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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),
 - Hepatitis B (hepB)
 - Haemophilus Influenzae 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>

Background

- 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.

Research Question

- 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?





Data

India



सत्यमेव जयते

Surveys

Most recent surveys

India DHS, 2019-21
India DHS, 2015-16
India DHS, 2005-06

Publications

Most recent publications

India DHS, 2019-21 - State Final Reports
India DHS, 2019-21 - Final Report
India DHS, 2015-16 - Final Report

Datasets

Most recent datasets

India Standard DHS 2019-21
India Standard DHS 2015-16
India Standard DHS 2005-06

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

National Family Health Survey (NFHS-5) 2019-21

COMPENDIUM OF FACT SHEETS

KEY INDICATORS INDIA AND 14 STATES/UTs (Phase-II)

Ministry of Health & Family Welfare
Government of India

Measuring Equity vs. Equality



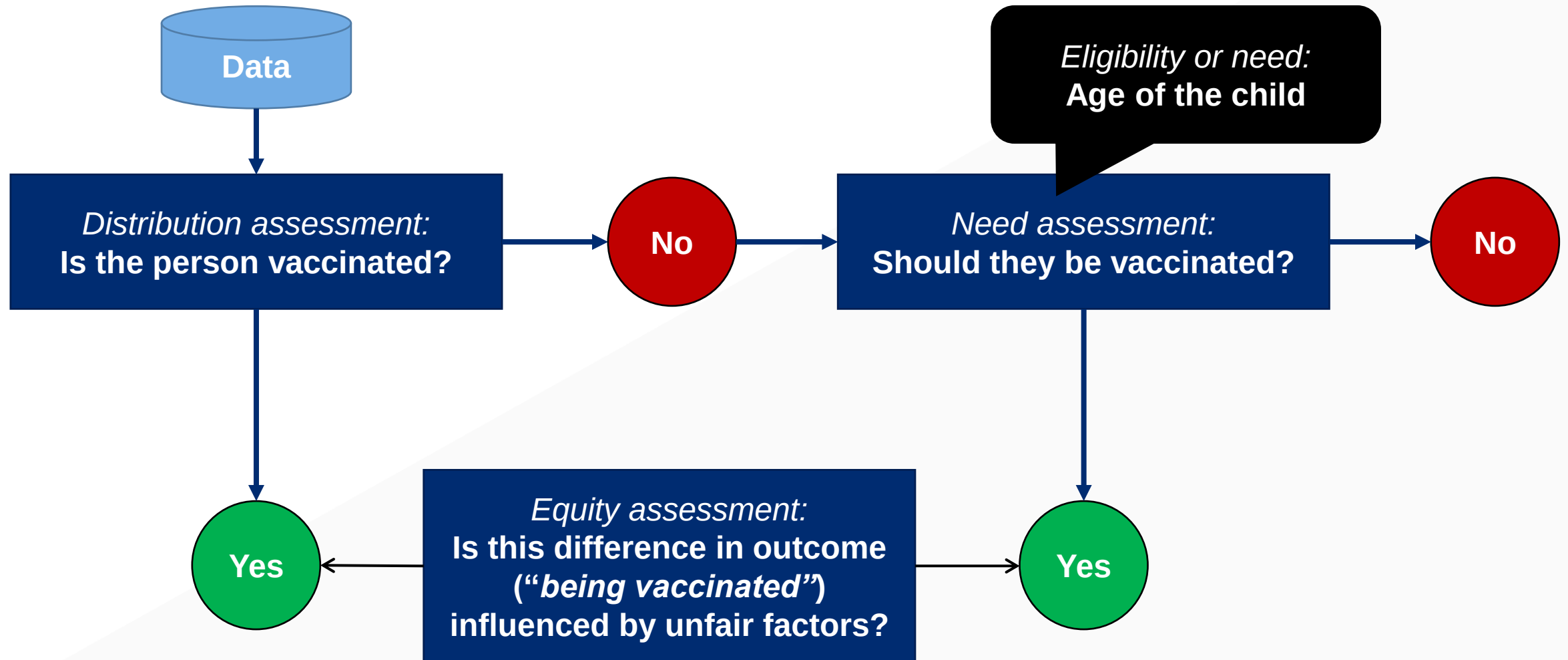
EQUALITY



EQUITY

Source:
<https://www.bu.edu/diversity/resource-toolkit/inequity-equality-equity-and-justice/>

Measuring Equity vs. Equality



Methodology: “Fair” and “Unfair” Factors

Fair Factors

Determinants of **need** for the service

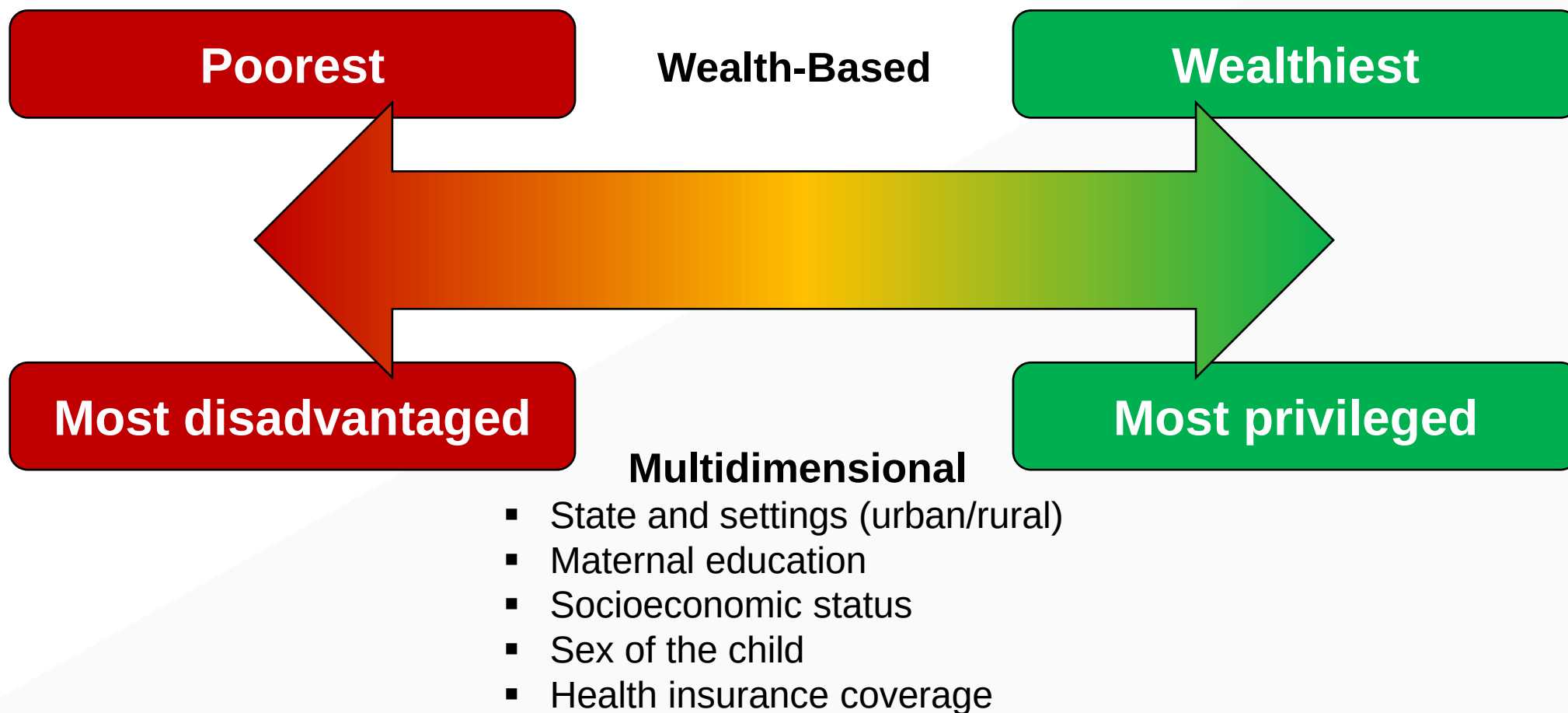
- Underage for a vaccine according to the National Immunization Schedule

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



Ranking

$$hc_{direct\ unfairness} = hc_{predicted}(N_{ref}, P_{ref}, Z_i, X_{ref})$$

$hc_{direct\ unfairness}$ is the measure of direct unfairness for healthcare coverage

$hc_{predicted}$ is the (predicted) probability of receiving care holding need/eligibility (N) and neutral (X) at reference levels

- N_{ref} is the vector of **need** and **eligibility (fair) variables** (*e.g.*, age of child for vaccination)
- P_{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_{ref} is the vector of neither fair nor unfair variables (variables that may confound the relationship between unfair predictors and coverage)

Ranking

Individuals either receive healthcare (h) = 1 or not (h) = 0 (binary variable).

