Worldwide Child Stunting since the Nineteenth Century

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Abstract

This paper conducts a meta-analysis of 877 historical child growth studies to reconstruct child stunting rates, the share of children who are too short for their age, for 121 countries from the earliest date possible to the present. This data complements and extends the modern Joint Malnutrition Estimates database of country-level stunting rates, which begins in the 1980s. We find that many European countries had stunting rates similar to current LMICs at the turn of the twentieth century, but child stunting fell in the early twentieth century reaching very low levels before World War II. Stunting rates were also very high in Japan and Korea. However, stunting rates were surprisingly low historically in the European settler colonies, Eastern Europe and the Caribbean. Historical comparisons of child stunting add a new dimension to the historical health transition and allow for more direct historical lessons for the fight against stunting today.

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1 Introduction

Poor child health remains an important global problem with an estimated 149 million children (22% of children) in 2021 experiencing stunted growth, i.e. being too short for their age (UNICEF, WHO and World Bank, 2021). Stunted growth reflects poor nutrition and chronic illness in childhood and leads to poor health and human capital outcomes in later life (Hoddinott et al., 2013). Child stunting rates are a widely used indicator of population health. They were a key indicator for Millenium Development Goal 1 and are an indicator for Sustainable Development Goal 2.2. However, although a wide number of nutritional surveys have been implemented to track child stunting since the mid-1980s, there is very limited evidence on stunting rates before then (Stevens et al., 2012).

Understanding the evolution of child stunting before 1985 is critical for three reasons. First, evidence on the secular increase in adult stature suggests that reductions in child stunting may have been a part of the historical health transition in currently high income countries (Baten and Blum, 2012; Hatton and Bray, 2010; NCD Risk Factor Collaboration, 2016). However, without historical estimates of child stunting for these countries, it is not possible to compare the levels or experiences of stunting decline between the past and the present. Second, a number of studies have scrutinised the past thirty years for countries that have experienced rapid stunting decline over a relatively short period of time (Bhutta et al., 2020; Headey et al., 2015, 2017; Headey and Hoddinott, 2015). Extending historical estimates of child stunting into the past can provide other candidate countries where closer examination might reveal interesting lessons for the current fight against child stunting. Third, looking at a longer time frame and a wider set of countries can provide insight into how quickly we should expect stunting rates to decline in the future.

2 Panel Inset: Research in Context

2.1 Systematic Review

2.2 Interpretation

3 Methods

3.1 Study Design

This study conducts a meta-analysis of child growth studies from the nineteenth century to the present in order to reconstruct estimates of country-level child stunting rates. We focussed our meta-analysis on extending the Joint Malnutrition Estimates (JME) database compiled by the WHO, World Bank and Unicef, which contains data for a large number of low and middle income countries (LMICs) mostly from the 1990s onward. This meant that we targeted studies from the 1980s or before, although we also include studies from more recent periods for high income countries that do not appear in the JME database. Where studies were included that overlapped with the JME database, they were carefully checked to prevent double counting.

3.2 Data Sources

We conducted a full search of published child growth studies using the search strategies described in Appendix A. To ensure completeness, we recruited a team of 42 data contributors whose expertise covered 33 countries around the world and who were fluent in 17 languages. The corresponding author and his team added a further 88 countries. Data contributors provided the data in standardised forms and completed a questionnaire on study quality and representativeness for each study. Typical studies provided the mean height by age and sex and a measure of the dispersion of height by age and sex such as a standard deviation, frequency distribution or percentiles. Very few studies provided individual-level data, and those that did were often excluded due to being non-representative. Some studies provided more than one stunting estimate because they

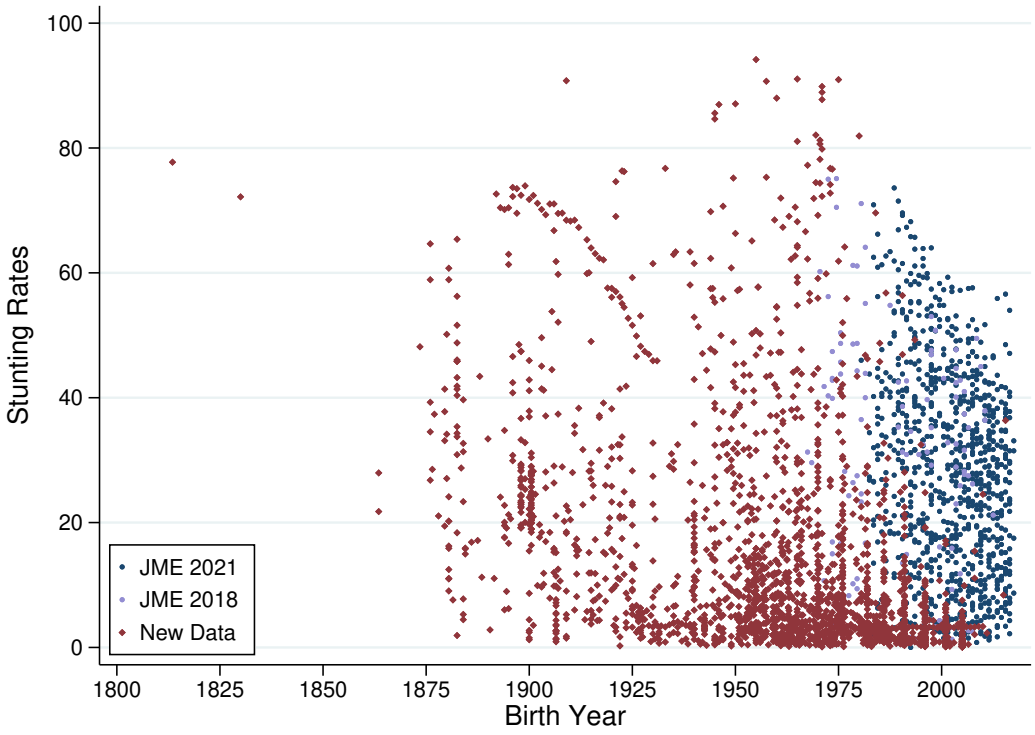


Figure 1: Stunting Rates in the Final Analytical Sample by Provenance

Notes:
Sources: Worldwide Historical Stunting Database and JME.

reported data for different spatial units, rural and urban areas, time periods or ethnic groups. The full inclusion and exclusion criteria are given in Appendix B, but several key differences from existing studies should be noted.

Unlike typical studies of child stunting, we include children over the age of five up to age 10.99. We include children over five because this dramatically increases the number of historical studies that we can analyse: early studies of child growth were often conducted in schools. By including these children, we assume that stunting over age five is closely correlated with stunting under age five. This assumption is justified for the following reasons. First, existing literature shows that at the population level, growth faltering occurs before age two and remains stable afterwards (Victora et al., 2010). Thus, we would not expect children over age five to experience further faltering. Whether children over age five can experience catch-up growth is currently more controversial (Alderman et al., 2006; Leroy et al., 2015; Lundeen et al., 2014; Prentice et al., 2013; Schneider et al., 2021; Wells, 2017). However, while recent research suggests that catch-up growth is possible, it appears to be rare and is unlikely to bias stunting rates over age five. We exclude children aged 11.0 or older since differences in the timing of the pubertal growth spurt may distort children's position relative to the growth reference. The WHO 2006 child growth standard and 2007 growth reference for school aged children were constructed to fit seamlessly together (de Onis et al., 2007). Taken together, this reasoning allows us to include children above the age of five in our analysis (see Appendix B.1.2).

