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Intersecting Vulnerabilities and Immunization Dropout in Uttar Pradesh: An Equity-Driven Analysis of Structural Disadvantage

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ABSTRACT

Despite progress in India's Universal Immunisation Programme, dropout between vaccine doses remains high among marginalised communities. This study investigates how maternal education, household poverty, caste, and religion intersect to shape child immunisation dropout in Uttar Pradesh. Using National Sample Survey data, we analyse dropout across key vaccine stages (Polio 1-3, DPT 1–3, BCG–Measles) with logistic regression models to estimate odds ratios and synergistic effects of multiple vulnerabilities. Results reveal a steep risk gradient: households facing triple deprivation show dropout rates up to five times higher than non-deprived households. Maternal education emerges as the strongest protective factor, substantially lowering dropout odds even in poor or minority households. Poverty or religious identity alone does not independently predict dropout; risk intensifies when combined with low education and social marginality. Findings highlight the need for intersectional diagnostics and equity-focused strategies—particularly maternal literacy and subgroup monitoring to sustain immunisation completion and achieve national and global coverage goals. **What We Already Know:** [1] Immunization dropout remains a persistent challenge in India, with states like Uttar Pradesh showing significantly lower completion rates than the national average. [2] Individual social determinants such as maternal education, household poverty, caste affiliation, and religious identity have been independently linked to vaccine discontinuity. [3] Aggregate reporting often obscures vulnerable subpopulations, limiting the effectiveness of targeted interventions in high-risk communities. **What This Article Adds:** [1] This study employs an intersectional framework to illustrate how overlapping disadvantages specifically, the combination of poverty, educational deprivation, and social marginalization compound the risk of dropout in early childhood immunization programs.[2] It quantitatively identifies maternal education as the most consistent and impactful protective factor across multiple immunization stages, even in socially excluded households. [3] The findings support a shift toward equity-focused immunization strategies that prioritize multidimensional vulnerability clusters over broad demographic categories.

Keywords: Immunization dropout, Inter-sectionality, Public health equity, Uttar Pradesh, Maternal education, Logistic regression

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Introduction

Immunization is one of the most impact and cost-effective public health interventions globally, credited with averting an estimated two to three million deaths annually, according to the World Health Organisation[1]. In India, the Universal Immunisation Programme (UIP) has significantly expanded vaccine access, reached millions of children and contributed to a decline in mortality from vaccine-preventable diseases[2]. Despite this progress, immunization dropout the failure to complete scheduled vaccine doses after an initial dose remains a persistent and under-addressed issue, particularly among marginalized populations and in structurally disadvantaged regions.

Nationally, dropout rates between initial and subsequent doses of vaccines, such as DPT, Polio, and Measles, continue to exhibit striking heterogeneity across states and territories[3]. NSS 75th round data reveal that while initial coverage rates for the first dose of oral polio vaccine (Polio1) and diphtheria-pertussis-tetanus vaccine (DPT1) are relatively high, the proportion of children receiving the complete series of three doses remains substantially lower in many states[4].

For instance, based on state-level disaggregated data, the dropout from DPT1 to DPT3 exceeds 20 per cent in several states, including Bihar (20.7%), Uttar Pradesh (21.0%), and Tripura (22.4%). Similarly, a dropout from BCG to Measles vaccination a proxy for completion of the infant immunisation schedule, crosses 40.0% in Bihar (40.3%), Nagaland (49.4%), and Tripura (42.7%). Even in comparatively better-performing states like Kerala, which has a dropout of 6.9% from Polio1 to Polio3 and 9.1% from DPT1 to DPT3, completion gaps remain. Nationally, India records a dropout of approximately 15% from DPT1 to DPT3 and over 30% from BCG to Measles.

These figures are not merely statistical aberrations but signify deeper structural and systemic exclusions. The prevailing approach to immunization planning in India often relies on aggregate coverage figures that mask underlying regional, socioeconomic, and socio-cultural disparities. Many health policy evaluations focus on supply-side constraints, such as inadequate cold-chain infrastructure, vaccine stock outs, or shortages of health workers[5-6]. While these factors are necessary, they do not sufficiently explain why children in the same region or village but from different social backgrounds experience starkly different immunization outcomes[7-9].