We can use a logistic framework and write $hc_{predicted}$ for individual i as:

$$p_i = \text{Probability}(h = 1 \mid N_{ref}, Z_i)$$

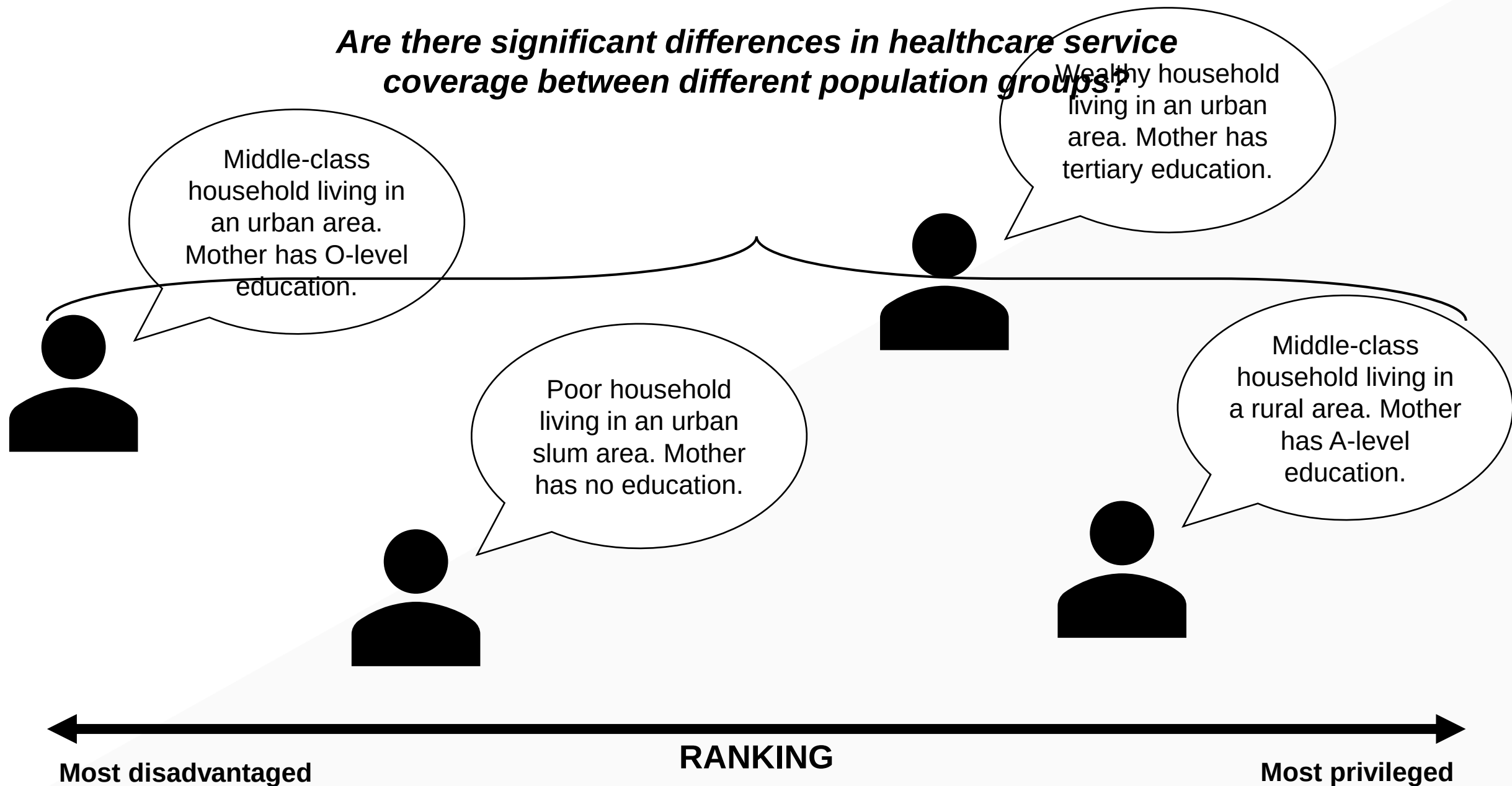
$$\text{logit}(p_i) = \alpha + \beta \cdot Z_i + \gamma \cdot N_{ref} + \varepsilon$$

β is the contribution to the variation of **each unfair factor** (Z_i)

γ is the contribution to the variation of **each fair factor** (need/eligibility; N_{ref})

Citations: E.C. Barbosa, R. Cookson. (2019). Multiple inequity in health care: an example from Brazil. Soc. Sci. Med., 228, pp. 1-8.
M. Fleurbaey, E. Schokkaert. (2009). Unfair inequalities in health and health care. J. Health Econ., 28, pp. 73-90.

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

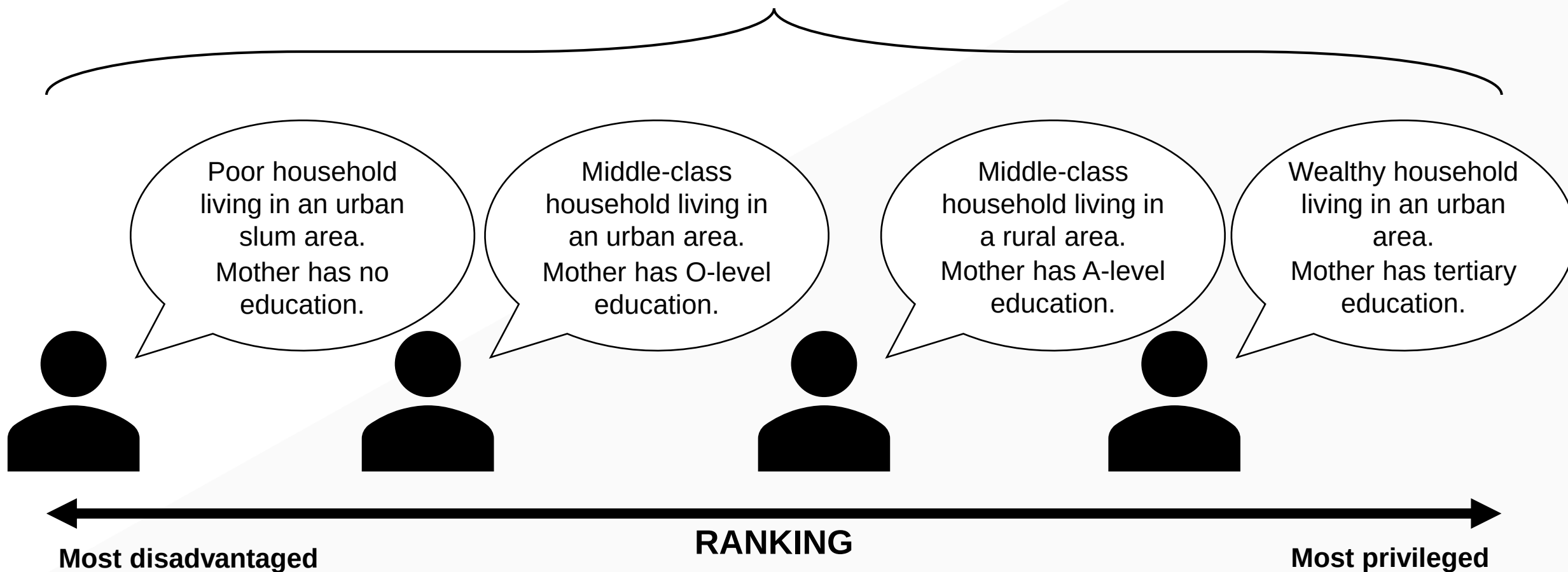


Are there significant differences in healthcare service coverage between different population groups?

If yes



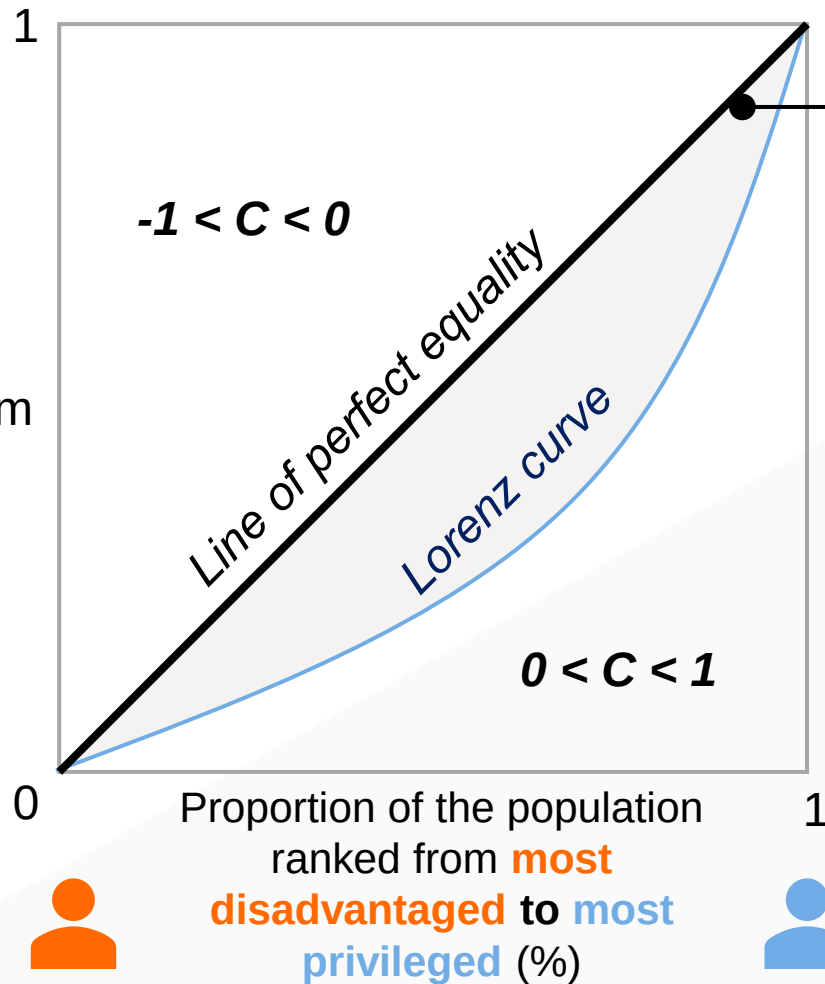
*What **factors** contribute most to those differences?*



Outcome: Concentration Index



Cumulative sum
of people
accessing
healthcare
(coverage)



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

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

$C = 0$, 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**

Outcome: Absolute Equity Gap

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.

