Coverage of vitamin A supplementation among under-five children in India and its relationship with childhood mortality – insights from multiple rounds of a nationally representative survey from 2005-06 to 2019-21

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Abstract:

We investigated the coverage of childhood vitamin A supplementation (VAS) across India from 2005-06 to 2019-21, and further explored how they related to childhood mortality. Data collected from mothers through standard questionnaires during the latest three rounds of National Family Health Survey (2005-06, 2015-16, and 2019-21) was used. Information on VAS in children aged 9-35 months was available from 2015-16 and 2019-21. Information on VAS among children aged 9-59 months was available from 2005-06 and 2015-16. Childhood VAS coverage was determined nationally and subnationally (*viz.*, individual states, geography, socio-demographic index, and developmental groups). Nearly 40% eligible children aged 9-59 months and 30% eligible children aged 9-35 months missed VAS during recent times. But improvements in VAS coverage were noticed over the years: from 18.6% (2005-06) to 60.5% (2015-16) among children aged 9-59 months; and from 64.5% (2015-16) to 71.2 % (2019-21) among children aged 9-35 months. There were coverage disparities, with Western India documenting the highest and Northeastern India documenting the lowest coverage values. During simple linear regression analysis, childhood mortality between 1-5 years age varied inversely as a function of VAS coverage among children aged 9-59 months, with the association being less pronounced in 2015-16 (β = -0.47) than in 2005-06 (β = -0.40). However, this relationship disappeared when we accounted for potential confounders (*viz.*, childhood immunization and socioeconomic factors) through multivariate analysis, suggesting that the role of VAS in promoting childhood survival may be limited during present times.

Keywords: vitamin A; child health; child mortality; child survival; nutrition; coverage

List of abbreviations:

BCG: Bacillus Calmette–Guérin
CD: Coverage Difference
CI: Confidence Interval
CNNS: Comprehensive National Nutrition Survey
CR: Coverage Ratio
DHS: Demographic and Health Survey
DPT: Diphtheria-Pertussis-Tetanus
EAG: Empowered Action Group
HCR: Head Count Ratio
IIPS: International Institute of Population Sciences
IMR: Infant Mortality Rate
MCV: Measles Containing Vaccine
MoHFW: Ministry of Health and Family Welfare
NFHS: National Family Health Survey
SDI: Socio-Demographic Index
U5MR: Under-Five Mortality Rate
USAID: United States Agency for International Development
UT: Union Territory
VAD: Vitamin A Deficiency
VAS: Vitamin A Supplementation
WHO: World Health Organization

Introduction:

Vitamin A, a key micronutrient, plays a vital role towards promoting growth and development, maintaining normal vision, improving bone growth, supporting immune function and other cellular activities [1-4]. Presence of vitamin A deficiency (VAD) is an important but preventable risk factor for morbidity and mortality during early childhood [5,6]. Defined biochemically in terms of serum (or plasma) retinol concentration below 0.7 µmol/L, VAD is a major public health issue worldwide [7]. Nearly 190 million pre-school children in the world are exposed to VAD, with substantial burden from South Asia and Africa [8]. Globally, VAD was responsible for 3.3 million disability adjusted life years (DALYs) and 23,800 deaths among under-five children in 2019 [9]. India has a high burden of subclinical and clinical VAD in pre-school children [10,11].

The World Health Organization (WHO) recommends biannual vitamin A supplementation (VAS) using massive vitamin A oral doses in children aged 6-59 months as an intervention against VAD [12]. India launched the National Prophylaxis Programme against Nutritional Blindness in the 1970s, under which administration of vitamin A mega doses was envisaged universally in all children aged 1-5 years [13,14]. With some evidence about the effect of VAS in preventing childhood mortality due to common infections (*e.g.*, diarrhea and measles), the VAS policy was revised in 1991 and infants aged 6-11 months were also included as beneficiaries [13]. This VAS programme is an ongoing exercise in India, with the first dose generally given at 9 months of age which coincides with the timing of measles vaccine [15]. The remaining 8 doses are administered at half-yearly intervals till the child is 5 years old. However, in recent times, there have been debates about the necessity for continuing universal VAS among under-five children in the country, with some researchers advocating a more targeted and need-based strategy instead of a universal approach [16-19]. There are gaps and heterogeneities in the outreach of the VAS programme across different parts of India [13,20,21], despite guidelines for universal coverage. Further, there have been attempts to draw connections between the varied coverage of VAS and the distribution of various child health consequences [6,22,23]. With this background, our primary objective was to determine the variations and trends in the coverage of childhood VAS across the different states and union territories (UTs) of India from 2005-06 to 2019-21. Additionally, we tried to examine how VAS coverage was associated with childhood mortality during that period.

