Ghana	2017	6-59	1165	iron, vitamin A				Ghana Micronutrient Survey

Country	Years	Age range (months)	Sample size	Core deficiencies measured	Zinc deficiency cutoff (µmol/l)	Serum folate cutoff (nmol/l)	RBC folate cutoff (nmol/l)	Data source
Guatemala	2013-2016	6-60	144	iron, vitamin A, zinc	9.3			Sistema de Vigilancia Epidemiológica de Salud y Nutrición (SIVESNU)
India	2016-2018	12-59	6514	iron, vitamin A, zinc	9.9		639	Comprehensive National Nutrition Survey (CNNS)
Liberia	2011	6-36	1434	iron, vitamin A				Liberia National Micronutrient Survey 2011
Malawi	2015-2016	6-59	1080	iron, vitamin A, zinc	9.3			Malawi Demographic and Health Survey 2015-2016
Mexico	2006	13-60	1253	iron, zinc	9.9	*		Encuesta Nacional de Salud y Nutrición (ENSANUT)
Mexico	2018-2019	12-48	965	iron, vitamin A, zinc	9.9			Encuesta Nacional de Salud y Nutrición (ENSANUT)
Mexico	2012	12-60	2595	iron, vitamin A		11.4		Encuesta Nacional de Salud y Nutrición (ENSANUT)
Nepal	2016	6-59	1647	iron, vitamin A, zinc	9.3		340	Nepal National Micronutrient Status Survey (NNMSS)
Nicaragua	2003-2005	6-60	953	iron, vitamin A				Sistema Integrado de Vigilancia de Intervenciones Nutricionales (SIVIN)
Pakistan	2011	6-59	6638	iron, vitamin A, zinc	9.3			Pakistan National Nutrition Survey
United Kingdom	2008-2019	12-48	140	iron, vitamin A		10	340	National Diet and Nutrition Survey (NDNS)
Vietnam	2010	11-60	360	iron, vitamin A, zinc	9.9	12		Laillou, A., Van Pham, T., Tran, N. T., Le, H. T., Wieringa, F., Rohner, F., et al. (2012). Micronutrient deficits are still public health issues among women and young children in Vietnam. PloS One, 7(4).

* An assay correction factor was not obtained for this survey.

Appendix Table 7. Included data sources and their characteristics (non-pregnant women 15-49 years). All data sources are nationally representative household surveys. Surveys are categorized as having measured iron deficiency if serum ferritin and one measure of inflammation (either AGP or CRP) have been measured, as having measured folate if serum folate or RBC folate have been measured, and zinc if serum zinc has been measured. Sample size noted here refers to the sample size for the core deficiencies measured in the survey. Cutoffs for zinc deficiency and folate deficiency are shown here because they vary by survey; cutoffs for all other deficiencies are shown in Appendix Table 4.

Country	Years	Age range (years)	Sample size	Core deficiencies measured	Zinc deficiency cutoff (µmol/l)	Serum folate cutoff (nmol/l)[1]	RBC folate cutoff (nmol/l)	Data source
Afghanistan	2013	15-49	1044	iron, zinc[2]	9.55			National Nutrition Survey
Azerbaijan	2013	15-49	2551	iron, folate		10		Azerbaijan Nutrition Survey
Bangladesh	2011	15-49	699	iron, folate, zinc	9.55	16.3		National Micronutrients Status Survey 2011-12
Cambodia	2014	16-49	689	iron, folate, zinc	10.1	15.9		Cambodia Demographic and Health Survey 2014
Cameroon	2009	15-47	332	iron, folate, zinc	9.55	13.4		Engle-Stone, R., Ndjebayi, A. O., Nankap, M., & Brown, K. H. (2012). Consumption of potentially fortifiable foods by women and young children varies by ecological zone and socio-economic status in Cameroon. The Journal of nutrition, 142(3), 555-565.
Côte d'Ivoire	2007	15-48	792	iron, folate		12		Rohner, F., Tschannen, A. B., Northrop-Clewes, C., Kouassi-Gohou, V., Bosso, P. E., & Mascie-Taylor, C. N. (2012). Comparison of a possession score and a poverty index in predicting anaemia and undernutrition in pre-school children and women of reproductive age in rural and urban Cote d'Ivoire. Public Health Nutrition, 15(9), 1620-1629.
Ecuador	2012	15-49	7230	iron, folate, zinc	10.7	10.3	551	Encuesta Nacional de Salud y Nutrición (ENSANUT-2012)
Ethiopia	2015	15-49	1607	iron, folate, zinc	9.55	13	442	Ethiopian National Micronutrient Survey
Georgia	2009	15-49	407	iron, folate		12		Georgia National Nutrition Survey
Ghana	2017	15-49	466	iron, folate		12		Ghana Micronutrient Survey