Again departing from earlier studies, we exclude children below the age of two from our analysis. As noted, children in unhealthy populations experience a typical pattern of growth faltering, slower than normal growth which leads them to fall behind the growth standard, between exact ages 0 and 2. Thus, children aged 0 to 2 mechanically have a lower stunting rate than children aged 2 to 5 (Alderman and Headey, 2018; Victora et al., 2010). This means that the age composition of the sample used to compute the stunting rate matters. Given that studies cover a wide variety of ages and many do not include children under age 5, excluding the younger age groups allowed for easier comparisons across studies. However, it does mean that our stunting estimates will be

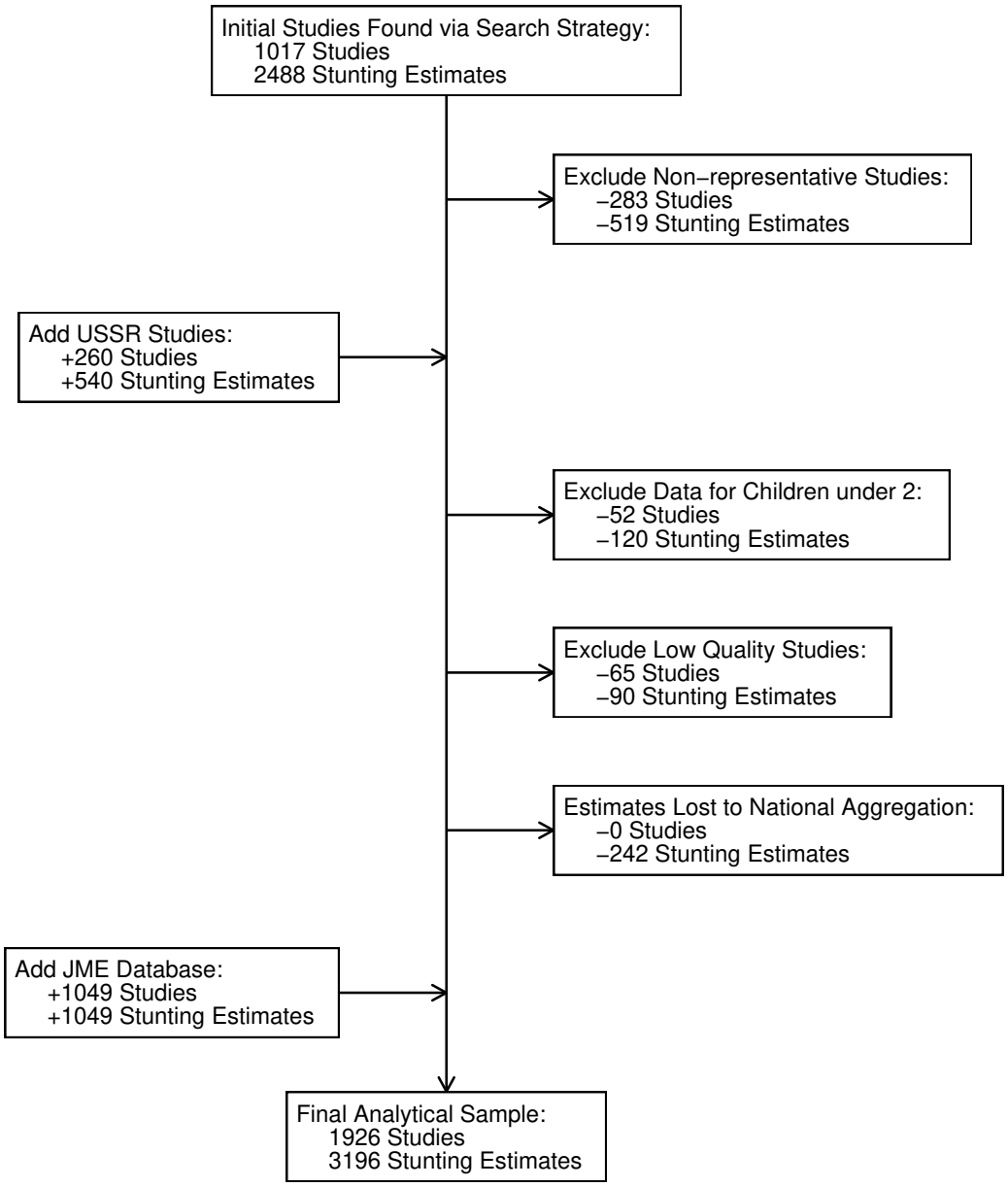
upwardly biased relative to those included in the JME database (see Appendix B.2.2 for further discussion).

In total, we found 1,017 studies that met the inclusion criteria and provided 2,488 stunting estimates (see Figure 2). We exclude studies where there was evidence of selection on socioeconomic status or health relative to the targeted population. However, we do include community and subnational studies that are not nationally representative (see Appendix B.2.1 for more detail). We also included 260 studies that were collected as part of an earlier analysis of child growth in the USSR (Brainerd, 2010). Unfortunately, the original sources for these studies are only available in Russia, and we were not able to acquire copies in order to follow the systematic procedure for assessing study quality followed for all other studies (see Appendix C.2). We include these studies because they were mostly conducted from the 1940s onward when best-practice sampling and measuring procedures were widely followed and because they provide exceptional data on Eastern Europe and Central Asia. However, they have not been scrutinised as carefully as other studies. We exclude some studies that only reported on children under age two; others that had low sample sizes and other data quality issues; and we lose a number of stunting estimates where we were able to aggregate regional or ethnic data to the national level. Finally, we include 1,045 studies from the JME database, adding coverage for LMICs in more recent periods. This left us with a total of 3,196 stunting estimates in our final analytical sample. Excluding the JME dataset, the studies that we collected reflect the measurements of approximately 131,064,140 children.

3.3 Data Validation and Estimating Child Stunting Rates

To compute stunting rates, we begin by computing means and standard deviations by age and sex for all studies following standard methods (Appendix C.1). We then ran a number of cross-validation checks, verifying outlier values of mean and standard deviation of height and centre-increment ages in the original studies. We also checked to ensure that data contributors had coded the representativeness of datasets consistently across studies (Appendix D). The height values often reflected a whole year age increment, i.e.

Figure 2: Meta-analysis results



Notes: JME is the Joint Malnutrition Estimates produced by UNICEF, the WHO and the World Bank.

Sources: JME and our data.

the mean and sd of height of girls age 4.00 to 4.99 (mean age 4.50), which means that the variance reported was not comparable to the WHO child growth standard/reference which refer to exact ages (children exactly 4.50). Thus, we used the method described by Healy (1962) to adjust the variance of the height distribution by age and sex so that it matched the standard/reference (Appendix E). After this adjustment, some studies still reported standard deviations of height that were implausible, so we winsorised coefficients of variation by age and sex at the 5th and 95th percentiles of all observed coefficients of variation (Appendix F). XX studies did not report measures of the dispersion of height, so we imputed standard deviations for these studies using the median coefficient of variation at each sex and age among the studies where we do observe measures of dispersion. While this does introduce some error into the final stunting rates, this error is relatively small (Appendix G.2).

To compute a stunting rate for each study, we first convert the reported mean and standard deviations of height into height-for-age Z-scores (HAZ) relative to the WHO standard/reference (Figure 3A and B). We then compute the mean and standard deviation of the combined distribution, i.e. as if all children were drawn from the same distribution, using standard methods and weighting by the sample size at each age where possible (Figure 3C). Finally, assuming that the combined HAZ distribution is normal, we compute the stunting rate as the share of the HAZ distribution below the stunting threshold of -2 (Figure 3D). We do these computations for each sex separately and then take the average stunting rate of boys and girls as the final stunting rate for the study. We follow the same procedure when aggregating regional or ethnic data to be nationally representative, using population as the weight (Appendix G.1). Although we assume that HAZ scores will be normally distributed, this is a reasonable assumption and especially for children aged 2-10.

3.4 Certainty of Evidence and Country-Level Stunting Rates

In order to make country-level comparisons across time, we aggregate studies by birth decade at the country level. Previous studies have used Bayesian Hierarchical Models to