What remains insufficiently explored in both academic and policy literature is the role of **intersectional disadvantage**. The way multiple social vulnerabilities combine and intensify the risk of immunization dropout. As Kimberlé Crenshaw originally articulated in the context of legal exclusion, inter-sectionality refers to the overlapping systems of oppression that individuals experience based on their multiple identities, including race, gender, class, and other characteristics[10].

Uttar Pradesh (UP), India's most populous state and home to approximately one-tenth of the country's children under the age of five, provides an illuminating context for analysing intersectional dropout. The state not only records one of the highest dropout rates nationally, approximately 21.0% from DPT1 to DPT3 and 33.4% from BCG to Measles but also features vast internal heterogeneity by region, religion, caste, literacy, and wealth. According to the National Family Health Survey-5 (NFHS-5), only 52.7% of children aged 12-23 months in UP were fully immunised in 2019-21, compared to the national average of 76.4%[11].

This paper examines the interplay between structural disadvantage and immunization dropout in the state of Uttar Pradesh. Structural disadvantage refers to the systemic and institutional barriers that impede access to basic services for specific communities over time, irrespective of individual effort.

Data and Methodology: The prevailing research tends to isolate individual factors that contribute to dropout. Many studies analysed the effect of maternal education[12-13], caste identity[14-15], or income[16-17] as independent variables. However, this approach overlooks the fact that the intersection of vulnerabilities yields non-linear, synergistic effects on health behaviour. A mother who is poor, non-educated, and from a marginalized religious community may face an order-of-magnitude greater difficulty in accessing and adhering to immunization schedules than one facing only one of those disadvantages.

Building upon the intersectional framework, we construct multiple deprivation typologies based on combinations of maternal education (present/absent), household poverty status, caste affiliation (SC/ST), and religion (Muslim/Non-Muslim). Using National Sample Survey (NSS) 75th round data for Uttar Pradesh, we assess dropout rates across common immunization milestones, including Polio 1 to Polio 3, DPT 1 to DPT 3, and BCG to Measles.

The study also employs logistic regression[18-19] to estimate the dropout risk across deprivation groups, using "triple-burdened" households (i.e., poor, uneducated, and Muslim or SC/ST) as the reference group.

Data: The NSS 75th round survey was conducted by the National Statistical Office (NSO)**,** which operates under the Ministry of Statistics and Programme Implementation (MoSPI), Government of India. The 75th round focused on *Household Social Consumption: Health* and was carried out between July 2017 and June 2018**,** using a stratified multi-stage sampling design across both rural and urban sectors.

Results

The regional analysis of Uttar Pradesh reveals sharp disparities in both the distribution of socioeconomic vulnerabilities and the resulting immunization dropout patterns. The five distinct regions—Northern Upper, Central, Eastern, Southern, and Southern Upper—exhibit different profiles of deprivation that are strongly associated with immunization continuity outcomes.

Table- 1: Proportion of different types of vulnerabilities in Uttar Pradesh, and its region, NSS-2017-18

Vulnerability	Uttar Pradesh	Region				
	Total	Northern Upper	Central	Eastern	Southern	Southern Upper
Poor	58.61	46.44	55.02	69.66	68.78	47.10
No Education	32.19	32.73	31.84	32.38	27.32	32.61
SC/ST	27.85	18.84	26.62	34.12	27.22	22.19
Muslim	21.22	44.6	28.72	18.61	5.76	14.09
Rural	84.94	71.77	69.57	92.06	83.17	81.57

The Eastern and Central regions, in particular, are marked by high levels of poverty, low maternal education, and greater concentrations of SC/ST populations. In Eastern Uttar Pradesh, nearly 70.0% of households are classified as poor, and over 34.0% belong to SC/ST communities. Educational attainment is uniformly low across the state, with approximately one-third of households reporting no maternal education; however, this burden is particularly acute in the Eastern and Central region. These same regions report the lowest rates of immunization completion. For instance, the dropout from DPT1 to DPT3 in Central UP is as high as 26.3%, while Eastern UP records a comparable figure of 25.7%. The dropout from BCG to measles, which marks the completion of the infant immunization schedule, is similarly high in these regions—over 35.0% in both Central and Eastern UP (Table-1).

