**Short maternal stature increases the risk of small-for-gestational-age and preterm birth in low- and middle-income countries:** Individual Participant Data Meta-analysis **and population attributable fraction.[[1]](#footnote-1)[[2]](#footnote-2)[[3]](#footnote-3)[[4]](#footnote-4)**

Naoko Kozuki, MSPH,1 Joanne Katz, ScD,1 Anne CC Lee, MD, 2 Joshua P Vogel, MBBS,3,4 Mariangela F Silveira, PhD,5 Ayesha Sania, ScD, 6 Gretchen A Stevens, DSc, 7 Simon Cousens, DipMathStat,8 Laura E Caulfield, PhD, 1 Parul Christian, DrPH, 1 Lieven Huybregts, PhD,9,10 Dominique Roberfroid, PhD, 11 Christentze Schmiegelow, PhD,12 Linda S Adair, PhD,13 Fernando Barros, PhD,5, 14 Melanie Cowan, MPH,15 Wafaie Fawzi, DrPH,6,16,17  Patrick Kolsteren, PhD,9,11 Mario Merialdi, MD,4,18 Aroonsri Mongkolchati, PhD,19 Naomi Saville, PhD,20,21 Cesar G Victora, PhD,5 Zulfiqar A Bhutta, PhD,22,23 Hannah Blencowe, MRCPCH, 8,24 Majid Ezzati, FMedSci,25 Joy E Lawn, PhD,8,26,27 Robert E Black, MD1 and the Child Health Epidemiology Reference Group Small-for-Gestational-Age/Preterm Birth Working Group

1Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe St., Baltimore, MD 21205, USA

2Department of Newborn Medicine, Brigham and Women’s Hospital, 75 Francis Street, Boston, MA 02115, USA

3School of Population Health, Faculty of Medicine, Dentistry and Health Sciences, University of Western Australia, 35 Stirling Highway Crawley WA 6009,Perth*,* Australia

4UNDP/UNFPA/UNICEF/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction (HRP), Department of Reproductive Health and Research, World Health Organization, Avenue Appia 20, Geneva, Switzerland, CH-1211

5Programa de Pós-graduacao em Epidemiologia, Universidade Federal de Pelotas, Rua Marechal Deodoro 1160, 3o piso, Centro, CEP 96020-220, Pelotas, RS, Brazil

6Department of Global Health and Population, Harvard School of Public Health, 677 Huntington Ave, Boston, MA 02115 USA

7Department of Health Statistics and Information Systems, World Health Organization, Avenue Appia 20, Geneva, Switzerland, CH-1211

8Maternal Reproductive and Child Health (MARCH) Center, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK

9Department of Food Safety and Food Quality, Ghent University, Coupure Links 653 – 9000 Ghent, Belgium

10Poverty, Nutrition and Health Division, International Food Policy Research Institute, 2033 K St, NW Washington, DC 20006-1002

11Woman and Child Health Research Center, Department of Public Health, Institute of Tropical Medicine Nationalestraat 155, 2000 Antwerpen, Belgium

12Centre for Medical Parasitology, Department of Immunology and Microbiology, University of Copenhagen, Oester Farimagsgade 5, building 22 & 23, 1014 Copenhagen K, Denmark

13University of North Carolina School of Public Health, 135 Dauer Drive, Chapel Hill, NC 27599, USA

14Programa de Pós-graduação em Saúde e Comportamento, Univertsidade Católica de Pelotas, Félix da Cunha, 412, CEP 96010-000, Centro, Pelotas, RS, Brasil

15Prevention of Noncommunicable Diseases Department, World Health Organization, Avenue Appia 20, Geneva, Switzerland, CH-1211

16Department of Nutrition, Harvard School of Public Health, 677 Huntington Ave, Boston, MA 02115 USA

17Department of Epidemiology, Harvard School of Public Health, 677 Huntington Ave, Boston, MA 02115 USA

18BD, 1 Becton Drive, MC 374, Franklin Lakes, NJ 07417-1885 USA

19ASEAN Institute for Health Development, Mahidol University, 999 Phuttamonthon 4 Rd, Salaya, Nakhon Pathom 73170, Thailand

20Institute for Global Health, UCL Institute of Child Health, 30 Guilford Street, London WC1N 1EH, UK

21Mother and Infant Research Activities, GPO Box 921, Kathmandu, Nepal

22Center of Excellent in Women and Child Health, Aga Khan University, Stadium Road P.O. Box 3500, Karachi 74800

23Center for Global Child Health, Hospital for Sick Children, 686 Bay Street, Toronto ON, M5G A04, Canada

24Facuty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK

25MRC-PHE Centre for Environment and Health, Department of Epidemiology and Biostatistics, School of Public Health, Imperial College, London, Norfolk Place, London W2 1PG, UK

26Saving Newborn Lives / Save the Children USA, 2000 M Street NW, Suite 500,Washington, DC 20036 27Research and Evidence Division, UK AID, 22 Whitehall, London, SW1A 2EG, UK

Corresponding author:

Joanne Katz, Department of International Health, Johns Hopkins School of Public Health, 615 N. Wolfe St. W5009, Baltimore, MD 21205, jkatz1@jhu.edu, phone number +1 410 955 7016, fax number +1 410 955 2429

Kozuki N

Katz J

Lee ACC

Vogel JP

Silveira MF

Sania A

Stevens GA

Cousens S

Caulfield LE

Christian P

Huybregts L

Roberfroid D

Schmiegelow C

Adair LS

Barros F

Cowan M

Fawzi W

Kolsteren P

Merialdi M

Mongkolchati A

Saville N

Victora CG

Bhutta ZA

Blencowe H

Ezzati M

Lawn JE

Black RE

Word Count:

Number of Figures:

Number of Tables:

Online supporting material submitted: 1 document

Running title: maternal height and small-for-gestational-age

**Abstract**

**Background**

Small-for-gestational-age (SGA) and preterm births are associated with adverse health consequences including neonatal and infant mortality, childhood undernutrition, and adulthood chronic disease.

**Objective**

Our specific aims were to estimate the association of short maternal stature with outcomes of SGA alone, preterm birth alone, or both, and to calculate the population attributable fraction of SGA and preterm birth associated with short maternal stature.

**Methods**

We used datasets from twelve population-based cohort studies and the WHO Global Survey on Maternal and Perinatal Health (13 out of 23 available datasets used) from low- and middle-income countries (LMIC). We included those with birthweight taken within 72 hours of birth, gestational age, and maternal height data (n=177,000). For each of these studies, we individually calculated risk ratios (RR) between height exposure categories of <145cm, 145-<150cm, and 150-<155cm (reference: ≥155cm) and outcomes of SGA, preterm birth, and their combination categories. SGA was defined using both the INTERGROWTH-21st birthweight standard and the 1991 U.S. birthweight reference. The associations were then meta-analyzed.

**Results**

All short stature categories were statistically significantly associated with term-SGA, preterm-appropriate-for-gestational-age (AGA), and preterm-SGA (reference: term-AGA). When using the INTERGROWTH-21st standard to define SGA, women <145cm had the highest adjusted RRs (aRR) (term-SGA: aRR 2.03, 95% CI: 1.76-2.35, preterm-AGA: aRR 1.45, 95% CI: 1.26-1.66, preterm-SGA: aRR 2·13, 95% CI: 1.42-3.21). Similar associations were seen for SGA defined by the U.S. reference. Annually 5.5 million term-SGA (18.6% of the global total), 550,800 preterm-AGA (5.0% of the global total), and 458,000 preterm-SGA births (16·5% of the global total) may be associated with maternal short stature.

**Conclusions**

Approximately 6.5 million SGA and/or preterm births in LMICs may be associated with short maternal stature annually. Reduction of this burden requires primary prevention of SGA, improvement of postnatal growth through early childhood, and possibly further intervention in late childhood and adolescence. It is vital for researchers to broaden the evidence base for addressing chronic malnutrition through multiple life stages, and for program implementers to explore effective, sustainable ways of reaching the most vulnerable populations.

**Key Words:**

Small-for-gestational-age, chronic malnutrition, neonatal health, maternal health, maternal height

**Introduction**

The WHO recently declared a global target of reducing the number of infants born low birthweight (LBW, <2500g) by 30% by the year 2025.([1](#_ENREF_1)) 20 million LBW infants are born each year, a large majority of those births occurring in low- and middle-income countries (LMIC).([2](#_ENREF_2)) LBW babies comprise those who did not grow properly (intrauterine growth restricted, IUGR) and those who were born too soon (preterm birth). Small-for-gestational-age (SGA) is defined as weighing below the 10th percentile of a gender-specific, population-based birthweight reference curve for gestational age,([3](#_ENREF_3)) and is a common proxy for IUGR. SGA and preterm birth have been linked to increased risk of neonatal and infant mortality, as well as long-term health consequences such as neurocognitive impairment and adult chronic disease.([4-7](#_ENREF_4)) The recently published Lancet Every Newborn Series([8](#_ENREF_8)) called for more research into effectively reducing the health burden associated with the 32.4 million SGA([9](#_ENREF_9)) and 13.7 million preterm infants([5](#_ENREF_5)) born each year in LMICs.

To prevent sub-optimal fetal development, it is important to understand the mechanisms leading to SGA and preterm birth. Previously reported risk factors include maternal acute malnutrition,([10](#_ENREF_10)) morbidities (e.g. gestational diabetes, pre-eclampsia/eclampsia, infections),([11](#_ENREF_11)) and reproductive health-related exposures (young/advanced age, low/high parity, short birth intervals).([12](#_ENREF_12), [13](#_ENREF_13)) Several studies have also reported maternal chronic protein-energy malnutrition as being associated with short stature.([10](#_ENREF_10), [14](#_ENREF_14)) If chronic malnutrition is indeed associated with these two neonatal outcomes, the aforementioned goal of reducing LBW births will go hand in hand with another WHO goal of reducing the number of stunted under-five children by 40% between 2010 and 2025.([1](#_ENREF_1))

One goal of the Child Health Epidemiology Reference Group (CHERG) SGA/Preterm Birth Working Group was to investigate the association of short maternal stature with SGA and preterm birth, and to calculate the population attributable fraction (PAF) of SGA and preterm associated with short maternal stature. Unlike previous meta-analyses on this topic, we use the same height cut-offs as those used in national health surveys to report prevalence of short stature. This allows us to have consistent exposure categories across the pooled studies and to calculate PAFs for LMICs. In addition, we attempt to distinguish the associations with SGA and preterm by differentiating the newborns by those who are SGA only, preterm only, both, or neither. Our findings will help inform strategies to reduce not only neonatal mortality and morbidities, but also adverse inter-generational health consequences associated with SGA and/or preterm birth.

**Methods**

We conducted Individual Participant Data Meta-Analysis([15](#_ENREF_15)) by first estimating associations on the individual studies with standardized exposure and outcome measures, and then meta-analyzing the associations.

*Datasets for risk ratio estimation.* 20studies from LMICs containing data on gestational age and neonatal weight were identified for a separate study.([4](#_ENREF_4)) Briefly, the study examined associations between SGA/preterm birth and neonatal and infant mortality. The datasets required gestational age, birth weight, and systematic vital status follow-up up to at least 28 days after delivery. The protocol for data identification is described more in detail in a separate publication.([4](#_ENREF_4)) For this analysis, we used the twelve datasets that also collected maternal height data. We do not expect systematic differences between the studies that contributed height data and those that did not (4 out of 8 datasets from Asia, 3 out of 7 datasets from Africa, 1 out of 4 datasets from LAC not included), although it should be noted that the exclusion of one of the LAC datasets leaves data only from Brazil for the region. The investigators were asked to conduct the analysis using standardized templates or to provide their dataset to the core working group. We also analyzed data from the WHO Global Survey on Maternal and Perinatal Health (WHOGS), a multi-national facility-based survey.([16](#_ENREF_16)) These data were retrospectively collected from hospital medical records. For each country surveyed, facilities from the capital city and two randomly selected provinces were sampled. In a previous CHERG analysis,([9](#_ENREF_9)) the WHOGS datasets were restricted to facilities with high quality and representative SGA and preterm prevalence data; facilities were excluded which had small sample size (500 births /facility), implausible preterm rates (>40% or <3%), and implausible low birthweight rates (<1%). Japan (a high-income country) was excluded, leaving 23 datasets. To assure representativeness, we further limited the WHO datasets to those countries that have high facility delivery rates, as all WHO data were taken from facilities. We included countries that had national-level facility delivery rates above 70% ([17](#_ENREF_17)) during the years the WHOGS was conducted (2003-2008),, leaving 13 datasets.

*Exposure variable.* Maternal height was categorized into the four groups used by major health surveys including the Demographic and Health Surveys (DHS): <145cm, 145-<150cm, 150-<155cm, and ≥155cm (as the reference group). Height was categorized rather than examined as a continuous variable to enable calculation of the population attributable fraction (PAF) using nationally-representative data on prevalence of short stature.

*Outcome variables.*We defined SGA as a birthweight below the 10th percentile of a sex-specific birthweight distribution by gestational age. We calculated SGA using two different distributions. We first calculated SGA using the INTERGROWTH-21st birthweight standard, a description of birthweight among fetuses in eight countries who experienced optimal growth. This standard includes gestational ages 33 to 42 completed weeks. Separately, we also used the U.S. 1991 birthweight reference([3](#_ENREF_3)) to define SGA, as it captures a wider gestational age range of 20 to 44 completed weeks and allows us to examine the entire birth cohort represented in our data. The U.S. 1991 reference is the most often cited birthweight reference,([18](#_ENREF_18)) allowing us to compare our results to the existing literature. The reference differs from the aforementioned standard, in that this is a description of birthweight in the population, not a description of optimal birthweight. We also examined the outcome of severe SGA (below third percentile). For the 1991 U.S. reference, the third percentile is not available, thus the third percentile cut-off value was taken from the 2000 U.S. birthweight reference.([19](#_ENREF_19)) To calculate SGA, we only used weights taken within 72 hours of birth to minimize misclassification. We defined preterm birth as gestational age <37 completed weeks. Methods of gestational age assessment differed across studies and are listed in Table 1a. We also created four mutually-exclusive outcome categories combining SGA and preterm birth to investigate how short stature is distinctly associated with the two outcomes. The categories were term-appropriate-for-gestational-age (AGA, weighing above the 10th percentile of a reference population) (as the comparison group), term-SGA, preterm-AGA, and preterm-SGA.

*Maternal height exposure distribution.* Data on the distribution of height of women of reproductive age by country were obtained through nationally-representative surveys, including Demographic and Health Surveys (DHS), the Stepwise approach to surveillance (STEPS) survey on chronic disease risk factors,([20](#_ENREF_20)) and other national surveys. We excluded data collected before the year 2000. For countries with multiple sources of data, the sources were prioritized by most recent year and then following a hierarchy: DHS, STEPS, and other surveys. Exceptions to this criterion were made based on data availability. For countries without data, regional averages were used. More details can be found in Web Text 1.

**Analysis**

For each study, Poisson regression with robust error variance was used to calculate risk ratios (RR) for the exposures and outcomes after log-binomial models did not converge in several individual studies.([21](#_ENREF_21)) Unadjusted and adjusted associations were estimated for each study. The adjusted analyses controlled for the following variables (as available): parity (0, 1-2, ≥3 live births), maternal age (<18, 18-<35, ≥35 years), maternal education (no education, 1-9 years, ≥10 years), antenatal care visits (<4 vs. ≥4 visits), and urinary tract infection. Categorical variables were used for parity and age to differentiate the potential adverse effects of nulliparity/high parity and also young/advanced age. Sensitivity analysis was conducted by additionally controlling for pre-/early-pregnancy BMI among the datasets with relevant information.

For the meta-analysis, we meta-analyzed the adjusted risk ratios, which is what we present throughout the text. We *a priori* decided to use random effects models with DerSimonian-Laird pooled RRs and 95% CIs,([22](#_ENREF_22)) under the assumption that the studies included in the meta-analysis were not functionally equivalent.([23](#_ENREF_23)) We calculated global estimates as well as Millennium Development Goal (MDG) regional estimates (Africa, Asia, Latin America and Caribbean). We conducted a meta-regression using the metareg command in Stata to explore heterogeneity of the RRs by region. We also conducted sensitivity analyses by separating the risk estimates of the prospective birth cohort studies and the WHOGS data. The metan command in Stata was used for the meta-analyses. We deemed alpha <0.05 as statistically significant.