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Methods:

Data sources and definitions:

We used data from the multiple rounds of National Family Health Survey (NFHS), which are conducted under the Demographic and Health Surveys (DHS) Program in India. The anonymized data from these survey rounds are hosted in the public domain (https://dhsprogram.com/Data/). The NFHS is a series of nationwide cross-sectional surveys, conducted across India from time-to-time using uniform methodology in the various states/UTs, encompassing health, nutritional, social and demographic indicators [24-26]. Details on the NFHS methodology and data collections tools are described elsewhere [27]. Briefly, various standardized methods and survey questionnaires were used in NFHS for collecting population level information on the indicators of interest. For instance, information on child health and nutrition was gathered from the mother using the woman's questionnaire.

In the context of the current study, the question "Within the last 6 months, was the child given a Vitamin A dose?" in the woman's questionnaire was relevant for understanding the coverage of childhood VAS. The 'YES' response was based on mother's recall or documentation in vaccination card. To facilitate recall, visual cues (such as common vitamin A preparations) were shown to mothers at the time of asking the question. For the present study, we obtained information on VAS coverage and childhood mortality in India from the three rounds of NFHS, namely NFHS-3, NFHS-4 and NFHS-5 that were conducted during the 2005-06, 2015-16 and 2019-21 reporting periods [24-26]. The NFHS-4 and NFHS-5 were carried out in all the existing states and UTs of India. The NFHS-3 was limited only to the states and the UT of Delhi. The NFHS-3 reports [24] provided information on VAS in children aged 9-59 months (N = 44,809). The NFHS-4 reports [25] provided information on VAS in children aged 9-35 months (N = 107,045) as well as 9-59 months (N = 204,645). The NFHS-5 reports [26] provided information on VAS in children aged 9-35 months (N = 98,226). This information was retrieved at the national level and the state/UT level from NFHS reports and factsheets. The various administrative units in India are enlisted in Supplementary material 1.

The effect of high dose VAS on improving the vitamin A status of the body (indicated by serum retinol levels) is transient, which lasts for around 1-3 months [17,28]. The NFHS captured information on childhood mortality through the woman's questionnaire, which recorded information from participating mothers about the birth and death histories of their children [24-26]. Accordingly, a complete history was recorded for each live birth including the survival status, and age at the time of the survey or age at death. This information was used in NFHS for computing various estimates of childhood mortality, expressed per 1000 live births. It included neonatal mortality rate (probability of dying in the first month of life), post-neonatal mortality rate (probability of dying after the first month of life but before the first birthday), infant mortality rate or IMR (probability of dying before the first birthday), and under-five mortality rate or U5MR (probability of dying before the fifth birthday) [24, 25]. For the current study, we abstracted two mortality estimates, namely IMR and U5MR, at the state/UT levels from NFHS reports. The difference between the two (*i.e.*, IMR subtracted from U5MR) indicated the mortality rate in children aged 1-5 years (per 1000 live births), which was used as a dependent variable during our analysis. This mortality estimate reflected the probability of death between first birthday and fifth birthday [26].

Sub-national groupings:

At a sub-national level, variations in VAS coverage rates were analyzed by geographical location, socio-demographic index (SDI) and special developmental groups. Geographically, the states/UTs were organized into 6 regions, namely East, West, North, South, Northeast and Central India. The states/UTs were also categorized into three groups according to the respective SDI values. The SDI is a composite indicator of social and economic development (calculated based on mean education, per capita income, fertility rate in women below the age of 25 years), expressed in the range of 0-1, with higher values reflecting greater levels of development. Indian states/UTs were categorized into low SDI (≤0.53), middle SDI (0.54-0.60) and high SDI (>0.60) [23,24]. Further, the states/UTs were classified into three special developmental groups, *viz.*, Empowered Action Group (EAG) states (namely Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, and Uttarakhand), Northeastern states (namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura) and 'other' states/UTs [24-26]. The EAG and Northeastern states are known to lag in infrastructural and health indicators and usually require special packages and support from the government, as

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compared to the 'other' states/UTs. These various sub-national groupings along with their respective member states/UTs are enumerated in Supplemental material 1.

