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# Monitoring equity in vaccination coverage: A systematic analysis of demographic and health surveys from 45 Gavi-supported countries

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ABSTRACT

*Objectives:* (1) To conduct a systematic analysis of inequalities in childhood vaccination coverage in Gavi-supported countries; (2) to comparatively assess alternative measurement approaches and how they may affect cross-country comparisons of the level of inequalities.
*Methods:* Using the most recent Demographic and Health Surveys (2005–2014) in 45 Gavi-supported countries, we measured inequalities in vaccination coverage across seven dimensions of social stratification and of vulnerability to poor health outcomes. We quantified inequalities using pairwise comparisons (risk differences and ratios) and whole spectrum measures (slope and relative indices of inequality). To contrast measurement approaches, we pooled the estimates using random-effects meta-analyses, ranked countries by the magnitude of inequality and compared agreement in country ranks.
*Results:* At the aggregate level, maternal education, multidimensional poverty, and wealth index poverty were the dimensions associated with the largest inequalities. In 36 out of 45 countries, inequalities were substantial, with a difference in coverage of 10 percentage points or more between the top and bottom of at least one of these social dimensions. Important inequalities by child sex, child malnutrition and urban/rural residence were also found in a smaller set of countries. The magnitude of inequality and ranking of countries differed across dimension and depending on the measure used. Pairwise comparisons could not be estimated in certain countries. The slope and relative indices of inequality were estimated in all countries and produced more stable country rankings, and should thus facilitate more reliable international comparisons.
*Conclusions:* Inequalities in vaccination coverage persist in a large majority of Gavi-supported countries. Inequalities should be monitored across multiple dimensions of vulnerability. Using whole spectrum measures to quantify inequality across multiple ordered social groups has important advantages. We illustrate these findings using an equity dashboard designed to support decision-making in the Sustainable Development Goals period.

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## 1. Background

Vaccination is an extremely effective public-health intervention and ensuring that all children enjoy its full benefits is a core component of the right to health [1]. Despite remarkable increases in coverage in recent decades, inequalities in access to basic vaccines persist and their elimination is now a focus of major international efforts [1].

Gavi, the Vaccine Alliance, is a global public-private partnership dedicated to saving children's lives and protecting people's health by increasing equitable use of vaccines in lower-income countries. Gavi routinely monitors inequalities in vaccination coverage within the countries it supports. However, similar to other global actors, Gavi has largely relied on wealth indices to assess social exclusion and on simple measures of inequality that focus on the

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coverage gap between the richest and poorest quintiles of the population [2]. This approach has two main limitations. First, wealth index poverty, measured by a household's ownership of selected assets, housing quality, and types of water access and sanitation facilities, may not be the only factor associated with lower vaccination coverage. Other factors, such as gender, ethnicity or education, may be of greater importance in some settings [3,4]. Second, comparing vaccination coverage between the richest and poorest quintiles only reflects the vaccination status of two fifth of the population. Alternative measures of inequality that take into account the entire population could provide a different assessment of the social gradient in vaccination coverage [5].

The recently adopted Sustainable Development Goals (SDGs) call upon the international community to "leave no one behind" [6]. Achieving this goal will therefore require that inequalities are effectively measured, monitored and addressed [7]. To inform this effort we conducted a systematic analysis of inequalities in childhood vaccination coverage across Gavi-supported countries. Our objectives were to: (1) provide an up-to-date portrait of inequalities and (2) evaluate how conclusions about the magnitude of inequalities and the comparative ranking of countries are influenced by different measurement approaches. Using these findings, we propose a strategy to monitor equity in vaccination coverage in the SDG period.

## 2. Methods

### 2.1. Data sources

In each country, we used data from the most recent Demographic and Health Surveys (DHS) conducted after 2004. The DHS are internationally comparable household surveys that collect demographic, socioeconomic and health-related information among nationally representative samples of households in low and middle-income countries (LMIC) [8]. Sampling strategies and methodology have been described previously [9]. Of the 73 Gavi-supported countries, 19 had never been surveyed by DHS, seven were last surveyed before 2005, and two had not collected vaccination data, leading to a final sample of 45 countries.

