Comparing Multivariate with Wealth-Based Ranking for Computing Inequity in Access to Child Immunization Services in India Over Time

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Background

• As of 2018, India has been undergoing an accelerated transition period from Gavi support to fully self-financing

• Historically, Gavi has supported pentavalent vaccine in India, which offers protection against five diseases:
  • Diphtheria-Tetanus-Pertussis (DTP),
  • Hepatits B (hepB)
  • Haemophilus Influenza Type B (Hib)

• Between 2000 and 2015, Gavi disbursed more than US$240 million to help India to immunise its children against life-threatening diseases and committed over 107 million over the next 5 years.

• Despite the importance of equity in Gavi’s strategic plans there is limited standardization in the measurement and tracking of equity in vaccine coverage, health impacts, and economic impacts of vaccines both over time and across settings (e.g. countries, regions, districts).

*https://www.gavi.org/our-alliance/strategy/phase-5-2021-2025/equity-goal
Many of the measures used to assess equity in health outcomes require ranking individuals along some dimension, usually by a measure of socioeconomic status (e.g. wealth quintiles).

This technique was translated to health outcomes from the income inequality measurement space where, for measures such as the Gini-Coefficient the X and Y axis of the underlying Lorenz curve utilize the same measure (e.g. income).

Means targeting for financial policies such as tax rates, subsidies, or public assistance are typically only a function of socioeconomic status.

 Means targeting for health is typically both a function of susceptibility or vulnerability in addition to means and need.

Utilizing wealth-based or single-dimension ranking criteria fail to capture a substantial degree of inequity relevant to the public health and healthcare sectors.

This research applies a multivariate ranking procedure to evaluate how much inequity in vaccination coverage is missed in India from 2005 – 2021.
• What is the difference between empirical inequity in fully-immunized for age status as measured through concentration indices and absolute equity gaps between wealth-based ranking procedures and a multivariate ranking procedure in India and how has it changed over time?
3 Rounds of the National family Health Survey (NFHS), which is India’s Demographic & Health Survey (DHS)

NFHS 3
2005-2006

NFHS 4
2015-2016

NFHS 5
2019-2021
Measuring Equity vs. Equality

Measuring Equity vs. Equality

Distribution assessment: Is the person vaccinated?

Need assessment: Should they be vaccinated?

Equity assessment: Is this difference in outcome ("being vaccinated") influenced by unfair factors?

Eligibility or need: Age of the child
Methodology: “Fair” and “Unfair” Factors

**Fair Factors**
Determinants of need for the service

- Underage for a vaccine according to the National Immunization Schedule

**Unfair Factors**
After controlling for need, these characteristics should not be correlated with receiving the service under an equitable distribution

- Socio-economics status (Metric: Wealth quintile)
- Urban/Rural designation (Metric: Residential location indicator)
- Sub-national administrative region (Metric: State)
- Sex of vaccine-recipient (Metric: Sex of child)
- Material education level (Metric: Years of education)
Ranking

Poorest

Wealth-Based

Most disadvantaged

Multidimensional
- State and settings (urban/rural)
- Maternal education
- Socioeconomic status
- Sex of the child
- Health insurance coverage

Wealthiest

Most privileged
\[ h_{c\text{direct unfairness}} = h_{c\text{predicted}}(N_{\text{ref}}, P_{\text{ref}}, Z_i, X_{\text{ref}}) \]

- \( h_{c\text{direct unfairness}} \) is the measure of direct unfairness for healthcare coverage.
- \( h_{c\text{predicted}} \) is the (predicted) probability of receiving care holding need/eligibility (\( N \)) and neutral (\( X \)) at reference levels.
  - \( N_{\text{ref}} \) is the vector of need and eligibility (fair) variables (e.g., age of child for vaccination).
  - \( P_{\text{ref}} \) is the vector of preference for healthcare variables.
  - \( Z_i \) is the vector of unfair variables (e.g., socioeconomic status, urban/rural, maternal education level).
  - \( X_{\text{ref}} \) is the vector of neither fair nor unfair variables (variables that may confound the relationship between unfair predictors and coverage).
Individuals either receive healthcare \((h) = 1\) or not \((h) = 0\) (binary variable). We can use a logistic framework and write \(h_{predicted}\) for individual \(i\) as:

\[
p_i = \text{Probability}(h = 1 | N_{ref}, Z_i)
\]

\[
\text{logit}(p_i) = \alpha + \beta \cdot Z_i + \gamma \cdot N_{ref} + \epsilon
\]