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

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

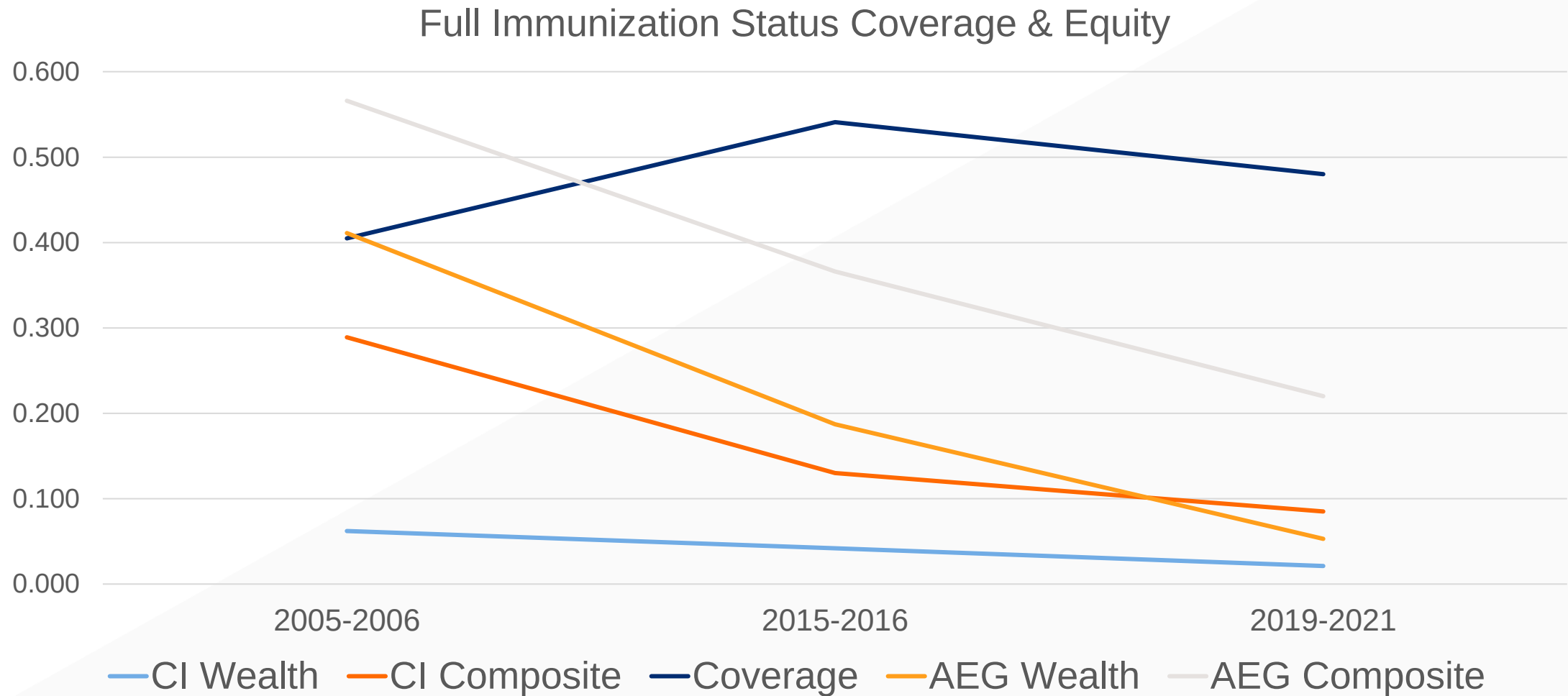
RESULTS

Results

NFHS3 (2005-2006)						NFHS4 (2015-2016)					NFHS5 (2019-2021)				
	Coverage	CI Wealth	CI Composite	AEG Wealth	AEG Composite	Coverage	CI Wealth	CI Composite	AEG Wealth	AEG Composite	Coverage	CI Wealth	CI Composite	AEG Wealth	AEG Composite
BCG	0.743 (0.739 , 0.747)	0.050 (0.048 , 0.052)	0.146 (0.141 , 0.151)	0.351 (0.339 , 0.363)	0.499 (0.489 , 0.509)	0.895 (0.894 , 0.897)	0.036 (0.035 , 0.037)	0.039 (0.038 , 0.040)	0.105 (0.101 , 0.109)	0.173 (0.169 , 0.177)	0.943 (0.942 , 0.945)	0.017 (0.015 , 0.019)	0.027 (0.025 , 0.029)	0.041 (0.037 , 0.045)	0.090 (0.086 , 0.094)
PENTA1	0.719 (0.715 , 0.723)	0.054 (0.052 , 0.056)	0.155 (0.150 , 0.160)	0.364 (0.352 , 0.376)	0.499 (0.487 , 0.511)	0.861 (0.860 , 0.862)	0.037 (0.037 , 0.037)	0.047 (0.047 , 0.047)	0.115 (0.111 , 0.119)	0.206 (0.202 , 0.210)	0.913 (0.911 , 0.914)	0.025 (0.023 , 0.027)	0.027 (0.025 , 0.029)	0.053 (0.047 , 0.059)	0.117 (0.111 , 0.123)
PENTA2	0.639 (0.635 , 0.643)	0.066 (0.063 , 0.069)	0.200 (0.194 , 0.206)	0.422 (0.410 , 0.434)	0.580 (0.568 , 0.592)	0.818 (0.816 , 0.820)	0.040 (0.040 , 0.040)	0.060 (0.059 , 0.061)	0.137 (0.131 , 0.143)	0.249 (0.243 , 0.255)	0.885 (0.883 , 0.887)	0.028 (0.026 , 0.030)	0.033 (0.031 , 0.035)	0.067 (0.061 , 0.073)	0.139 (0.133 , 0.145)
PENTA3	0.533 (0.529 , 0.538)	0.070 (0.067 , 0.073)	0.256 (0.250 , 0.262)	0.444 (0.430 , 0.458)	0.612 (0.600 , 0.624)	0.746 (0.745 , 0.748)	0.044 (0.044 , 0.044)	0.084 (0.083 , 0.085)	0.170 (0.164 , 0.176)	0.306 (0.300 , 0.312)	0.840 (0.838 , 0.842)	0.029 (0.028 , 0.030)	0.044 (0.043 , 0.045)	0.083 (0.075 , 0.091)	0.165 (0.157 , 0.173)
POLIO1	0.903 (0.900 , 0.906)	0.002 (0.001 , 0.003)	0.038 (0.036 , 0.040)	0.110 (0.100 , 0.120)	0.190 (0.180 , 0.200)	0.872 (0.870 , 0.873)	0.034 (0.033 , 0.035)	0.038 (0.038 , 0.038)	0.100 (0.096 , 0.104)	0.163 (0.159 , 0.167)	0.900 (0.898 , 0.901)	0.026 (0.024 , 0.028)	0.027 (0.025 , 0.029)	0.047 (0.041 , 0.053)	0.117 (0.111 , 0.123)
POLIO2	0.864 (0.861 , 0.867)	0.009 (0.008 , 0.010)	0.049 (0.046 , 0.052)	0.139 (0.129 , 0.149)	0.229 (0.217 , 0.241)	0.820 (0.819 , 0.822)	0.036 (0.036 , 0.036)	0.050 (0.049 , 0.051)	0.120 (0.114 , 0.126)	0.200 (0.194 , 0.206)	0.857 (0.855 , 0.859)	0.028 (0.026 , 0.030)	0.039 (0.037 , 0.041)	0.068 (0.060 , 0.076)	0.157 (0.149 , 0.165)
POLIO3	0.779 (0.775 , 0.782)	0.011 (0.010 , 0.012)	0.072 (0.068 , 0.076)	0.143 (0.131 , 0.155)	0.275 (0.263 , 0.287)	0.674 (0.672 , 0.676)	0.034 (0.033 , 0.035)	0.081 (0.079 , 0.083)	0.133 (0.127 , 0.139)	0.268 (0.262 , 0.274)	0.778 (0.776 , 0.781)	0.028 (0.027 , 0.029)	0.057 (0.056 , 0.058)	0.081 (0.073 , 0.089)	0.200 (0.192 , 0.208)
MCV1	0.596 (0.591 , 0.600)	0.060 (0.057 , 0.063)	0.232 (0.226 , 0.238)	0.399 (0.385 , 0.413)	0.550 (0.538 , 0.562)	0.817 (0.816 , 0.819)	0.036 (0.035 , 0.037)	0.061 (0.060 , 0.062)	0.131 (0.125 , 0.137)	0.210 (0.204 , 0.216)	0.861 (0.858 , 0.863)	0.027 (0.026 , 0.028)	0.057 (0.055 , 0.059)	0.102 (0.092 , 0.112)	0.204 (0.194 , 0.214)
FULL	0.405 (0.400 , 0.409)	0.062 (0.059 , 0.065)	0.289 (0.282 , 0.296)	0.411 (0.397 , 0.425)	0.566 (0.554 , 0.578)	0.541 (0.539 , 0.543)	0.042 (0.041 , 0.043)	0.130 (0.128 , 0.132)	0.187 (0.181 , 0.193)	0.366 (0.360 , 0.372)	0.480 (0.477 , 0.483)	0.021 (0.020 , 0.022)	0.085 (0.082 , 0.088)	0.053 (0.043 , 0.063)	0.220 (0.212 , 0.228)

