

# Mapping disparities in education across low- and middle-income countries

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Local Burden of Disease Educational Attainment Collaborators\*

Educational attainment is an important social determinant of maternal, newborn, and child health<sup>1–3</sup>. As a tool for promoting gender equity, it has gained increasing traction in popular media, international aid strategies, and global agenda-setting<sup>4–6</sup>. The global health agenda is increasingly focused on evidence of precision public health, which illustrates the subnational distribution of disease and illness<sup>7,8</sup>; however, an agenda focused on future equity must integrate comparable evidence on the distribution of social determinants of health<sup>9–11</sup>. Here we expand on the available precision SDG evidence by estimating the subnational distribution of educational attainment, including the proportions of individuals who have completed key levels of schooling, across all low- and middle-income countries from 2000 to 2017. Previous analyses have focused on geographical disparities in average attainment across Africa or for specific countries, but—to our knowledge—no analysis has examined the subnational proportions of individuals who completed specific levels of education across all low- and middle-income countries<sup>12–14</sup>. By geolocating subnational data for more than 184 million person-years across 528 data sources, we precisely identify inequalities across geography as well as within populations.

Education, as a social determinant of health, is closely linked to several facets of the Sustainable Development Goals (SDGs) of the United Nations<sup>2</sup>. In addition to the explicit focus of SDG 4 on educational attainment, improved gender equality (SDG 5) and maternal, newborn, and child health (SDG 3) have well-documented associations with increased schooling<sup>15–17</sup>. In 2016, after years of deprioritization, aid to education reached its highest level since 2002<sup>18</sup>. Despite this shift, only 22% of aid to basic education—defined as primary and lower-secondary—went to low-income countries in 2016 compared to 36% in 2002<sup>19</sup>. This reflects a persistent pattern in which the distribution of aid does not align with the greatest need, even at the national level. Beyond international aid, domestic policy is also a crucial tool for expanding access to education, especially at higher levels. However, policy-makers often do not have access to a rigorous evidence base at a subnational level. This analysis presents the subnational distribution of education to support the growing evidence base of precision public health data, which shows widespread disparity of health outcomes as well as their social determinants.

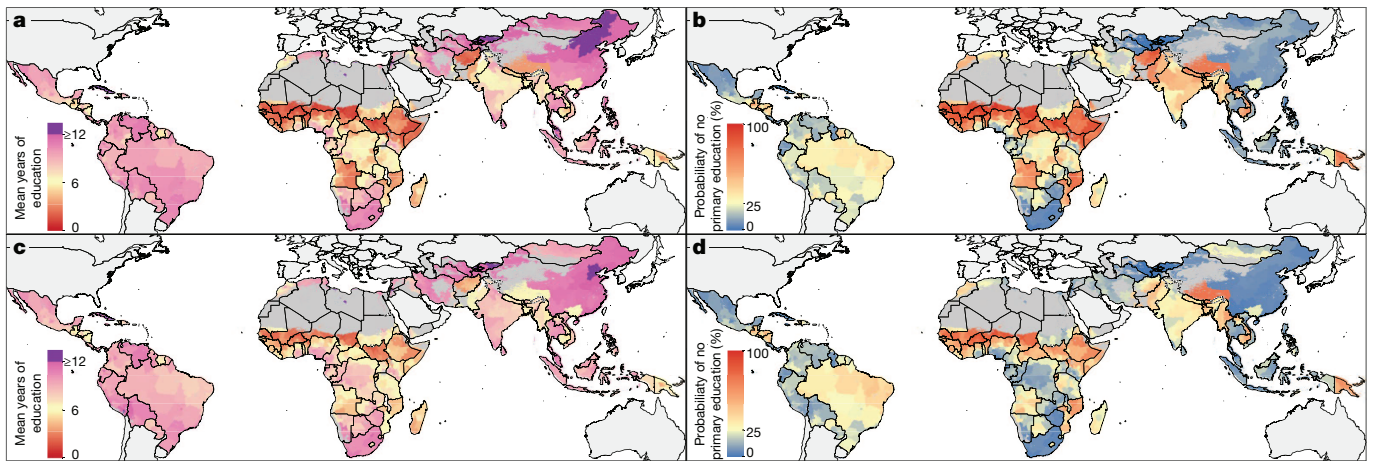
## Mapping education across gender

Despite widespread improvement in educational attainment since 2000, gender disparity persists in 2017 in many regions. Figure 1 illustrates the mean number of years of education and the proportion of individuals with no primary school attainment for men and women of reproductive age (15–49 years) in 2017. The average educational attainment is very low across much of the Sahel region of sub-Saharan Africa, consistent with previously published data<sup>14</sup>. In 2017, there was a large gender disparity in many regions, with men attaining higher average