Country	Years	Age range (years)	Sample size	Core deficiencies measured	Zinc deficiency cutoff (µmol/l)	Serum folate cutoff (nmol/l)[1]	RBC folate cutoff (nmol/l)	Data source
Guatemala	2013-2016	15-49	209	iron, zinc	9.55			Sistema de Vigilancia Epidemiológica de Salud y Nutrición (SIVESNU)
India	2016-2018	15-19	2348	iron, folate, zinc	10.7		639	Comprehensive National Nutrition Survey (CNNS)
Malawi	2015-2016	15-49	746	iron, folate, zinc	9.55	10	340	Malawi Demographic and Health Survey 2015-2016
Mexico	2012	15-49	3603	iron, folate		11.4		Encuesta Nacional de Salud y Nutrición (ENSANUT)
Mexico	2006	15-49	1813	iron, zinc	10.7			Encuesta Nacional de Salud y Nutrición (ENSANUT)
Nepal	2016	15-49	2125	iron, folate, zinc	9.55		340	Nepal National Micronutrient Status Survey (NNMSS)
Pakistan	2011	15-49	7390	iron, zinc	9.55			Pakistan National Nutrition Survey
United Kingdom	2008-2019	15-49	1310	iron, folate, zinc	10.7	10	340	National Diet and Nutrition Survey (NDNS)
United States of America	2015-2016	15-49	551	iron, folate, zinc	9.55	10	340	National Health and Nutrition Examination Survey (NHANES)
Vietnam	2010	15-49	1348	iron, folate, zinc	10.1	12		Laillou, A., Van Pham, T., Tran, N. T., Le, H. T., Wieringa, F., Rohner, F., et al. (2012). Micronutrient deficits are still public health issues among women and young children in Vietnam. PloS one, 7(4).

Notes:

1. Assay correction factors were obtained from reference (6), Tables 2-5, if the survey was included. For remaining surveys, correction factors were provided by the US CDC.
2. Folate deficiency was measured, however, folate was measured in a subsample that did not overlap with zinc and ferritin measurements.

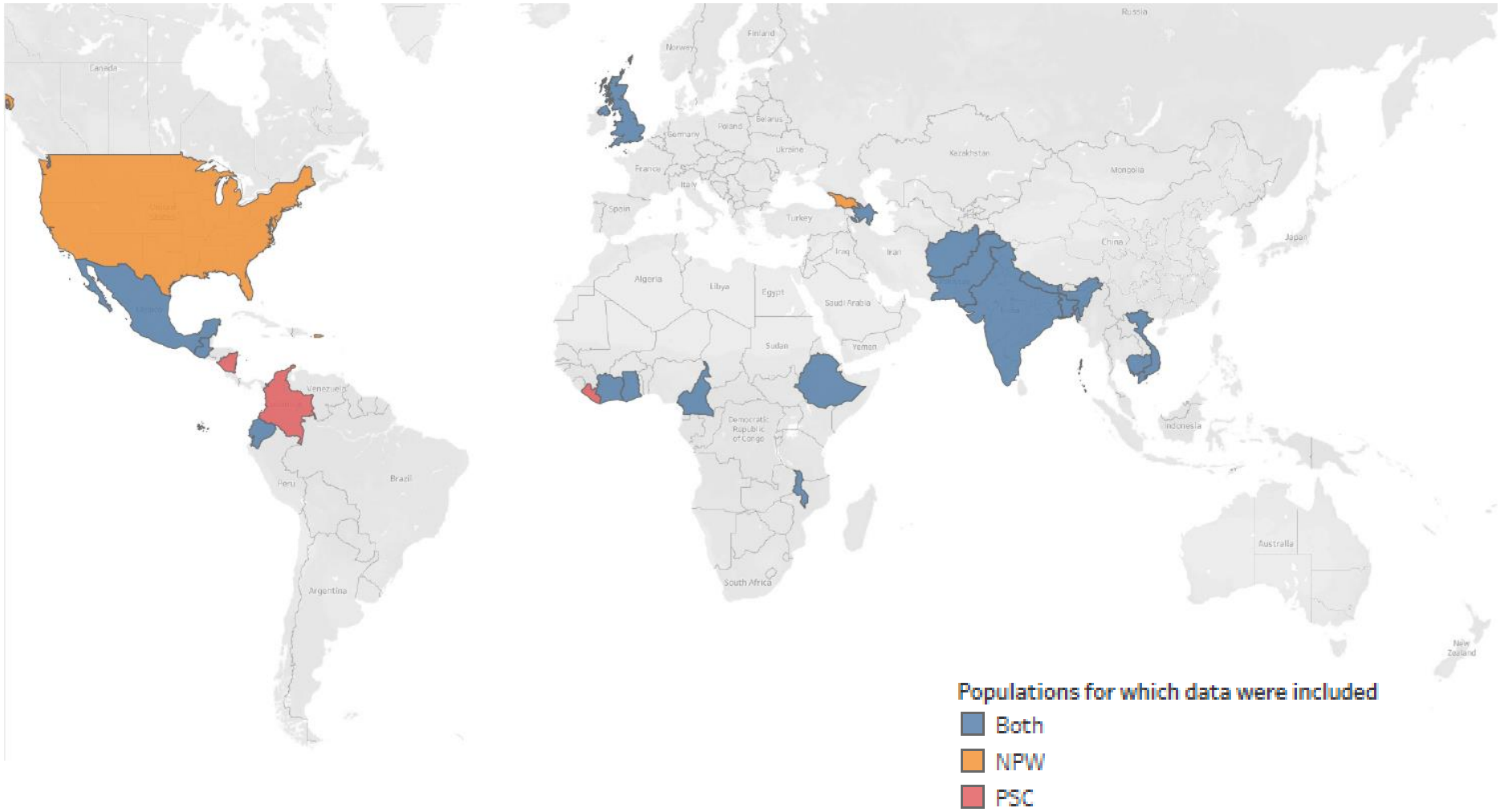
Appendix Table 8. Laboratory methods for each included survey and each biomarker used in our analysis of the prevalence of at least one of three core micronutrient deficiencies. Not determined indicates that we did not locate the information in the documentation.