### 2.2. Measures

We assessed inequalities in the receipt of the third dose of diphtheria-tetanus-pertussis-containing vaccine (DTP3) and of measles-containing vaccines (MCV) in children aged 12–23 months [10]. DTP3 coverage is tracked by many agencies as a standard indicator of health system performance, as it reflects the ability of a family to access and utilize immunization services through the routine system on multiple visits. MCV coverage was used to track progress towards Millennium Development Goal 4 [11]. Vaccination status is ascertained in the DHS by checking vaccination cards or, if the card is not available, by asking the child's caregiver [12].

To determine which dimensions would be relevant to the measurement of inequalities in vaccination coverage, we used a framework for the analysis of inequities in child health of the Commission on Social Determinants of Health [13]. Following this framework, we selected dimensions related to children's socioeconomic position and to their differential exposure and vulnerability to poor health outcomes: wealth index poverty, maternal and paternal education, multidimensional poverty, urban/rural residence, child sex and child malnutrition.

We used the wealth index constructed by the DHS. The wealth index is estimated by principal component analysis and based on a household's ownership of selected assets, housing construction materials, and types of water access and sanitation facilities [14]. We used the mother or female caregiver's highest level of education attended and highest level completed to construct a variable with six categories: no education, incomplete primary, complete primary, incomplete secondary, complete secondary, higher education (attended). The mother also reported the level of education of her current or most recent partner, which was used as a proxy for paternal education. We included the multidimensional poverty index (MPI), an indicator of overlapping deprivations at the household level. The MPI, presented in the Human Development Report since 2010, is based on three dimensions measured by 10 indicators commonly available in the DHS: living standards (assets, housing materials, sanitation, water, electricity, cooking fuel), education (children school attendance, educational achievement of adults) and health (child mortality, malnutrition) [15,16]. We included the MPI because of its ability to identify children at higher risk of poor health outcomes and thus at highest priority for vaccination. The construction of the MPI is described in the appendix. Urban/rural residence and child sex were taken directly from the DHS. We considered three indicators of malnutrition. A child was considered stunted, wasted, or underweight if her or his z-score for height-for-age, weight-for-height, or weight-for-age, respectively, was less than 2 standard deviations from the median of the reference population for children of the same age and sex [17].

### 2.3. Statistical analyses

We used two approaches to quantify the inequalities: pairwise comparisons (risk difference (RD) and risk ratio (RR)) and whole spectrum measures (slope index of inequality (SII) and relative index of inequality (RII)) [5,18,19]. We used the RD and RR to compare the risk of vaccination between two contrasting subgroups as defined in Table 1. We used logistic regression to model the log odds of vaccination and transformed the coefficients into marginal predicted risks to calculate the RD and RR.

For indicators with multiple subgroups and a natural ordering (wealth index, education and MPI (Table 1)), we also calculated

**Table 1**
Dimensions of vulnerability and definitions of subgroups used to measure inequalities in vaccination coverage.

| | Pairwise Reference | | Continuous/categorical |
|---|---|---|---|
| Wealth index | Q1 (poorest) | Q5 (richest) | Continuous |
| Maternal education | None | Complete secondary or higher education | 6 categories[a] |
| Paternal education | None | Complete secondary or higher education | 6 categories[a] |
| Multidimensional Poverty Index (MPI) | MPI poor[b] | Non MPI poor | Continuous |
| Sex of the child | Female | Male | – |
| Place of residence | Rural | Urban | – |
| Malnutrition | Stunted[c] | Non-stunted | – |

[a] 6 categories of education: no education, incomplete primary, complete primary, incomplete secondary, complete secondary, higher education (attended).
[b] A household is identified as MPI poor if deprived in at least one third of the weighted MPI indicators (score $\geqslant 0.33$).
[c] A child is identified as stunted if her of his height-for-age score is less than 2 standard deviations from the median z-score.

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