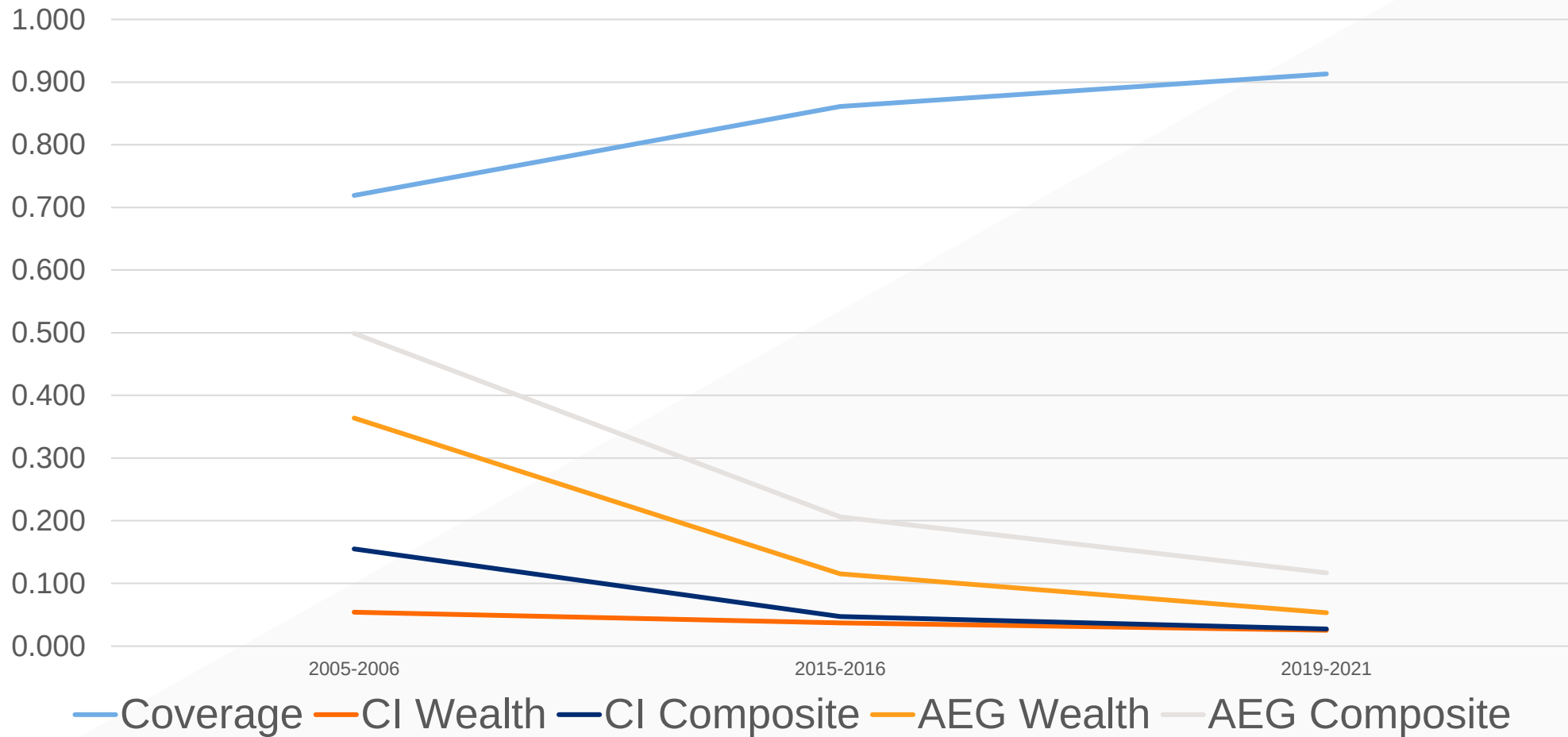
Vaccine	NFHS Year	Coverage	CI Wealth	CI Composite	AEG Wealth	AEG Composite
BCG	2005-2006	0.743	0.050	0.146	0.351	0.499
	2015-2016	0.895	0.036	0.039	0.105	0.173
	2019-2021	0.943	0.017	0.027	0.041	0.090
PENTA1	2005-2006	0.719	0.054	0.155	0.364	0.499
	2015-2016	0.861	0.037	0.047	0.115	0.206
	2019-2021	0.913	0.025	0.027	0.053	0.117
PENTA2	2005-2006	0.639	0.066	0.200	0.422	0.580
	2015-2016	0.818	0.040	0.060	0.137	0.249
	2019-2021	0.885	0.028	0.033	0.067	0.139
PENTA3	2005-2006	0.533	0.070	0.256	0.444	0.612
	2015-2016	0.746	0.044	0.084	0.170	0.306
	2019-2021	0.840	0.029	0.044	0.083	0.165
POLIO1	2005-2006	0.903	0.002	0.038	0.110	0.190
	2015-2016	0.872	0.034	0.038	0.100	0.163
	2019-2021	0.900	0.026	0.027	0.047	0.117
POLIO2	2005-2006	0.864	0.009	0.049	0.139	0.229
	2015-2016	0.820	0.036	0.050	0.120	0.200
	2019-2021	0.857	0.028	0.039	0.068	0.157
POLIO3	2005-2006	0.779	0.011	0.072	0.143	0.275
	2015-2016	0.674	0.034	0.081	0.133	0.268
	2019-2021	0.778	0.028	0.057	0.081	0.200
MCV1	2005-2006	0.596	0.060	0.232	0.399	0.550
	2015-2016	0.817	0.036	0.061	0.131	0.210
	2019-2021	0.861	0.027	0.057	0.102	0.204
FULL	2005-2006	0.405	0.062	0.289	0.411	0.566
	2015-2016	0.541	0.042	0.130	0.187	0.366
	2019-2021	0.480	0.021	0.085	0.053	0.220