Survey	Serum ferritin	Serum zinc	Retinol-binding protein	Serum retinol	Serum folate	RBC folate	AGP	CRP
Afghanistan, 2013	Not determined	AAS	-	Not determined	-	-	Not determined	Not determined
Azerbaijan, 2013	ELISA	coupled POES, using Variation Vista Pro	ELISA	-	MA	-	ELISA	ELISA
Bangladesh, 2011	ELISA	AAS	-	HPLC	PBA	-	TAI	TAI
Cambodia, 2014	ELISA	AAS	ELISA	-	PBA	-	ELISA	ELISA
Cameroon, 2009	ELISA	inductively-coupled atomic emission spectrometry	ELISA	-	PBA	-	ELISA	ELISA
Colombia, 2010	ECLIA	AAS	-	HPLC	-	-	-	TAI
Côte d'Ivoire, 2007	Dade-Behringer Dimension AR	-	Not determined	-	MA	-	Not determined	Dade-Behringer Dimension AR
Ecuador, 2012	ECLIA	AAS	-	HPLC	-	PBA	-	Not determined
Ethiopia, 2015	TAI	AAS	-	HPLC	-	MA	TAI	TAI
Georgia, 2009	photometric turbidimetric method using the "Turbi-Quick" Immuno/ Coagulation Analyzer	-	-	-	MA	-	-	photometric turbidimetric method using the "Turbi-Quick" Immuno/ Coagulation Analyzer
Ghana, 2017	ELISA	-	ELISA	-	Cobas e411 analyzer	-	Not determined	Not determined
Guatemala, 2013-2016	ELISA	AAS	ELISA	-	-	-	Not determined	Not determined
India, 2016-2018	2 site sandwich immunoassay	AAFS	-	HPLC Reverse phase chromatography	-	PBA	-	Nephelometry, Particle-enhanced immunonephelometry