education across central and western sub-Saharan Africa and South Asia. Considerable variation remains between the highest- and lowest-performing administrative units within countries in 2017. For Uganda in 2017, this indicator ranged from 1.9 years of education (95% uncertainty interval, 0.8–3.0 years) in rural Kotido to 11.1 years (10.1–12 years) in Kampala, the capital city. Figure 1b, d displays the proportion of men and women aged 15–49 years who have not completed primary school. By considering the variation within populations in different locations, these maps help to identify areas with large populations in the vulnerable lower end of the attainment distribution. We estimated large improvements in the proportions of individuals who have completed primary school in Mexico and China. However, across much of the world women in this age group failed to complete primary school at a much higher rate than their male counterparts.

Despite continued lack of gender parity in education among the reproductive age group, vast progress towards parity has been made among the 20–24 age group. Extended Data Fig. 2 further examines gender parity in 2000 and 2017. This figure highlights two additional advantages of our analytic framework. First, we examined a younger group aged 20–24 years. Although education in this group is less directly relevant to maternal, newborn, and child health than education in the full window of reproductive age, these estimates allowed us to capture how the landscape of education has shifted over time (that is, across successive cohorts) and is therefore more likely to pick up improvements to access and retention in education systems that have been made since 2000. Second, we illustrate the probability that this estimated ratio is credibly different from 1 (parity between sexes) given the full uncertainty in our data and model. In 2000, we estimated that men completed schooling at a higher rate than women across much

\*A list of participants and their affiliations appears in the online version of the paper.