Data analysis:

The coverage of VAS in India was defined as the percentage of surveyed children who had received a dose of vitamin A during the preceding 6 months of the concerned NFHS survey round. The VAS coverage values were derived among children aged 9-59 months during NFHS-3, among children aged 9-35 months and 9-59 months during NFHS-4, and among children aged 9-35 months during NFHS-5. The point estimates were supplemented with interval estimates, by calculating 95% confidence intervals (CIs). For documenting changes in the coverage between a certain survey round and the previous survey round, we calculated coverage difference (CD) and coverage ratio (CR). Besides, the VAS coverage was examined at the level of individual states/UTs by plotting choropleth maps. Heterogeneities in VAS coverage were depicted across the aforementioned sub-national groupings using boxplots.

Besides, the association between VAS coverage values (treated as the primary independent variable) in the various states/UTs and the corresponding mortality rates in children aged 1-5 years (treated as a dependent variable) was investigated through correlation analysis and simple linear regression. The data points are presented in Supplementary material 2. Since the VAS coverage data during NFHS-5 was available only for children aged 9-35 months, therefore the association analysis was limited only for NFHS-3 and NFHS-4. To account for the role of potential confounders (such as socioeconomic factors, sanitation, and immunization), we considered additional parameters as covariates for our analysis, namely head count ratio (HCR) and immunization coverage rates of important childhood vaccines; *viz.*, Bacillus Calmette–Guérin (BCG) vaccine, three doses of diphtheria-pertussis-tetanus (DPT1, DPT2, DPT3) vaccine, and measles containing vaccine (MCV). The HCR is a socioeconomic and developmental construct that intends to measure multidimensional poverty, *i.e.*, extent of deprivation in a population beyond monetary terms. It is a composite metric that represents the proportion of population who are 'poor' across 3 equally weighted dimensions, namely standard of living (includes 7 indicators; *viz.*, sanitation, drinking water, cooking fuel, electricity, assets, housing, and bank account), health (includes 2 indicators; *viz.*, maternal health and child-adolescent mortality), and education (includes 2 indicators; *viz.*, years of schooling and school attendance). The HCR values for states/UTs in India were available for the 2005-06 (NFHS-3) and 2015-16 (NFHS-4) reporting periods from NITI Aayog reports [29, 30]. The estimates of childhood immunization coverage during these reporting periods across the states/UTs in India, based on NFHS data, were available from Nayar *et al* (2022) [31]. Multivariate regression models incorporating these covariates were constructed to examine if they influenced the attributions of childhood mortality to VAS coverage.

All the statistical analyses were performed using MS Office Excel (Microsoft Office Professional Plus 2019, Microsoft Corporation, USA) and JASP 0.18.2 (JASP, University of Amsterdam, the Netherlands).

Ethics statement*:*

The various rounds of NFHS are implemented in India through the International Institute for Population Sciences (IIPS) Mumbai under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India. Technical assistance for NFHS is provided by ICF International under the DHS Program with funding from the United States Agency for International Development (USAID). The ethical aspects and all procedures were reviewed and approved by Institutional Review Boards of IIPS Mumbai, ICF International, the US Centers for Disease Control and Prevention, and an independent ethics review committee constituted by the MoHFW. The survey rounds were conducted according to the guidelines laid down in the Declaration of Helsinki. The respondents provided informed signed consent to participate in the survey after being intimated about the purpose and procedures of the survey. The NFHS datasets are available in the public domain, hosted by the DHS Program website (https://dhsprogram.com/Data/), in an anonymized manner with participant identifiers removed. Therefore, no separate ethical approval was necessary for the current analyses.

Results

Patterns and trends in the coverage of VAS:

The VAS coverage in children belonging to the 9-59 months age group in India during 2005-06 (NFHS-3) was 18.6% (95% CI: 18.2%-18.9%), which markedly increased to 60.5% (95% CI: 60.3%-60.7%) during 2015-16 (NFHS-4). This amounted to a CD value of 41.9% and

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CR of 3.3. Among children aged 9-35 months, the national coverage of VAS in 2015-16 (NFHS-4) was 64.5% (95% CI: 64.2%-64.8%) that subsequently increased to 71.2 % (95% CI: 70.9%-71.5%) during 2019-21 (NFHS-5), corresponding to a CD value of 6.7% and CR of 1.1 (Table 1).