We calculated the PAFs of term-SGA, preterm-AGA, and preterm-SGA that were associated with maternal short stature. The PAF represents the proportion of these outcomes that would be reduced/averted if exposure risk is brought to a theoretical minimum level.

We used the height distribution among women of reproductive age from the U.S. National Health and Nutrition Examination Survey (NHANES) (2011-2012) as the theoretical minimum risk level (<145cm=0.57% of women <145cm, 3.03% of women 145-<150cm, 9.66% of women 150-<155cm, and 86.74% of women ≥155cm).([24](#_ENREF_24)) While healthier populations do exist, we use the U.S. distribution as a counterfactual that allows for greater comparisons with existing literature. PAFs were calculated for each country, then multiplied by the number of SGA/preterm neonates born annually in the country (2010 estimates)([5](#_ENREF_5), [9](#_ENREF_9)) to calculate the number that could be averted. Details on how uncertainty ranges were derived can be found in Web Text 2. The data were then summarized by MDG region. Stata (version 13) was used for the analyses.

**Results**

***Included studies***

We identified twelve prospective cohort studies from LMICs, with four studies from Asia,([25-28](#_ENREF_25)) Africa([29-32](#_ENREF_29)), and the Americas([33-36](#_ENREF_33)) respectively (Table 1). The studies included 40,375 live births, of whom 36,803 (91·2%) had maternal height, gestational age, and birth weight (taken within 72 hours of birth) data. Details of the studies can be found in Table 1 and Supplemental Table 1. Among the 13 WHOGS datasets, 140,197 live births had maternal height, gestational age, and birthweight data (see Supplemental Table 2 and 3 for more details).

***Associations***

The associations between height and adverse neonatal outcomes were similar across the three regions (Supplemental Table 4 for SGA defined by Intergrowth standard, Supplemental Table 5 for SGA defined by U.S. 1999 reference). Meta-regressions between each height category and each outcome showed no statistically significant difference in RRs by region (data not presented). For that reason, we report global associations here, and use these associations to calculate PAF. See Supplemental Figures 1-3 for the forest plot of the associations between height <145cm and term-SGA, preterm-AGA, and preterm-SGA (Intergrowth) respectively (other forest plots not presented).

SGA defined by the INTERGROWTH-21st standard and the U.S. 1991 reference showed almost identical risk ratios. Thus, we present in the text the results for SGA defined by the INTERGROWTH-21st standard only, and in the web appendix for both the INTERGROWTH-21st standard (Supplemental Tables 4 and 6), and the U.S. 1991 reference (Supplemental Table 5 and 7).

Very short stature (<145cm) had the strongest associations with all adverse neonatal outcomes we examined, compared to the reference group of ≥155cm. Height <145cm had an adjusted RR (aRR) of 1.98 (95% CI: 1.72-2.27, P<0.001) for SGA <10% and aRR of 2.11 (95% CI: 1.85-2.41, P<0.001) for SGA <3%. Height showed a dose-response relationship with the SGA outcomes; the magnitude of the associations became smaller with increasing height (Figure 1, Supplemental Tables 4 and 6).

Women with height <145cm had aRR of 1.42 (95% CI: 1.10-1.83, P=0.006) with preterm birth (compared to all term births regardless of SGA status). The association for 145-<150cm was aRR 1.08, (95% CI: 1.01-1.15, P=0.036) and for 150-<155cm was aRR 1.05 (95% CI: 0.99-1.12, P=0.090), the last association not being significant. There was no clear dose-response relationship at the global level between height and the risk of preterm birth (Figure 1, Supplemental Table 4).

All height categories below the reference were statistically significantly associated with risk of term-SGA, preterm-AGA, and preterm-SGA (compared to term-AGA), with women <145cm having the highest RR (term-SGA: aRR 2.03, 95% CI: 1.76-2.35, P<0.001, preterm-AGA: aRR 1.44, 95% CI: 1.26-1.66, P=0.011, preterm-SGA: aRR 2·13, 95% CI: 1.42-3.21, P=0.031). (Figure 1, Supplemental Table 4). While confidence intervals overlapped, the magnitude of the associations decreased for all three of these outcomes as height increased.

The analyses were stratified by population-based birth cohort studies and the WHOGS (Supplemental Tables 6 and 7). The association between short maternal stature and SGA was weaker in the WHOGS data than in the cohort studies. For preterm birth, the population-based cohort study data and WHOGS data produced similar results.

Only nine of our datasets had pre-/early pregnancy maternal weight; controlling for early pregnancy BMI in these datasets did not result in substantial changes in RRs (Supplemental Table 8). We also conducted a sensitivity analysis, removing the two studies that had over 20% missing data, ([25](#_ENREF_25)) ([30](#_ENREF_30)) and we saw no major change in the association (data not presented).

***Prevalence of short stature among women of reproductive age***

Of 138 LMICs, nationally-representative data (collected year 2000 or after) for women of reproductive age were available from 80 countries. The data were obtained from DHS (n=52), STEPS (n=24), China Health and Nutrition Survey, Indonesia Family Life Survey, Mexico National Health and Nutrition Survey, and Thailand National Health Examination Survey (Supplemental Table 9). The 80 countries represent over 80% of women of reproductive age in LMICs, using UN World Population Prospects estimates from 2010.([37](#_ENREF_37))

Across the MDG sub-regional averages, the prevalence of <155cm ranged from 19·8% in the Caucasus and Central Asia to 68·5% in Southern Asia, with a median of 32·4%. The prevalence of <145cm ranged from 0·7% in the Caucasus and Central Asia to 10·7% in Southern Asia, with a median of 2·3% (Figure 2, Supplemental Table 10). Figure 2 also includes the U.S. NHANES prevalence to allow for visualization of the counterfactual we used to calculate PAR.

***Population attributable fraction***

Using the INTERGROWTH-21st standard, the proportion of term-SGA associated with maternal short stature ranged from 3.4% in the Caucasus and Central Asia to 24.3% in Southern Asia. In total, 5.5 million (95% CI: 5.2-5.8 million) term-SGA births were associated with maternal short stature, or 18.6% of the global total (95% CI: 17.4-19.7%).

The proportion of preterm-AGA associated with maternal short stature ranged from 0.7% in the Caucasus and Central Asia to 7.9% in Southern Asia. In total, 550,800 (95% CI: 360,400-719,200) preterm-AGA births were associated with maternal short stature, or 5.0% of the global total (95% CI: 3.3-6.6%). (Table 2).

Finally, the proportion of preterm-SGA associated with maternal short stature ranged from 2·8% in the Caucasus and Central Asia to 23.3% in South-eastern Asia. In total, 457,500 (95% CI: 380,600-526,900) preterm-SGA births were associated with maternal short stature, or 16.5% of the global total (95% CI: 13.7-18.9%). (Table 2)

Southern Asia has the largest total number of term-SGA (16·2 million), preterm-AGA (4·0 million), and preterm-SGA (1·2 million) births. Of these, 3.9 million term-SGA, 315,000 preterm-AGA, and 268,000 preterm-SGA babies were associated with maternal short stature. (Table 2). National PAF estimates are available in Supplemental Table 11. India had the largest absolute number of all three outcomes associated with short maternal stature, followed by Pakistan, Bangladesh, and Indonesia.

**Discussion**

Our study found evidence of statistically significant associations between short maternal stature and term-SGA, preterm-AGA, and preterm-SGA outcomes respectively. Close to 6.5 million SGA and/or preterm births in LMICs may be attributed to factors that are associated with short maternal stature. SGA and preterm births have higher risk of adverse health consequences including neonatal and infant mortality,([4](#_ENREF_4)) childhood undernutrition,([6](#_ENREF_6)) and adulthood chronic disease.([7](#_ENREF_7)) In light of the INTERGROWTH-21st study findings that show optimal fetal growth at the population level is similar across the globe, it highlights a greater need to address fetal growth restriction in low resource settings.

The associations and PAFs we present here should be interpreted as either having a direct causal link with short stature and/or operating through underlying factors that are highly associated or correlated with short stature. The association between short stature and SGA and/or preterm birth could be a function of residual confounding. For instance, short stature may be correlated with acute malnutrition, low socioeconomic status, or poor access to or quality of antenatal care. While we controlled for available confounders in our analysis, we expect the associations may still partly be driven by factors external to maternal height and chronic malnutrition. We controlled for maternal BMI in a subset of studies, and saw no major changes in the associations. One possible biological mechanism linking short stature directly to SGA/preterm birth is low uterine volume and/or small pelvic size.([38](#_ENREF_38)) Small uterine volume is considered to restrict fetal growth,([39](#_ENREF_39)) and Kramer et al. hypothesize that earlier filling of the pelvis could lead to early spontaneous labor.([38](#_ENREF_38)) Shorter women, through chronic malnutrition, may also be more susceptible to infections during pregnancy,([40](#_ENREF_40)) thus have higher risk of adverse newborn outcomes. There is also some literature suggesting that placental epigenetic modifications contribute to intrauterine growth([41](#_ENREF_41)) and also to adulthood height determination([42](#_ENREF_42)); such potentially trans-generational factors may play a role as well.

The need for health intervention in LMICs to improve height attainment has been highlighted in various publications. Silventoinen states that in low-resource settings, a larger percentage of height variation within the population is attributable to the environment over genetics, and highlights nutrition and disease as the main environmental contributors to attained height.([43](#_ENREF_43)) The association between socioeconomic status and height diminishes in a population as standard of living increases. Subramanian et al. also reported the association between socioeconomic status and attained height as being a consistent pattern across LMICs.([44](#_ENREF_44), [45](#_ENREF_45)) Other studies have also reported changes in population height with economic development,([46](#_ENREF_46)) which likely serves as a proxy for adverse nutritional and disease exposures. For example, in Brazil, between 1974 and 2007, the national prevalence of stunting dropped from 59.0 to 11.2% among those in the lowest income quintile and 12.1% to 3.3% in the highest income quintile, a 33-year span when Brazil saw major reductions in inequality indices.([47](#_ENREF_47))

Our study contributes unique data by creating mutually exclusive, combination categories of preterm and/or SGA, allowing us to differentiate maternal stature’s associations with each of these outcomes. We found that short stature has a stronger association with SGA than with preterm birth. While the exposure and outcome definitions were not exactly comparable, our associations were similar to those reported in previous literature. The WHO Collaborative Study of Maternal Anthropometry and Pregnancy Outcomes meta-analysis reported a pooled crude OR of 1·9 (95% CI: 1·8-2·0) for SGA (using a different U.S. standard reference distribution([48](#_ENREF_48)) from the one we used) and 1·2 (95% CI: 1·1-1·2) for preterm birth, comparing the lowest to highest quartile of height in each dataset.([10](#_ENREF_10)) Their meta-analysis did not use adjusted associations, and their use of quartile cut-offs for height did not allow for PAF calculation. The Knowledge Synthesis Group’s systematic review reported an association between short stature and SGA (two studies, crude pooled OR 1·39, 95% CI: 1·15-1·68) and inconsistencies in association for preterm birth.([14](#_ENREF_14)) The pooled crude RR for preterm birth was 1·23 (95% CI: 1·11-1·37), but the adjusted data available in some of the included studies showed no statistical significance. Also, the definition of SGA and of short stature was not standardized across the included studies; the height cut-offs of “short stature” ranged from <155cm to <173cm.

There may be the potential to intervene across an individual’s lifespan to prevent maternal stunting. Existing literature has stressed the “1000 days” principle, emphasizing exposures in-utero and up to two years of age as the main drivers of child development and linear growth.([49](#_ENREF_49)) SGA neonates have higher risk of childhood stunting,([6](#_ENREF_6)) which has subsequently been associated with adulthood stunting. A Guatemalan study that followed birth cohorts through their own pregnancies have also reported maternal birth size and birth length as predictive of their offspring’s birth size and birth length, even after controlling for maternal weight or height at the time of pregnancy.([50](#_ENREF_50)) There is also literature reporting that girls born SGA have smaller uterine volume in adolescence.([51](#_ENREF_51)) Systematic reviews have reported a 34% reduction with protein-energy supplementation([52](#_ENREF_52)) and a 13% reduction with micronutrient supplementation (compared to iron and folate supplementation) in the odds of SGA.([53](#_ENREF_53)) However, there is low coverage, inequities in benefit (e.g. better-off women benefiting more), and weak evidence of health impact using supplementation programs to impact height.([54](#_ENREF_54)) Most programs have also been conducted in Africa, despite the higher burden of stunting and SGA in Asia. There are potential concerns pertaining to protein-energy supplementation in South Asia; supplementation leading to larger fetal size but no changes to attained maternal height could potentially increase rates of cephalopelvic disproportion and obstructed labor. A recent systematic review reported increases in birth weight and no increased risk of neonatal mortality and stillbirths with protein-energy supplementation, but only included one study from South Asia.([52](#_ENREF_52))

There is increasing focus on the potential for intervention in adolescence to reduce stunting, as promoted by the UNICEF / Sub-committee on Nutrition Through the Life-Cycle. There has been minimal research conducted in later childhood or in adolescence to examine if and to what degree growth trajectories can be altered. Importantly, interventions would need to result in increased stature without inducing overweight or early menarche. A recently published study notes that even in the absence of intervention, individuals can experience catch-up growth between two years of age and mid-childhood and also between mid-childhood and early adulthood.([55](#_ENREF_55)) This evidence argues for investing in further research on childhood and adolescent interventions to improve linear growth.

There are several limitations to our analysis. First, we did not explore height as a continuous variable. In many countries, national height prevalence data were only available in the categories we report here. Furthermore, we needed RRs by height categories to subsequently calculate PAF. We expect maternal height to shift during pregnancy due to spinal compression and pedal changes. However, we expect minimal impact on our results, as this should minimally alter the height distributions as categorized in 5cm increments. Due to the lack of data, we were unable to explore exposures such as infections and weight gain, and outcomes such as stillbirth. For several studies, gestational age was obtained through date of last menstrual period. While most studies conducted active pregnancy surveillance, we still expect some discrepancy between true and calculated gestational age. We expect that our uncertainty intervals for the PAFs are narrower than they should be, as the uncertainty associated with the national height distribution estimates was not taken into account. Finally, nationally-representative data on prevalence of maternal short stature, SGA, and/or preterm were not available for every country and had to be extrapolated from available data.

**Summary**

About 6.5 million preterm and/or SGA births in LMICs annually may be associated with short maternal stature. Reduction of this burden requires primary prevention of SGA, improvement of postnatal growth through early childhood, and possibly further intervention in late childhood and adolescence. We also found dose response associations between stature and adverse neonatal outcomes, suggesting that even incremental change could lead to health impact. The WHO has declared goals of reducing the number of LBW newborns by 30% and stunted under-five children by 40% between 2010 and 2025.([1](#_ENREF_1)) To meet these and other post-MDG neonatal and child health goals, it is vital for researchers to broaden the evidence base for addressing chronic malnutrition through multiple life stages, and for program implementers to explore effective, sustainable ways of reaching the most vulnerable populations.

**Acknowledgments**

The individual studies would like to acknowledge the role played by following people in those studies: Anthony Costello, Subarna Khatry, Hermann Lanou, John Lusingu, Steven LeClerq, Dharma Manandhar, Daniel Minja, Gernard I. Msamanga, Willy Urassa, and Nelly Zavaleta. This article represents the views of the named authors only.

**Author Contribution Statement**

NK, JK, and ACL designed the research, NK, JK, ACL conducted the research, LEC, PC, LH, DR, CS, LSA, FB, MC, WF, PK, MM, AM, NS, and CGV provided essential materials, NK, ACL JPV, MFS, AS, and GAS analyze data, NK, JK, ACL wrote paper, NK had primary responsibility for final content, ZAB, HB, SC, ME, JEL, REB provided critical input in the study design. All authors have read and approved the final manuscript.

**References**

1. World Health Organization. Nutrition - global targets 2025 Geneva: World Health Organization; [cited 2013 Oct 21]. Available from: <http://www.who.int/nutrition/topics/nutrition_globaltargets2025/en/>.

2. UNICEF and World Health Organization. Low Birthweight: Country, Regional and Global Estimates. New York: 2004.

3. Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M. A United States national reference for fetal growth. Obstetrics and gynecology. 1996;87(2):163-8.

4. Katz J, Lee AC, Kozuki N, Lawn JE, Cousens S, Blencowe H, Ezzati M, Bhutta ZA, Marchant T, Willey BA, et al. Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: a pooled country analysis. Lancet. 2013.

5. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal R, Adler A, Vera Garcia C, Rohde S, Say L, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012;379(9832):2162-72.

6. Christian P, Lee SE, Donahue Angel M, Adair LS, Arifeen SE, Ashorn P, Barros FC, Fall CH, Fawzi WW, Hao W, et al. Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. International journal of epidemiology. 2013.

7. Barker DJ, Osmond C, Golding J, Kuh D, Wadsworth ME. Growth in utero, blood pressure in childhood and adult life, and mortality from cardiovascular disease. Bmj. 1989;298(6673):564-7.

8. Lawn JE, Blencowe H, Oza S, You D, Lee AC, Waiswa P, Lalli M, Bhutta Z, Barros AJ, Christian P, et al. Every Newborn: Progress, priorities, and potential beyond survival. Lancet. 2014.

9. Lee AC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, Adair L, Baqui AH, Bhutta ZA, Caulfield LE, et al. National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. Lancet Global Health. 2013;1(1):e26-e36.

10. A WHO collaborative study of maternal anthropometry and pregnancy outcomes. International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics. 1997;57(1):1-15.

11. Jacobsson B, Ladfors L, Milsom I. Advanced maternal age and adverse perinatal outcome. Obstetrics and gynecology. 2004;104(4):727-33.

12. Kozuki N, Lee AC, Silveira MF, Sania A, Vogel JP, Adair L, Barros F, Caulfield LE, Christian P, Fawzi WW, et al. The associations of parity and maternal age with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. BMC public health. 2013;13(Suppl 3):S2.

13. Kozuki N, Lee AC, Silveira MF, Victora CG, Adair L, Humphrey J, Ntozini R, Black RE, Katz J. The associations of birth intervals with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. BMC public health. 2013;13(Suppl 3):S3.

14. Han Z, Lutsiv O, Mulla S, McDonald SD. Maternal height and the risk of preterm birth and low birth weight: a systematic review and meta-analyses. J Obstet Gynaecol Can. 2012;34(8):721-46.

15. Riley RD, Lambert PC, Abo-Zaid G. Meta-analysis of individual participant data: rationale, conduct, and reporting. Bmj. 2010;340:c221.

16. Shah A, Faundes A, Machoki M, Bataglia V, Amokrane F, Donner A, Mugerwa K, Carroli G, Fawole B, Langer A, et al. Methodological considerations in implementing the WHO Global Survey for Monitoring Maternal and Perinatal Health. Bulletin of the World Health Organization. 2008;86(2):126-31.

17. UNICEF. State of the World's Children 2010. New York: 2010.

18. Katz J, Wu LA, Mullany LC, Coles CL, Lee AC, Kozuki N, Tielsch JM. Prevalence of small-for-gestational-age and its mortality risk varies by choice of birth-weight-for-gestation reference population. PloS one. 2014;9(3):e92074.

19. Oken E, Kleinman KP, Rich-Edwards J, Gillman MW. A nearly continuous measure of birth weight for gestational age using a United States national reference. BMC Pediatr. 2003;3:6.

20. World Health Organization Regional Office for Africa. STEPS survey on chronic disease risk factors [cited 2013 10/16]. Available from: <http://www.afro.who.int/en/clusters-a-programmes/hpr/health-risk-factors/diseases-surveillance/surveillance-country-profiles/step-survey-on-noncommunicable-disease-risk-factors.html>.

21. Zou G. A modified poisson regression approach to prospective studies with binary data. American journal of epidemiology. 2004;159(7):702-6.

22. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986;7(3):177-88.

23. Borenstein M. HL, Higgins JPT., Rothstein HR. Chapter 13. Fixed-Effect Versus Random-Effects Models. Introduction to Meta-Analysis. Chichester, UK: John Wiley & Sons, Ltd; 2009.

24. Centers for Disease Control. NHANES 2011-2012 Examination Data 2014 [cited 2013 Aug 10]. Available from: <http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Examination&CycleBeginYear=2011>.

25. Christian P, West KP, Khatry SK, Leclerq SC, Pradhan EK, Katz J, Shrestha SR, Sommer A. Effects of maternal micronutrient supplementation on fetal loss and infant mortality: a cluster-randomized trial in Nepal. The American journal of clinical nutrition. 2003;78(6):1194-202.

26. Adair LS. Low birth weight and intrauterine growth retardation in Filipino infants. Pediatrics. 1989;84(4):613-22.

27. Isaranurug S, Mo-suwan L, Choprapawon C. A population-based cohort study of effect of maternal risk factors on low birthweight in Thailand. J Med Assoc Thai. 2007;90(12):2559-64.

28. Osrin D, Vaidya A, Shrestha Y, Baniya RB, Manandhar DS, Adhikari RK, Filteau S, Tomkins A, Costello AM. Effects of antenatal multiple micronutrient supplementation on birthweight and gestational duration in Nepal: double-blind, randomised controlled trial. Lancet. 2005;365(9463):955-62.

29. Huybregts L, Roberfroid D, Lanou H, Menten J, Meda N, Van Camp J, Kolsteren P. Prenatal food supplementation fortified with multiple micronutrients increases birth length: a randomized controlled trial in rural Burkina Faso. The American journal of clinical nutrition. 2009;90(6):1593-600.

30. Roberfroid D, Huybregts L, Lanou H, Henry MC, Meda N, Menten J, Kolsteren P. Effects of maternal multiple micronutrient supplementation on fetal growth: a double-blind randomized controlled trial in rural Burkina Faso. The American journal of clinical nutrition. 2008;88(5):1330-40.

31. Schmiegelow C, Minja D, Oesterholt M, Pehrson C, Suhrs HE, Bostrom S, Lemnge M, Magistrado P, Rasch V, Lusingu J, et al. Factors associated with and causes of perinatal mortality in northeastern Tanzania. Acta obstetricia et gynecologica Scandinavica. 2012;91(9):1061-8.

32. Fawzi WW, Msamanga GI, Urassa W, Hertzmark E, Petraro P, Willett WC, Spiegelman D. Vitamins and perinatal outcomes among HIV-negative women in Tanzania. The New England journal of medicine. 2007;356(14):1423-31.

33. Santos IS, Barros AJ, Matijasevich A, Domingues MR, Barros FC, Victora CG. Cohort profile: the 2004 Pelotas (Brazil) birth cohort study. International journal of epidemiology. 2011;40(6):1461-8.

34. Victora CG, Barros FC. Cohort profile: the 1982 Pelotas (Brazil) birth cohort study. International journal of epidemiology. 2006;35(2):237-42.

35. Victora CG, Hallal PC, Araujo CL, Menezes AM, Wells JC, Barros FC. Cohort profile: the 1993 Pelotas (Brazil) birth cohort study. International journal of epidemiology. 2008;37(4):704-9.

36. Caulfield LE, Zavaleta N, Figueroa A, Leon Z. Maternal zinc supplementation does not affect size at birth or pregnancy duration in Peru. The Journal of nutrition. 1999;129(8):1563-8.

37. United Nations Department of Economic and Social Affairs Population Division. World Population Prospects: The 2010 Revision. 2011.

38. Kramer MS, McLean FH, Eason EL, Usher RH. Maternal nutrition and spontaneous preterm birth. American journal of epidemiology. 1992;136(5):574-83.

39. Christian P. Nutrition and maternal mortality in developing countries. In: Lammi-Keefe CJ CS, Philipson EH, editor. Handbook of Nutrition and Pregnancy. Totowa, NJ: Humana Press; 2008.

40. Schaible UE, Kaufmann SH. Malnutrition and infection: complex mechanisms and global impacts. PLoS medicine. 2007;4(5):e115.

41. Fowden AL, Forhead AJ, Coan PM, Burton GJ. The placenta and intrauterine programming. Journal of neuroendocrinology. 2008;20(4):439-50.

42. Timasheva Y, Putku M, Kivi R, Kozich V, Mannik J, Laan M. Developmental programming of growth: genetic variant in GH2 gene encoding placental growth hormone contributes to adult height determination. Placenta. 2013;34(11):995-1001.

43. Silventoinen K. Determinants of variation in adult body height. Journal of biosocial science. 2003;35(2):263-85.

44. Subramanian SV, Ozaltin E, Finlay JE. Height of nations: a socioeconomic analysis of cohort differences and patterns among women in 54 low- to middle-income countries. PloS one. 2011;6(4):e18962.

45. Li L, Manor O, Power C. Early environment and child-to-adult growth trajectories in the 1958 British birth cohort. The American journal of clinical nutrition. 2004;80(1):185-92.

46. Frongillo EA, Jr., de Onis M, Hanson KM. Socioeconomic and demographic factors are associated with worldwide patterns of stunting and wasting of children. The Journal of nutrition. 1997;127(12):2302-9.

47. Monteiro CA, Benicio MH, Conde WL, Konno S, Lovadino AL, Barros AJ, Victora CG. Narrowing socioeconomic inequality in child stunting: the Brazilian experience, 1974-2007. Bulletin of the World Health Organization. 2010;88(4):305-11.

48. Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M. Fetal growth and perinatal viability in California. Obstetrics and gynecology. 1982;59(5):624-32.

49. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013;382(9890):427-51.

50. Ramakrishnan U, Martorell R, Schroeder DG, Flores R. Role of intergenerational effects on linear growth. The Journal of nutrition. 1999;129(2S Suppl):544S-9S.

51. Ibanez L, Potau N, Enriquez G, de Zegher F. Reduced uterine and ovarian size in adolescent girls born small for gestational age. Pediatric research. 2000;47(5):575-7.

52. Imdad A, Bhutta ZA. Maternal nutrition and birth outcomes: effect of balanced protein-energy supplementation. Paediatric and perinatal epidemiology. 2012;26 Suppl 1:178-90.

53. Haider BA, Bhutta ZA. Multiple-micronutrient supplementation for women during pregnancy. The Cochrane database of systematic reviews. 2012;11:CD004905.

54. Victora CG, Barros FC, Assuncao MC, Restrepo-Mendez MC, Matijasevich A, Martorell R. Scaling up maternal nutrition programs to improve birth outcomes: a review of implementation issues. Food and nutrition bulletin. 2012;33(2 Suppl):S6-26.

55. Prentice AM, Ward KA, Goldberg GR, Jarjou LM, Moore SE, Fulford AJ, Prentice A. Critical windows for nutritional interventions against stunting. The American journal of clinical nutrition. 2013;97(5):911-8.

56. UNICEF. Inter-agency Group for Child Mortality Estimation (IGME) [cited 2012 October 13]. Available from: <http://www.childinfo.org/mortality_igme.html>.

**Table 1: Studies included in the individual participant data meta-analysis (details of WHO data available in Supplemental Table 1)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Study | Setting | Primary Study design | Population represented | Original cohort, *n* | Analyzed cohort1, *n* | NMR | LBW, % | Preterm, % | % SGA | Facility delivery, % | Method of gestational age assessment | women with height <145cm, % | Timing of height measurement |
| Asia | | | | | | | | | | | | | |
| Nepal (1999)([25](#_ENREF_25)) | Rural Sarlahi, NEPAL | Cluster RCT of multiple micronutrient supplementation | Recruitment of all pregnant women in study area | 4,130 | 3,169 | 42 | 39 | 22 | 56 | 6 | LMP | 15.8 | first or early second trimester |
| Nepal (2003)([28](#_ENREF_28)) | Dhanusha, NEPAL | RCT of antenatal micronutrient supplementation | Antenatal clinic-based recruitment of pregnant women in study area | 1,106 | 1,050 | 25 | 22 | 7 | 53 | 53 | Ultrasound | 13.5 | <20 weeks gestation |
| Philippines (1983)([26](#_ENREF_26)) | Urban Cebu, PHILLIPINES | Longitudinal Health-nutritional survey of infant feeding patterns | Population based, random cluster sample of census | 3,080 | 2,757 | 14 | 11 | 18 | 25 | 34 | LMP, Ballard to confirm | 12.8 | 6th-7th month of pregnancy |
| Thailand (2001)([27](#_ENREF_27)) | Bangkok, THAILAND | Prospective follow-up of birth cohort | Longitudinal birth cohort of all births in four districts | 4,245 | 3,814 | 5 | 8 | 9 | 22 | 99 | Best obstetric estimate (LMP, ultrasound, or clinical assessment) | 3.2 | 28 weeks gestation |
| Africa | | | | | | | | | | | | | |
| Burkina Faso (2004)([30](#_ENREF_30)) | Hounde, BURKINA FASO | RCT of multiple micronutrient supplementation | Prospective, community based cohort | 1,373 | 1,049 | 21 | 17 | 16 | 35 | 77 | ultrasound | 0.2 | first or early second trimester |
| Burkina Faso (2006)([29](#_ENREF_29)) | Hounde, BURKINA FASO | RCT of maternal fortified food supplementation | Prospective, community based cohort | 1,316 | 1,061 | 20 | 16 | 18 | 29 | 84 | ultrasound | 0.1 | first or early second trimester |
| Tanzania (2001)([32](#_ENREF_32)) | Urban Dar es Salaam, TANZANIA | RCT of muti-vitamin supplementation | Facility based, antenatal clinics | 7,752 | 6,846 | 28 | 8 | 17 | 20 | 97 | LMP | 3.5 | 12-27 weeks gestation |
| Tanzania (2008)([31](#_ENREF_31)) | Korogwe, TANZANIA | Observational malaria study | Facility based recruitment, ANC clinics, community f/u | 915 | 795 | 33 | 11 | 5 | 22 | 88 | ultrasound | 0.5 | ≤24 weeks gestation |
| Americas | | | | | | | | | | | | | |
| Brazil (1982)([34](#_ENREF_34)) | Urban Pelotas city, Rio Grande do Sul, Southern BRAZIL | Longitudinal Birth Cohort Survey | Population based, all births in Pelotas hospitals (100% facility delivery) | 5,914 | 5,808 | 11 | 7 | 6 | 17 | 100 | LMP | 2.2 | Immediately after delivery |
| Brazil (1993)([35](#_ENREF_35)) | Urban Pelotas city, Rio Grande do Sul, Southern BRAZIL | Longitudinal Birth Cohort Survey | Population based, all births in Pelotas hospitals (100% facility delivery) | 5,279 | 5,203 | 7 | 9 | 11 | 19 | 100 | LMP and Dubowitz | 0.8 | Immediately after delivery |
| Brazil (2004)([33](#_ENREF_33)) | Urban Pelotas city, Rio Grande do Sul, Southern BRAZIL | Longitudinal Birth Cohort Survey | Population based, all births in Pelotas hospitals (100% facility delivery) | 4,287 | 4,287 | 10 | 11 | 16 | 15 | 100 | LMP and ultrasound if available, Dubowtiz | 0.6 | Three months postpartum |
| Peru (1995)([36](#_ENREF_36)) | Urban shantytown, Lima, PERU | RCT of maternal zinc supplementation | facility-based | 978 | 964 | 0 | 4 | 5 | 11 | 100 | LMP, clinical indications, ultrasound if available | 11.6 | 10-24 weeks gestation |

1With data on maternal height, gestational age, and birthweight taken within 72 hours of birth.