Survey	Serum ferritin	Serum zinc	Retinol-binding protein	Serum retinol	Serum folate	RBC folate	AGP	CRP
Liberia, 2011	ELISA	-	ELISA	-	-	-	ELISA	ELISA
Malawi, 2015-2016	ELISA	Atomic emission spectrometry	ELISA	-	-	MA	ELISA	ELISA
Mexico, 2012	ECLIA	-	-	Not determined	PBA	-	-	TAI
Mexico, 2006	Dade-Behringer Dimension AR	coupled POES, using Variation Vista Pro	-	-	-	-	-	nephelometry
Mexico, 2018-2019	Not determined	Not determined	-	Not determined	-	-	-	Not determined
Nepal, 2016	ELISA	AAS	ELISA	-	-	MA	ELISA	ELISA
Nicaragua, 2003-2005	ELISA	-	-	HPLC	-	-	Not determined	-
Pakistan, 2011	TAI	AAFS	-	HPLC	-	-	TAI	TAI
United Kingdom, 2008-2019	Not determined	Not determined	-	Not determined	-	MA	-	Not determined
United States of America, 2015-2016	Roche Elecsys-170 (Sandwich)	ICP-DRC-MS	-	-	-	MA	-	Highly sensitive Near Infrared Particle Immunoassay rate methodology
Viet Nam, 2010	ELISA	AAFS	-	reverse-phase HPLC	MA	-	-	ELISA

Abbreviations: AAFS, atomic absorption flame spectroscopy; AAS, atomic absorption spectrophotometer; cELISA, Competitive enzyme-linked immunosorbent assay; ECLIA, electrochemiluminescence immunoassay; ELISA, enzyme-linked immunoassay; HPLC, High-Performance Liquid Chromatography; ICP-DRC-MS, Inductively coupled plasma dynamic reaction cell mass spectrometry; MA, microbiological assay; PBA, Protein binding assay; TAI, Turbidimetric Agglutination Immunoassay

Appendix Figure 4. Geographic distribution of included data sources. Two data sources on non-pregnant women and three data sources on pre-school aged children were obtained from Mexico; all other countries contributed no more than one data source per demographic group.



6. Methods for adjusting for unmeasured deficiencies

As discussed in Section 5, all data sources that measured at least two of three core micronutrients were included. Serum ferritin and at least one marker of inflammation were measured in all included datasets for both population groups (non-pregnant women and preschool aged children). Other core micronutrients were not measured in some datasets. Data sources that measured only two of the three core micronutrients underestimate the prevalence of deficiency when considering all three core micronutrients. To adjust for this bias, we estimated the prevalence of all three deficiencies in these datasets (Appendix Figure 5 illustrates this process). We initially aimed to do so by computing a correction factor for each of four country income groups, however, there were less than two data sources measuring all three core micronutrients in some country income-population groups. Therefore, we fit regressions with socio-demographic index (SDI) as a country-and-year-level covariate. SDI is a composite index of educational attainment, fertility levels, and gross national income per capita, which reflects a country's development level (16). SDI has also been shown to be correlated with multiple health status indicators (16). We also tested the inclusion of the prevalence of the two measured core deficiencies as a study-level covariate, but it did not improve Akaike information criterion (AIC) for any regression. Finally, we tested several measures of micronutrient availability in diet as country-level covariates (17), but found that either they did not improve model fit or fitted coefficients were implausible, *i.e.*, higher dietary availability was associated with higher prevalence of deficiency. The regression took the following form:

$$y_i \sim Binomial(n_i, \pi_i)$$

$$\pi_i = logit^{-1}(\mu + X_i\beta)$$

Where:

π_i $p(d_3 | \text{no } d_1, \text{no } d_2)$ in survey i, where d_1, d_2 are the measured deficiencies and d_3 is the unmeasured deficiency

n_i the effective sample size of π_i, taking into account each survey's design

μ intercept

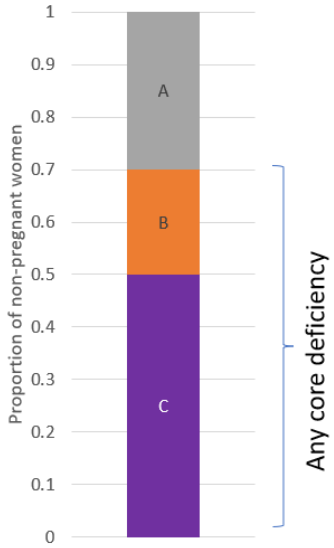
X_i country-level covariate (socio-demographic index, SDI)

β coefficient of the country-level covariate (SDI)

y_i computed as $n_i\pi_i$, to account for the surveys' design effect

Four separate adjustment regression equations were fit using data from surveys that measured all three core micronutrients. Regressions were fit using the glm command, Stata version 16.1. Standard errors were estimated by drawing 500 bootstrap samples with replacement.

Appendix Figure 5. Illustration of the process to adjust for unmeasured folate status, in datasets providing data iron and zinc status on non-pregnant women.