When examined by individual state/UTs, we observed widespread variations in VAS coverage across the country during all the three NFHS rounds (Figures 1A-1D). While the VAS coverage values among children aged 9-59 months ranged from 5.6% (in Uttar Pradesh) to 40.2% (in Mizoram) during 2005-06 (NFHS-3) (Figure 1A), the values ranged from 29.5% (in Nagaland) to 89.5% (in Goa) during 2015-16 (NFHS-4) (Figure 1B). On the other hand, among children aged 9-35 months, VAS coverage in 2015-16 (NFHS-4) ranged from 30.6% (in Nagaland) to 91.8% (in Goa) (Figure 1C). The coverage of VAS during that survey was higher in the age group of 9-35 months than that in the broader age group of 9-59 months – a pattern which was observed in every state/UT (Figure 1B-1C). More recently, during 2019-21 (NFHS-5), VAS coverage among 9-35 years old children ranged from 44.8% (in Lakshadweep) to 91.9 % (in Goa) (Figure 1D).

The VAS coverage values were found to be heterogeneous across the various sub-national groupings (Figure 2A-2C). Geographically, the highest coverage was evident in western India; whereas northeast India had the lowest coverage (Figure 2A). This was reflected in the analysis across special developmental groups as well, wherein the northeastern states achieved comparatively lower coverage than the EAG states and ‘other’ states/UTs (Figure 2C). In both these sub-national classifications, the northeastern states also exhibited the highest coverage variability. However, the median VAS coverage values were somewhat comparable among the SDI-based subgroups (Figure 2B).

Relationship of VAS coverage with childhood mortality:

The mortality rates in children aged 1-5 years in the various states/UTs across India were inversely associated with the corresponding VAS coverage values (r = -0.40, $P < 0.05$ in 2005-06; and r = -0.47, $P < 0.01$ in 2015-16). The R^2 values of regression for these mortality rates on VAS coverage during 2005-06 and 2015-16 were 16.0% and 22.4%, respectively. However, this inverse relationship was less prominent during the latter survey round in 2015-16 (β =-0.40, 95%

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CI = -0.67, -0.03) in comparison to the former round during 2005-06 (β = -0.47, 95% CI = -0.19, -0.04). This was also evident in the regression plots for the two survey years (Figure 3), wherein the slope of the regression line for 2015-16 was visibly less steep than the one for 2005-06.

These analyses were verified using multivariate regression to account for potential confounding (Table 2). Unlike in simple regression, we found that VAS coverage was not a statistically significant predictor of childhood mortality ($P > 0.05$) when adjusted for covariates, either during 2005-06 (β = 0.03, 95% CI = -0.19, 0.25) or 2015-16 (β = -0.01, 95% CI = -0.09, 0.08). Instead, HCR was found to independently predict the mortality in a statistically significant manner ($P < 0.01$). This association persisted during both the 2005-06 (β = 0.49, 95% CI = 0.09, 0.36) and 2015-16 (β = 0.57, 95% CI = 0.07, 0.24) survey rounds. Altogether, the regression models explained 72% of the variance in mortality during 2005-06, and 54% of the variance during 2015-16.

Discussion:

Deficiency of vitamin A in children is an important public health problem in south Asia. Historically, India has contributed considerably to the global burden of childhood VAD. Although recent epidemiological findings indicate a decrease in prevalence of VAD among under-five Indian children [32], the magnitude continues to be sizeable. In this context, outreach of the universal VAS programme and its implications assume significance. Previous assessment of the VAS programme during the 2015-16 reporting period had unravelled widespread coverage gaps and inequalities, which conformed to statistically significant spatial patterns. It was found that around 40% eligible children had not received VAS, despite guidelines for universal coverage [20]. In the present study, we found that the outreach of VAS programme has improved over the years. However, coverage disparities continue to exist among the various states/UTs – often along geographical and developmental lines. This is in concordance with other studies which suggested that the receipt of VAS among children in India is influenced by socioeconomic determinants, such as maternal education, household wealth, and place of residence [33].