**Table 2: Number and percentage of small-for-gestational-age and preterm births attributable to short maternal stature, U.S. population as counterfactual**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UN MDG Subregion | Term-SGA, *n*1 | Term-SGA attributed to maternal short stature, *n* (95% CI) | PAF, % (95% CI) | Preterm-AGA, *n* | Preterm-AGA attributed to maternal short stature, *n* (95% CI) | PAF, % (95% CI) | Preterm-SGA, *n* | Preterm-SGA attributed to maternal short stature, *n* (95% CI) | PAF, % (95% CI) |
| Caucasus and Central Asia | 207,000 | 7,100 (6,400, 7,900) | 3.4  (3.1, 3.8) | 117,500 | 880  (250, 1,500) | 0.7  (0.2, 1.2) | 33,800 | 940  (630, 1,200) | 2.8  (1.9, 3.7) |
| Eastern Asia | 900,900 | 76,500  (70,500, 82,200) | 8.5  (7.8, 9.1) | 980,800 | 21,100  (11,200, 30,100) | 2.1  (1.1, 3.1) | 281,400 | 21,200  (16,200, 25,900) | 7.5  (5.8, 9.2) |
| Latin America and the Caribbean | 1,180,000 | 178,200  (166,500, 189,600) | 15.1  (14.1, 16.1) | 735,300 | 34,000  (22,200, 44,600) | 4.6  (3.0, 6.1) | 194,100 | 28,700  (23,800, 33,300) | 14.8  (12.2, 17.2) |
| Northern Africa | 295,900 | 19,200  (17,700, 20,700) | 6.5  (6.0, 7.0) | 217,500 | 3,500  (1,900, 5,000) | 1.6  (0.9, 2.3) | 41,700 | 2,300  (1,800, 2,900) | 5.6  (4.4, 6.8) |
| Oceania | 51,000 | 6,700  (6,200, 7,200) | 13.2  (12.2, 14.1) | 15,200 | 450  (250, 630) | 2.9  (1.6, 4.1) | 4,400 | 500  (400, 570) | 11.3  (9.4, 13.1) |
| South-eastern Asia | 2,336,400 | 564,100  (530,300, 596,700) | 24.1  (22.7, 25.5) | 1,163,400 | 89,200  (59,500, 115,500) | 7.7  (5.1, 9.9) | 334,000 | 77,500  (65,300, 88,300) | 23.2  (19.5, 26.4) |
| Southern Asia | 16,213,600 | 3,939,700  (3,703,400, 4,166,300) | 24.3  (22.8, 25.7) | 4,008,800 | 314,800  (214,200, 402,800) | 7.9  (5.3, 10.0) | 1,150,300 | 267,600  (226,400, 304,000) | 23.3  (19.7, 26.4) |
| Sub-Saharan Africa | 7,525,300 | 640,100  (593,000, 684,800) | 8.5  (7.9, 9.1) | 3,304,700 | 79,100  (47,200, 108,300) | 2.4  (1.4, 3.3) | 632,000 | 50,300  (39,800, 60,300) | 8.0  (6.3, 9.5) |
| Western Asia | 958,200 | 82,200  (75,500, 88,800) | 8.6  (7.9, 9.3) | 379,400 | 8,000  (3,700, 11,800) | 2.1  (1.0, 3.1) | 108,800 | 8,500  (6,500, 10,400) | 7.8  (5.9, 9.6) |
| TOTAL LMIC | 29,668,300 | 5,513,900  (5,169,600, 5,844,200) | 18.6  (17.4, 19.7) | 10,922,600 | 550,800  (360,400, 719,200) | 5.0  (3.3, 6.6) | 2,780,500 | 457,500  (380,600 526,900) | 16.5  (13.7, 18.9) |

AGA = appropriate-for-gestational-age

LMIC = low- and middle-income countries

PAF = percent attributable fraction

SGA = small-for-gestational-age

1n’s were rounded to the closest 100, but the PAFs were calculated prior to rounding

**Figure 1: Pooled adjusted risk ratios between short maternal stature (<145cm, 145-<150cm, 150-<155cm, reference: ≥155cm) and adverse neonatal outcomes using the INTERGROWTH-21st standard to define SGA**

**Panel A: SGA <10%, SGA <3%, and preterm birth**

**Panel B: term-SGA, preterm-AGA, and preterm-SGA**

n = number of studies included in the pooled association

**Figure 2: Height distribution among women of reproductive age, by UN MDG subregions, and U.S. NHANES data used as the theoretical minimum**

Data derived from 80 nationally representative surveys (52 DHS, 24 STEPS, 4 other)

**ONLINE SUPPLEMENTAL MATERIALS**

**Supplemental Table 1: Height distribution among women of reproductive age, cohort population-based studies**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Study | <145cm,% | 145-<150cm, % | 150-<155cm, % | ≥155cm, % |
| Asia | | | | |
| Nepal (1999) | 15.8 | 31.5 | 32.7 | 19.9 |
| Nepal (2003) | 13.5 | 30.6 | 32.9 | 23.1 |
| Philippines (1983) | 12.8 | 32.3 | 35.6 | 19.3 |
| Thailand (2001) | 3.2 | 10.3 | 29.3 | 57.2 |
| Africa | | | | |
| Burkina Faso (2004) | 0.2 | 0.8 | 8.3 | 90.6 |
| Burkina Faso (2006) | 0.1 | 1.2 | 8.8 | 89.9 |
| Tanzania (2001) | 3.5 | 12.2 | 29.1 | 55.6 |
| Tanzania (2008) | 0.5 | 5.5 | 25.2 | 68.9 |
| Americas | | | | |
| Brazil (1982) | 2.2 | 8.8 | 26.9 | 62.2 |
| Brazil (1993) | 0.8 | 1.4 | 17.7 | 77.7 |
| Brazil (2004) | 0.6 | 2.4 | 9.9 | 87.2 |
| Peru (1995) | 11.6 | 28.3 | 33.7 | 26.4 |

**Supplemental Table 2: Included datasets from the WHO Global Survey on Maternal and Perinatal Health(**[**16**](#_ENREF_16)**)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Country | Survey year | Analyzed cohort1, *n* | NMR2 | LBW, % | Preterm, % | SGA, % | women with height <145cm, % | Facility birth, % |
| Algeria3 | 2004 | 15,080 | 20 | 6.1% | 5.8% | 11.2% | 0.1 | 95 |
| Angola | 2004 | 3,110 | 47 | 6.9% | 5.7% | 20.3% | 2.1 | 46 |
| Argentina3 | 2004 | 7,139 | 10 | 8.6% | 9.6% | 10.9% | 1 | 99 |
| Brazil3 | 2004 | 4,848 | 15 | 10.0% | 8.8% | 17.4% | 1.5 | 98 |
| Cambodia | 2007 | 5,426 | 28 | 8.6% | 7.0% | 26.8% | 2.5 | 22 |
| China3 | 2007 | 14,561 | 14 | 5.4% | 6.7% | 10.4% | 0.4 | 92 |
| Cuba3 | 2004 | 12,570 | 4 | 5.9% | 5.3% | 14.1% | 1 | 100 |
| DR Congo3 | 2004 | 8,240 | 49 | 14.0% | 13.8% | 22.9% | 4 | 70 |
| Ecuador3 | 2004 | 11,245 | 13 | 12.1% | 8.3% | 26.0% | 6 | 74 |
| India | 2007 | 23,759 | 35 | 25.1% | 14.8% | 50.1% | 4.4 | 39 |
| Kenya | 2004 | 2,688 | 31 | 9.1% | 11.9% | 19.9% | 1.2 | 39 |
| Mexico3 | 2004 | 19,481 | 10 | 8.6% | 8.5% | 18.2% | 2.2 | 86 |
| Nepal | 2007 | 8,172 | 31 | 12.6% | 9.4% | 34.9% | 9.5 | 18 |
| Nicaragua3 | 2004 | 5,613 | 16 | 8.5% | 7.3% | 18.5% | 3.9 | 74 |
| Niger | 2004 | 8.078 | 38 | 10.7% | 7.6% | 29.3% | 9.5 | 17 |
| Nigeria | 2004 | 7,596 | 43 | 8.3% | 10.2% | 20.9% | 3.5 | 35 |
| Paraguay3 | 2004 | 3,103 | 16 | 7.4% | 10.3% | 10.0% | 1.2 | 85 |
| Peru3 | 2004 | 13,934 | 12 | 8.5% | 9.7% | 10.5% | 4.5 | 72 |
| Philippines | 2007 | 10,616 | 14 | 16.2% | 8.7% | 34.8% | 4.2 | 44 |
| Sri Lanka3 | 2007 | 14,911 | 9 | 14.4% | 7.3% | 33.2% | 5.4 | 98 |
| Thailand3 | 2007 | 9,472 | 9 | 10.2% | 11.2% | 17.3% | 1.5 | 97 |
| Uganda | 2004 | 10,314 | 32 | 6.4% | 8.4% | 12.9% | 1.4 | 41 |
| Vietnam | 2007 | 13115 | 14 | 5.7% | 4.5% | 17.5% | 0.8 | 64 |

1Number of women with height data from medical records.

2The studies did not have neonatal mortality rates available. We extracted national NMRs from the UN-IGME for the survey year.([56](#_ENREF_56))

3Countries that were included in the analysis (with national facility delivery rate over 70%).

**Supplemental Table 3: Height distribution among women of reproductive age, WHOGS survey**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Study | <145cm,% | 145-<150cm, % | 150-<155cm, % | ≥155cm, % |
| Algeria1 | 0.1 | 0.5 | 6.8 | 92.5 |
| Angola | 2.1 | 4.9 | 17.3 | 75.7 |
| Argentina1 | 1.0 | 4.7 | 18.1 | 76.2 |
| Brazil1 | 1.5 | 6.0 | 20.5 | 71.9 |
| Cambodia | 2.5 | 10.7 | 33.2 | 53.5 |
| China1 | 0.4 | 1.5 | 13.2 | 84.9 |
| Cuba1 | 1.0 | 4.4 | 17.8 | 76.8 |
| DR Congo1 | 4.0 | 10.1 | 20.6 | 65.3 |
| Ecuador1 | 6.0 | 13.5 | 30.6 | 49.8 |
| India | 4.4 | 13.9 | 50.7 | 31 |
| Kenya | 1.2 | 5.3 | 15.8 | 77.7 |
| Mexico1 | 2.2 | 7.7 | 28.2 | 62.0 |
| Nepal | 9.5 | 20.9 | 51.0 | 18.7 |
| Nicaragua1 | 3.9 | 12.4 | 35.1 | 48.6 |
| Niger | 0.2 | 1.3 | 9.9 | 88.5 |
| Nigeria | 3.5 | 3.5 | 16.7 | 76.4 |
| Paraguay1 | 1.2 | 4.3 | 19.1 | 75.4 |
| Peru1 | 4.5 | 14.0 | 32.5 | 49.1 |
| Philippines | 4.2 | 14.0 | 32.5 | 49.1 |
| Sri Lanka1 | 5.4 | 14.5 | 33.6 | 46.5 |
| Thailand1 | 1.5 | 8.3 | 26.2 | 63.9 |
| Uganda | 1.4 | 4.6 | 18.3 | 75.7 |
| Vietnam | 0.8 | 6.0 | 33.2 | 59.9 |

1The WHOGS datasets that were included in the analysis.

**Supplemental Table 4: Regional and global risk ratios between maternal height categories (<145cm, 145-<150cm, 150-<155cm) and adverse neonatal outcomes (reference: ≥155cm), INTERGROWTH-21st birthweight standard**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Region | <145cm | | | | | 145-<150cm | | | | | 150-<155cm | | | | |
| *n* | Risk ratio | LI | UI | I2 | *n* | Risk ratio | LI | UI | I2 | *n* | Risk ratio | LI | UI | I2 |
| SGA <10% (compared with ≥10%) | Asia | 7 | 2.03 | 1.59 | 2.60 | 86.3 | 7 | 1.66 | 1.36 | 2.02 | 84.3 | 7 | 1.40 | 1.21 | 1.61 | 81.8 |
| Africa | 4 | 2.04 | 1.71 | 2.45 | 0.0 | 6 | 1.69 | 1.48 | 1.93 | 0.0 | 6 | 1.44 | 1.31 | 1.58 | 0.0 |
| Americas | 12 | 1.92 | 1.53 | 2.41 | 74.0 | 12 | 1.58 | 1.42 | 1.74 | 48.0 | 12 | 1.32 | 1.23 | 1.42 | 51.1 |
| GLOBAL | 23 | 1.98 | 1.72 | 2.27 | 75.0 | 25 | 1.62 | 1.49 | 1.76 | 63.2 | 25 | 1.36 | 1.29 | 1.45 | 62.0 |
| SGA <3% (compared with ≥10%) | Asia | 7 | 2.27 | 1.86 | 2.77 | 38.3 | 7 | 1.89 | 1.49 | 2.40 | 71.7 | 7 | 1.46 | 1.30 | 1.64 | 34.5 |
| Africa | 2 | 2.12 | 1.42 | 3.17 | 30.9 | 6 | 1.84 | 1.50 | 2.26 | 0.0 | 6 | 1.49 | 1.20 | 1.86 | 48.1 |
| Americas | 12 | 2.00 | 1.63 | 2.44 | 27.7 | 12 | 1.58 | 1.26 | 1.97 | 59.2 | 12 | 1.25 | 1.14 | 1.38 | 30.6 |
| GLOBAL | 21 | 2.11 | 1.85 | 2.41 | 31.2 | 25 | 1.71 | 1.49 | 1.96 | 56.9 | 25 | 1.36 | 1.26 | 1.47 | 47.8 |
| Preterm (compared with term) | Asia | 7 | 1.21 | 1.00 | 1.46 | 43.3 | 7 | 1.16 | 1.05 | 1.28 | 0.0 | 7 | 1.05 | 0.94 | 1.17 | 60.6 |
| Africa | 4 | 2.28 | 0.73 | 7.14 | 96.8 | 6 | 1.04 | 0.79 | 1.37 | 13.1 | 6 | 1.19 | 0.95 | 1.49 | 64.2 |
| Americas | 12 | 1.28 | 1.04 | 1.57 | 46.3 | 12 | 1.05 | 0.95 | 1.15 | 38.8 | 12 | 1.01 | 0.95 | 1.08 | 7.6 |
| GLOBAL | 23 | 1.42 | 1.10 | 1.83 | 87.8 | 25 | 1.08 | 1.01 | 1.15 | 27.1 | 25 | 1.05 | 0.99 | 1.12 | 46.5 |
| Term-SGA (compared with term-AGA) | Asia | 7 | 2.06 | 1.59 | 2.66 | 86.9 | 7 | 1.69 | 1.37 | 2.08 | 84.2 | 7 | 1.42 | 1.23 | 1.64 | 81.9 |
| Africa | 4 | 2.13 | 1.76 | 2.58 | 0.0 | 6 | 1.75 | 1.55 | 1.99 | 0.0 | 6 | 1.47 | 1.33 | 1.61 | 0.0 |
| Americas | 12 | 1.98 | 1.57 | 2.51 | 74.1 | 12 | 1.62 | 1.45 | 1.80 | 58.2 | 12 | 1.36 | 1.26 | 1.48 | 60.1 |
| GLOBAL | 23 | 2.03 | 1.76 | 2.35 | 76.3 | 25 | 1.66 | 1.52 | 1.82 | 68.1 | 25 | 1.40 | 1.31 | 1.49 | 64.4 |
| Preterm-AGA (compared with term-AGA) | Asia | 7 | 1.46 | 1.22 | 1.75 | 38.1 | 7 | 1.26 | 1.12 | 1.42 | 0.0 | 7 | 1.11 | 0.97 | 1.27 | 63.2 |
| Africa | 2 | 1.53 | 0.49 | 4.80 | 85.3 | 4 | 1.17 | 0.83 | 1.65 | 18.8 | 6 | 1.14 | 0.87 | 1.49 | 66.8 |
| Americas | 12 | 1.50 | 1.23 | 1.83 | 37.0 | 12 | 1.03 | 0.94 | 1.14 | 10.7 | 12 | 1.05 | 0.97 | 1.14 | 25.8 |
| GLOBAL | 21 | 1.44 | 1.26 | 1.66 | 46.3 | 23 | 1.11 | 1.02 | 1.20 | 19.8 | 25 | 1.08 | 1.00 | 1.16 | 52.6 |
| Preterm-SGA (compared with term-AGA) | Asia | 5 | 2.68 | 1.80 | 4.00 | 0.0 | 6 | 1.90 | 1.40 | 2.58 | 0.0 | 7 | 1.22 | 0.90 | 1.66 | 0.0 |
| Africa | 1 | 1.06 | 0.14 | 8.05 | - | 3 | 1.36 | 0.56 | 3.28 | 29.5 | 5 | 1.47 | 0.96 | 2.25 | 1.4 |
| Americas | 9 | 1.85 | 1.00 | 3.44 | 53.7 | 10 | 1.34 | 1.00 | 1.81 | 0.0 | 12 | 1.14 | 0.93 | 1.41 | 33.9 |
| GLOBAL | 15 | 2.13 | 1.42 | 3.21 | 44.8 | 19 | 1.57 | 1.29 | 1.91 | 0.0 | 24 | 1.21 | 1.04 | 1.40 | 14.0 |