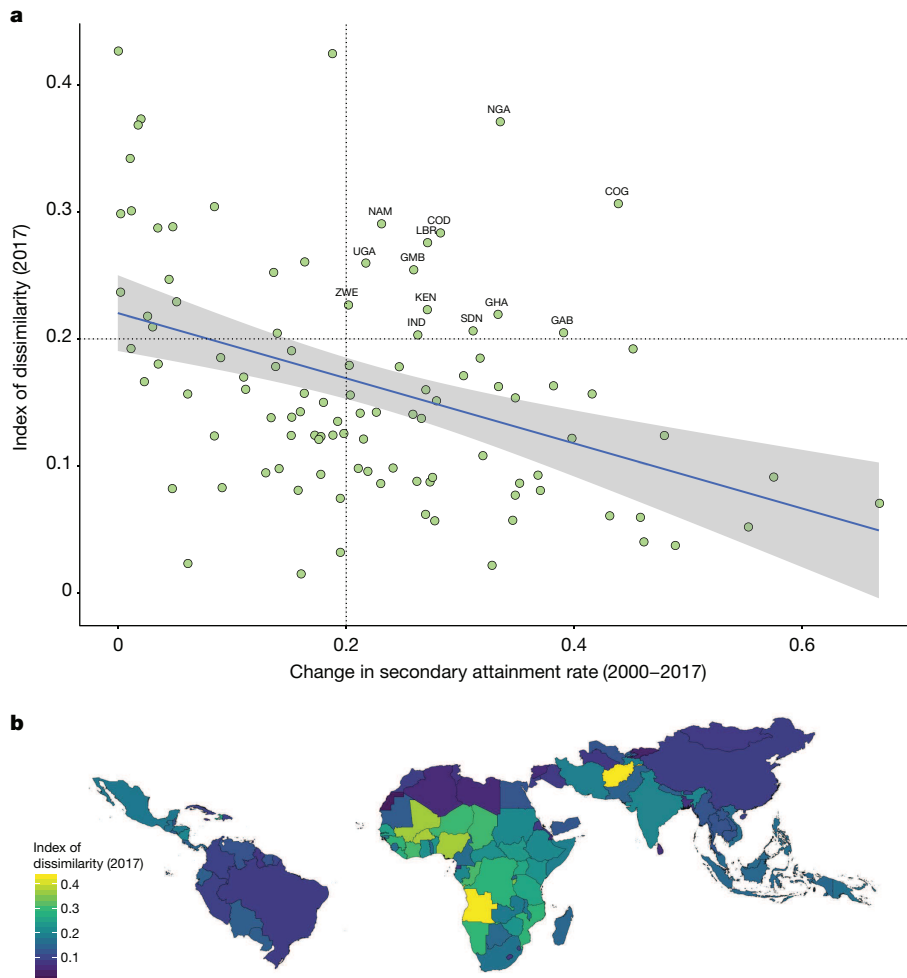


**Fig. 1 | Average educational attainment and proportion of individuals with no completed primary education at the first administrative level and absolute difference between women and men aged 15–49 years. a–d, Mean**

educational attainment for women (a) and men (c) and the proportion of individuals with no primary school education for women (b) and men (d) aged 15–49 years in 2017. Maps were produced using ArcGIS Desktop 10.6.

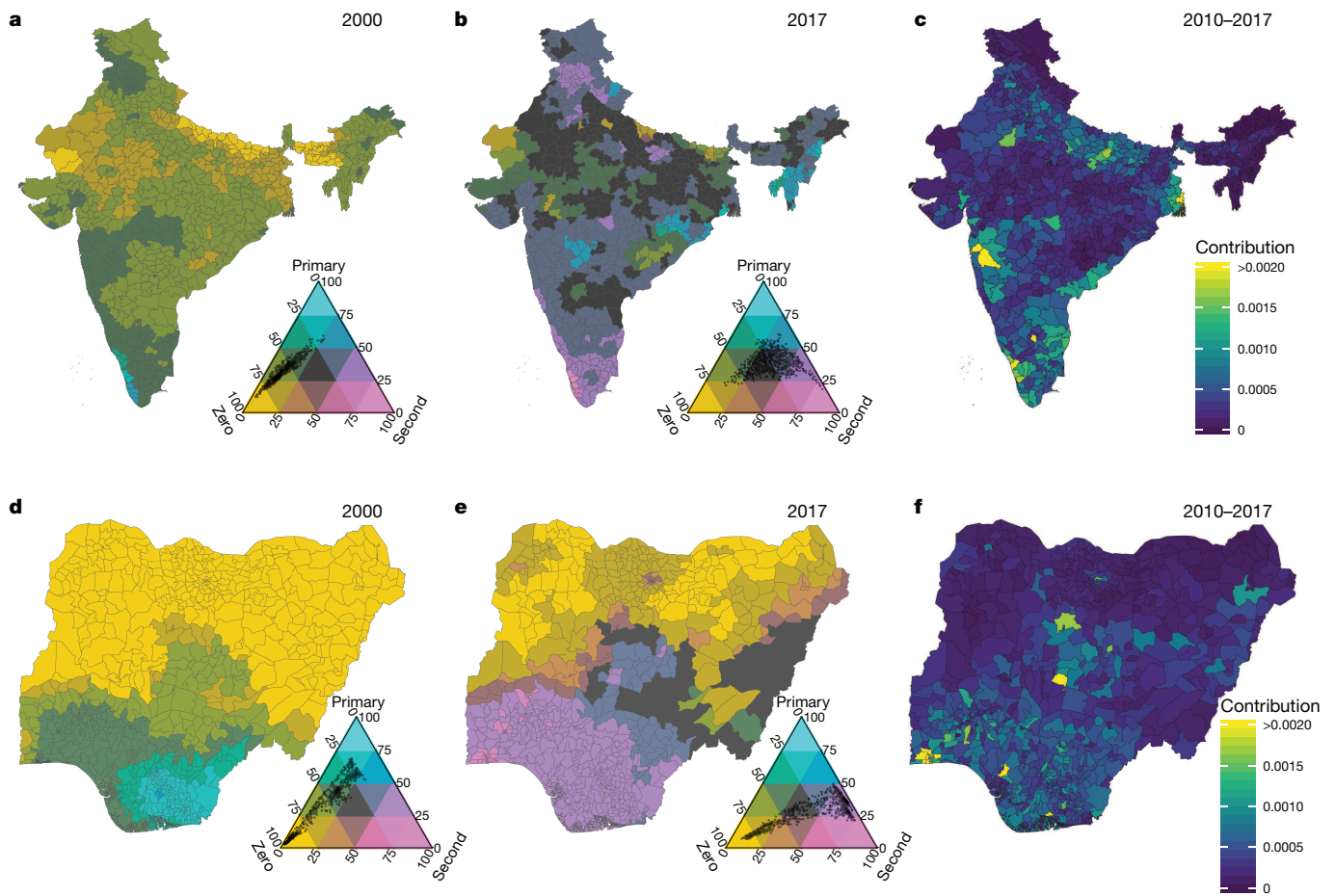
of the world, particularly for primary school education (that is, the probability that the parity ratio is greater than 1 was over 95%). This was true in most countries for both primary and secondary completion rates, but especially so in Burundi, Angola, Uganda, and Afghanistan