Table-2: Percentage of different dimensions of vulnerability in Uttar Pradesh and its region, NSS 2017-18

Vulnerability	Uttar Pradesh	Region				
	Total	Northern Upper	Central	Eastern	Southern	Southern Upper
All Three	9.12	4.01	9.12	12.32	6.30	6.22
Education/Caste	2.26	1.48	0.90	3.05	6.12	1.87
Caste/Wealth	10.65	6.56	10.70	14.10	10.97	6.63
Education/Wealth	13.71	12.71	11.50	14.27	11.13	15.16
Caste	5.81	6.78	5.89	4.64	3.82	7.46
Education	7.08	14.52	10.30	2.73	3.76	9.34
Wealth	25.12	23.15	23.68	28.96	40.36	19.07
None	26.21	30.75	27.87	19.89	17.50	34.21

By contrast, Southern Upper and Northern Upper UP exhibit markedly lower dropout rates. These regions also report higher shares of non-deprived households and lower concentrations of intersecting vulnerabilities. Southern Upper UP has the highest proportion of households with no reported deprivation—approximately 34.0% and correspondingly reports lower dropout rates across nearly all immunization sequences. In Northern Upper UP, despite a high percentage of Muslim households (approximately 45 percent), dropout remains relatively controlled, likely due to lower poverty incidence and marginally better education profiles in this region.

Table-3: Heat-map of child Immunization rate and dropouts' rate in child immunization in different Regions of Uttar Pradesh, NSS 2017-18

Immunization and dropouts	Regions of Uttar Pradesh				
	Northern Upper	Central	Eastern	Southern	Southern Upper
BCG	97.97	97.37	91.54	87.6	96.12
Polio	86.9	72.89	70.01	60.58	81.16
DPT	87.31	67.2	64.13	65.68	78.91
Measles	77.8	63.24	61.87	65.37	63.87
Dropouts in Polio 1 to Polio2	4.22	9.73	11.43	12.73	5.05
Dropouts in Polio 2 to Polio 3	3.91	14.97	13.73	17.53	8.85
Dropouts in Polio 1 to Polio 3	7.84	23.19	23.58	28.03	12.92
Dropouts in DPT 1 to DPT 2	3.85	9.93	9.31	11.42	5.9
Dropouts in DPT 2 to DPT 3	3.99	18.31	18.26	13.61	8.99
Dropouts in DPT 1 to DPT 3	7.7	26.33	25.74	23.5	14.09
Dropouts in BCG to Measles	20.76	35.48	36.27	26.32	33.86
Dropouts in DPT to Measles	12.24	21.21	20.85	15.92	24.05
Dropouts in Polio to DPT	0.99	11.73	12.38	2	6.79

Moving beyond regional averages, the disaggregated data based on deprivation typologies offers further clarity (from supplementary figure 1). Households were grouped into combinations such as "All Three" (poverty, lack of maternal education, and caste marginalization), dual-vulnerability combinations (e.g., education and wealth deprivation), and single-vulnerability categories.

Households experiencing all three deprivations consistently registered the highest dropout rates across all immunization stages. For example, 25.3% of children in these households dropped out between the first and third doses of DPT, and nearly 40.0% failed to complete the schedule from BCG to Measles. Households facing two simultaneous vulnerabilities such as education and wealth deprivation fared slightly better but still exhibited dropout rates exceeding 20.0% across DPT and Polio regimens.

Interestingly, the presence of education alone particularly maternal education appears to reduce dropout rates significantly. In households classified as poor dropout remains relatively low across all vaccine intervals. Children from such households experienced a DPT 1 to DPT 3 dropout rate of just 6.3%, and a BCG to Measles dropout rate of approximately 13.0%. Similarly, in households with no reported deprivation, dropout rates are consistently and significantly lower than the state average. Only 4.7 percent of children from these households dropped out between DPT1 and DPT3, and fewer than 15.0% failed to receive Measles after BCG.

A more nuanced portrait emerges when the analysis is structured around specific identity configurations that combine religious background, education, and socioeconomic status (from supplementary figure 2). Households that are poor, non-educated, and Muslim consistently reported the highest dropout across nearly all vaccine schedules. For instance, over 21.0 of children from these households dropped out between DPT1 and DPT3, and 36.5% did not complete the BCG to Measles continuum. However, the presence of maternal education—regardless of religious or economic background—was associated with markedly improved outcomes.