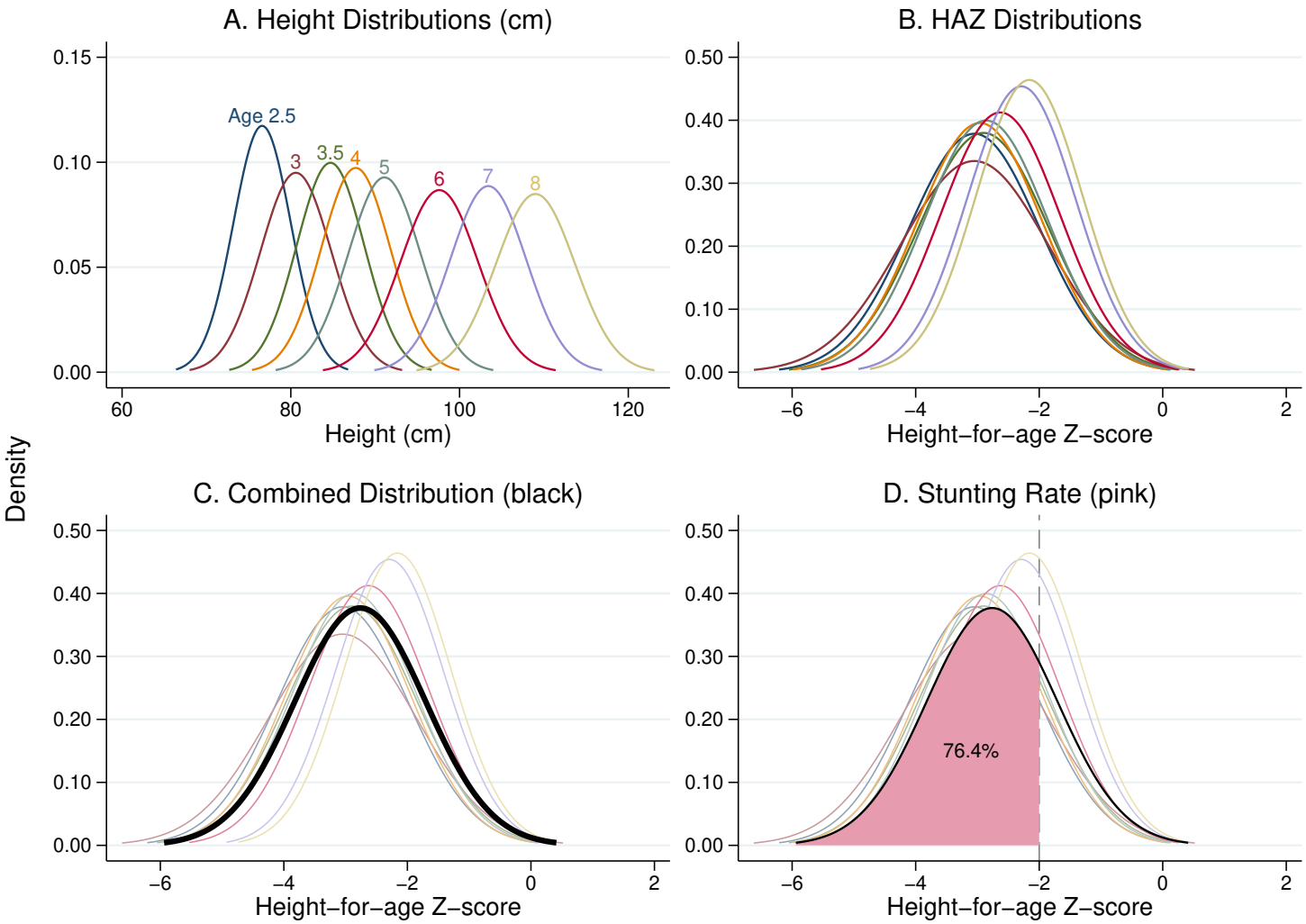


Figure 3: Process of aggregating height distributions at various ages into a single stunting rate

Notes: The height distributions are for Guatemalan girls measured in 1977 as part of the INCAP study. See text and Appendix G.1 for how the computations work.
Sources: Data from Martorell et al. (1995).

produce global and large regional trends and uncertainty in child stunting rates (Stevens et al., 2012). We do not follow their procedure or attempt other statistical modelling for several reasons. First, the country-level coverage of the data is sparse before the mid-twentieth century. Thus, any modelling to create global trends would require heroic out of sample prediction. Second, the majority of our studies are not nationally representative, which makes extrapolation from them difficult. Third, any modelling exercise would require there to be stable hierarchies or relationships between study characteristics and stunting across time. However, these relationship were not stable: for instance, the size of the urban health penalty varied across European countries, and the penalty relative to rural areas closed at different speeds and times periods (need citations). This makes modelling the relationships extremely difficult. Finally, modelling is not necessary to draw important conclusions from the dataset. As a team of social scientists and historians, we prefer a more nuanced approach that considers any conclusions we draw alongside the certainty of evidence of the underlying studies from which we are drawing these conclusions.

Thus, we proceed by systematically assessing the certainty of evidence for each study. We adapt the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach for a descriptive study such as our own (Schünemann et al. 2019), considering the various domains for downgrading or upgrading the certainty of evidence for each study and assigning each study a certainty of evidence score. Our approach is described in Appendix H. This exercise confirms that the certainty of evidence improves markedly over time as more nationally representative random samples become available, but that certainty is rather low for early periods of the data. We consider these certainty of evidence scores in the discussion below.

We also use the certainty of evidence score when creating stunting estimates by country and birth decade. Rather than averaging all studies within a country-decade bin, studies with very high certainty of evidence scores are weighted more highly than those with lower scores. This ensures that high-quality, nationally representative studies are not polluted by small community studies (Appendix I).

3.5 Role of the Funding Source

This project was supported through a grant from The Suntory and Toyota International Centres for Economics and Related Disciplines (STICERD) at the London School of Economics and Political Science. STICERD had no input into the study design, implementation, analysis or interpretation. The corresponding author had access to all data and is responsible for the contents of the final study.

4 Results

Figure 4 shows the composition of our analytical sample by region and time period and also differentiates between the number of studies (Figure 4A) and the number of birth decade by country observations, which appear in our graphs and maps below (Figure 4B). The dataset is obviously strongest in the period from 1980 to the present, but there is also substantial worldwide data in the periods 1900-49 and 1950-79.

Figure 5 presents stunting rates for countries by birth decade and region, and Figure 6 presents a series of world maps with cross-sectional stunting rates for different sets of birth cohorts. The results show that stunting rates were higher for nearly all countries in the late nineteenth or early twentieth centuries.

In Europe (Figures 5G-J), stunting rates were as high in the UK, Netherland, Germany, Belgium, Spain, Italy and Greece as they are (and have been) in LMICS in the past couple of decades. However, Scandinavian countries, Switzerland and Ukraine had relatively low stunting rates in the early twentieth century. Stunting rates declined later in Southern Europe, Belgium, Hungary and Belarus than in other European countries.

In the Americas (Figures 5A-F), stunting rates were low from the earliest points of our data in the United States and Canada and in the Cono Sur region of South America: Uruguay, Argentina and Chile. Stunting rates were also persistently low across the Caribbean with the exception of Haiti, although data for most Caribbean countries is only available from the 1940s onward. Stunting rates were higher in Mexico and Central America as well as in the rest of South America. Guatamala had the highest stunting