LI = Lower interval

UI = Upper interval

**Supplemental Table 5: Regional and global risk ratios between maternal height categories (<145cm, 145-<150cm, 150-<155cm) and adverse neonatal outcomes (reference: ≥155cm), U.S. 1991 birthweight reference**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Region | <145cm | | | | | 145-<150cm | | | | | 150-<155cm | | | | |
| *n* | Risk ratio | LI | UI | I2 | *n* | Risk ratio | LI | UI | I2 | *n* | Risk ratio | LI | UI | I2 |
| SGA <10% (compared with ≥10%) | Asia | 7 | 1.87 | 1.61 | 2.18 | 82.0 | 7 | 1.58 | 1.38 | 1.81 | 87.5 | 7 | 1.37 | 1.22 | 1.53 | 84.8 |
| Africa | 5 | 2.12 | 1.44 | 3.12 | 78.2 | 6 | 1.34 | 1.11 | 1.63 | 43.9 | 6 | 1.40 | 1.30 | 1.52 | 0.0 |
| Americas | 12 | 1.90 | 1.62 | 2.23 | 71.0 | 12 | 1.56 | 1.41 | 1.73 | 62.3 | 12 | 1.31 | 1.24 | 1.38 | 42.9 |
| GLOBAL | 24 | 1.94 | 1.73 | 2.16 | 79.8 | 25 | 1.53 | 1.42 | 1.65 | 72.6 | 25 | 1.34 | 1.28 | 1.40 | 62.7 |
| SGA <3% (compared with ≥10%) | Asia | 7 | 2.26 | 1.84 | 2.78 | 71.3 | 7 | 1.86 | 1.51 | 2.28 | 80.9 | 7 | 1.45 | 1.25 | 1.69 | 73.6 |
| Africa | 3 | 2.14 | 1.62 | 2.82 | 0.0 | 6 | 1.92 | 1.62 | 2.27 | 0.0 | 6 | 1.46 | 1.27 | 1.68 | 18.6 |
| Americas | 12 | 2.03 | 1.66 | 2.48 | 54.3 | 12 | 1.54 | 1.32 | 1.80 | 55.5 | 12 | 1.24 | 1.17 | 1.31 | 0.0 |
| GLOBAL | 22 | 2.11 | 1.86 | 2.39 | 55.4 | 25 | 1.69 | 1.51 | 1.88 | 63.2 | 25 | 1.34 | 1.26 | 1.43 | 50.8 |
| Term-SGA (compared with term-AGA) | Asia | 7 | 1.87 | 1.58 | 2.21 | 85.9 | 7 | 1.61 | 1.39 | 1.86 | 87.3 | 7 | 1.37 | 1.22 | 1.54 | 85.5 |
| Africa | 5 | 2.24 | 1.74 | 2.88 | 68.1 | 6 | 1.61 | 1.44 | 1.79 | 3.1 | 6 | 1.45 | 1.35 | 1.56 | 0.0 |
| Americas | 12 | 1.86 | 1.59 | 2.18 | 61.6 | 12 | 1.63 | 1.47 | 1.80 | 62.2 | 12 | 1.33 | 1.26 | 1.41 | 49.1 |
| GLOBAL | 24 | 1.94 | 1.74 | 2.16 | 79.5 | 25 | 1.61 | 1.49 | 1.73 | 72.5 | 25 | 1.37 | 1.30 | 1.44 | 67.8 |
| Preterm-AGA (compared with term-AGA) | Asia | 7 | 1.46 | 1.26 | 1.68 | 4.7 | 7 | 1.23 | 1.09 | 1.39 | 0.0 | 7 | 1.10 | 0.98 | 1.24 | 54.4 |
| Africa | 2 | 1.81 | 0.50 | 6.58 | 97.6 | 5 | 1.56 | 0.88 | 2.79 | 78.9 | 6 | 1.30 | 1.01 | 1.67 | 60.3 |
| Americas | 12 | 1.33 | 1.08 | 1.64 | 33.0 | 12 | 1.10 | 1.00 | 1.21 | 9.6 | 12 | 1.06 | 0.96 | 1.16 | 41.1 |
| GLOBAL | 21 | 1.45 | 1.19 | 1.76 | 72.1 | 24 | 1.18 | 1.07 | 1.29 | 36.6 | 25 | 1.10 | 1.03 | 1.18 | 50.2 |
| Preterm-SGA (compared with term-AGA) | Asia | 6 | 3.01 | 2.33 | 3.90 | 0.0 | 6 | 2.25 | 1.62 | 3.12 | 46.5 | 7 | 1.39 | 1.17 | 1.65 | 0.0 |
| Africa | 2 | 1.04 | 0.38 | 2.80 | 0.0 | 4 | 1.32 | 0.81 | 2.13 | 0.0 | 6 | 1.61 | 1.07 | 2.41 | 50.4 |
| Americas | 11 | 2.06 | 1.28 | 3.31 | 59.7 | 11 | 1.14 | 0.94 | 1.38 | 0.0 | 11 | 1.19 | 1.06 | 1.33 | 0.0 |
| GLOBAL | 20 | 2.31 | 1.68 | 3.18 | 55.4 | 21 | 1.48 | 1.20 | 1.83 | 47.1 | 24 | 1.29 | 1.18 | 1.42 | 2.8 |

1As the definition of preterm birth is not affected by the reference/standard used to define SGA, the preterm RRs are the same as Supplemental Table 2a.

LI = Lower interval

UI = Upper interval

**Supplemental Table 6: Regional and global risk ratios between maternal height categories (<145cm, 145-<150cm, 150-<155cm) and adverse neonatal outcomes (reference: ≥155cm), stratified by data source, INTERGROWTH-21st birthweight standard**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Data source | <145cm | | | | | 145-<150cm | | | | | 150-<155cm | | | | |
| *n* | Risk ratio | LI | UI | I2 | *n* | Risk ratio | LI | UI | I2 | *n* | Risk ratio | LI | UI | I2 |
| SGA <10% (compared with ≥10%) | Cohort studies | 10 | 2.28 | 1.75 | 2.98 | 82.1 | 12 | 1.68 | 1.43 | 1.98 | 71.2 | 12 | 1.41 | 1.26 | 1.59 | 65.8 |
| WHO surveys | 13 | 1.81 | 1.54 | 2.13 | 68.2 | 13 | 1.60 | 1.47 | 1.75 | 45.9 | 13 | 1.34 | 1.26 | 1.44 | 61.2 |
| SGA <3% (compared with ≥10%) | Cohort studies | 9 | 2.48 | 1.91 | 3.21 | 46.7 | 12 | 1.83 | 1.49 | 2.26 | 49.3 | 12 | 1.39 | 1.23 | 1.58 | 19.8 |
| WHO surveys | 12 | 1.99 | 1.72 | 2.32 | 20.6 | 13 | 1.62 | 1.34 | 1.97 | 64.6 | 13 | 1.34 | 1.20 | 1.49 | 62.6 |
| Preterm (compared with term) | Cohort studies | 11 | 1.54 | 0.92 | 2.67 | 93.2 | 12 | 1.05 | 0.96 | 1.16 | 0.0 | 12 | 1.09 | 0.98 | 1.21 | 39.3 |
| WHO surveys | 12 | 1.29 | 1.08 | 1.55 | 52.8 | 13 | 1.07 | 0.97 | 1.18 | 49.6 | 13 | 1.03 | 0.96 | 1.11 | 53.2 |
| Term-SGA (compared with term-AGA) | Cohort studies | 10 | 2.28 | 1.74 | 2.98 | 82.2 | 12 | 1.71 | 1.45 | 2.03 | 72.6 | 12 | 1.45 | 1.28 | 1.63 | 66.2 |
| WHO surveys | 13 | 1.89 | 1.58 | 2.27 | 71.3 | 13 | 1.65 | 1.50 | 1.82 | 57.9 | 13 | 1.38 | 1.28 | 1.48 | 65.6 |
| Preterm-AGA (compared with term-AGA) | Cohort studies | 9 | 1.38 | 1.03 | 1.84 | 53.7 | 10 | 1.14 | 1.01 | 1.27 | 0 | 12 | 1.14 | 1.05 | 1.25 | 6.8 |
| WHO surveys | 12 | 1.51 | 1.30 | 1.75 | 35.2 | 13 | 1.08 | 0.95 | 1.22 | 40.7 | 13 | 1.04 | 0.94 | 1.15 | 68.0 |
| Preterm-SGA (compared with term-AGA) | Cohort studies | 6 | 3.57 | 2.13 | 5.98 | 0.0 | 9 | 1.65 | 1.09 | 2.51 | 0 | 11 | 1.26 | 0.99 | 1.60 | 4.9 |
| WHO surveys | 9 | 1.55 | 1.00 | 2.41 | 36.2 | 10 | 1.54 | 1.21 | 1.96 | 10.9 | 13 | 1.19 | 0.98 | 1.44 | 24.2 |

LI = Lower interval

UI = Upper interval

**Supplemental Table 7: Regional and global risk ratios between maternal height and adverse neonatal outcomes (reference: ≥155cm), stratified by data source, U.S. 1991 birthweight reference**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Data source | <145cm | | | | | 145-<150cm | | | | | 150-<155cm | | | | |
| n | Risk ratio | LI | UI | I2 | n | Risk ratio | LI | UI | I2 | n | Risk ratio | LI | UI | I2 |
| SGA <10% (compared with ≥10%) | Cohort studies | 11 | 2.33 | 1.86 | 2.92 | 86.7 | 12 | 1.59 | 1.36 | 1.85 | 79.8 | 12 | 1.40 | 1.28 | 1.55 | 67.2 |
| WHO surveys | 13 | 1.74 | 1.55 | 1.94 | 65.7 | 13 | 1.52 | 1.41 | 1.63 | 57.1 | 13 | 1.31 | 1.25 | 1.38 | 58.8 |
| SGA <3% (compared with ≥10%) | Cohort studies | 9 | 2.60 | 1.97 | 3.44 | 73.1 | 12 | 1.83 | 1.52 | 2.20 | 62.2 | 12 | 1.37 | 1.21 | 1.55 | 50.1 |
| WHO surveys | 13 | 1.93 | 1.71 | 2.18 | 30.9 | 13 | 1.60 | 1.39 | 1.85 | 66.2 | 13 | 1.34 | 1.24 | 1.44 | 54.9 |
| Term-SGA (compared with term-AGA) | Cohort studies | 11 | 2.23 | 1.78 | 2.80 | 85.7 | 12 | 1.68 | 1.43 | 1.97 | 78.5 | 12 | 1.44 | 1.28 | 1.62 | 75.8 |
| WHO surveys | 13 | 1.80 | 1.59 | 2.04 | 71.5 | 13 | 1.59 | 1.48 | 1.71 | 58.3 | 13 | 1.33 | 1.27 | 1.40 | 58.2 |
| Preterm-AGA (compared with term-AGA) | Cohort studies | 9 | 1.36 | 1.03 | 1.79 | 52.6 | 11 | 1.17 | 1.04 | 1.32 | 9.5 | 12 | 1.18 | 1.06 | 1.32 | 32.7 |
| WHO surveys | 12 | 1.47 | 1.12 | 1.93 | 78.7 | 13 | 1.16 | 1.01 | 1.33 | 52.4 | 13 | 1.06 | 0.97 | 1.16 | 59.1 |
| Preterm-SGA (compared with term-AGA) | Cohort studies | 9 | 3.06 | 2.17 | 4.33 | 0.0 | 9 | 1.74 | 1.29 | 2.33 | 0.0 | 11 | 1.30 | 1.04 | 1.63 | 0.0 |
| WHO surveys | 11 | 1.96 | 1.27 | 3.03 | 67.6 | 12 | 1.38 | 1.04 | 1.84 | 65.3 | 13 | 1.30 | 1.14 | 1.47 | 29.5 |

1As the definition of preterm birth is not affected by the reference/standard used to define SGA, the preterm RRs are the same as Supplemental Table 2a.

LI = Lower interval

UI = Upper interval

**Supplemental Table 8: Meta-analyzed adjusted risk ratios between maternal height categories (<145cm, 145-<150cm, 150-<155cm) and adverse neonatal outcomes (reference: ≥155cm), without and with BMI as a control variable, U.S. 1991 reference**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Data source | *n* | <145cm | *n* | 145-<150cm | *n* | 150-<155cm |
| SGA <10% (compared with ≥10%) | Not controlled for BMI | 8 | 2.80 (2.18, 3.60) | 9 | 1.67 (1.38, 2.03) | 9 | 1.43 (1.31, 1.55) |
| Controlled for BMI | 7 | 2.78 (2.24, 3.44) | 9 | 1.82 (1.55, 2.14) | 9 | 1.47 (1.32, 1.63) |
| SGA <3% (compared with ≥10%) | Not controlled for BMI | 7 | 2.81 (2.14, 3.69) | 9 | 1.66 (1.45, 1.88) | 9 | 1.36 (1.19, 1.56) |
| Controlled for BMI | 7 | 2.95 (2.20, 3.97) | 9 | 1.89 (1.55, 2.31) | 9 | 1.40 (1.19, 1.65) |
| Preterm (compared with term) | Not controlled for BMI | 8 | 1.67 (0.83, 3.35) | 9 | 1.19 (1.02, 1.39) | 9 | 1.12 (0.99, 1.28) |
| Controlled for BMI | 7 | 1.48 (1.07, 2.07) | 9 | 1.22 (1.02, 1.46) | 9 | 1.17 (1.01, 1.35) |
| Term-SGA (compared with term-AGA) | Not controlled for BMI | 8 | 2.83 (2.15, 3.73) | 9 | 1.81 (1.52, 2.15) | 9 | 1.47 (1.31, 1.64) |
| Controlled for BMI | 6 | 2.83 (2.16, 3.72) | 9 | 2.09 (1.76, 2.47) | 9 | 1.69 (1.45, 1.96) |
| Preterm-AGA (compared with term-AGA) | Not controlled for BMI | 7 | 1.76 (1.32, 2.39) | 9 | 1.41 (1.18, 1.69) | 9 | 1.28 (1.11, 1.48) |
| Controlled for BMI | 6 | 1.72 (1.26, 2.36) | 9 | 1.44 (1.18, 1.75) | 9 | 1.34 (1.12, 1.62) |
| Preterm-SGA (compared with term-AGA) | Not controlled for BMI | 6 | 4.27 (2.58, 7.06) | 6 | 1.95 (1.32, 2.88) | 8 | 1.22 (0.91, 1.64) |
| Controlled for BMI | 5 | 4.84 (2.56, 9.14) | 5 | 1.99 (1.19, 3.33) | 8 | 1.54 (1.11, 2.12) |

**Supplemental Table 9: List of low- and middle-income countries with data on height prevalence among women of reproductive age**

|  |  |  |  |
| --- | --- | --- | --- |
| UN MDG region | Country | Source of data | Year of Survey |
| Oceania | Fiji | Steps | 2011 |
| Kiribati | Steps | 2004 |
| Marshall Islands | Steps | 2002 |
| Papua New Guinea | Steps | 2007 |
| Samoa | Steps | 2013 |
| Solomon Islands | Steps | 2005 |
| Tonga | Steps | 2011 |
| Eastern Asia | China | China Health and Nutrition Survey | 2000 |
| Mongolia | Steps | 2013 |
| Western Asia | Jordan | DHS | 2012 |
| Qatar | Steps | 2012 |
| Turkey | DHS | 2003 |
| South-eastern Asia | Cambodia | DHS | 2010 |
| Indonesia | Family Life Survey | 2007 |
| Thailand | National Health Examination Survey | 2004 |
| Timor-Leste | DHS | 2009 |
| Vietnam | Steps | 2009 |
| Southern Asia | Bangladesh | DHS | 2011 |
| India | DHS | 2005 |
| Maldives | DHS | 2009 |
| Nepal | Steps | 2013 |
| Pakistan | DHS | 2012 |
| Sri Lanka | Steps | 2006 |
| Caucasus and Central Asia | Armenia | DHS | 2005 |
| Azerbaijan | DHS | 2006 |
| Kazakhstan | DHS | 1999 |
| Kyrgyzstan | DHS | 1997 |
| Uzbekistan | DHS | 2002 |
| Northern Africa | Algeria | Steps | 2003 |
| Egypt | DHS | 2008 |
| Libyan Arab Jamahiriya | Steps | 2009 |
| Morocco | DHS | 2004 |
| Sub-Saharan Africa | Benin | DHS | 2011 |
| Botswana | Steps | 2007 |
| Burkina Faso | DHS | 2010 |
| Burundi | DHS | 2010 |
| Cameroon | DHS | 2011 |
| Cape Verde | Steps | 2007 |
| Chad | DHS | 2004 |
| Comoros | Steps | 2011 |
| Congo | DHS | 2011 |
| Côte d'Ivoire | DHS | 2011 |
| Democratic Republic of the Congo | DHS | 2007 |
| Eritrea | Steps | 2010 |
| Ethiopia | DHS | 2011 |
| Gabon | DHS | 2012 |
| Gambia | Steps | 2010 |
| Ghana | DHS | 2008 |
| Guinea | DHS | 2012 |
| Kenya | DHS | 2008 |
| Lesotho | DHS | 2009-2010 |
| Liberia | DHS | 2007 |
| Madagascar | DHS | 2008 |
| Malawi | DHS | 2010 |
| Mali | DHS | 2006 |
| Mozambique | DHS | 2011 |
| Namibia | DHS | 2006 |
| Niger | DHS | 2012 |
| Nigeria | DHS | 2008 |
| Rwanda | DHS | 2010 |
| São Tomé and Príncipe | DHS | 2008-2009 |
| Senegal | DHS | 2011 |
| Seychelles | Steps | 2004 |
| Sierra Leone | DHS | 2008 |
| South Africa | DHS | 2003 |
| Swaziland | DHS | 2006 |
| Togo | Steps | 2010 |
| Uganda | DHS | 2011 |
| United Republic of Tanzania | DHS | 2010 |
| Zambia | DHS | 2007 |
| Zimbabwe | DHS | 2011 |
| Latin America and the Caribbean | Bolivia | DHS | 2008 |
| Colombia | DHS | 2010 |
| Dominica | Steps | 2007 |
| Guyana | DHS | 2009 |
| Haiti | DHS | 2012 |
| Honduras | DHS | 2011 |
| Mexico | National Health and Nutrition Survey | 2006 |
| Nicaragua | DHS | 2001 |
| Peru | DHS | 2011 |
| Saint Lucia | Steps | 2012 |
| Uruguay | Steps | 2006 |