Poor but educated Muslim households, for example, recorded a DPT1 to DPT3 dropout of just 10.2 percent, while non-poor, educated Muslims had a dropout rate of just 8.1 percent. In these groups, the risk of dropout was drastically lower than that faced by triple-deprived households despite overlapping religious or economic vulnerabilities. In contrast, non-poor but non-educated households—both Muslim and non-Muslim experienced dropout rates similar to their poorer counterparts, suggesting that wealth alone does not ensure vaccine schedule completion in the absence of maternal education.

These descriptive findings point unequivocally to a cumulative model of deprivation and risk. Dropout does not stem from a single cause but rather reflects the **confluence of disadvantages,** with education emerging as the most consistent differentiator of immunization outcomes. Notably, households that are simultaneously poor and uneducated but do not belong to minority religious groups perform nearly identically to triple-deprived households, indicating that the interaction between economic and educational disadvantage holds more explanatory power than social identity alone.

In sum, the descriptive data lays bare a hierarchical structure of immunization risk: at the base are children with no deprivation, whose dropout rates are minimal. As dimensions of vulnerability accumulate first education, then wealth, and finally caste or religion dropout rates climb, revealing how **structural barriers operate not in isolation but in intersectional compounds.**

Logistic Regression Result

The logistic regression models provide compelling statistical validation of the descriptive patterns observed earlier. Using "All Three" as the reference category (odds ratio = 1), which comprises households lacking maternal education, facing poverty, and belonging to marginalized caste or religious groups, the analysis reveals the relative risk reduction experienced by other deprivation clusters across multiple immunization dropout pathways.

Table-4: Logistic Regression results of dropouts in child immunization rate and different types of vulnerabilities (caste-based)

	All Three	Education/ Caste	Caste/ Wealth	Education/ Wealth	Caste	Education	Wealth	None
Drop outs in Polio 1 to Polio 2	1 (ref)	0.623*** (0.449-0.863)	0.094** (0.012-0.683)	0.901 (0.733-1.10)	0.21** (0.051-0.876)	0.771*** (0.629 0.947)	0.172*** (0.069-0.426)	0.055*** (0.017-0.176)
Drop outs in Polio 2 to Polio 3	1 (ref)	0.858 (0.638-1.15)	0.162** (0.039-0.670)	0.916 (0.744-1.128)	0 .280** (0.086-0.907)	0.886 (0.723-1.086)	0.178*** (0.077-0.411)	0.062*** (0.023-0.170)
Drop outs in Polio 1 to Polio 3	1 (ref)	0.73*** (0.577-0.863)	0.122*** (0.038-0.392)	0.897 (0.764-1.05)	0.234*** (0.092-0.592)	0.822** (0.703-0.961)	0.164*** (0.088-0.307)	0.055*** (0.025-0.118)
Drop outs in DPT 1 to DPT 3	1(ref)	0.78** (0.620-0.982)	0.072***(0.017-0.298)	0.901(0.770-1.05)	0.414** (0.201-0.854)	0.822** (0.704-0.960)	0.119*** (0.060-0.235)	0.087*** (0.048-0.157)
Drop outs in BCG to Measles	1 (ref)	0.773** (0.634-0.943)	0.125*** (0.056-0.278)	0.925 (0.804-1.06)	0.181*** (0.088-0.372)	0.785*** (0.685-0.901)	0.154*** (0.099-0.241)	0.0971 (0.065-0.144)
Drop outs in DPT to Measles	1 (ref)	0.844 (0.648-1.09)	0.268*** (0.120-0.598)	0.97 (0.805-1.16)	0.24*** (0.094-0.615)	0.865 (0.721-1.03)	0.27*** (0.160-0.439)	0.153*** (0.096-0.245)
Drop outs in Polio to DPT	1 (ref)	0.981 (0.678-1.41)	0.129** (0.017-0.948)	0.817 (0.622-1.07)	0.994 (0.413-2.39)	0.773* (0.592-1.00)	0.19*** (0.069-0.531)	0.362*** (0.203-0.646)