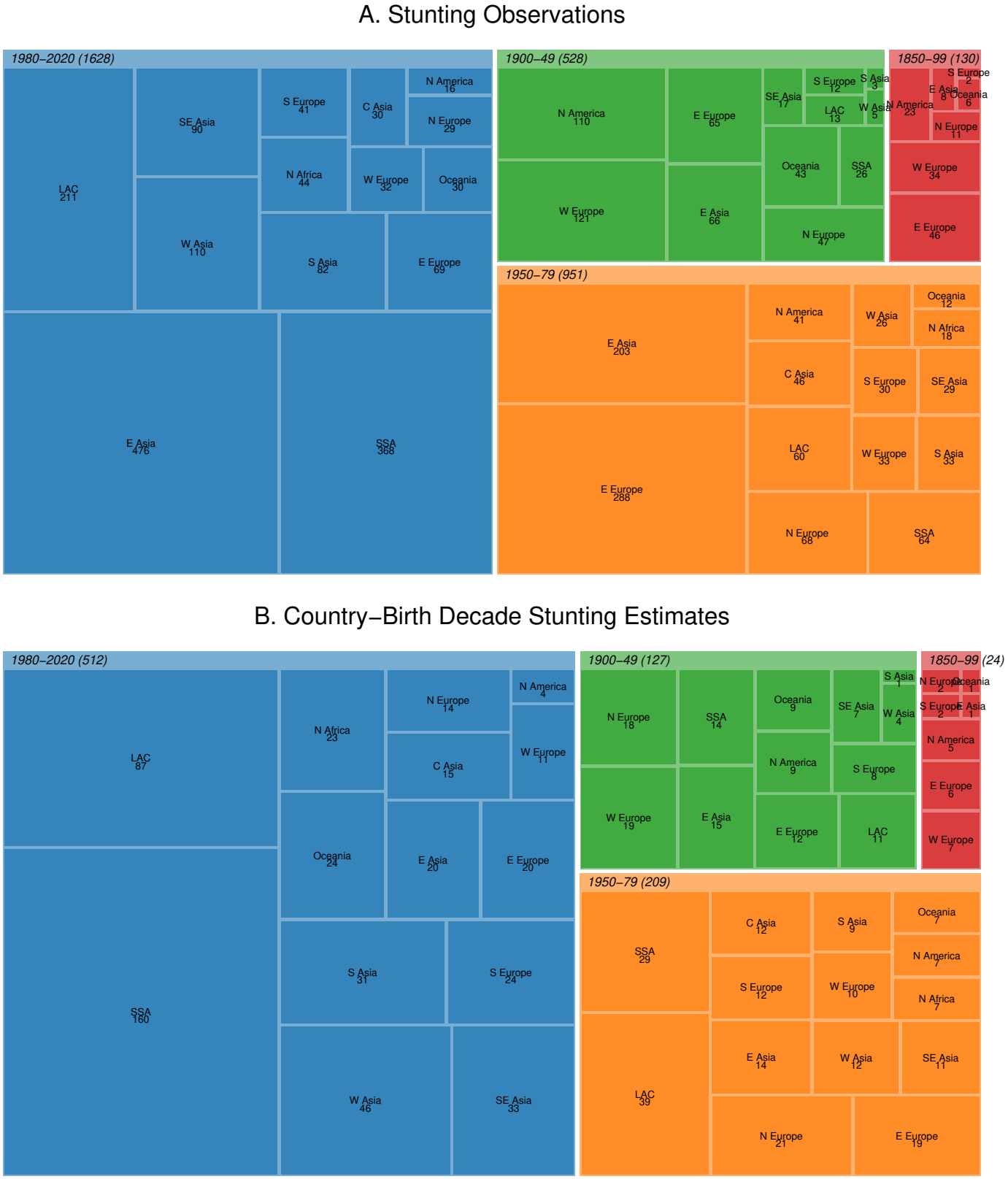


Figure 4: Number of Stunting Observations (A) and Country-Birth Decade Stunting Estimates (B) by Region and Period

Notes: LAC - Latin America and the Caribbean; SSA - Sub-Saharan Africa; Oceania includes Australia and New Zealand and countries in Melanesia, Micronesia and Polynesia. Created using treemap in Stata (Naqvi 2022).
Sources: Worldwide Historical Stunting Dataset and JME.

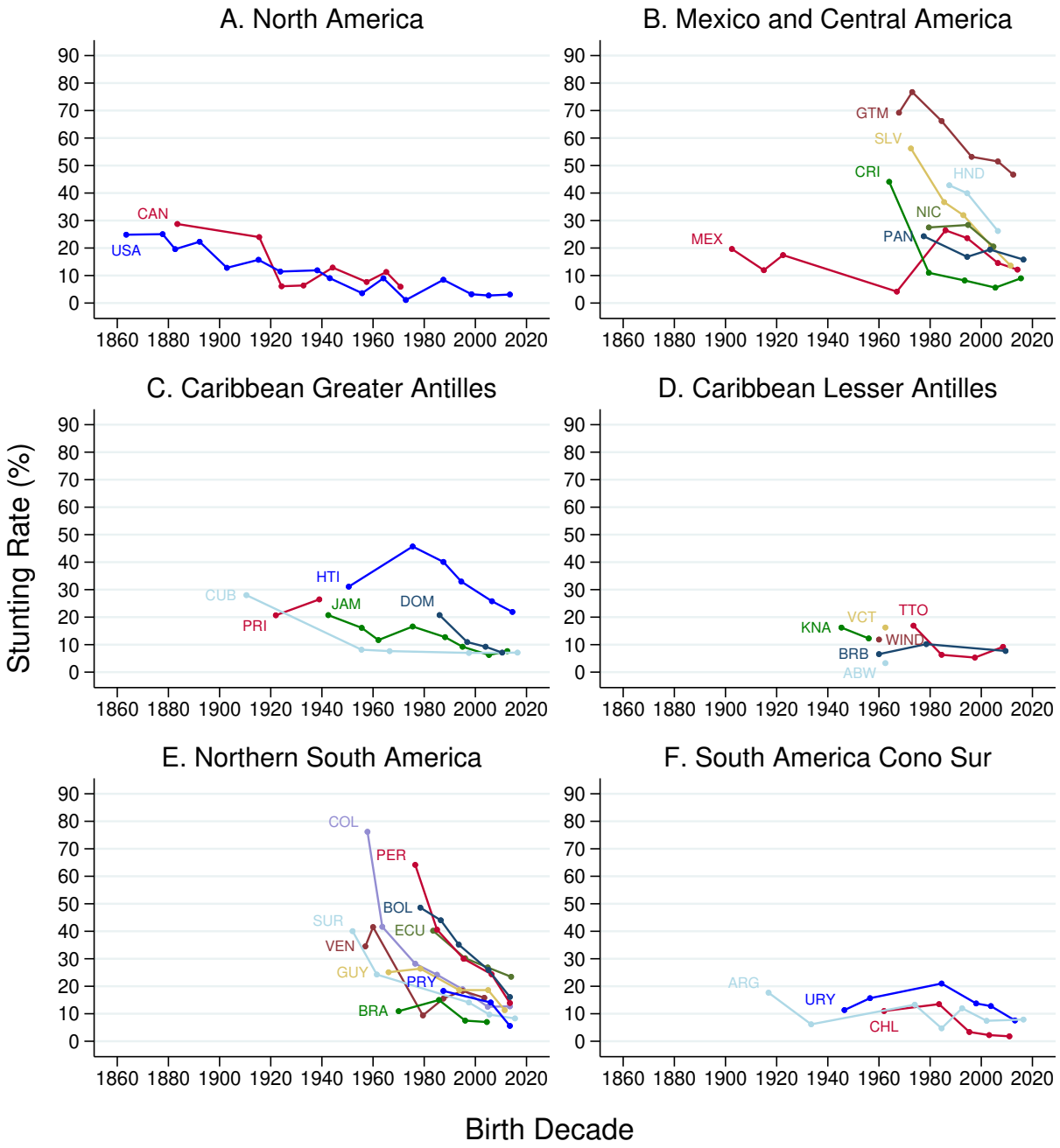


Figure 5: Country-Level Time Series: Americas

Notes: JME is the Joint Malnutrition Estimates produced by UNICEF, the WHO and the World Bank.

Sources: JME and our data.