Categories of non-pregnant women:

A. Not deficient in any of iron, zinc or folate
B. Folate deficiency (d_3) but no iron or zinc deficiency
C. Iron or zinc deficiency (d_1 or d_2), regardless of folate status

Compute for each survey dataset that measure all three micronutrients:

$\pi_i = p(d_3 | \text{no } d_1, \text{no } d_2) = B / (A+B)$

Predict $\hat{\pi}$ for each survey where only C is known *(i.e.,* only iron and zinc biomarkers were measured), and estimate B as:

$B = \hat{\pi}*(1-C)$

Appendix Table 9. Regression variables and fitted coefficients for each model used to predict the prevalence of only the unmeasured micronutrient deficiency among individuals who are not deficient in either of the measured core deficiencies.

Population	**Dependent variable (π)**	**Data sources used to fit the model (n)**	**Intercept (μ), 95% confidence interval and p-value**	**Regression coefficient (β) 95% confidence interval and p-value**
Preschool-aged children (6-59 months)	p(zinc deficiency|no vitamin A deficiency, no iron deficiency)	15	0.05 (-1.7, 1.8), p=0.958	-1.6 (-5.0, 1.8), p=0.361
Preschool-aged children (6-59 months)	p(vitamin A deficiency|no zinc deficiency, no iron deficiency)	15	-0.17 (-3.3, 3.0), p = 0.914	-2.7 (-8.0, 2.6), p=0.314
Non-pregnant women 15-49 years	p(zinc deficiency|no folate deficiency, no iron deficiency)	11	0.46 (-2.5, 3.4), p=0.762	-1.35 (-6.7, 4.0), p=0.622

Population	Dependent variable (π)	Data sources used to fit the model (n)	Intercept (μ), 95% confidence interval and p-value	Regression coefficient (β) 95% confidence interval and p-value
Non-pregnant women 15-49 months	p(folate deficiency|no zinc deficiency, no iron deficiency)	11	0.62 (-2.0, 3.2), p=0.637	-3.6 (-8.4, 1.2), p=0.142

The prevalence of any deficiency ($d_{1,2,3}$) for each survey *i* that measures deficiencies 1 and 2 but not the third is computed as:

$$\hat{p}(d_{1,2,3}) = p(d_{1,2}) + \hat{\pi}\left(1 - p(d_{1,2})\right)$$

where $d_{1,2}$ refers to the prevalence of deficiency 1 or deficiency 2. Estimating the prevalence of an unmeasured micronutrient deficiency results in a less certain estimate than implied by the survey sample size and survey design. In order to propagate uncertainty to the next step, we computed an effective sample size (n*) for each survey that takes into account both the sampling uncertainty and the uncertainty from the regression-based adjustment. We computed this n* by rearranging the usual formula for the variance of an estimated probability of a binomial distribution to express the effective sample size n* as:

$$n^* = \frac{\hat{p}(d_{1,2,3})\left(1-\hat{p}(d_{1,2,3})\right)}{var\left(\hat{p}(d_{1,2,3})\right)}$$

The variance of $\hat{p}(d_{1,2,3})$ is derived from the equation for $\hat{p}(d_{1,2,3})$ using standard formulas for expected values and variances. The result of the derivation is an expression that uses the prevalence of deficiency of the first or second micronutrient and the conditional probability of deficiency in the third given the first two are not deficient, as well as the effective sample size associated with the prevalence of deficiency of the first or second micronutrient, as follows:

$$var\left(\hat{p}(d_{1,2,3})\right) = \frac{np(d_{1,2})\left(1-p(d_{1,2})\right)(1-\hat{\pi})^2 + nVar(\hat{\pi})\left(1-p(d_{1,2})\right)p(d_{1,2}) + n^2Var(\hat{\pi})\left(1-p(d_{1,2})\right)^2}{n^2}$$

7. Methods for estimating regional and global prevalence of at least one micronutrient deficiency

Our aim was to estimate the prevalence of any of three core micronutrient deficiencies globally and in 7 world regions. To do so, we fit a Bayesian hierarchical logistic regression model. Bayesian hierarchical models are well-suited for estimation of uncertainty, particularly when data are sparse (18), and are recommended for global and regional estimates of health indicators with limited data (19,20). The model's hierarchical structure allowed the estimate for each region to be informed by data from the region and also by data from other regions. We fitted the following regression:

$$y_i \sim Binomial(n_i, p_i)$$
$$p_i = logit^{-1}(\mu + \alpha_{j[i]} + X_i\beta + e_i)$$
$$\alpha_j \sim N(0, \tau^2)$$
$$e_i \sim N(0, \omega^2)$$