For the dropout from Polio 1 to Polio 3, children in households deprived of education and those from a caste background alone had statistically significantly lower odds of dropout, with an odds ratio of 0.73 ($p<0.01$), indicating a 27% reduction in dropout risk relative to the most disadvantaged group. Households experiencing deprivation in both caste and wealth showed an

even more dramatic decrease in dropout risk, with an odds ratio of 0.122 (p <0.01), implying nearly 88% lower odds of dropout. In contrast, the education and wealth group showed no statistically significant difference from the reference category (OR = 0.897, CI = 0.764–1.05), suggesting that unless caste-based vulnerabilities are also addressed, the combination of poverty and low education may not strongly predict this form of dropout. Households with only caste deprivation exhibited an odds ratio of 0.234 (p<0.01), reflecting a substantial decline in risk. Those experiencing only educational deprivation also showed lower dropout odds at 0.822 (p<0.05), while wealth-only deprivation yielded a more pronounced protective effect, with an odds ratio of 0.164 (p<0.01). Notably, children in households with no deprivation had the lowest odds of dropout by a wide margin, with an odds ratio of 0.055 (p<0.01), confirming the cumulative protection conferred by the absence of structural disadvantage.

Table 5: Logistic Regression results of dropouts in child immunization rate and different types of vulnerabilities (Religion-based)

	Poor, Non-educated, Muslim	**Non-Poor, Educated, Muslim**	**Poor, Non-Educated, Non-Muslim**	**Non-Poor, Educated, Non-Muslim**	**Non-Poor, Non-Educated, Muslim**	**Poor, Educated, Muslim**	**Non-Poor, Non-Educated, Non-Muslim**	**Poor, Educated, Non-Muslim**
Drop outs in Polio 1 to Polio 2	1(ref)	1	1.16 (0.911 -147)	0.119*** (0.048-0.296)	0.743* (0.545-1.01)	0.115** (0.015-0.841)	0.957 (0.747-1.22)	0.206*** (0.082-0.515)
Drop outs in Polio 1 to Polio 3	1(ref)	0.076*** (0.018-0.312)	1.06 (0.889-1.27)	0.095*** (0.049-0.183)	0.819* (0.654-1.02)	0.045*** (0.006-0.329)	0.947 (0.787-1.13)	0.221*** (0.123-0.398)
Drop outs in DPT 1 to DPT 3	1(ref)	0.159*** (0.057-0.441)	1.18* (0.986-1.41)	0.161*** (0.096-0.270)	0.986 (0.792-1.22)	0.088*** (0.021-0.365)	1 (0.832-1.20)	0.145*** (0.073-0.290)
Drop outs in Bcg to Measles	1(ref)	0.106*** (0.048-0.234)	0.992 (0.848-1.16)	0.116*** (0.078-0.172)	0.713*** (0.590-0.863)	0.172*** (0.084-0.354)	0.863* (0.737-1.01)	0.147*** (0.092-0.235)
Drop outs in DPT to Measles	1(ref)	0.09*** (0.027-0.290)	0.9 (0.735-1.10)	0.171*** (0.108-0.272)	.654*** (0.509-0.841)	0.252*** (0.112-0.566)	0.876 (0.714-1.07)	0.25*** (0.150-0.416)
Drop outs in Polio to DPT	1(ref)	0.88*** (0.364-2.12)	1.15 (0.839-1.59)	0.499** (0.271-0.916)	1.03 (0.707-1.52)	0.163* (.022-1.20)	1.03 (0.748-1.435)	0.247*** (0.088-0.696)

A similar pattern emerges for the transition from DPT 1 to DPT 3 dropout. The education-caste group displayed an odds ratio of 0.78 (p < 0.05), indicating a modest but statistically significant reduction in the odds of being in the high-risk group. The caste-wealth group exhibited strikingly low dropout odds, with an odds ratio of 0.072 (p<0.01), indicating a strong protective effect when maternal education is present, even in the context of caste and economic marginalization. The education-wealth combination did not produce a statistically significant result, with an odds ratio of 0.901. The caste-only group showed a substantial reduction in risk (OR = 0.414, p<0.05), as did the education-only households (OR = 0.822, p<0.05). Wealth-only households had substantially lower odds of dropout, at 0.119 (p<0.01), while non-deprived households had even lower odds at 0.087 (p<0.01).