Results: Full Immunization Status

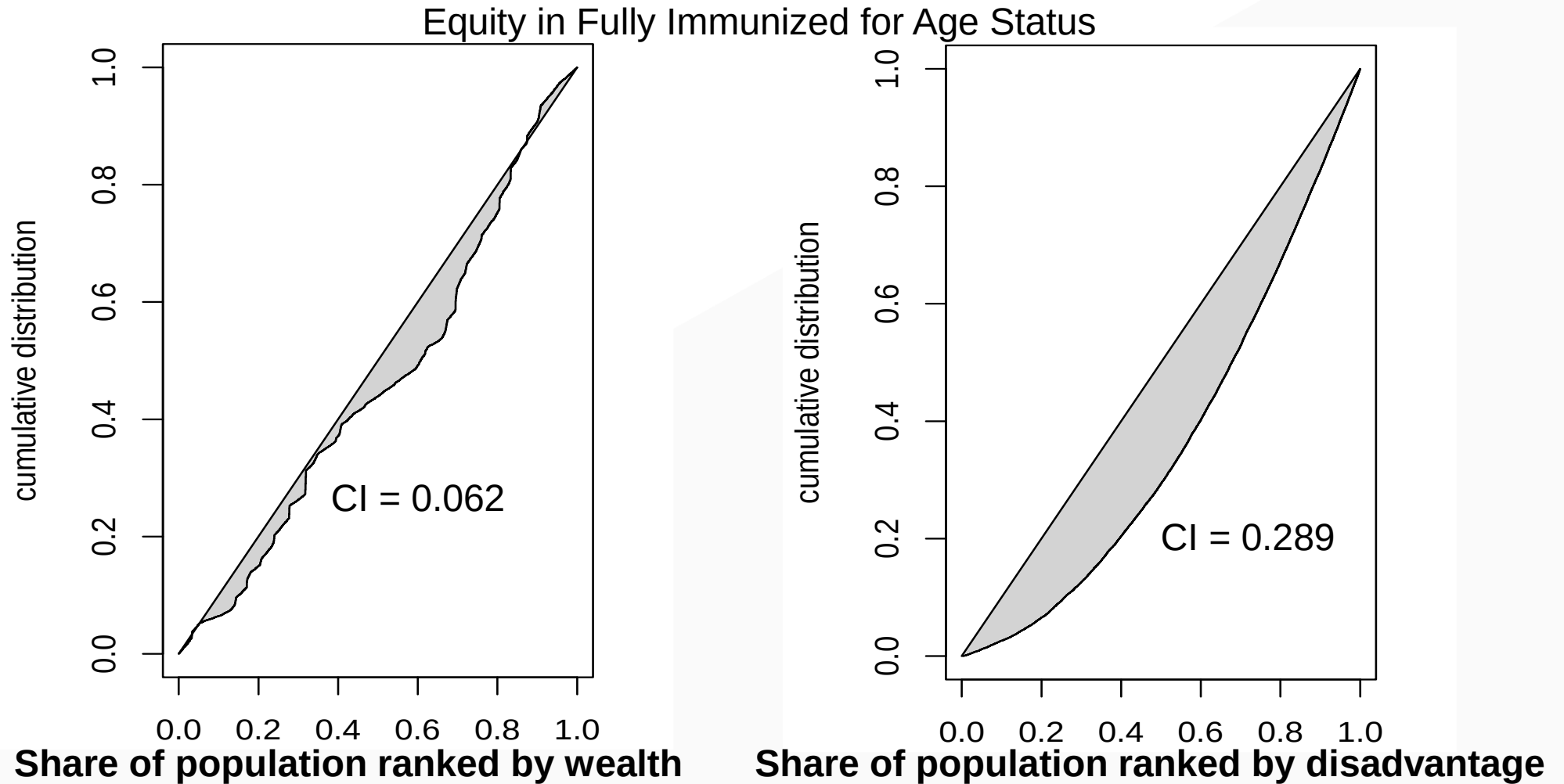


Results: Penta 1st Dose Coverage & Equity

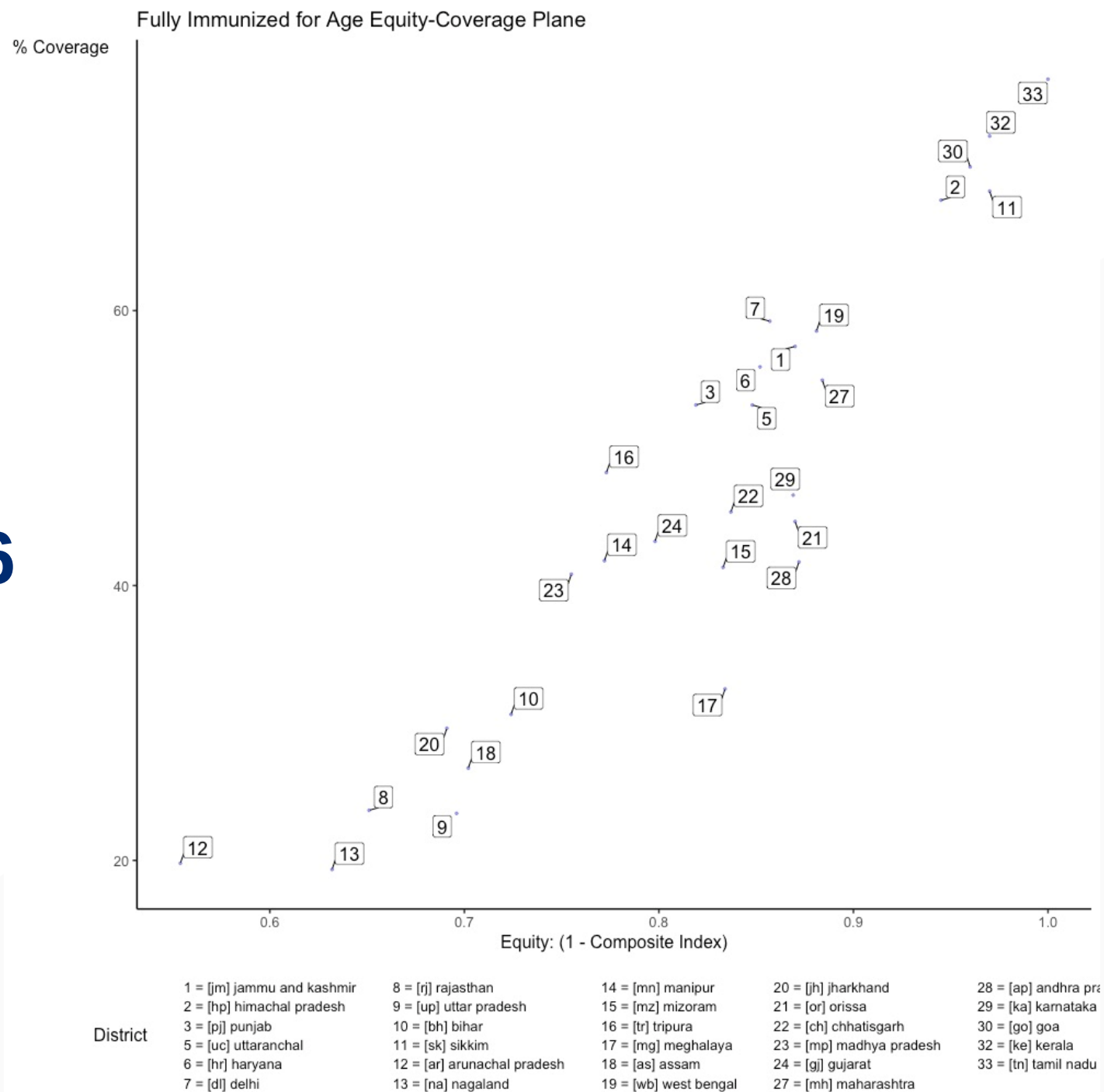
Pentavalent 1st Dose Coverage & Equity



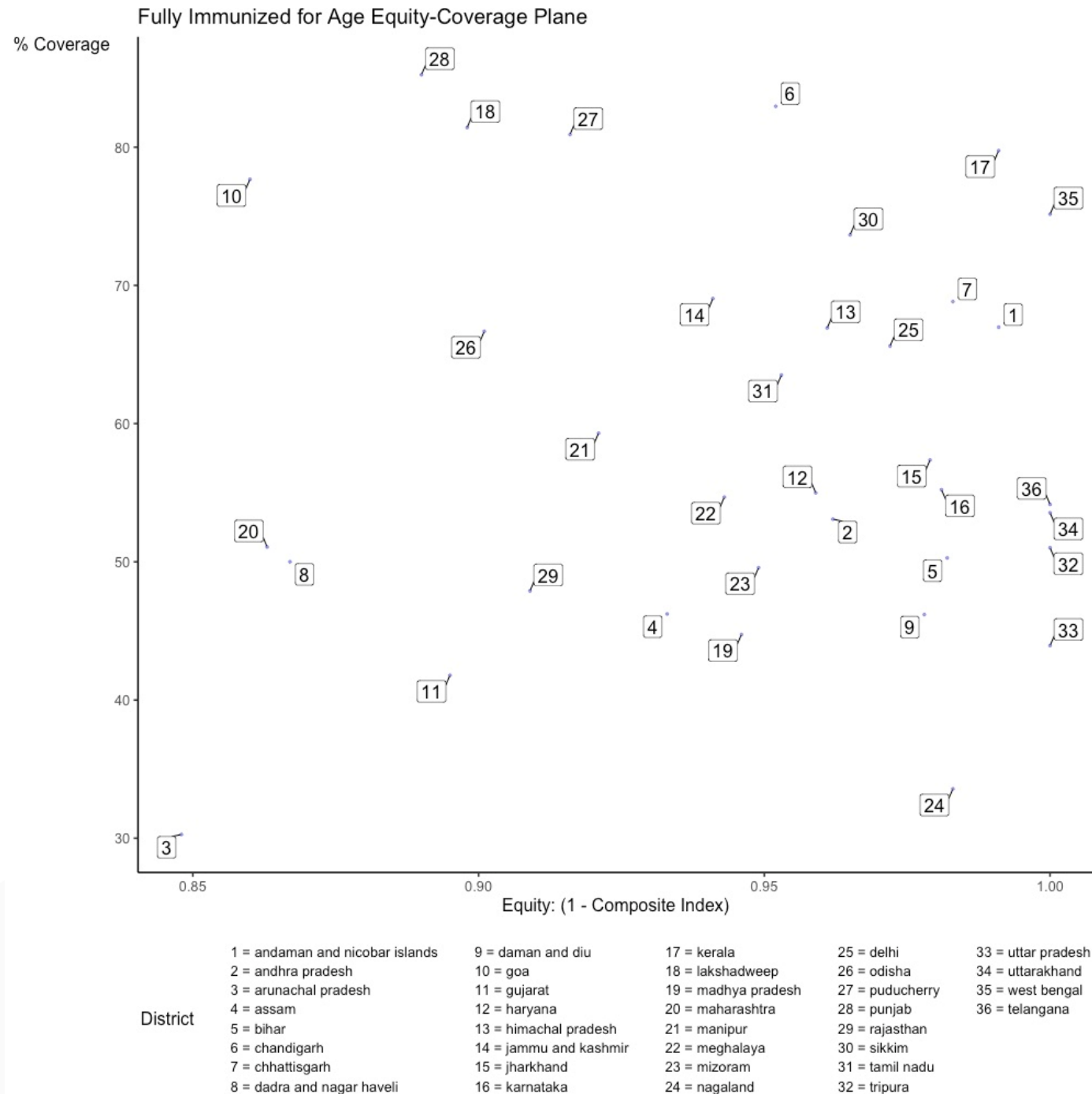
Example from India NFHS-3 (2005-2006)