\(\beta\) is the contribution to the variation of each unfair factor \((Z_i)\)

\(\gamma\) is the contribution to the variation of each fair factor \((\text{need/eligibility}; N_{ref})\)

**Citations:**
Are there significant differences in healthcare service coverage between different population groups?

- **Middle-class household living in an urban area. Mother has O-level education.**
- **Poor household living in an urban slum area. Mother has no education.**
- **Wealthy household living in an urban area. Mother has tertiary education.**
- **Middle-class household living in a rural area. Mother has A-level education.**

Most disadvantaged

**RANKING**

Most privileged
Are there significant differences in healthcare service coverage between different population groups?

If yes

What factors contribute most to those differences?

- Poor household living in an urban slum area. Mother has no education.
- Middle-class household living in an urban area. Mother has O-level education.
- Middle-class household living in a rural area. Mother has A-level education.
- Wealthy household living in an urban area. Mother has tertiary education.
Outcome: Concentration Index

\[ CI_W \approx \frac{2}{\mu_{hc}} \text{cov}(hc_{direct}, F(hc_{direct \text{ unfairness}})) \]

Where \( \mu_{hc} \) is the average healthcare coverage in the population, \( \text{cov}(h,r) \) the covariance between the individual level healthcare coverage (\( hc_{direct} \)) and the cumulative distribution function of direct unfairness (\( F(hc_{direct \text{ unfairness}}) \)).

- \( C = 0 \), perfect equality
- \( 0 < C < 1 \), most of the healthcare coverage is allocated to the more privileged households
- \( -1 < C < 0 \), most of it is allocated to the more disadvantaged households

Cumulative sum of people accessing healthcare (coverage)
The **Absolute Equity Gap** (AEG) is difference between health outcome attainment between the most advantaged 20% of the population and the least advantaged 20% of the population.

\[
AEG = \text{mean(outcome)}_{\text{top 20\%}} - \text{mean(outcome)}_{\text{bottom 20\%}}
\]

A larger AEG means that the distribution of vaccines is **less** equitable between the most disadvantaged and most privileged groups.
RESULTS
## Results

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Results: Penta 1st Dose Coverage & Equity

Pentavalent 1st Dose Coverage & Equity

Coverage CI Wealth CI Composite AEG Wealth AEG Composite

Example from India NFHS-3 (2005-2006)

Equity in Fully Immunized for Age Status

- **Share of population ranked by wealth**
  - CI = 0.062

- **Share of population ranked by disadvantage**
  - CI = 0.289
Fully Immunized for Age Equity-Coverage Plane

Equity: (1 - Composite Index)

% Coverage

District
1 = [jm] jammu and kashmir
2 = [hp] himachal pradesh
3 = [pg] punjab
5 = [uc] uttaranchal
6 = [hr] haryana
7 = [dl] delhi
8 = [raj] rajasthan
9 = [up] uttar pradesh
10 = [bh] bihar
11 = [sk] sikkim
12 = [ar] arunachal pradesh
13 = [nj] nagaland
14 = [mni] manipur
15 = [rn] mizoram
16 = [tr] tripura
17 = [mg] meghalaya
18 = [as] assam
19 = [ma] meghalaya
20 = [jh] jharkhand
21 = [or] orissa
22 = [ch] chattisgarh
23 = [mp] madhya pradesh
24 = [gu] gujarat
25 = [pt] puducherry
26 = [kn] karnataka
27 = [tn] tamil nadu
28 = [ap] andhra pr
29 = [tk] tripura
30 = [go] goa
31 = [wa] west bengal
32 = [kl] kerala
33 = [nt] nagaland

2005-2006
Fully Immunized for Age Equity-Coverage Plane

% Coverage

Equity: (1 - Composite Index)