For BCG to Measles dropout, the education-caste group again showed a statistically significant protective association, with an odds ratio of 0.773 (p<0.05). Households deprived in caste and wealth recorded significantly lower dropout odds (OR = 0.125, p<0.01), while the education-wealth category again showed no statistically significant effect (OR = 0.925, CI = 0.804–1.06). Caste-only households experienced a meaningful reduction in odds (OR = 0.181, p<0.01), and those deprived of education alone had odds of 0.785 (p<0.01). The wealth-only category had a significant protective effect (OR = 0.154, p<0.01), while the

non-deprived households showed comparatively low odds (OR = 0.0971), although without a reported significance star, suggesting borderline significance.

For the DPT to Measles dropout, the regression results were more variable. While the education-caste combination showed no significant association (OR = 0.844, CI = 0.648–1.09), the caste-wealth category did exhibit significantly reduced odds of dropout (OR = 0.268, $p<0.01$). Education wealth was also associated with lower odds (OR = 0.97, not significant), whereas caste-only households showed significant protection (OR = 0.24, $p<0.01$). Education-only households were not significantly different (OR = 0.865), but the wealth-only group showed a sharp reduction in dropout risk (OR = 0.265, $p<0.01$). Non-deprived children again had the lowest odds of dropout (OR = 0.153, $p<0.01$).

Polio to DPT dropout patterns suggest that the education-caste and education-wealth categories were not significant (OR = 0.981 and OR = 0.817, respectively). However, the caste-wealth cluster had an odds ratio of 0.129 ($p<0.05$), while the caste-only group had borderline significance (OR = 0.994, CI crossing 1). The education-only group showed a strong protective effect (OR = 0.773, $p<0.10$), and the wealth-only group was even more protective (OR=0.192, $p<0.01$). Again, the non-deprived group recorded significantly low odds of dropout (OR = 0.362, $p<0.01$).

Further disaggregated models comparing identity-specific clusters using "Poor, Non-educated, Muslim" households as the reference group underscore these patterns. For the DPT1 to DPT3 outcome, non-poor, educated Muslim households had odds of 0.159 ($p <0.01$), while poor, educated Muslims recorded odds of 0.088 ($p<0.01$), implying strong protection from education despite continued poverty. Non-poor, educated non-Muslims performed similarly (OR = 0.161, $p<0.01$), as did poor, educated non-Muslims (OR = 0.145, $p <0.01$). In contrast, all uneducated households—regardless of religion or income—showed odds ratios of around or above 1.0, including poor non-Muslim households (OR =1.18, $p<0.10$), which reinforces the notion that maternal education is the most consistent and decisive determinant of immunization completion.

Dropout from BCG to Measles displayed the exact ordering: non-poor, educated Muslims had an odds ratio of 0.106 ($p<0.01$); poor, educated Muslims scored 0.172 ($p<0.01$); and poor, educated non-Muslims stood at 0.147 ($p<0.01$). All three showed large and statistically significant reductions compared to the reference group, illustrating that education almost entirely offsets the increased risk posed by poverty and minority identity.

Across every model, the consistency of these trends reveals that single vulnerabilities such as being Muslim, being poor, or being a member of the SC/ST category do not predict dropout in isolation. Only in combination, particularly when linked to educational deprivation, do they become strongly predictive of immunization failure. These patterns underscore the synergistic nature of structural disadvantage, where cumulative exposure to multiple vulnerabilities multiplies dropout risk in a non-linear manner.

Education, above all, emerges as the core protective factor. Its presence mitigates the risk associated with poverty and minority status, while its absence amplifies the effect of every other disadvantage. Children whose mothers have any formal education—regardless of household wealth, caste, or religion consistently demonstrate substantially lower dropout rates across all vaccine sequences. This finding carries profound policy implications for health communication, health worker training, and maternal empowerment initiatives.

Conclusion

Immunization dropout in Uttar Pradesh exposes systemic exclusion rooted in intersecting vulnerabilities rather than single factors. Poverty, caste, and religion combine with low maternal education to create severe inequities at vaccine transition points. Logistic regression shows that maternal education is the strongest protective factor, reducing dropout odds even among disadvantaged households. Poverty or minority identity alone does not drive dropout, underlining the value of intersectional diagnostics. To address these issues, public health leaders must act: prioritize maternal literacy programs, equip frontline workers with disaggregated data tools, and develop equity-focused interventions that urgently close immunization gaps and sustain universal coverage for all marginalized subgroups.

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