(Extended Data Fig. 2a, c). By 2017, many countries moved significantly towards parity in both secondary and primary completion rates with the exception of large regions within central and western sub-Saharan Africa (Extended Data Fig. 2b, d).



**Fig. 2 | National progress in secondary attainment rates for women aged 20–24 years compared with the national index of dissimilarity in 2017. a, Change in secondary attainment rates for women age 20–24 years between 2000 and**

2017 compared with the national index of dissimilarity in 2017 (simple linear regression lines are included). b, Map of the national index of dissimilarity in 2017. Maps were produced using ArcGIS Desktop 10.6.



**Fig. 3 | Attainment rates and contributions to national change in secondary rates for women aged 20–24 years in India and Nigeria, 2000–2017.** **a, b**, Attainment rates for women aged 20–24 years in 2000 (**a**) and 2017 (**b**) at the second administrative level in India. **c**, Additive contributions of changes in the attainment rates at the second administrative level to change in the rate at the national level between 2000 and 2017 in India. **d, e**, Attainment rates for

women aged 20–24 years in 2000 and 2017 at the second administrative level in Nigeria. **f**, Additive contributions of changes in the attainment rates at the second administrative level to change in the rate at the national level between 2000 and 2017 in Nigeria. On all ternary maps, the ‘Zero’ category includes all individuals with either no schooling or some primary schooling without completion. Maps were produced using ArcGIS Desktop 10.6.

### Inequalities within and between countries

The subnational estimates of attainment presented here enable a closer examination of within-country inequality and associated trends over time. Figure 2 plots the national change in secondary attainment rates for women aged 20–24 years with the index of dissimilarity across second administrative-level units in 2017. The index of dissimilarity is an intuitive measure of geographical inequality that can be interpreted as the percentage of women with secondary attainment that would have to move in order to equalize secondary rates across all subnational districts. We estimated that countries that experienced more national progress over the period tended to be more spatially equal in 2017. However, the top-right quadrant of the graph highlights several countries that experienced substantial national progress yet remain some of the most geographically unequal countries today.

We further examined national progress between 2000 and 2017 in two such countries, India and Nigeria, where rates of secondary attainment increased from 10.9% (8.5–12.5%) to 37.2% (33.6–41.1%) and from 11.5% (6.2–18.3%) to 45.0% (37.0–52.5%), respectively (Fig. 3). The geographical distribution between two cohorts—women aged 20–24 years in 2000 and 2017—was analysed by examining all proportions simultaneously (Fig. 3a, b). We estimate that there has been a massive shift towards primary and secondary completion coupled with greater geographical variability in completion rates (that is, spread of the dots that represent subnational units in the legend). The majority of the 2017 cohort living

in the northwest and northeast of India never completed secondary school. Urban centres in the south, such as Bangalore and Mumbai, have seen considerable progress compared with more rural regions. In Nigeria, we estimate substantial national improvement; however, the country remained one of the most spatially unequal in 2017 (Fig. 3d, e). The more-urban south, particularly around Lagos, experienced much faster progress than the more-rural north. The implications of the population distribution were explored by decomposing the improvement in the national rate of secondary completion since 2000 for each country into the additive contributions of rate changes at the second administrative level (Fig. 3c, f). This demonstrates that national progress was largely driven by improvements in populous urban regions (particularly Maharashtra, India, and Lagos, Nigeria), underscoring the importance of how subnational progress (or lack thereof) contributes differentially to narratives surrounding national change.