**Supplemental Table 10: Height distribution among women of reproductive age, by UN MDG subregion**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UN MDG region | Height distribution, % | | | |
| <145cm | 145-<150cm | 150-<155cm | ≥155cm |
| Oceania | 2.3% | 8.5% | 16.8% | 72.4% |
| Eastern Asia | 2.0% | 7.8% | 22.6% | 67.7% |
| Western Asia | 1.3% | 7.2% | 22.3% | 69.1% |
| South-eastern Asia | 8.9% | 23.6% | 35.8% | 31.6% |
| Southern Asia | 10.7% | 24.6% | 33.2% | 31.5% |
| Caucasus and Central Asia | 0.7% | 3.7% | 15.3% | 80.2% |
| Northern Africa | 1.5% | 5.4% | 17.7% | 75.5% |
| Sub-Saharan Africa | 2.6% | 7.0% | 18.8% | 71.6% |
| Latin America and the Caribbean | 4.8% | 13.0% | 24.1% | 58.1% |
| U.S. (NHANES) - counterfactual | 0.6% | 3.0% | 9.7% | 86.7% |

**Supplemental Table 11: SGA (Intergrowth standard) and preterm attributable to maternal short stature for all low- and middle-income countries (followed by regional summaries), U.S. height distribution as counterfactual**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **country** | **Term-SGA babies, n** | **Term-SGA babies attributable to short maternal stature** | | | **PAF** | | | **Preterm-AGA babies, n** | **Preterm-AGA babies attributable to short maternal stature** | | | **PAF** | | | **Preterm-SGA babies, n** | **Preterm-SGA babies attributable to short maternal stature** | | | **PAF** | | |
| **n** | **LI** | **UI** | **%** | **LI** | **UI** | **n** | **LI** | **UI** | **%** | **LI** | **UI** | **n** | **LI** | **UI** | **%** | **LI** | **UI** |
| Armenia | 6600 | 304 | 276 | 333 | 4.6 | 4.2 | 5.0 | 4000 | 41 | 15 | 65 | 1.0 | 0.4 | 1.6 | 1200 | 46 | 33 | 60 | 3.9 | 2.7 | 5.0 |
| Azerbaijan | 26100 | 1033 | 923 | 1144 | 4.0 | 3.5 | 4.4 | 12000 | 103 | 28 | 173 | 0.9 | 0.2 | 1.4 | 3400 | 109 | 73 | 144 | 3.2 | 2.1 | 4.2 |
| Georgia | 7000 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 3600 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 1000 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Kazakhstan | 50200 | 1324 | 1178 | 1472 | 2.6 | 2.3 | 2.9 | 23600 | 138 | 38 | 233 | 0.6 | 0.2 | 1.0 | 6800 | 143 | 92 | 193 | 2.1 | 1.4 | 2.8 |
| Kyrgyzstan | 16300 | 401 | 347 | 455 | 2.5 | 2.1 | 2.8 | 10500 | 53 | 7 | 98 | 0.5 | 0.1 | 0.9 | 3000 | 56 | 31 | 80 | 1.9 | 1.0 | 2.7 |
| Tajikistan | 28100 | 1959 | 1782 | 2132 | 7.0 | 6.3 | 7.6 | 15900 | 263 | 104 | 409 | 1.7 | 0.7 | 2.6 | 4600 | 270 | 191 | 345 | 5.9 | 4.1 | 7.5 |
| Turkmenistan | 12300 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 8300 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 2400 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Uzbekistan | 60400 | 2103 | 1872 | 2342 | 3.5 | 3.1 | 3.9 | 39600 | 283 | 57 | 488 | 0.7 | 0.1 | 1.2 | 11400 | 319 | 207 | 427 | 2.8 | 1.8 | 3.7 |
| Caucasus and Central Asia | 207000 | 7124 | 6378 | 7879 | 3.4 | 3.1 | 3.8 | 117500 | 880 | 249 | 1466 | 0.7 | 0.2 | 1.2 | 33800 | 942 | 627 | 1249 | 2.8 | 1.9 | 3.7 |
| China | 810700 | 68922 | 63570 | 74091 | 8.5 | 7.8 | 9.1 | 910900 | 19634 | 10459 | 27971 | 2.2 | 1.1 | 3.1 | 261400 | 19691 | 15065 | 24080 | 7.5 | 5.8 | 9.2 |
| Democratic People's Republic of Korea | 47400 | 3976 | 3656 | 4272 | 8.4 | 7.7 | 9.0 | 29000 | 603 | 308 | 868 | 2.1 | 1.1 | 3.0 | 8300 | 615 | 468 | 755 | 7.4 | 5.6 | 9.1 |
| Mongolia | 5000 | 414 | 380 | 445 | 8.3 | 7.6 | 8.9 | 6800 | 136 | 66 | 199 | 2.0 | 1.0 | 2.9 | 1900 | 139 | 105 | 170 | 7.3 | 5.5 | 9.0 |
| Republic of Korea | 37800 | 3171 | 2916 | 3407 | 8.4 | 7.7 | 9.0 | 34100 | 709 | 362 | 1021 | 2.1 | 1.1 | 3.0 | 9800 | 727 | 553 | 891 | 7.4 | 5.6 | 9.1 |
| Eastern Asia | 900900 | 76483 | 70522 | 82216 | 8.5 | 7.8 | 9.1 | 980800 | 21083 | 11195 | 30058 | 2.1 | 1.1 | 3.1 | 281400 | 21172 | 16191 | 25896 | 7.5 | 5.8 | 9.2 |
| Antigua and Barbuda | 100 | 14 | 13 | 14 | 13.6 | 12.7 | 14.5 | 100 | 4 | 3 | 5 | 3.9 | 2.5 | 5.1 | 21 | 3 | 2 | 3 | 12.8 | 10.5 | 14.9 |
| Argentina | 66600 | 9042 | 8438 | 9633 | 13.6 | 12.7 | 14.5 | 43800 | 1695 | 1103 | 2244 | 3.9 | 2.5 | 5.1 | 11600 | 1480 | 1218 | 1734 | 12.8 | 10.5 | 14.9 |
| Bahamas | 800 | 109 | 101 | 116 | 13.6 | 12.7 | 14.5 | 400 | 15 | 10 | 20 | 3.9 | 2.5 | 5.1 | 100 | 13 | 11 | 15 | 12.8 | 10.5 | 14.9 |
| Barbados | 500 | 68 | 63 | 72 | 13.6 | 12.7 | 14.5 | 200 | 8 | 5 | 10 | 3.9 | 2.5 | 5.1 | 100 | 13 | 11 | 15 | 12.8 | 10.5 | 14.9 |
| Belize | 1400 | 190 | 177 | 203 | 13.6 | 12.7 | 14.5 | 600 | 23 | 15 | 31 | 3.9 | 2.5 | 5.1 | 200 | 26 | 21 | 30 | 12.8 | 10.5 | 14.9 |
| Bolivia | 48600 | 11818 | 11107 | 12509 | 24.3 | 22.9 | 25.7 | 38500 | 2928 | 1937 | 3775 | 7.6 | 5.0 | 9.8 | 10100 | 2370 | 2004 | 2684 | 23.5 | 19.8 | 26.6 |
| Brazil | 347100 | 47126 | 43978 | 50206 | 13.6 | 12.7 | 14.5 | 221000 | 8552 | 5566 | 11325 | 3.9 | 2.5 | 5.1 | 58300 | 7440 | 6123 | 8714 | 12.8 | 10.5 | 14.9 |
| Chile | 19800 | 2688 | 2509 | 2864 | 13.6 | 12.7 | 14.5 | 13800 | 534 | 348 | 707 | 3.9 | 2.5 | 5.1 | 3700 | 472 | 389 | 553 | 12.8 | 10.5 | 14.9 |
| Colombia | 113100 | 14967 | 13896 | 15957 | 13.2 | 12.3 | 14.1 | 63900 | 2222 | 1250 | 3098 | 3.5 | 2.0 | 4.8 | 16900 | 2037 | 1616 | 2431 | 12.1 | 9.6 | 14.4 |
| Costa Rica | 6200 | 842 | 786 | 897 | 13.6 | 12.7 | 14.5 | 7900 | 306 | 199 | 405 | 3.9 | 2.5 | 5.1 | 2100 | 268 | 221 | 314 | 12.8 | 10.5 | 14.9 |
| Cuba | 7900 | 1073 | 1001 | 1143 | 13.6 | 12.7 | 14.5 | 5600 | 217 | 141 | 287 | 3.9 | 2.5 | 5.1 | 1500 | 191 | 158 | 224 | 12.8 | 10.5 | 14.9 |
| Dominica | 200 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 100 | 0 | 0 | 0 | 0.1 | 0.0 | 0.3 | 21 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Dominican Republic | 24000 | 3258 | 3041 | 3471 | 13.6 | 12.7 | 14.5 | 18400 | 712 | 463 | 943 | 3.9 | 2.5 | 5.1 | 4900 | 625 | 515 | 732 | 12.8 | 10.5 | 14.9 |
| Ecuador | 25800 | 3503 | 3269 | 3732 | 13.6 | 12.7 | 14.5 | 12000 | 464 | 302 | 615 | 3.9 | 2.5 | 5.1 | 3200 | 408 | 336 | 478 | 12.8 | 10.5 | 14.9 |
| El Salvador | 15900 | 2159 | 2015 | 2300 | 13.6 | 12.7 | 14.5 | 12800 | 495 | 322 | 656 | 3.9 | 2.5 | 5.1 | 3400 | 434 | 357 | 508 | 12.8 | 10.5 | 14.9 |
| Grenada | 200 | 27 | 25 | 29 | 13.6 | 12.7 | 14.5 | 200 | 8 | 5 | 10 | 3.9 | 2.5 | 5.1 | 42 | 5 | 4 | 6 | 12.8 | 10.5 | 14.9 |
| Guatemala | 55800 | 7576 | 7070 | 8071 | 13.6 | 12.7 | 14.5 | 28400 | 1099 | 715 | 1455 | 3.9 | 2.5 | 5.1 | 7500 | 957 | 788 | 1121 | 12.8 | 10.5 | 14.9 |
| Guyana | 2200 | 222 | 206 | 237 | 10.1 | 9.3 | 10.8 | 1400 | 37 | 22 | 51 | 2.6 | 1.6 | 3.6 | 400 | 37 | 30 | 44 | 9.3 | 7.5 | 11.0 |
| Haiti | 84900 | 3621 | 3302 | 3951 | 4.3 | 3.9 | 4.7 | 29700 | 278 | 112 | 430 | 0.9 | 0.4 | 1.4 | 7800 | 287 | 210 | 362 | 3.7 | 2.7 | 4.6 |
| Honduras | 27900 | 5802 | 5440 | 6154 | 20.8 | 19.5 | 22.1 | 19500 | 1248 | 841 | 1621 | 6.4 | 4.3 | 8.3 | 5200 | 1032 | 865 | 1185 | 19.9 | 16.6 | 22.8 |
| Jamaica | 8100 | 1100 | 1026 | 1172 | 13.6 | 12.7 | 14.5 | 4100 | 159 | 103 | 210 | 3.9 | 2.5 | 5.1 | 1100 | 140 | 116 | 164 | 12.8 | 10.5 | 14.9 |
| Mexico | 184800 | 37922 | 35566 | 40272 | 20.5 | 19.2 | 21.8 | 128800 | 8449 | 5813 | 10752 | 6.6 | 4.5 | 8.3 | 33900 | 6685 | 5620 | 7637 | 19.7 | 16.6 | 22.5 |
| Nicaragua | 17400 | 3281 | 3068 | 3488 | 18.9 | 17.6 | 20.0 | 10200 | 539 | 333 | 728 | 5.3 | 3.3 | 7.1 | 2700 | 478 | 394 | 554 | 17.7 | 14.6 | 20.5 |
| Panama | 8000 | 1086 | 1014 | 1157 | 13.6 | 12.7 | 14.5 | 4500 | 174 | 113 | 231 | 3.9 | 2.5 | 5.1 | 1200 | 153 | 126 | 179 | 12.8 | 10.5 | 14.9 |
| Paraguay | 14300 | 1942 | 1812 | 2068 | 13.6 | 12.7 | 14.5 | 9700 | 375 | 244 | 497 | 3.9 | 2.5 | 5.1 | 2500 | 319 | 263 | 374 | 12.8 | 10.5 | 14.9 |
| Peru | 58400 | 14011 | 13160 | 14833 | 24.0 | 22.5 | 25.4 | 34500 | 2579 | 1703 | 3332 | 7.5 | 4.9 | 9.7 | 9100 | 2105 | 1777 | 2386 | 23.1 | 19.5 | 26.2 |
| Saint Lucia | 400 | 8 | 6 | 10 | 1.9 | 1.4 | 2.4 | 200 | 1 | 0 | 2 | 0.5 | 0.0 | 1.1 | 100 | 1 | 0 | 2 | 1.0 | 0.0 | 2.2 |
| Saint Vincent and the Grenadines | 200 | 27 | 25 | 29 | 13.6 | 12.7 | 14.5 | 200 | 8 | 5 | 10 | 3.9 | 2.5 | 5.1 | 42 | 5 | 4 | 6 | 12.8 | 10.5 | 14.9 |
| Suriname | 1500 | 204 | 190 | 217 | 13.6 | 12.7 | 14.5 | 700 | 27 | 18 | 36 | 3.9 | 2.5 | 5.1 | 200 | 26 | 21 | 30 | 12.8 | 10.5 | 14.9 |
| Trinidad and Tobago | 2900 | 394 | 367 | 419 | 13.6 | 12.7 | 14.5 | 1300 | 50 | 33 | 67 | 3.9 | 2.5 | 5.1 | 300 | 38 | 32 | 45 | 12.8 | 10.5 | 14.9 |
| Uruguay | 5900 | 157 | 133 | 178 | 2.7 | 2.3 | 3.0 | 4000 | 34 | 14 | 52 | 0.8 | 0.4 | 1.3 | 1000 | 19 | 10 | 29 | 1.9 | 1.0 | 2.9 |
| Venezuela | 29100 | 3951 | 3687 | 4209 | 13.6 | 12.7 | 14.5 | 18800 | 727 | 474 | 963 | 3.9 | 2.5 | 5.1 | 4900 | 625 | 515 | 732 | 12.8 | 10.5 | 14.9 |
| Latin America and the Caribbean | 1180000 | 178186 | 166491 | 189611 | 15.1 | 14.1 | 16.1 | 735300 | 33967 | 22214 | 44568 | 4.6 | 3.0 | 6.1 | 194126 | 28694 | 23754 | 33293 | 14.8 | 12.2 | 17.2 |
| Algeria | 67300 | 3395 | 3106 | 3663 | 5.0 | 4.6 | 5.4 | 44300 | 549 | 275 | 800 | 1.2 | 0.6 | 1.8 | 8500 | 372 | 274 | 466 | 4.4 | 3.2 | 5.5 |
| Egypt | 164300 | 12918 | 11927 | 13841 | 7.9 | 7.3 | 8.4 | 114900 | 2360 | 1345 | 3291 | 2.1 | 1.2 | 2.9 | 22000 | 1548 | 1201 | 1885 | 7.0 | 5.5 | 8.6 |
| Libyan Arab Jamahiri | 8900 | 207 | 188 | 226 | 2.3 | 2.1 | 2.5 | 10200 | 57 | 26 | 87 | 0.6 | 0.3 | 0.9 | 1900 | 37 | 26 | 48 | 2.0 | 1.4 | 2.5 |
| Morocco | 40800 | 1951 | 1765 | 2138 | 4.8 | 4.3 | 5.2 | 34800 | 379 | 137 | 602 | 1.1 | 0.4 | 1.7 | 6700 | 267 | 186 | 345 | 4.0 | 2.8 | 5.2 |
| Tunisia | 14600 | 737 | 674 | 795 | 5.0 | 4.6 | 5.4 | 13300 | 165 | 82 | 240 | 1.2 | 0.6 | 1.8 | 2600 | 114 | 84 | 143 | 4.4 | 3.2 | 5.5 |
| Northern Africa | 295900 | 19208 | 17660 | 20664 | 6.5 | 6.0 | 7.0 | 217500 | 3509 | 1865 | 5020 | 1.6 | 0.9 | 2.3 | 41700 | 2337 | 1770 | 2887 | 5.6 | 4.2 | 6.9 |
| Fiji | 2900 | 42 | 39 | 45 | 1.5 | 1.3 | 1.6 | 1400 | 5 | 3 | 7 | 0.3 | 0.2 | 0.5 | 400 | 5 | 4 | 6 | 1.3 | 1.0 | 1.6 |
| Kiribati | 300 | 10 | 9 | 12 | 3.4 | 2.9 | 3.9 | 200 | 1 | 0 | 3 | 0.7 | 0.0 | 1.3 | 45 | 1 | 1 | 2 | 2.5 | 1.2 | 3.8 |
| Marshall Islands | 300 | 70 | 66 | 74 | 23.4 | 21.9 | 24.7 | 100 | 7 | 4 | 9 | 6.9 | 4.4 | 9.2 | 22 | 5 | 4 | 6 | 22.1 | 18.5 | 25.4 |
| Micronesia (Federated States of) | 600 | 43 | 40 | 46 | 7.2 | 6.7 | 7.7 | 200 | 4 | 2 | 5 | 1.9 | 1.2 | 2.5 | 100 | 7 | 5 | 8 | 6.8 | 5.5 | 8.0 |
| Papua New Guinea | 41700 | 6204 | 5733 | 6638 | 14.9 | 13.7 | 15.9 | 10600 | 388 | 214 | 545 | 3.7 | 2.0 | 5.1 | 3000 | 429 | 355 | 495 | 14.3 | 11.8 | 16.5 |
| Samoa | 100 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 200 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 45 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Solomon Islands | 3700 | 266 | 247 | 286 | 7.2 | 6.7 | 7.7 | 1600 | 30 | 19 | 40 | 1.9 | 1.2 | 2.5 | 500 | 34 | 27 | 40 | 6.8 | 5.5 | 8.0 |
| Tonga | 200 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 200 | 0 | 0 | 1 | 0.2 | 0.0 | 0.5 | 45 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Vanuatu | 1200 | 86 | 80 | 93 | 7.2 | 6.7 | 7.7 | 700 | 13 | 8 | 18 | 1.9 | 1.2 | 2.5 | 200 | 14 | 11 | 16 | 6.8 | 5.5 | 8.0 |
| Oceania | 51000 | 6723 | 6213 | 7194 | 13.2 | 12.2 | 14.1 | 15200 | 447 | 250 | 628 | 2.9 | 1.6 | 4.1 | 4357 | 494 | 407 | 572 | 11.3 | 9.4 | 13.1 |
| Brunei Darussalam | 1400 | 329 | 308 | 348 | 23.5 | 22.0 | 24.8 | 700 | 51 | 34 | 66 | 7.3 | 4.8 | 9.5 | 200 | 45 | 38 | 51 | 22.4 | 18.8 | 25.6 |
| Cambodia | 52100 | 11197 | 10481 | 11878 | 21.5 | 20.1 | 22.8 | 26100 | 1598 | 987 | 2152 | 6.1 | 3.8 | 8.2 | 7500 | 1519 | 1263 | 1750 | 20.2 | 16.8 | 23.3 |
| Indonesia | 891600 | 237175 | 223602 | 250466 | 26.6 | 25.1 | 28.1 | 525000 | 45947 | 31533 | 58593 | 8.8 | 6.0 | 11.2 | 150700 | 38678 | 32856 | 43702 | 25.7 | 21.8 | 29.0 |
| Lao People's Democratic Republic | 28800 | 6759 | 6345 | 7155 | 23.5 | 22.0 | 24.8 | 11800 | 858 | 567 | 1118 | 7.3 | 4.8 | 9.5 | 3400 | 761 | 640 | 870 | 22.4 | 18.8 | 25.6 |
| Malaysia | 103900 | 24384 | 22889 | 25811 | 23.5 | 22.0 | 24.8 | 55100 | 4007 | 2649 | 5219 | 7.3 | 4.8 | 9.5 | 15800 | 3535 | 2972 | 4044 | 22.4 | 18.8 | 25.6 |
| Myanmar | 243300 | 57099 | 53600 | 60442 | 23.5 | 22.0 | 24.8 | 79800 | 5803 | 3836 | 7558 | 7.3 | 4.8 | 9.5 | 22900 | 5124 | 4308 | 5862 | 22.4 | 18.8 | 25.6 |