District

1 = jammu & kashmir
2 = himachal pradesh
3 = punjab
4 = chandigarh
5 = uttarakhand
6 = haryana
7 = nct of delhi
8 = rajasthan
9 = uttar pradesh
10 = bihar
11 = sikkin
12 = arunachal pradesh
13 = nagaland
14 = manipur
15 = tripura
16 = mizoram
17 = meghalaya
18 = assam
19 = west bengal
20 = jharkhand
21 = odisha
22 = chhattisgarh
23 = madhya pradesh
24 = gujarat
25 = dodra & nagar haveli and daman & diu
26 = maharashtra
27 = andhra pradesh
28 = karnataka
29 = goa
30 = lakshadweep
31 = kerala
32 = tamil nadu
33 = puducherry
34 = andaman & nik
35 = telangana
36 = ladakh
2005-2006
2019-2020

DTP1 Vaccination Equity-Coverage Plane

% Coverage vs Equity: (1 - Composite Index)

District

1 = jammu & kashmir
2 = himachal pradesh
3 = punjab
4 = chandigarh
5 = uttarakhand
6 = haryana
7 = not of delhi
8 = rajasthan
9 = uttar pradesh
10 = bihar
11 = sikkim
12 = arunachal pradesh
13 = nagaland
14 = manipur
15 = mizoram
16 = tripura
17 = meghalaya
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20 = jharkhand
21 = odisha
22 = chattisgarh
23 = madhya pradesh
24 = gujarat
25 = dadra & nagar haveli and dampur & diu
26 = mahrashtra
27 = maharashtra
28 = andhra pradesh
29 = karnataka
30 = goa
31 = lakshadweep
32 = kerala
33 = tamil nadu
34 = puducherry
35 = andaman & nik
36 = tatangana
37 = tabalik
Decomposition of Fully-Immunized Inequity

**2005-2006**
- Underage: 0%
- District: 8.5%
- Urban/Rural: 1.6%
- Maternal Education Level: 31.1%
- Wealth Quintile: 25.7%
- Sex of Child: 0.4%
- Covered by Health Insurance: 0%
- Unexplained Variation: 32.7%

CI = 0.289

**2015-2016**
- Underage: 0%
- District: 0.1%
- Urban/Rural: 1.5%
- Maternal Education Level: 22.9%
- Wealth Quintile: 16.3%
- Sex of Child: 0%
- Covered by Health Insurance: 5.84%
- Unexplained Variation: 53.2%

CI = 0.130

**2019-2021**
- Underage: 0%
- District: 1.6%
- Urban/Rural: 0.7%
- Maternal Education Level: 3.9%
- Wealth Quintile: 9.2%
- Sex of Child: 0.1%
- Covered by Health Insurance: 4.91%
- Unexplained Variation: 79.5%

CI = 0.085
Decomposition of DTP/Penta1 Inequity

2005-2006

- Underage: 3.3%
- District: 14.3%
- Urban/Rural: 3.6%
- Maternal Education Level: 31.8%
- Wealth Quintile: 25.6%
- Sex of Child: 0.8%
- Covered by Health Insurance: 0%
- Unexplained Variation: 20.7%

CI = 0.155

2015-2016

- Underage: 6.1%
- District: 1%
- Urban/Rural: 2.4%
- Maternal Education Level: 34.2%
- Wealth Quintile: 21.4%
- Sex of Child: 0%
- Covered by Health Insurance: 8.09%
- Unexplained Variation: 26.9%

CI = 0.047

2019-2021

- Underage: 20.8%
- District: 7.3%
- Urban/Rural: 0.1%
- Maternal Education Level: 28.8%
- Wealth Quintile: 23.1%
- Sex of Child: 0.1%
- Covered by Health Insurance: 8.08%
- Unexplained Variation: 11.7%

CI = 0.027
Conclusions

- Using wealth-based ranking ignores significant amounts of inequity in immunization coverage associated with other sociodemographic factors.

- Improvements in immunization equity between 2005 and 2016 were more pronounced in India when using composite equity indicator.

- Large heterogeneity between states in both coverage and equity over time.

- Inequity in fully-immunized status has gotten more random over time whereas inequity in pentavalent coverage has roughly the same predictors over time suggesting strategies to improve each outcome would likely need to differ.
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