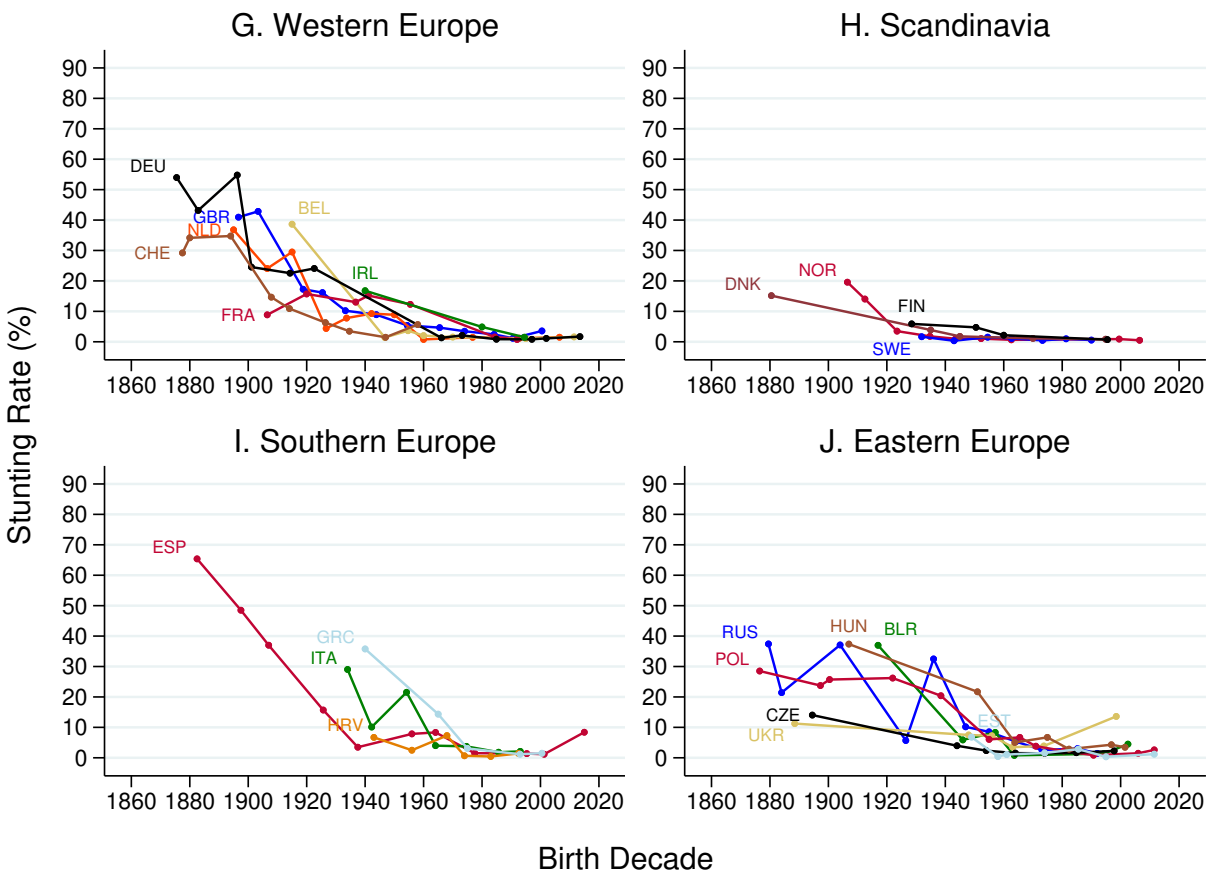


Figure 5: (Cont.) Country-Level Time Series: Europe

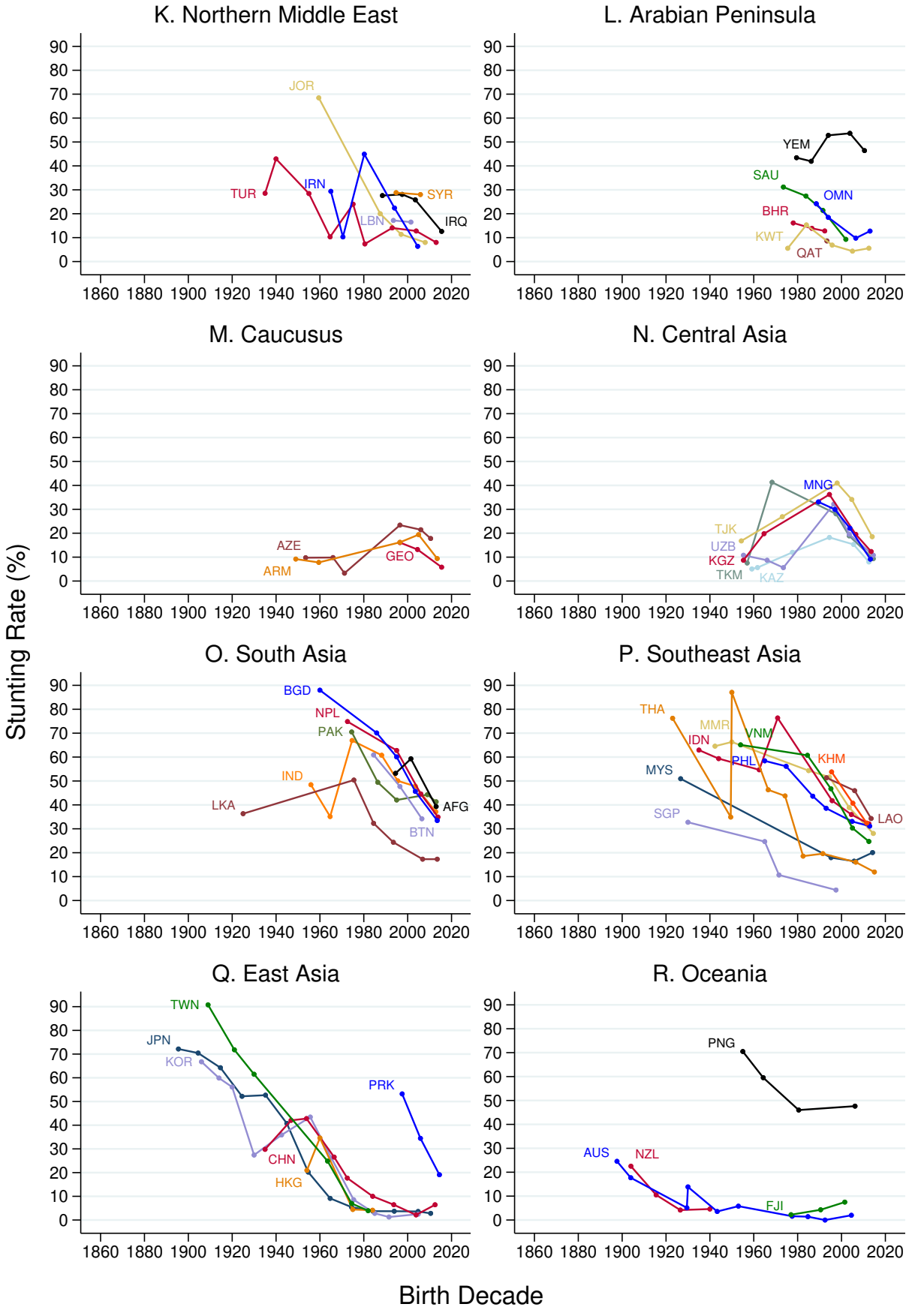


Figure 5: (Cont.) Country-Level Time Series: Asia

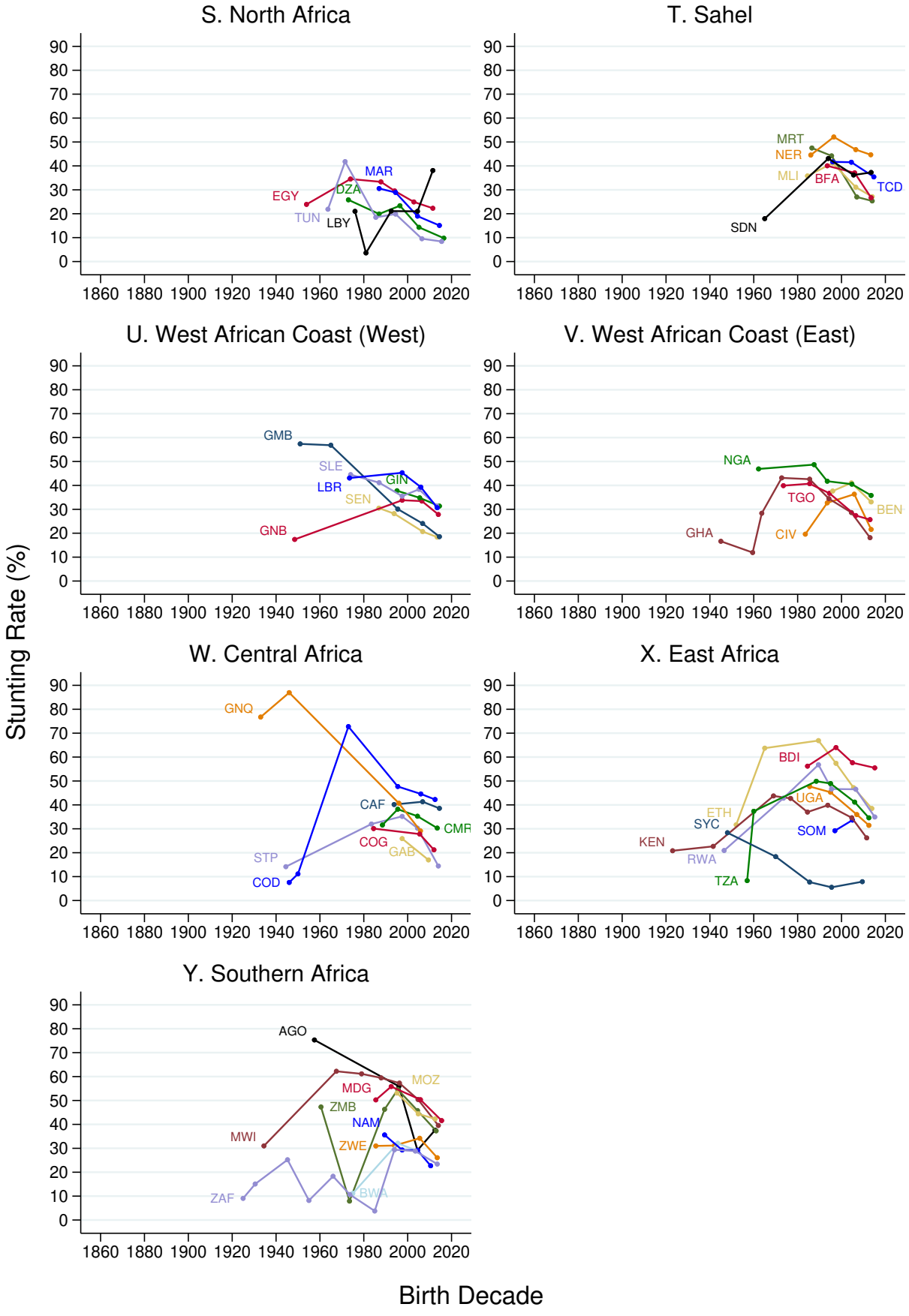


Figure 5: (Cont.) Country-Level Time Series: Africa

rate historically and despite some decline, continues to have the highest stunting rate in the Americas.