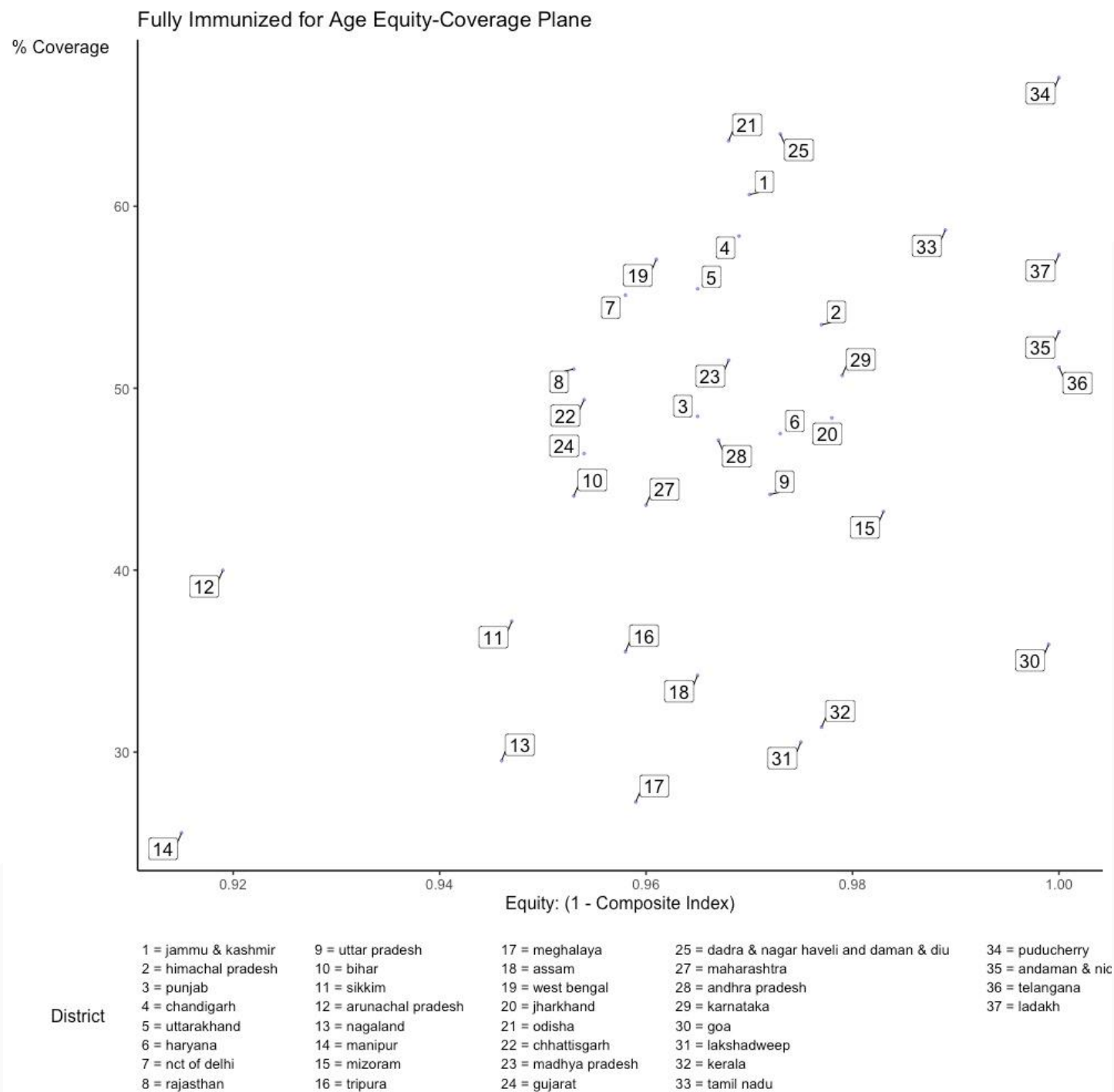
2005-2006



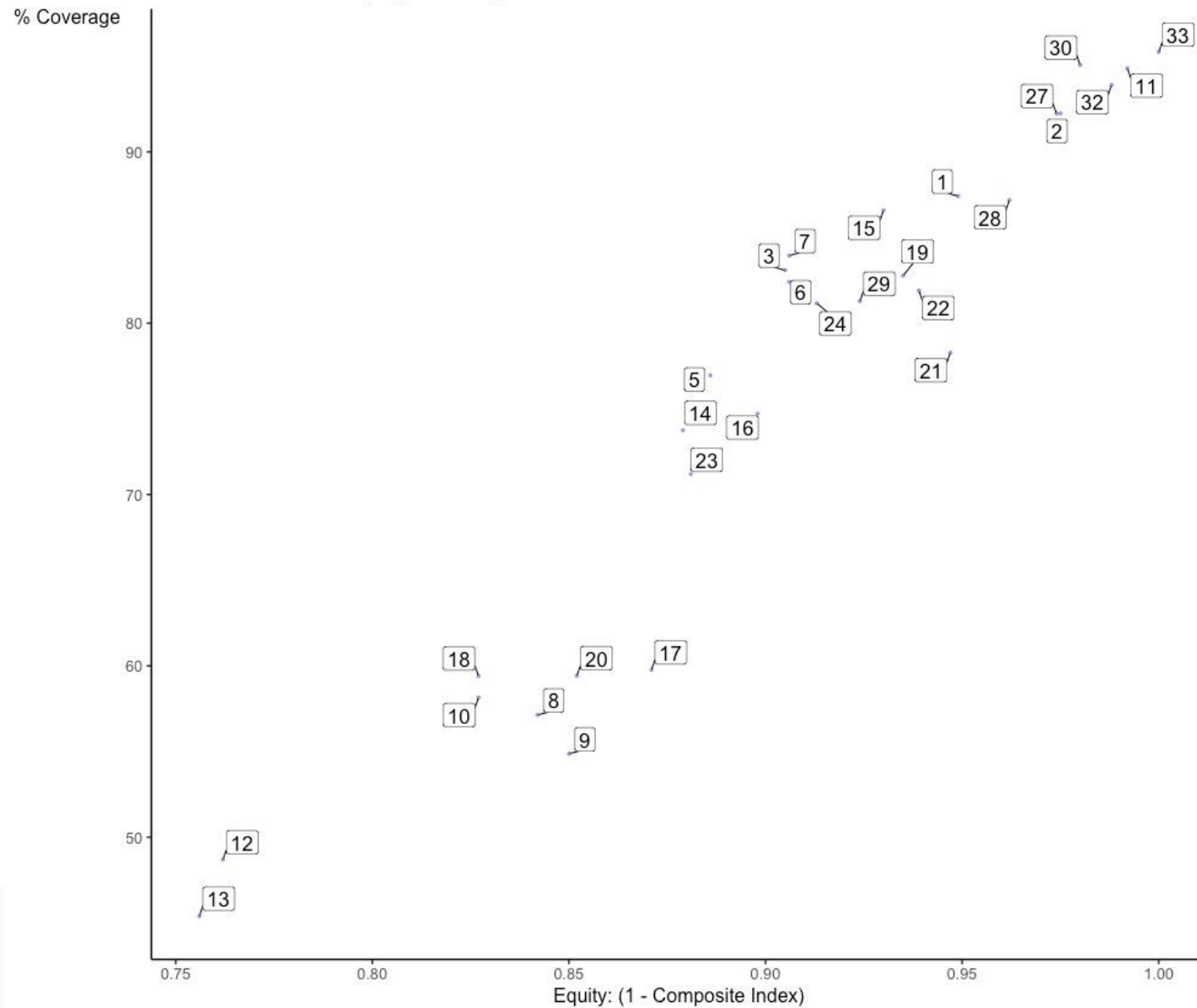
2015-2016



2019-2020



DTP1 Vaccination Equity-Coverage Plane



District

1 = [jm] jammu and kashmir
2 = [hp] himachal pradesh
3 = [pj] punjab
5 = [uc] uttaranchal
6 = [hr] haryana
7 = [dl] delhi

8 = [rj] rajasthan
9 = [up] uttar pradesh
10 = [bh] bihar
11 = [sk] sikkim
12 = [ar] arunachal pradesh
13 = [na] nagaland

14 = [mn] manipur
15 = [mz] mizoram
16 = [tr] tripura
17 = [mg] meghalaya
18 = [as] assam
19 = [wb] west bengal