Each survey *i* is nested in region *j*, with:

p_i prevalence of any of three core deficiencies ($d_{1,2,3}$) in survey *i* with effective sample size n_i

μ intercept

α_j random intercepts for each region j

X_i country-level covariate

β coefficient of the country-level covariate

e_i residual survey error (non-sampling error)

y_i computed as $n_i p_i$, to account for uncertainty in the surveys' estimated prevalence

The model's hierarchical structure allows the estimate for each region to be informed by data from the region and by data from other regions, particularly in regions where data are sparse or inconsistent (all regions in this analysis). For surveys that measured all three core deficiencies, y_i and n_i were computed directly from the survey data as described in Section 5; in other cases, they were estimated as described in Section 6. One time-varying country-level covariate, the socio-demographic index, a measure of a country's level of development, allowed for borrowing strength from countries of similar development level. Each survey's effective sample size reflected uncertainty from the survey's complex survey design and from the use of a model to predict an unmeasured core micronutrient, if applicable. Finally, the residual error term allowed country survey data to vary beyond what is expected from their effective sample sizes. This allowed for non-sampling survey error as well for country-level deviations from what might be expected based on region and socio-demographic index. All analyses were done separately for children and non-pregnant women.

The basic model structure and candidate time-varying covariate (SDI) were selected *a priori.* SDI has been shown to be correlated with multiple health status indicators (16). Prior to model fitting, SDI was plotted against the prevalence of any deficiency to confirm the relationship was plausible and monotonic (Appendix Figures 6-7), and the fitted coefficient for SDI was checked to confirm that it was plausible (*i.e.*, higher SDI corresponds to lower prevalence of any deficiency). We set the prior on the variance of the random intercepts for each region (τ^2) and the variance of the residual survey error (ω^2) as uniform distributions from 0 to 5, following Gelman and Hill (18). All other priors were uninformative. Trace plots were examined and the Gelman-Rubin convergence statistic was computed to confirm adequate mixing. Finally, posterior predictions were compared to input data to confirm model fit. Fitted coefficients are shown in Appendix Table 10.

Appendix Table 10. Fitted regression coefficients for each model used to predict the regional and global prevalence of any of the three core micronutrient deficiencies.