### Discussion and limitations

We have built on previous modelling efforts that focused on the geographical distribution of average education<sup>14</sup> by extending our estimation to the distribution of attainment, highlighting not only average attainment but also the proportions of individuals who completed key levels of schooling that are central to policy efforts. As we demonstrate, throughout much of the world women lag behind their male



counterparts, and there is significant heterogeneity across subnational regions. Countries such as South Africa, Peru, and Colombia have seen tremendous improvement since 2000 in the proportion of the young adult population who have completed secondary school. As this trend continues, it will be important to focus not only on attainment but also on quality of education. However, many young women across the world still faced obstacles to attaining even a basic level of education in 2017 (Extended Data Fig. 3). This represents a missed opportunity for the global health community to focus on a well-studied determinant of maternal, newborn, and child health. Even with only marginal returns to health in the short term, studies suggest that, on average, communities will also see increased human capital, social mobility, and less engagement in child marriage or early childbearing<sup>20,21</sup>.

Children and adolescents do not complete formal schooling for many reasons. Many factors differentially affect girls, such as cost, late or no school enrolment, forced withdrawal of married adolescents, and the social influence of family members concerning the traditional roles of girls and women<sup>4,20,22,23</sup>. A critical step is acknowledging that commercialization in the area of education typically leads to higher inequity<sup>24</sup>. Treating public education as a societal good by increasing access, particularly in underserved rural communities, reduces inequality. Identifying areas that are stagnating or worsening, particularly in the realm of basic education for young women across the world, is an important first step to targeted, long-term reform efforts that will ultimately have widespread benefits for equity in health and development.

Many recent international calls to improve the social determinants of health have stated that measurement of inequity within countries is critical to understanding and tracking the problem, noting that geography is an increasingly important dimension of inequity<sup>24–26</sup>. Where people are born greatly determines their life chances, and continuing to consider development and human capital formation on a national level is insufficient<sup>24</sup>. The goal of this analysis is to identify local areas that may have experienced negligible improvements, but further rigorous research is required to contextualize these patterns within the unique mix of structural obstacles that each community faces. There are many indirect costs for attending school and each disadvantaged area that we identify in our analysis may experience them in different ways. These include the demand for children to work, the opportunity or monetary costs of attending school, distance to school, lack of compulsory education requirements, high fees for attendance, political instability, and many other forces. Overcoming these obstacles to improve educational attainment alone will not necessarily result in a more-educated and healthy population for each country as highly educated individuals may be more likely to emigrate, resulting in ‘brain drain’. This is especially true for countries that have been economically crippled over the past two decades and may lack the economic capacity to absorb a more highly educated labour force. Opening access to education will need to be coupled with economic reforms, both internationally and domestically, if countries are to fully experience dividends in human capital and health.

Over the next decade of the SDG agenda, it will be important to maintain the progress that has been made to reprioritise investment in education systems. There remains an alarming lack of distributional accountability in aid, especially to basic education, for which most funding is not going to the countries that need it most<sup>19</sup>. Connections between educational attainment and health offer promising opportunities for co-financing initiatives. For example, USAID recently invested US\$90 million in HIV funding to the construction of secondary schools in sub-Saharan Africa. Global health leaders have noted the need to invest in precise data systems and eliminate data gaps to effectively target resources, develop equitable policy, and track accountability<sup>7</sup>. Our analysis provides a robust evidence base for such decision-making and advocacy. Decades of research on the effect of basic education on maternal, newborn, and child health positions this issue squarely in the purview of the global health agenda. It is crucial for the global health community to invest in long-term, sustainable improvement in

the underlying distribution of human capital, as this is the only way to truly influence health equity across generations.

## Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at <https://doi.org/10.1038/s41586-019-1872-1>.

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