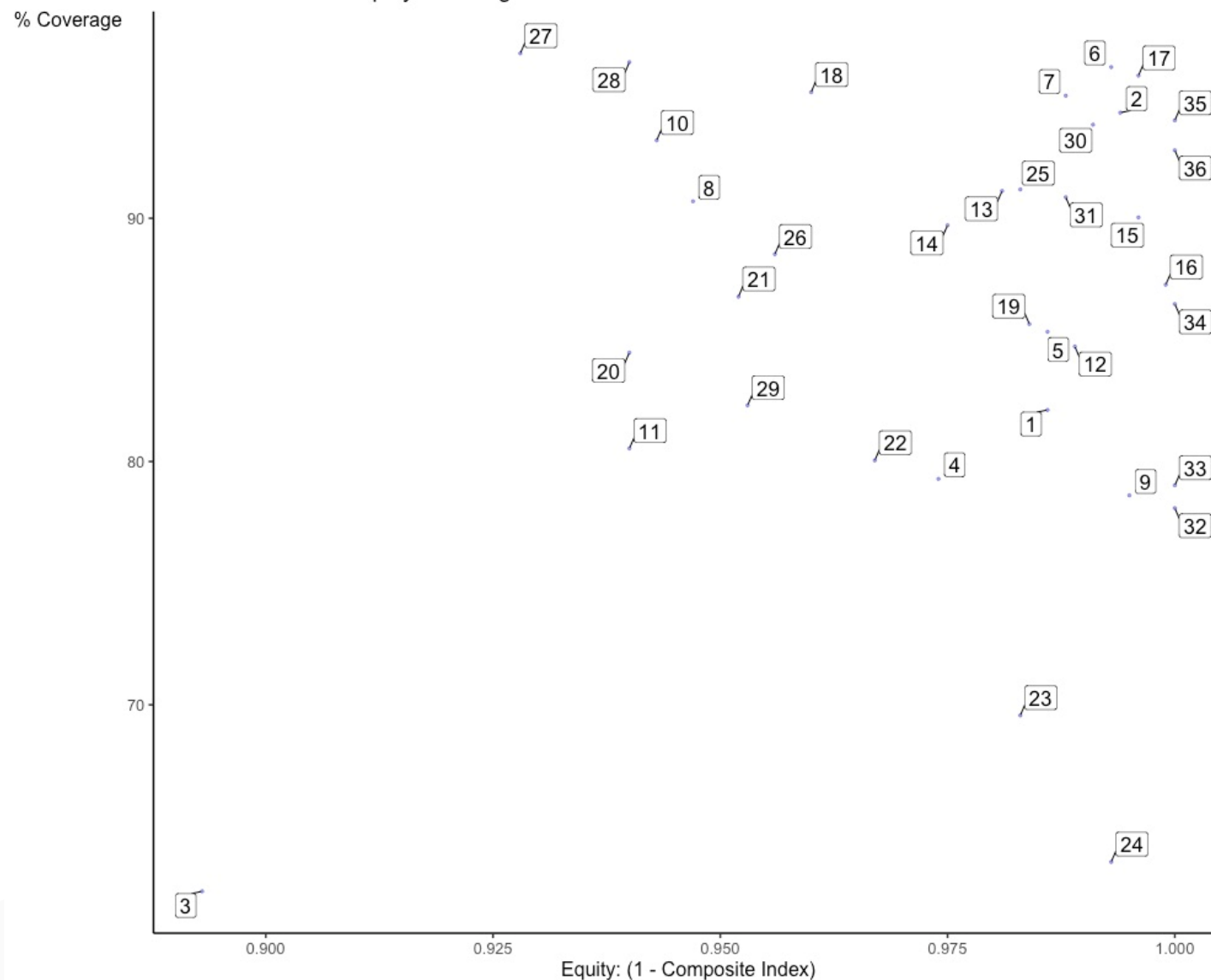
20 = [jh] jharkhand
21 = [or] orissa
22 = [ch] chhatisgarh
23 = [mp] madhya pradesh
24 = [gj] gujarat
27 = [mh] maharashtra

28 = [ap] andhra pradesh
29 = [ka] karnataka
30 = [go] goa
32 = [ke] kerala
33 = [tn] tamil nadu

2005-2006

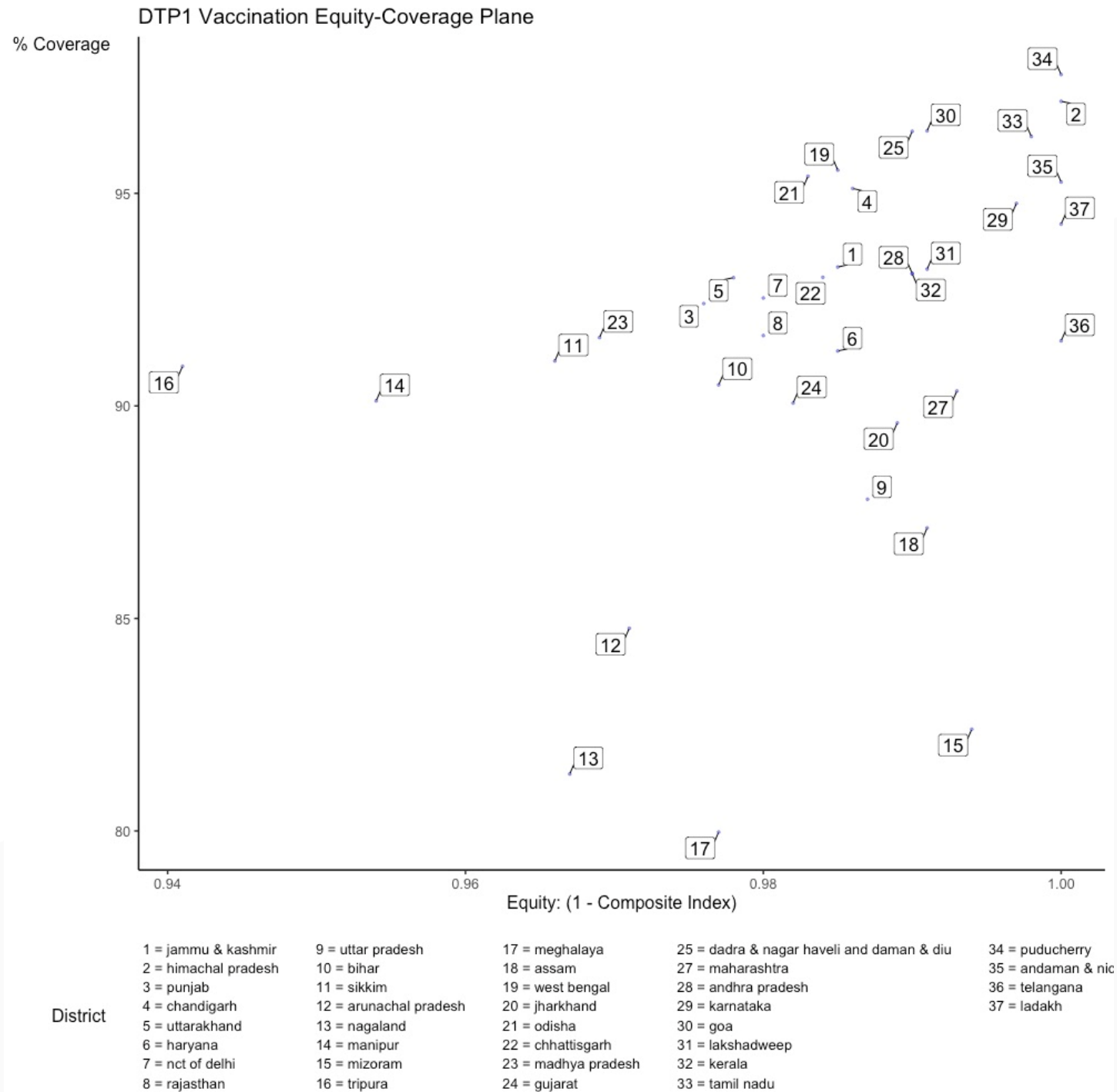
2015-2016

DTP1 Vaccination Equity-Coverage Plane



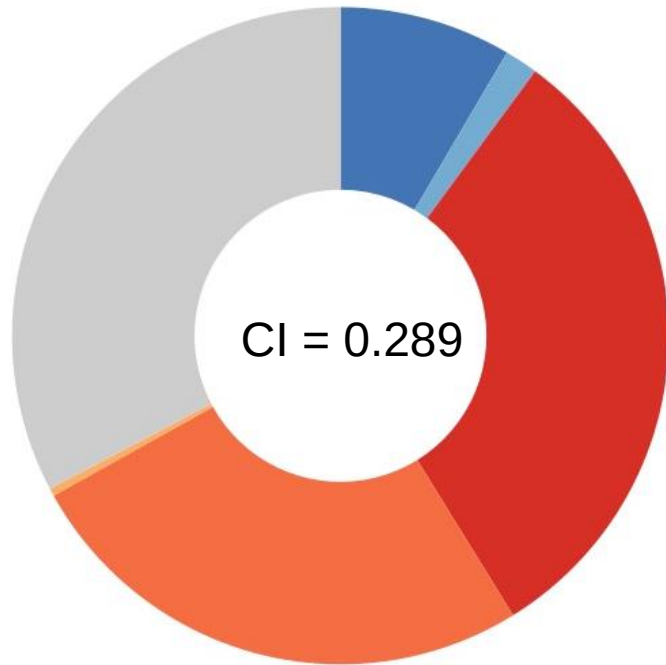
1 = andaman and nicobar islands	9 = daman and diu	17 = kerala	25 = delhi	33 = uttar pradesh
2 = andhra pradesh	10 = goa	18 = lakshadweep	26 = odisha	34 = uttarakhand
3 = arunachal pradesh	11 = gujarat	19 = madhya pradesh	27 = puducherry	35 = west bengal
4 = assam	12 = haryana	20 = maharashtra	28 = punjab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