| Philippines | 708900 | 166370 | 156173 | 176109 | 23.5 | 22.0 | 24.8 | 271100 | 19715 | 13031 | 25678 | 7.3 | 4.8 | 9.5 | 77800 | 17407 | 14635 | 19914 | 22.4 | 18.8 | 25.6 |
| Singapore | 6900 | 1619 | 1520 | 1714 | 23.5 | 22.0 | 24.8 | 4000 | 291 | 192 | 379 | 7.3 | 4.8 | 9.5 | 1200 | 268 | 226 | 307 | 22.4 | 18.8 | 25.6 |
| Thailand | 135300 | 20934 | 19443 | 22313 | 15.5 | 14.4 | 16.5 | 78200 | 3165 | 1702 | 4481 | 4.0 | 2.2 | 5.7 | 22500 | 3163 | 2518 | 3767 | 14.1 | 11.2 | 16.7 |
| Timor-Leste | 10300 | 3033 | 2851 | 3197 | 29.4 | 27.7 | 31.0 | 4100 | 425 | 300 | 532 | 10.4 | 7.3 | 13.0 | 1200 | 345 | 295 | 386 | 28.7 | 24.6 | 32.1 |
| Viet Nam | 153900 | 35217 | 33078 | 37298 | 22.9 | 21.5 | 24.2 | 107500 | 7318 | 4694 | 9747 | 6.8 | 4.4 | 9.1 | 30800 | 6644 | 5536 | 7648 | 21.6 | 18.0 | 24.8 |
| South-eastern Asia | 2336400 | 564115 | 530290 | 596731 | 24.1 | 22.7 | 25.5 | 1163400 | 89179 | 59525 | 115522 | 7.7 | 5.1 | 9.9 | 334000 | 77488 | 65286 | 88300 | 23.2 | 19.5 | 26.4 |
| Afghanistan | 518000 | 125801 | 118346 | 133081 | 24.3 | 22.8 | 25.7 | 124200 | 9785 | 6714 | 12479 | 7.9 | 5.4 | 10.0 | 35700 | 8353 | 7070 | 9485 | 23.4 | 19.8 | 26.6 |
| Bangladesh | 1108500 | 309267 | 290624 | 326469 | 27.9 | 26.2 | 29.5 | 329500 | 31044 | 21580 | 39249 | 9.4 | 6.5 | 11.9 | 94600 | 25744 | 21970 | 28888 | 27.2 | 23.2 | 30.5 |
| Bhutan | 2900 | 704 | 663 | 745 | 24.3 | 22.8 | 25.7 | 1200 | 95 | 65 | 121 | 7.9 | 5.4 | 10.0 | 300 | 70 | 59 | 80 | 23.4 | 19.8 | 26.6 |
| India | 12000000 | 3013474 | 2835349 | 3185496 | 25.1 | 23.6 | 26.5 | 2734500 | 225675 | 154780 | 286467 | 8.3 | 5.7 | 10.5 | 784600 | 190307 | 161603 | 215451 | 24.3 | 20.6 | 27.5 |
| Iran (Islamic Republic of) | 177600 | 43132 | 40576 | 45628 | 24.3 | 22.8 | 25.7 | 127400 | 10037 | 6887 | 12800 | 7.9 | 5.4 | 10.0 | 36500 | 8541 | 7229 | 9697 | 23.4 | 19.8 | 26.6 |
| Maldives | 900 | 229 | 215 | 242 | 25.4 | 23.9 | 26.9 | 300 | 25 | 17 | 32 | 8.3 | 5.7 | 10.6 | 89 | 22 | 19 | 25 | 24.6 | 20.8 | 27.8 |
| Nepal | 261700 | 70023 | 65783 | 73981 | 26.8 | 25.1 | 28.3 | 78900 | 6963 | 4772 | 8832 | 8.8 | 6.0 | 11.2 | 22600 | 5887 | 5019 | 6618 | 26.0 | 22.2 | 29.3 |
| Pakistan | 2061300 | 358758 | 334636 | 381281 | 17.4 | 16.2 | 18.5 | 581300 | 28814 | 17776 | 38909 | 5.0 | 3.1 | 6.7 | 166800 | 26790 | 21770 | 31533 | 16.1 | 13.1 | 18.9 |
| Sri Lanka | 82700 | 18361 | 17254 | 19426 | 22.2 | 20.9 | 23.5 | 31500 | 2321 | 1612 | 2953 | 7.4 | 5.1 | 9.4 | 9100 | 1933 | 1621 | 2207 | 21.2 | 17.8 | 24.3 |
| Southern Asia | 16213600 | 3939748 | 3703445 | 4166349 | 24.3 | 22.8 | 25.7 | 4008800 | 314760 | 214203 | 401840 | 7.9 | 5.3 | 10.0 | 1150289 | 267648 | 226360 | 303984 | 23.3 | 19.7 | 26.4 |
| Angola | 187400 | 13656 | 12662 | 14602 | 7.3 | 6.8 | 7.8 | 83100 | 1636 | 998 | 2228 | 2.0 | 1.2 | 2.7 | 15900 | 1049 | 827 | 1270 | 6.6 | 5.2 | 8.0 |
| Benin | 84400 | 3805 | 3502 | 4101 | 4.5 | 4.1 | 4.9 | 31100 | 455 | 315 | 580 | 1.5 | 1.0 | 1.9 | 5900 | 246 | 195 | 298 | 4.2 | 3.3 | 5.0 |
| Botswana | 8500 | 21 | 8 | 33 | 0.2 | 0.1 | 0.4 | 6000 | 16 | 7 | 25 | 0.3 | 0.1 | 0.4 | 1100 | 1 | 0 | 5 | 0.1 | 0.0 | 0.4 |
| Burkina Faso | 135900 | 582 | 442 | 726 | 0.4 | 0.3 | 0.5 | 65100 | 76 | 0 | 152 | 0.1 | 0.0 | 0.2 | 12500 | 29 | 0 | 61 | 0.2 | 0.0 | 0.5 |
| Burundi | 61600 | 9929 | 9282 | 10566 | 16.1 | 15.1 | 17.2 | 27000 | 1234 | 786 | 1654 | 4.6 | 2.9 | 6.1 | 5200 | 783 | 641 | 913 | 15.0 | 12.3 | 17.6 |
| Cameroon | 135900 | 3587 | 3230 | 3919 | 2.6 | 2.4 | 2.9 | 74900 | 489 | 217 | 746 | 0.7 | 0.3 | 1.0 | 14300 | 312 | 211 | 409 | 2.2 | 1.5 | 2.9 |
| Cape Verde | 900 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 1000 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 200 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Central African Republic | 38500 | 2805 | 2601 | 3000 | 7.3 | 6.8 | 7.8 | 16300 | 321 | 196 | 437 | 2.0 | 1.2 | 2.7 | 3100 | 205 | 161 | 248 | 6.6 | 5.2 | 8.0 |
| Chad | 174600 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 55100 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 10600 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Comoros | 9600 | 1231 | 1144 | 1314 | 12.8 | 11.9 | 13.7 | 3900 | 136 | 82 | 186 | 3.5 | 2.1 | 4.8 | 700 | 82 | 66 | 98 | 11.8 | 9.5 | 14.0 |
| Congo | 31300 | 1475 | 1347 | 1594 | 4.7 | 4.3 | 5.1 | 20000 | 238 | 119 | 350 | 1.2 | 0.6 | 1.7 | 3800 | 153 | 110 | 193 | 4.0 | 2.9 | 5.1 |
| Cote d'Ivoire | 193500 | 11134 | 10151 | 12091 | 5.8 | 5.2 | 6.2 | 79200 | 1059 | 435 | 1608 | 1.3 | 0.5 | 2.0 | 15200 | 748 | 542 | 947 | 4.9 | 3.6 | 6.2 |
| Democratic Republic of the Congo | 574600 | 70690 | 65843 | 75303 | 12.3 | 11.5 | 13.1 | 286600 | 10074 | 6509 | 13372 | 3.5 | 2.3 | 4.7 | 54800 | 6276 | 5124 | 7388 | 11.5 | 9.4 | 13.5 |
| Djibouti | 7800 | 568 | 527 | 608 | 7.3 | 6.8 | 7.8 | 2600 | 51 | 31 | 70 | 2.0 | 1.2 | 2.7 | 500 | 33 | 26 | 40 | 6.6 | 5.2 | 8.0 |
| Equatorial Guinea | 5900 | 430 | 399 | 460 | 7.3 | 6.8 | 7.8 | 3500 | 69 | 42 | 94 | 2.0 | 1.2 | 2.7 | 700 | 46 | 36 | 56 | 6.6 | 5.2 | 8.0 |
| Eritrea | 40200 | 3814 | 3509 | 4114 | 9.5 | 8.7 | 10.2 | 19600 | 431 | 194 | 644 | 2.2 | 1.0 | 3.3 | 3700 | 312 | 237 | 383 | 8.4 | 6.4 | 10.4 |
| Ethiopia | 795700 | 102631 | 95208 | 10945 | 12.9 | 12.0 | 13.8 | 221100 | 7646 | 4454 | 10554 | 3.5 | 2.0 | 4.8 | 42300 | 4969 | 3964 | 5923 | 11.7 | 9.4 | 14.0 |
| Gabon | 9000 | 341 | 310 | 371 | 3.8 | 3.4 | 4.1 | 5600 | 49 | 20 | 74 | 0.9 | 0.4 | 1.3 | 1100 | 35 | 25 | 45 | 3.2 | 2.3 | 4.1 |
| Gambia | 20200 | 1418 | 1297 | 1537 | 7.0 | 6.4 | 7.6 | 7700 | 192 | 137 | 240 | 2.5 | 1.8 | 3.1 | 1500 | 102 | 81 | 123 | 6.8 | 5.4 | 8.2 |
| Ghana | 168700 | 9583 | 8683 | 10407 | 5.7 | 5.1 | 6.2 | 93600 | 1336 | 609 | 2022 | 1.4 | 0.7 | 2.2 | 17900 | 854 | 591 | 1100 | 4.8 | 3.3 | 6.1 |
| Guinea | 87500 | 3679 | 3340 | 4008 | 4.2 | 3.8 | 4.6 | 45600 | 457 | 196 | 700 | 1.0 | 0.4 | 1.5 | 8700 | 308 | 216 | 396 | 3.5 | 2.5 | 4.6 |
| Guinea-Bissau | 21700 | 1581 | 1466 | 1691 | 7.3 | 6.8 | 7.8 | 5500 | 108 | 66 | 147 | 2.0 | 1.2 | 2.7 | 1000 | 66 | 52 | 80 | 6.6 | 5.2 | 8.0 |
| Kenya | 206600 | 11136 | 10163 | 12054 | 5.4 | 4.9 | 5.8 | 157900 | 2174 | 1080 | 3204 | 1.4 | 0.7 | 2.0 | 30200 | 1388 | 987 | 1753 | 4.6 | 3.3 | 5.8 |
| Lesotho | 11900 | 1158 | 1068 | 1242 | 9.7 | 9.0 | 10.4 | 6000 | 144 | 74 | 208 | 2.4 | 1.2 | 3.5 | 1200 | 104 | 80 | 127 | 8.7 | 6.7 | 10.6 |
| Liberia | 33800 | 3563 | 3301 | 3806 | 10.5 | 9.8 | 11.3 | 18000 | 488 | 274 | 682 | 2.7 | 1.5 | 3.8 | 3400 | 326 | 257 | 391 | 9.6 | 7.6 | 11.5 |
| Madagascar | 169900 | 35809 | 33580 | 37948 | 21.1 | 19.8 | 22.3 | 87300 | 5497 | 3553 | 7257 | 6.3 | 4.1 | 8.3 | 16700 | 3324 | 2774 | 3831 | 19.9 | 16.6 | 22.9 |
| Malawi | 134700 | 16039 | 14862 | 17146 | 11.9 | 11.0 | 12.7 | 100500 | 3023 | 1620 | 4300 | 3.0 | 1.6 | 4.3 | 19200 | 2073 | 1636 | 2484 | 10.8 | 8.5 | 12.9 |
| Mali | 238100 | 3171 | 2812 | 3520 | 1.3 | 1.2 | 1.5 | 69300 | 275 | 144 | 400 | 0.4 | 0.2 | 0.6 | 13300 | 142 | 93 | 193 | 1.1 | 0.7 | 1.4 |
| Mauritania | 52000 | 3789 | 3513 | 4052 | 7.3 | 6.8 | 7.8 | 15100 | 297 | 181 | 405 | 2.0 | 1.2 | 2.7 | 2900 | 191 | 151 | 232 | 6.6 | 5.2 | 8.0 |
| Mauritius | 3100 | 226 | 209 | 242 | 7.3 | 6.8 | 7.8 | 1800 | 35 | 22 | 48 | 2.0 | 1.2 | 2.7 | 300 | 20 | 16 | 24 | 6.6 | 5.2 | 8.0 |
| Mozambique | 222700 | 34396 | 32058 | 36633 | 15.4 | 14.4 | 16.4 | 121600 | 5127 | 3052 | 7025 | 4.2 | 2.5 | 5.8 | 23300 | 3311 | 2663 | 3902 | 14.2 | 11.4 | 16.7 |
| Namibia | 13300 | 302 | 278 | 325 | 2.3 | 2.1 | 2.4 | 7300 | 44 | 26 | 60 | 0.6 | 0.4 | 0.8 | 1400 | 28 | 22 | 35 | 2.0 | 1.5 | 2.5 |
| Niger | 276400 | 7727 | 6923 | 8507 | 2.8 | 2.5 | 3.1 | 59700 | 415 | 167 | 649 | 0.7 | 0.3 | 1.1 | 11400 | 256 | 168 | 343 | 2.2 | 1.5 | 3.0 |
| Nigeria | 1379500 | 124090 | 115235 | 132440 | 9.0 | 8.4 | 9.6 | 649400 | 16682 | 10762 | 22139 | 2.6 | 1.7 | 3.4 | 124200 | 10298 | 8274 | 12285 | 8.3 | 6.7 | 9.9 |
| Rwanda | 47300 | 5920 | 5505 | 6319 | 12.5 | 11.6 | 13.4 | 34900 | 1160 | 690 | 1594 | 3.3 | 2.0 | 4.6 | 6700 | 771 | 618 | 913 | 11.5 | 9.2 | 13.6 |
| Sao Tome and Principe | 700 | 27 | 25 | 30 | 3.9 | 3.5 | 4.2 | 400 | 5 | 3 | 7 | 1.3 | 0.9 | 1.7 | 100 | 3 | 2 | 4 | 3.4 | 2.5 | 4.3 |
| Senegal | 127900 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 38000 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 7300 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Seychelles | 200 | 0 | 0 | 1 | 0.2 | 0.1 | 0.4 | 100 | 0 | 0 | 0 | 0.2 | 0.1 | 0.4 | 16 | 0 | 0 | 0 | 0.4 | 0.0 | 0.7 |
| Sierra Leone | 60500 | 11118 | 10229 | 11977 | 18.4 | 16.9 | 19.8 | 19100 | 1407 | 1023 | 1748 | 7.4 | 5.4 | 9.2 | 3600 | 646 | 513 | 762 | 17.9 | 14.3 | 21.2 |
| Somalia | 94500 | 6886 | 6385 | 7364 | 7.3 | 6.8 | 7.8 | 40900 | 805 | 491 | 1097 | 2.0 | 1.2 | 2.7 | 7800 | 515 | 406 | 623 | 6.6 | 5.2 | 8.0 |
| South Africa | 230500 | 15649 | 14412 | 16816 | 6.8 | 6.3 | 7.3 | 71200 | 1149 | 598 | 1652 | 1.6 | 0.8 | 2.3 | 13600 | 837 | 655 | 1007 | 6.2 | 4.8 | 7.4 |
| Sudan | 565000 | 41171 | 38174 | 44025 | 7.3 | 6.8 | 7.8 | 158100 | 3113 | 1899 | 4239 | 2.0 | 1.2 | 2.7 | 30200 | 1993 | 1570 | 2412 | 6.6 | 5.2 | 8.0 |
| Swaziland | 5900 | 342 | 312 | 370 | 5.8 | 5.3 | 6.3 | 4000 | 56 | 27 | 83 | 1.4 | 0.7 | 2.1 | 800 | 40 | 29 | 50 | 5.0 | 3.6 | 6.3 |
| Togo | 39900 | 1246 | 1117 | 1371 | 3.1 | 2.8 | 3.4 | 21600 | 168 | 68 | 263 | 0.8 | 0.3 | 1.2 | 4100 | 103 | 68 | 138 | 2.5 | 1.7 | 3.4 |
| Uganda | 337900 | 21529 | 19752 | 23216 | 6.4 | 5.8 | 6.9 | 172400 | 2683 | 1338 | 3892 | 1.6 | 0.8 | 2.3 | 33000 | 1843 | 1382 | 2281 | 5.6 | 4.2 | 6.9 |
| United Republic of Tanzania | 297000 | 39667 | 36958 | 42335 | 13.4 | 12.4 | 14.3 | 178900 | 6301 | 3684 | 8668 | 3.5 | 2.1 | 4.8 | 34200 | 4221 | 3395 | 4981 | 12.3 | 9.9 | 14.6 |
| Zambia | 110400 | 9859 | 9115 | 10555 | 8.9 | 8.3 | 9.6 | 65100 | 1554 | 900 | 2147 | 2.4 | 1.4 | 3.3 | 12500 | 1000 | 777 | 1214 | 8.0 | 6.2 | 9.7 |
| Zimbabwe | 72200 | 2330 | 2106 | 2556 | 3.2 | 2.9 | 3.5 | 52000 | 382 | 140 | 609 | 0.7 | 0.3 | 1.2 | 9900 | 264 | 183 | 345 | 2.7 | 1.8 | 3.5 |
| Sub-Saharan Africa | 7525300 | 640113 | 593047 | 684751 | 8.5 | 7.9 | 9.1 | 3304700 | 79058 | 47230 | 108259 | 2.4 | 1.4 | 3.3 | 632016 | 50308 | 39823 | 60304 | 8.0 | 6.3 | 9.5 |
| Bahrain | 3800 | 284 | 260 | 308 | 7.5 | 6.8 | 8.1 | 2500 | 43 | 18 | 65 | 1.7 | 0.7 | 2.6 | 700 | 45 | 34 | 57 | 6.5 | 4.8 | 8.1 |
| Iraq | 135300 | 10126 | 9261 | 10983 | 7.5 | 6.8 | 8.1 | 57200 | 986 | 415 | 1497 | 1.7 | 0.7 | 2.6 | 16400 | 1065 | 787 | 1333 | 6.5 | 4.8 | 8.1 |
| Jordan | 24000 | 1110 | 983 | 1237 | 4.6 | 4.1 | 5.2 | 17200 | 162 | 26 | 287 | 0.9 | 0.2 | 1.7 | 4900 | 180 | 113 | 244 | 3.7 | 2.3 | 5.0 |
| Kuwait | 6600 | 494 | 452 | 536 | 7.5 | 6.8 | 8.1 | 4000 | 69 | 29 | 105 | 1.7 | 0.7 | 2.6 | 1200 | 78 | 58 | 98 | 6.5 | 4.8 | 8.1 |
| Lebanon | 7100 | 531 | 486 | 576 | 7.5 | 6.8 | 8.1 | 4000 | 69 | 29 | 105 | 1.7 | 0.7 | 2.6 | 1100 | 71 | 53 | 89 | 6.5 | 4.8 | 8.1 |
| Oman | 8300 | 621 | 568 | 674 | 7.5 | 6.8 | 8.1 | 5500 | 95 | 40 | 144 | 1.7 | 0.7 | 2.6 | 1600 | 104 | 77 | 130 | 6.5 | 4.8 | 8.1 |
| Qatar | 2600 | 141 | 127 | 154 | 5.4 | 4.9 | 5.9 | 1700 | 20 | 7 | 33 | 1.2 | 0.4 | 1.9 | 500 | 23 | 16 | 29 | 4.5 | 3.2 | 5.9 |
| Saudi Arabia | 78900 | 5905 | 5400 | 6405 | 7.5 | 6.8 | 8.1 | 27700 | 478 | 201 | 725 | 1.7 | 0.7 | 2.6 | 8000 | 520 | 384 | 650 | 6.5 | 4.8 | 8.1 |
| Syrian Arab Republic | 77300 | 5785 | 5291 | 6275 | 7.5 | 6.8 | 8.1 | 39200 | 676 | 285 | 1026 | 1.7 | 0.7 | 2.6 | 11300 | 734 | 542 | 919 | 6.5 | 4.8 | 8.1 |
| Turkey | 246600 | 29724 | 27521 | 31794 | 12.1 | 11.2 | 12.9 | 120800 | 3642 | 1940 | 5200 | 3.0 | 1.6 | 4.3 | 34600 | 3787 | 3000 | 4527 | 10.9 | 8.7 | 13.1 |
| United Arab Emirates | 5500 | 412 | 376 | 446 | 7.5 | 6.8 | 8.1 | 5400 | 93 | 39 | 141 | 1.7 | 0.7 | 2.6 | 1500 | 97 | 72 | 122 | 6.5 | 4.8 | 8.1 |
| Yemen | 362200 | 27109 | 24791 | 29402 | 7.5 | 6.8 | 8.1 | 94200 | 1624 | 684 | 2465 | 1.7 | 0.7 | 2.6 | 27000 | 1753 | 1295 | 2195 | 6.5 | 4.8 | 8.1 |
| Western Asia | 958200 | 82242 | 75518 | 88791 | 8.6 | 7.9 | 9.3 | 379400 | 7957 | 3712 | 11793 | 2.1 | 1.0 | 3.1 | 108800 | 8458 | 6429 | 10393 | 7.8 | 5.9 | 9.6 |