Stunting rates varied enormously over time and across space in Asia (Figures 5K-Q). Stunting rates were lowest historically in the Caucusus and Central Asia, though stunting rates appear to follow an inverse-U shape from the 1950s to the present. Stunting rates were also relatively low in the Middle East with the exception of Yemen, which has seen high and stable stunting rates. Turning to South Asia, the historical data shows that stunting rates were even higher in South Asia before the current JME data begins, though stunting rates have declined markedly across South Asia. Stunting rates were also high in the past across Southeast Asia and all countries have experienced declines in the stunting rates (Singapore at a lower level). East Asian stunting rates were exceptionally high historically with stunting rates in the early twentieth century of 72%, 67% and 91% for Japan, Korea and Taiwan respectively. Stunting rates in these countries began falling before the Second World War and had reached very low levels by the late 1970s. China has also experienced substantial stunting decline but with a two-decade delay from the rest of East Asia.

Stunting rates were low from the early twentieth century in Oceania (Figure 5R) with Austalia and New Zealand experiencing decline from a low level. Papua New Guinea also experienced stunting decline since the 1950s but from a far high level.

In Africa (Figures 5S-Y), there was again considerable variation across countries and over time. Stunting rates were lower in North Africa than in Sub-Saharan Africa. While some countries such as the Gambia have experienced dramatic declines in child stunting, others have experience relatively stable stunting rates: Egypt, Nigeria and Somalia. An outlier in East Africa is the Seychelles (Figure 5X), where stunting rates fell from c. 30% in the 1950s to c. 8% by the 1990s, far below other East African countries. Many African countries also present an inverse-U pattern of child stunting across the second half of the twentieth century.

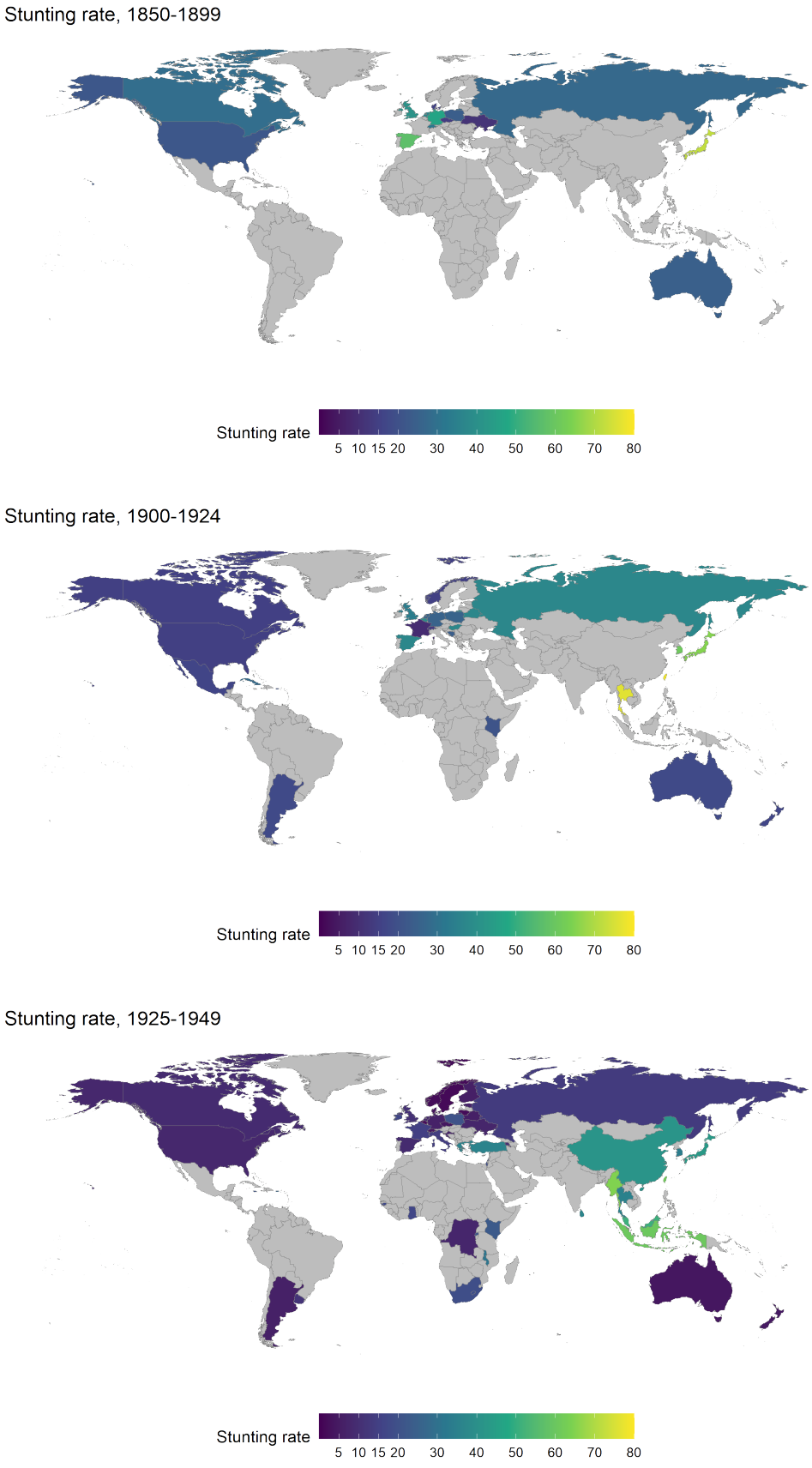


Figure 6: Global Child Stunting, 1850-2020

Sources: JME and our data.