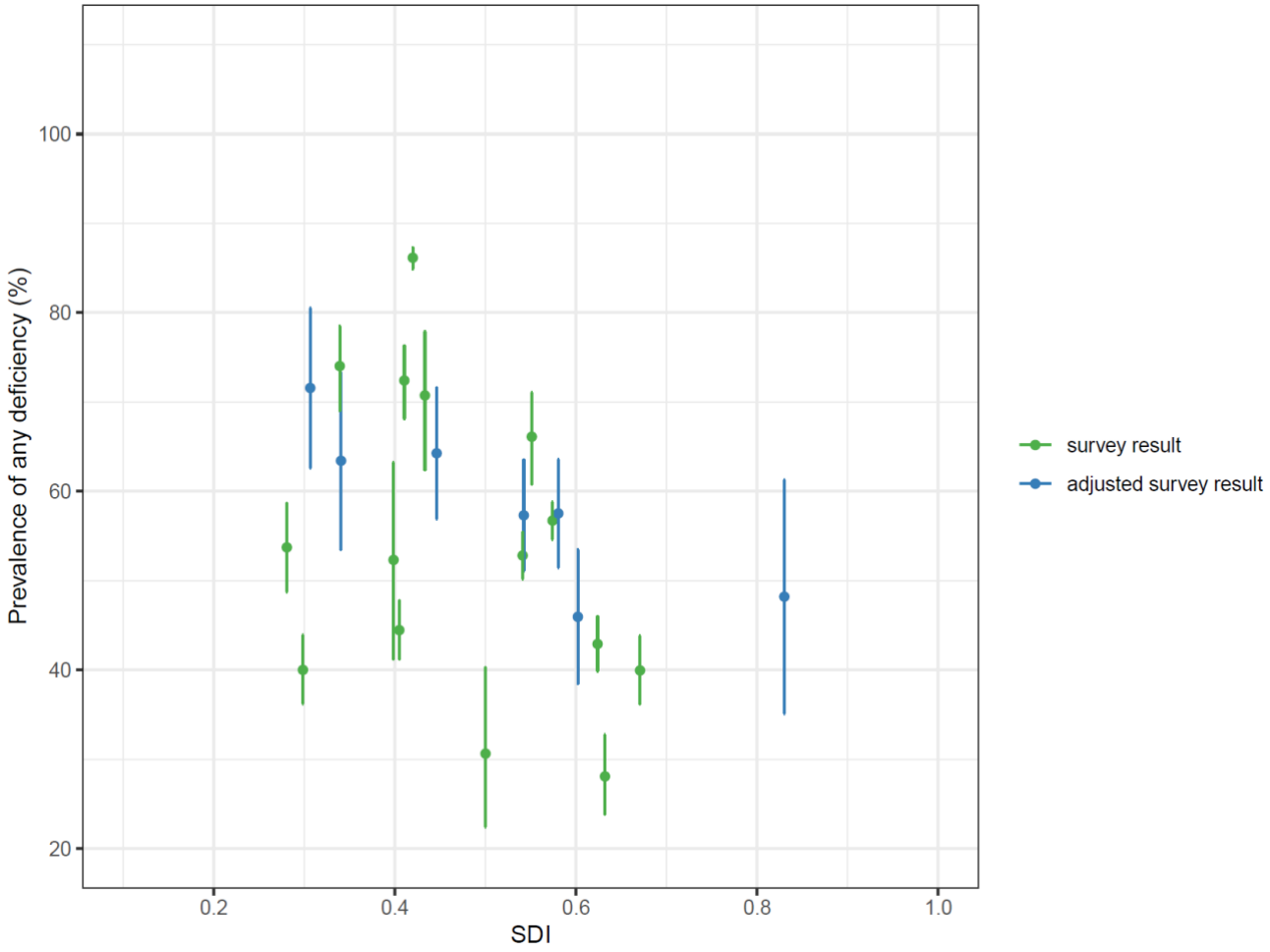
	Preschool-aged children (6-59 months)		**Non-pregnant women aged 15-49 years**	
	22 data sources		*20 data sources*	
Max Gelman-Rubin Rc	1.050		1.032	
	Fitted coefficient	95% credible interval	Fitted coefficient	95% credible interval
Intercept (μ)	0.10	-0.47, 1.19	0.88	0.18, 1.66
Coefficient of SDI (β)	-1.37	-4.16, 1.60	-1.48	-5.69, 3.30
Variance of region intercepts (τ^2)	0.48	0.01, 2.65	0.88	0.01, 3.89
Variance of non-sampling error (ω^2)	0.48	0.23, 0.95	0.99	0.41, 2.20

We fitted the Bayesian model using the bayes: melogit command in Stata version 16.1, which employs a Monte Carlos Markov Chain (MCMC) algorithm. Four chains were fit, and we obtained 1000 posterior samples of the model coefficients per chain (for a total of 4000 posterior samples). From these coefficient samples, 4000 samples of the prevalence of any deficiency were computed for each of 184 countries listed in Appendix Table 1. Numbers of persons affected by at least one micronutrient deficiency was computed for each sample by multiplying country-age-sex-group population totals for 2013 from the UN Population Division's 2019 Revision of the World Population Prospects by the prevalence of at least one deficiency (21).