2019-2020



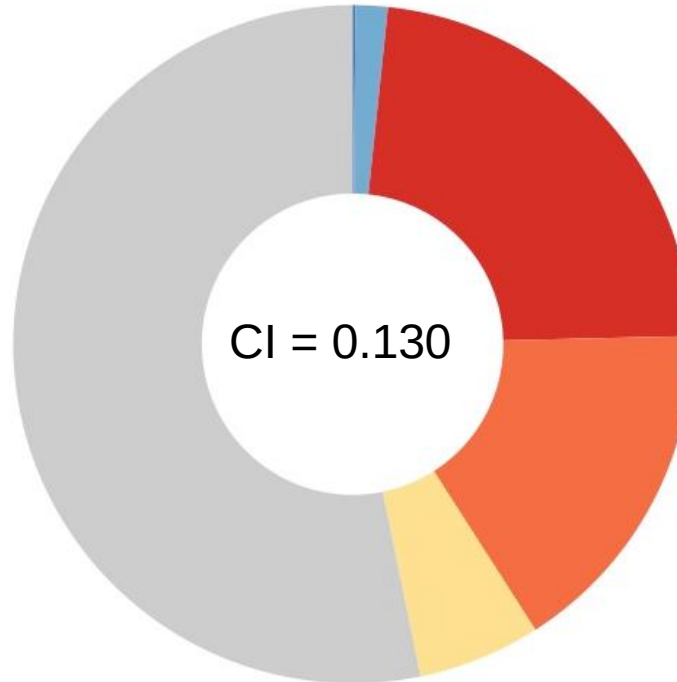
Decomposition of Fully-Immunized Inequity

2005-2006



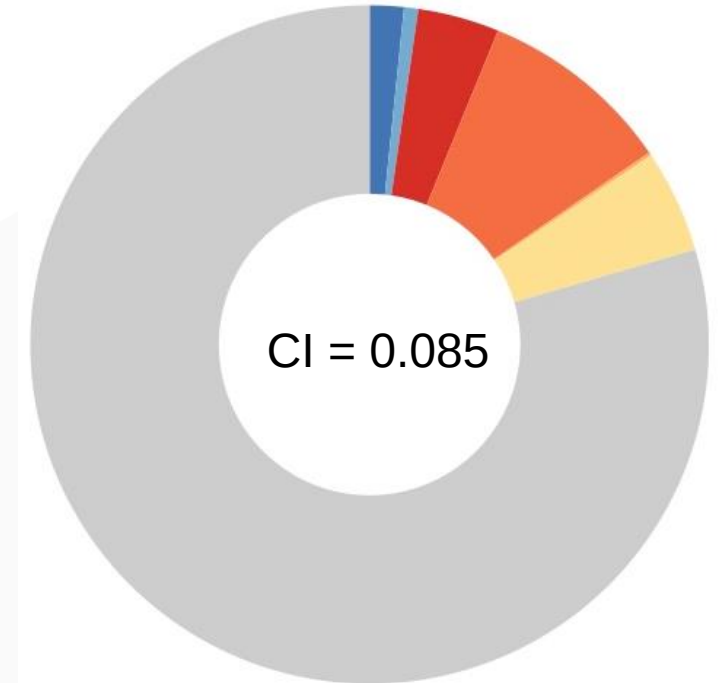
- Underage: 0%
- District: 8.5%
- Urban/Rural: 1.6%
- Maternal Education Level: 31.1%
- Wealth Quintile: 25.7%
- Sex of Child: 0.4%
- Covered by Health Insurance: 0%
- Unexplained Variation: 32.7%

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%

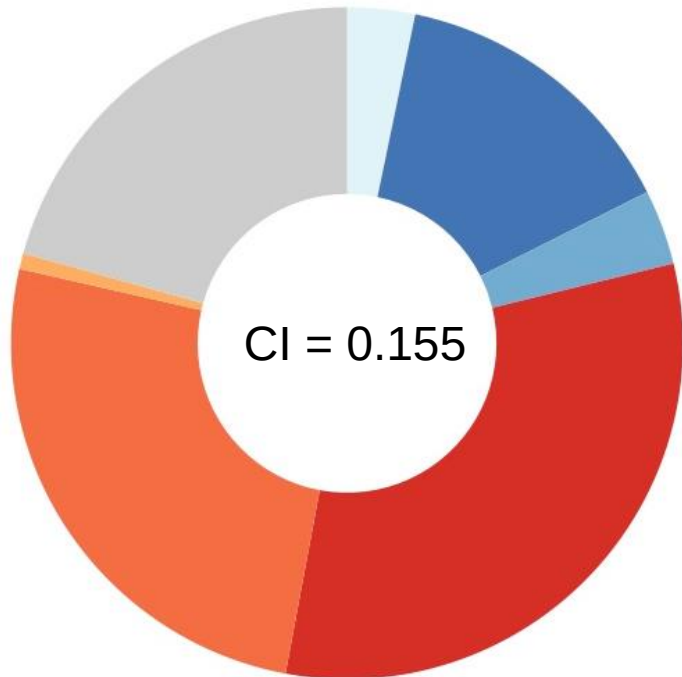
2019-2021



- 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%

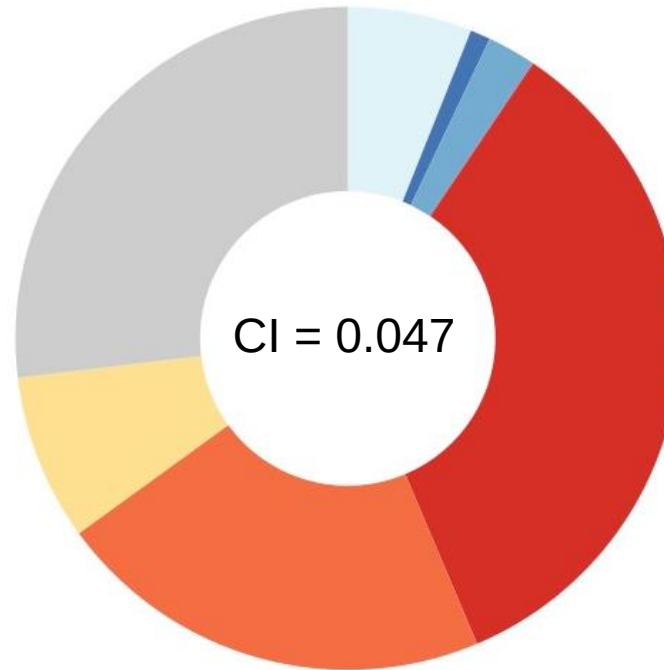
Decomposition of DTP/Penta1 Inequity

2005-2006



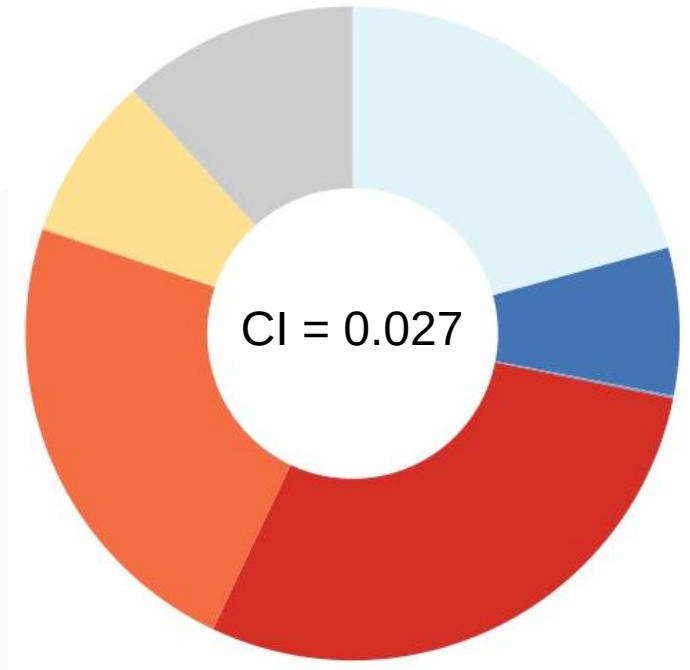
- Underage: 3.3%
- District: 14.3%
- Urban/Rural: 3.6%
- Maternal Education Level: 31.8%
- Wealth Quintile: 25.6%
- Sex of Child: 0.8%
- Covered by Health Insurance: 0%
- Unexplained Variation: 20.7%

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%

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%

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.

Thank You!



*Learn more
about
VERSE!*

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IVAC
International Vaccine
Access Center