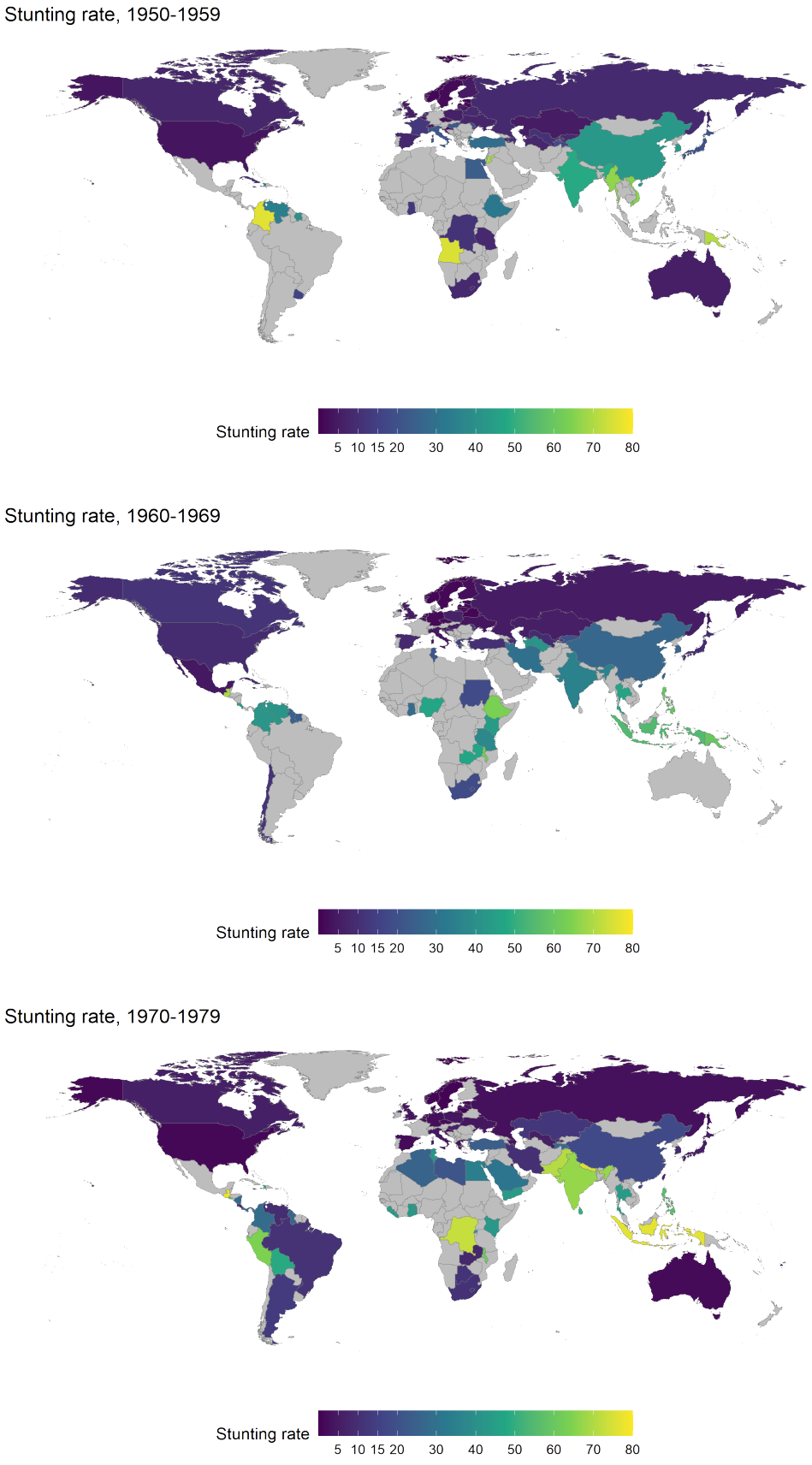


Figure 6: (Cont.) Global Child Stunting, 1850-2020

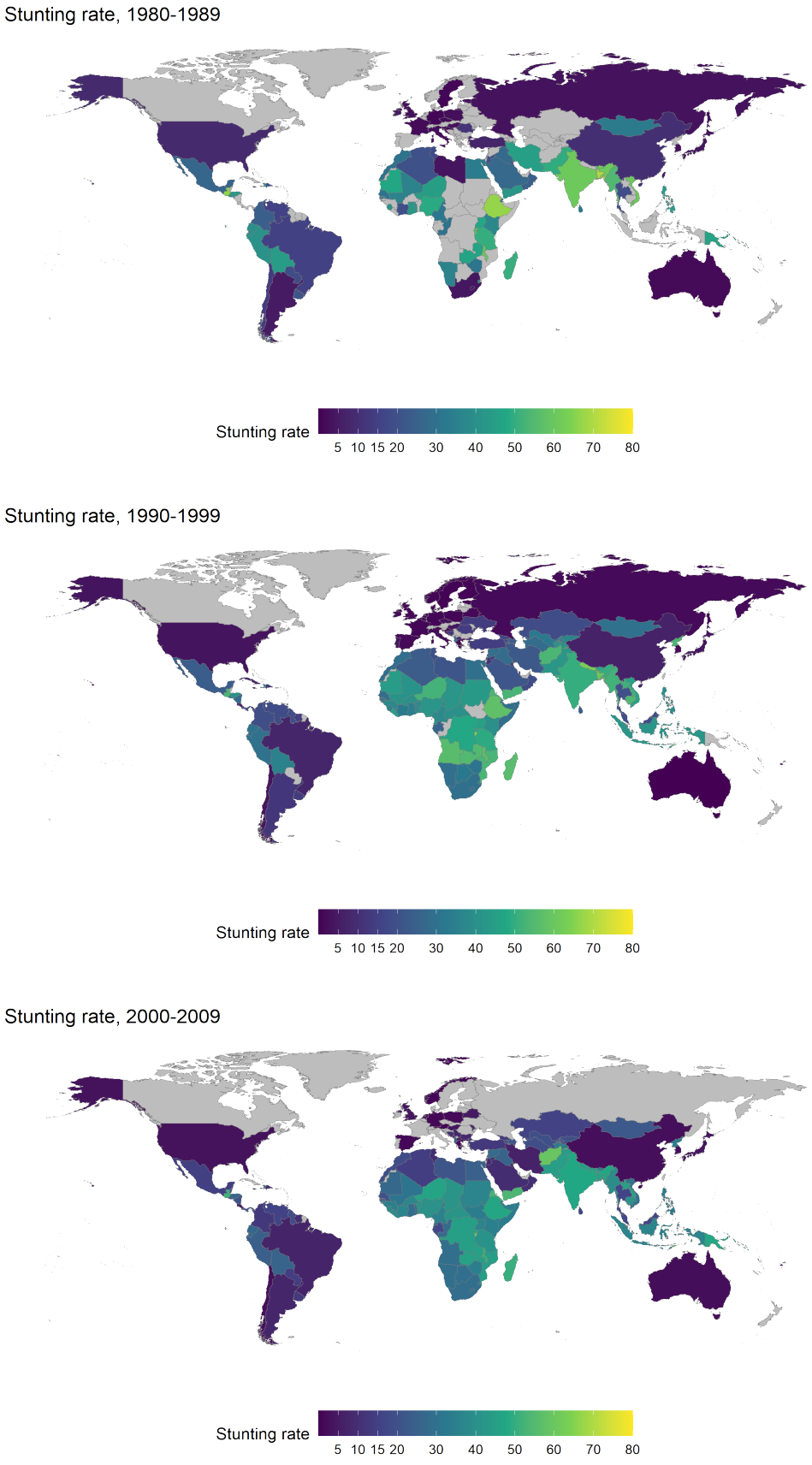


Figure 6: (Cont.) Global Child Stunting, 1850-2020

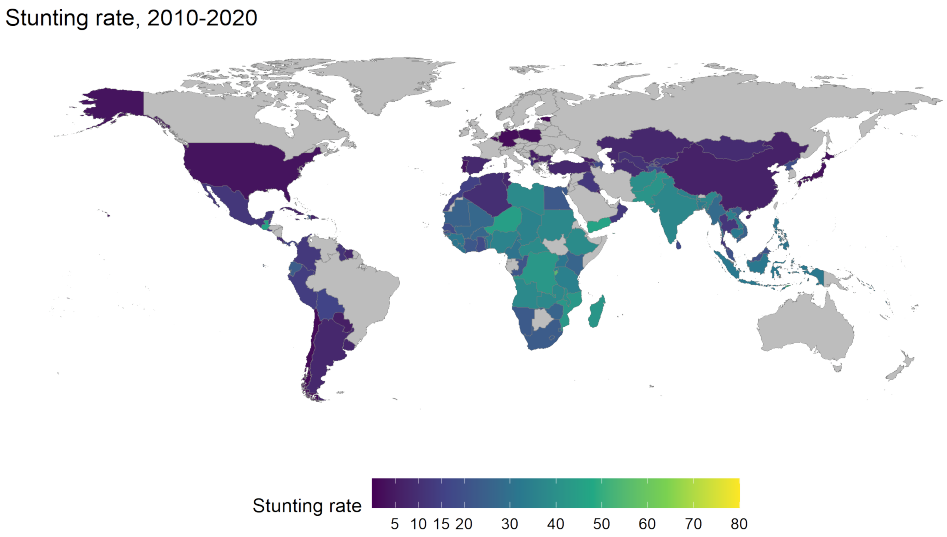


Figure 6: (Cont.) Global Child Stunting, 1850-2020

5 Discussion

Considering the results and the certainty of evidence of the studies underpinning each dataset, we have several interesting findings. First, most currently high income countries (HICs) that we observe historically experienced some decline in the stunting rate. The largest declines occurred in Southern Europe and East Asia, but stunting rates were high in the early twentieth century even among countries like the UK and Germany that were leaders in terms of GDP in that period (Bolt and Zanden, 2014). The variation in stunting rates among currently HICs in the early twentieth century was likely related to urbanisation and nutrition. Highly urbanised and industrialising countries like the UK, Germany and Belgium had higher stunting rates than more rural countries like those in Scandinavia and North America in part because urban areas had more virulent disease environments and were subject to coal pollution (Bailey et al., 2016, 2018). Stunting rates were also lower in countries with greater access to rich sources of animal protein, mirroring more recent findings on child stunting (Baten, 2009; Headey et al., 2018). The high levels of child stunting in East Asia were likely a product of virulent disease environments and relatively poor nutrition (Mosk, 1996; Schneider and Ogasawara, 2018).