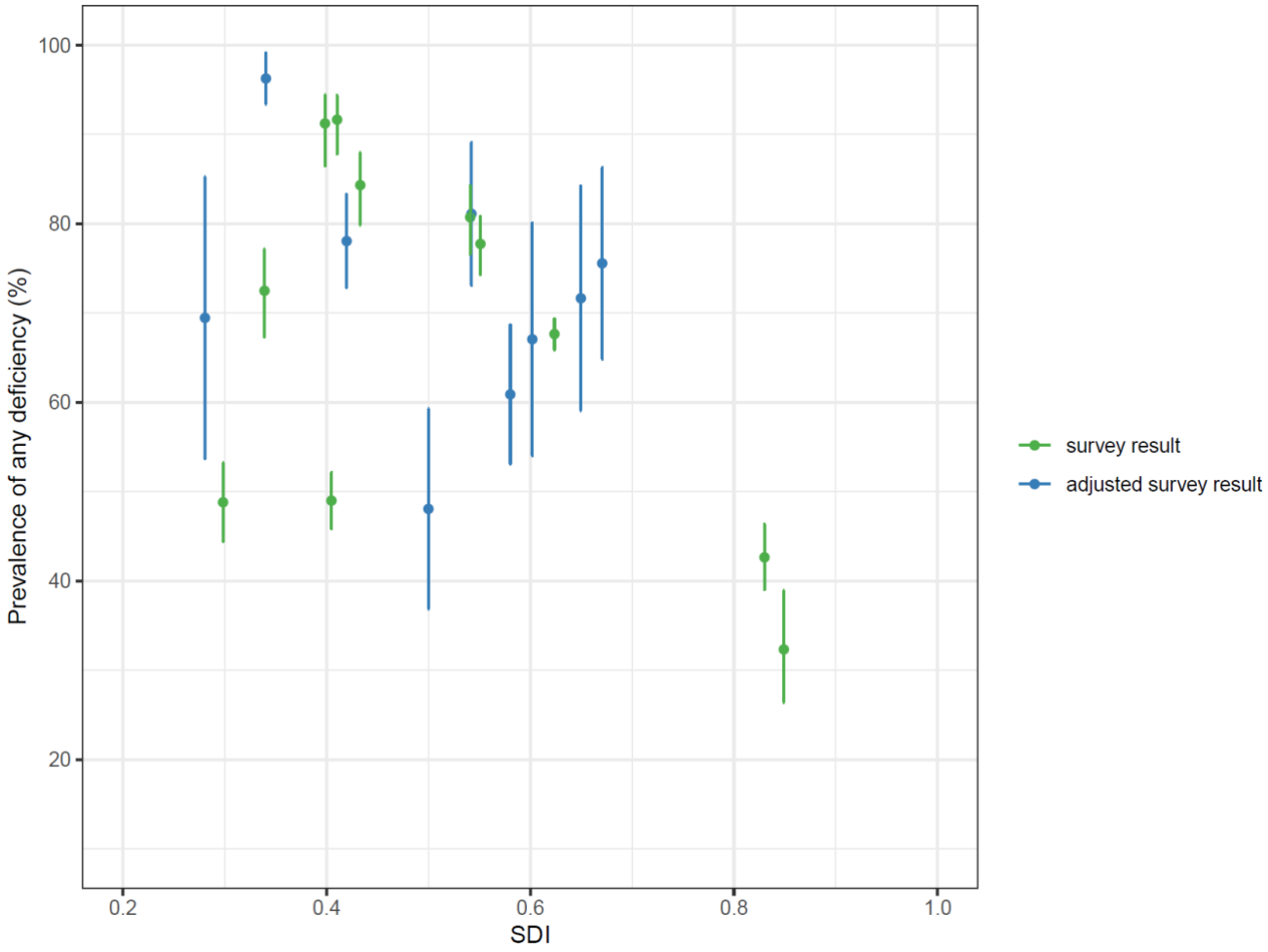
Population data for 2013 were used because it was the median year of survey data included in the analysis. Although country-specific values were computed on the basis of each country's region and socio-demographic index value, it would not be appropriate to present these because our model did not include country effects. Therefore, numbers of persons affected by at least one micronutrient deficiency was computed for each sample, region and demographic group by summing country values. Uncertainty intervals were computed as the 2.5^{th}-97.5^{th} percentiles of these 4000 samples.

The following sources of uncertainty are reflected in the final uncertainty intervals: sampling error from each data source, non-sampling error, *e.g*. because of differences in laboratory methods employed, and uncertainty due to estimation of unmeasured deficiency. Uncertainty from adjustment of micronutrient biomarker concentrations for inflammation was not reflected in the uncertainty intervals, nor was uncertainty around thresholds used to define deficiency. Further, due to the limited number of countries with more than one data source, the model did not include separate terms for non-sampling survey error and for each country (as in nearly all cases, each country contributes only one survey so it would not be possible to estimate these). Not including a term for each country implicitly assumed that country covariates fully explain within-region country-to-country variability, which is likely not true. This approach underestimated uncertainty from making predictions from country-representative data.

Appendix Figure 6. Prevalence of iron, vitamin A or zinc deficiency vs. socio-demographic index (SDI), children 6-59 months. Vertical bars represent 95% confidence interval. Data shown in green measured all three micronutrient deficiencies, and 95% confidence intervals reflect complex survey design. Data shown in blue were estimated as described in section 6 and confidence intervals include uncertainty from the complex survey design and the regression adjustment model.



Appendix Figure 7. Prevalence of iron, folate or zinc deficiency vs. socio-demographic index (SDI), non-pregnant women 15-49 years. Vertical bars represent 95% confidence interval. Data shown in green measured all three micronutrient deficiencies, and 95% confidence intervals reflect complex survey design. Data shown in blue were estimated as described in section 6 and confidence intervals include uncertainty from the complex survey design and the regression adjustment model.



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