PAF = percent attributable fraction

**Supplemental Figure 1: The associations between maternal height <145cm (reference: ≥155cm) and birth outcome of term-SGA**

****

**Supplemental Figure 2: The associations between maternal height <145cm (reference: ≥155cm) and birth outcome of Preterm-AGA**

****

**Supplemental Figure 3: The associations between maternal height <145cm (reference: ≥155cm) and birth outcome of Preterm-SGA**

****

**Supplemental Text 1: Derivation of height distribution by country**

The height data were available by five-year age increments in DHS datasets for women of reproductive age (15 to 49 years of age). The data for each five-year age increment were weighted by the female population distribution across those age groups as reported by the United Nations World Population Prospects for 2010,([37](#_ENREF_37)) in order to create a single weighted average country-level height prevalence estimate for all women of reproductive age. However, for some of the other surveys, prevalence data were not available for all reproductive age categories (e.g. prevalences for 15-<20 and/or 20-<25 year old categories were not available for some STEPS datasets). In those situations, the short stature prevalence for the missing age categories was extrapolated (see next paragraph). We made data inclusion exceptions to seven countries with newer Steps data and older DHS data by prioritizing the DHS data (Lesotho, Liberia, Rwanda, Sao Tome and Principe, Sierra Leone, Swaziland, Tanzania); their Steps datasets did not have data available for each age category or had data usage concerns. In these datasets, the DHS data were older by four years maximum.

For countries without national height data, the median prevalence for their UN-MDG region was used.

We calculated a Millennium Development Goal (MDG) subregional “height prevalence ratio” among the datasets that had prevalence data, comparing the height prevalence between an age category and a reference age category (25-<30 years old). The ratio was applied to the existing reference category data for countries with missing data to impute the prevalence for the missing age category. More specifically, for each country with no missing data, a ratio was calculated for prevalence of <145cm among 15-<20 year olds versus among 25-<30 year olds, for prevalence of 145-<150cm among 15-<20 year olds versus among 25-<30 year olds, and for prevalence of 150-<155cm among 15<20 year olds versus among 25-<30 year olds. The same was done for the other missing age groups. Then those ratios were averaged within an MDG subregion to calculate a subregional “height ratio.” For the datasets with missing age groups, the reference age category prevalence was then multiplied by the appropriate subregional “height ratio” to fill in the missing data. The prevalence of ≥155cm was calculated as one minus the summed prevalence of the other three height categories. Once prevalence estimates were available in all age categories, they were subsequently weighted by the population distribution, as was done with the datasets without any missing data. For the countries without data, we used the average prevalence of the remaining countries within its MDG subregion.

**Supplemental Text 2: Calculation of uncertainty ranges for PAF**

Uncertainty ranges were calculated using a bootstrap approach; 1000 estimates of the SGA and preterm risk ratios for each height category were taken respectively, from a normal distribution based around the meta-analyzed RRs and their standard errors. Using those RRs, 1000 PAFs were calculated for each country, and the 2.5th and 97.5th percentile PAFs were used as the uncertainty range. The uncertainty range does not take into account the uncertainty associated with the height category distribution estimates based on the national surveys due to lack of access to some of the original survey data.

1. Funding was provided by the Bill & Melinda Gates Foundation [810-2054] by a grant to the US Fund for UNICEF to support the activities of the Child Health Epidemiology Reference Group. Financial support for analysis was offered to investigators through a subcontract mechanism administered by the US Fund for UNICEF. The funding sources of the individual studies are as follows: Nepal (1999) - USAID, UNICEF Country Office (Kathmandu, Nepal), BMGF; Nepal (2003) - Wellcome Trust; Philippines (1983) - NIH, Nestle's Coordinating Center for Nutritional Research, Wyeth International, Ford Foundation, US National Academy of Science, World Health Organization (WHO), Carolina Population Center, USAID; Thailand (2001) - Thailand Research Fund, Health System Research Office, Ministry of Public Health, Thailand; Burkina Faso (2004) - Nutrition Third World, Belgian Ministry of Development; Burkina Faso (2006) - Flemish University Council, Nutrition Third World, Belgian Ministry of Development, Nutriset; Tanzania (2001) – National Institute of Child Health and Human Development; Tanzania (2008) - European Union Framework 7; Brazil (1982) - International Development Research Center for Canada, WHO, UK Overseas Development Administration; Brazil (1993) - UN Development Fund for Women; Brazil (2004) – Wellcome Trust; Peru (1995) – Office of Health and Nutrition (USAID). [↑](#footnote-ref-1)
2. All authors report no conflict of interest. [↑](#footnote-ref-2)
3. Supplemental Materials. Supplemental Tables 1a, 1b, 2a, 2b, 3a, 3b, 4, 5, 6, and 7, Supplemental Figures 1a-c, and Supplemental Text 1 and 2 are available from the “Online Supporting Material” link in the online posting of the article and from the same link in the online table of contents at [jn.nutrition.org](http://jn.nutrition.org/). [↑](#footnote-ref-3)
4. Abbreviations: AGA = appropriate-for-gestational-age, aRR = adjusted risk ratio, CHERG = Child Health Epidemiology Reference Group, DHS = Demographic and Health Surveys, IUGR = intrauterine growth restriction, LBW = low birth weight, LMIC = low- and middle-income countries, MDG = Millennium Development Goals, NHANES = National Health and Nutrition Examination Survey, PAF = population attributable fraction, SGA = Small-for-gestational-age, WHOGS = WHO Global Survey on Maternal and Perinatal Health [↑](#footnote-ref-4)