However, the results do not support a simple, monotonic view of stunting decline. There were periods of increasing stunting rates in a number of countries. Notable re-

versals include Japan during the Second World War: the decadal stunting rates reported in Figure 5Q hide a 12 percentage point increase in the stunting rate (see Figure 7 below) caused by food shortages and disruption of the health system during the war (Schneider et al., 2021). Many other European countries experienced similar increases in child stunting during the First World War, but this pattern was not universal. Rationing during the World Wars in Britain improved nutritional outcomes and did not strongly affect child stunting (Harris, 1995; Magee, 1946). South Korea also experienced an increase in the stunting rate during the Korean War. These findings align with studies on the effect of war in LMICs in more recent periods (Akresh et al., 2012, 2011).

A number of countries experienced inverse-U shaped trends in child stunting in the second half of the twentieth century. These include the (now) former Soviet Republics in the Caucusus and Central Asia, Haiti and several countries in Sub-Saharan Africa. These trends must be viewed with some scepticism, especially in Africa, since the certainty of evidence of earlier studies is often low. For instance, the very low stunting rates in the 1940s and 1950s for the Democratic Republic of Congo seem implausible (Figure 5W). Although the studies purported to be representative of their targeted population, they were based on community or sub-national samples that may not have reflected the country as a whole. Early African studies tended to be conducted by European researchers in locations easily accessible to outsiders, which may have led them to inadvertently oversample healthier sub-groups (Jedwab et al., 2022). This evidence is discussed in detail in Appendix J. In any case, the causes of child stunting in Africa are related to poor nutrition, low access to sanitation and clean water and malarial infections, and there is no reason to think that these conditions deteriorated across the twentieth century (Moradi, 2008, 2009).

The inverse-U pattern in the former Soviet Republics seems plausible given the economic disruption and dislocation before and after the collapse of the Soviet Union (Figures 5M-N). GDP per capita declined sharply and child mortality increased or stagnated in most of the Soviet Bloc. Life expectancy decreased in many countries as well, though some of this was due to increased adult mortality (Stillman, 2006). These effects were

likely felt more strongly in the Caucusus and Central Asia than in the European part of the Soviet Union because these regions were poorer and had less developed health systems.

Another interesting finding is that stunting rates have been persistently low across the Caribbean (excluding Haiti) for most of the twentieth century despite the Caribbean being poor relative to other regions (Figures 5C-D). This is consistent with earlier studies that showed that Caribbean countries experienced a relatively early health transition beginning in the 1920s (Riley, 2005a). In Jamaica, reductions in child stunting likely resulted as the consequence of public health investments funded by the Rockefeller Foundation. Their anti-hookworm campaigns led to the construction of improved pit latrines, reducing open defecation and diarrhoeal mortality. They also funded mosquito control interventions through the larvicide Paris green, which led to a decline in malarial deaths. Riley (2005b) also argues that these efforts galvanised the Jamaican people who learned about good hygiene practice and began to demand better health services from the British colonial government. Taken together these factors may explain why the stunting rate was only 21% in the 1940s when our first stunting estimate is available (Headey et al., 2017; Spears, 2020).

Our study also includes several countries whose stunting rate can be observed across the health transition. Here we focus on Japan where we have very reliable, nationally representative data for birth cohorts going back to the 1890s (Figure 7). Stunting rates were extremely high, above 70%, in the late nineteenth century and began declining at a relatively slow rate (0.79 percentage points per year on average) in the first half of the twentieth century. At this rate, it would have taken 89 years for Japan's stunting rate to fall to its current, stable level. However, after the Second World War, Japan experienced very rapid reductions in the stunting rate (2.18 percentage points per year), allowing it to reach very low levels of stunting much more quickly. This rate of stunting is one the fastest ever observed: restricting ourselves to the JME dataset and measuring the percentage point rate of decline from the earliest to latest observation, only one country has had a faster decline: North Korea. Countries often praised as success stories such as

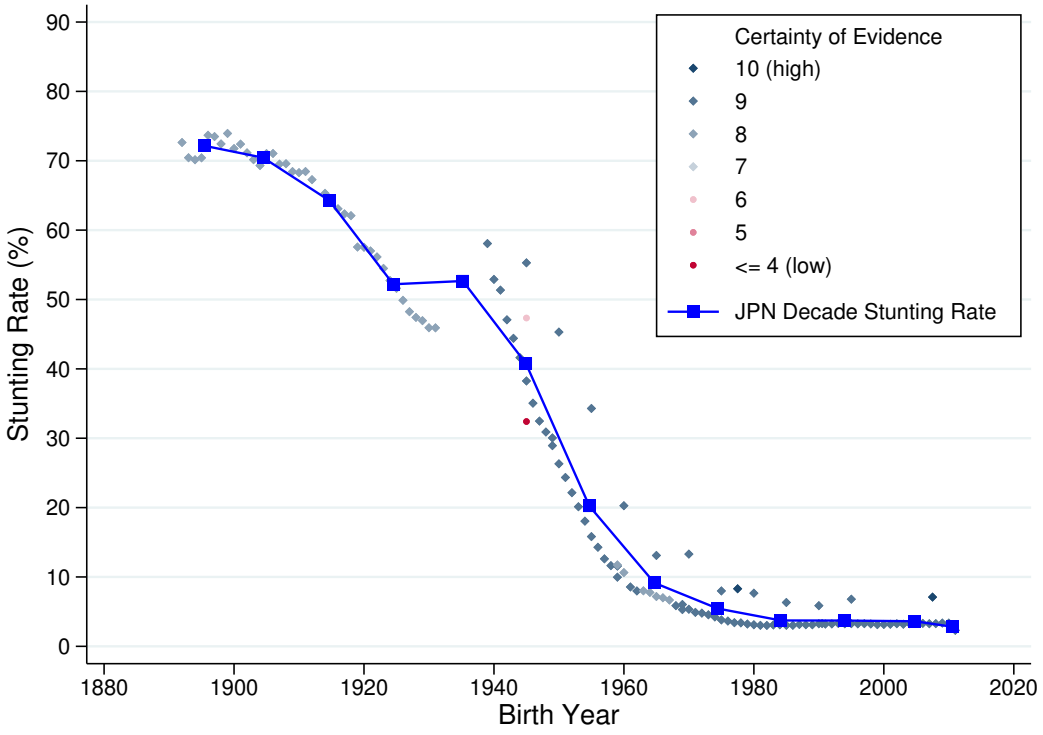


Figure 7: Study-level Stunting Rate Estimates for Japan

Notes:

Sources: Worldwide Historical Stunting Dataset and JME (2021).

Nepal, Ethiopia and Peru (Bhutta et al., 2020) experienced rates of decline of 1.11, 0.99 and 0.91 percentage points per year respectively. While the post-war experience of Japan and the other East Asian Tigers may not seem relevant to today's LMICs, perhaps there are lessons to be drawn from their experience.

The main limitation of our study is the varying certainty of evidence of the studies in our meta-analysis. While we have followed objective inclusion and exclusion criteria strictly in determining which studies entered the final analytical sample, some historical estimates are considerably more reliable than others. Another limitation is that our method for computing decade by country stunting rates does not account for differences in study characteristics, i.e. we may have urban studies in one decade and rural ones in the next, increasing the variability of stunting estimates. Any use of our dataset in the future will require careful consideration of the studies underpinning the trends for any given country. To facilitate this assessment, for each country we provide a graph with

all studies graded by their certainty of evidence score in Appendix K, and we provide summarised details for each study in Appendix L.

In conclusion, our extension of child stunting rates back to the nineteenth century suggests that the eradication of child stunting was a key feature of the health transition in nearly all countries. Reductions in child stunting reflect the secular increase in adult stature that has been well studied (Baten and Blum, 2012; Cole, 2003; NCD Risk Factor Collaboration, 2016), but having a common indicator across countries and over time allows for intriguing comparisons such as those highlighted above. Although we have not estimated a global stunting rate using our data, it is clear that the global stunting rate was far higher in 1900 than the 33% level estimated for 2000. Thus, the global burden of malnutrition has reduced dramatically in the past 120 years.

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