We witnessed an encouraging and noteworthy trend in states like Odisha and Chhattisgarh, which despite being EAG states, had achieved impressive improvements in outreach, with recent VAS coverage rates above 80%. Experiences in some EAG states like

Odisha and Bihar is a testimony to the fact that feasibility issues and resource constraints may be surmounted by strong leadership and political commitment, intersectoral coordination, social mobilization and communication, appropriate training, regular supervision and monitoring, and careful microplanning [34,35]. In contrast, coverage in northeast India was found to relatively lag behind than in the other parts of the country. The northeastern region is home to a considerable proportion of tribal population who live in rural areas. Limited infrastructure, poorly accessible terrain, logistical difficulties, and administrative challenges further hinder the delivery of public health services in the region [33]. Particularly, in the states of Nagaland and Manipur, we found that VAS was not provided to more than half of the eligible children. Incidentally, the northeastern region also harbours a considerable burden of childhood VAD, as reported on the basis of serum retinol measurements during the Comprehensive National Nutrition Survey (CNNS) [32,36,37]. With this background, it is desirable that comprehensive investigations are launched to identify and understand the systemic barriers in the region, which have been hampering the implementation of childhood VAS programme.

The universal VAS programme was launched in India with the goal of preventing VAD and VAD-associated adverse health outcomes in children. It was initiated during the 1970s as a remedy against the high burden of nutritional blindness [14]. Subsequently, with the drastic decline in prevalence of VAD-associated blindness, the justification for continuing VAS was redefined in terms of benefits to child survival [13,14]. It was suggested that high doses of vitamin A supplements helped in preventing mortality by primarily conferring protection against childhood diarrhoea, measles, and respiratory infections [6,38,39]. The WHO has been recommending universal VAS as a crucial intervention for reducing childhood morbidity and mortality in settings where VAD is an important public health problem [12]. But the relevance and usefulness of continuing the practice of universal VAS in the present times is widely questioned [16-19]. There are views that the practice of providing mega doses of vitamin A indiscriminately to all under-five children does not offer any substantive benefits to child survival, and rather causes ‘more harm than good’ due to risks of vitamin A toxicity [17]. There are calls for realignment or scaling back of the existing universal VAS programmes globally including in India [16,19]. But there are also counter arguments suggesting that discontinuation of universal VAS would bear detrimental child health outcomes [13]. Thus, a nuanced and evidence-based consideration of the matter is vital. Cochrane reviews found that VAS was associated with meaningful reductions in child morbidity and mortality [6,40]. In India, the DEVTA cluster randomized trial between 1999 and 2004 involving nearly 1 million pre-school children from the state of Uttar Pradesh revealed modest effects of VAS on reducing child mortality. In fact, a meta-analysis of the DEVTA trial along with eight previously conducted randomized trials detected a weighted average reduction in mortality by 11% (95% CI: 5-16%) [41]. However, a meta-analysis of only Indian studies reported no significant reduction in the risk of all-cause mortality in under-five children with VAS [23]. Reports from Africa suggested that VAS was instrumental in averting a considerable number of child deaths during the past decades [42,43]. But it was also appreciated that the excess mortality which may be potentially prevented by VAS has declined in contemporary times [43]. Likewise, a pooled-analysis of population-based surveys between 1991 and 2013 from developing countries revealed that child deaths attributable to VAD had decreased globally over time and almost eliminated in regions other than south Asia and sub-Saharan Africa [44]. In this context, our analysis indicated subtle relationships between child mortality and VAS. During univariate analysis, child mortality in India appeared to be associated negatively with VAS. The states/UTs which had achieved higher VAS coverage values tended to have lower mortality rates in children aged 1-5 years, but the strength of this relationship appeared to have dampened over the years. However, when adjusted for potential confounders (such as childhood immunization and socioeconomic indicators) through multivariate analysis, this apparently inverse relationship between child mortality and VAS disappeared. It points towards a possibility that the supposed benefits of VAS that may be accrued on child survival have diminished and are no longer relevant as they perhaps were in the previous century. The factors like improvements in living standards, environmental sanitation, nutrition, and vaccination rates in India (as elsewhere in the world) may have contributed to the declining role of VAS in promoting childhood survival [45-47]. This was in agreement with the present findings wherein we found that states/UTs with higher HCR values (which is a composite indicator of deprivation in living standards, education, and health) were likely to have higher mortality rates in children aged 1-5 years, a relationship that was consistent even after accounting for confounders.

India is a big and populous country with many states/UTs that have tremendous heterogeneity in terms of health, geography, economic development, food habits, ethnicity, and socio-cultural practices [48-50]. In fact, remarkable diversities exist even among different districts or blocks within the same state [51-53]. In this regard, it is desirable to have reliable small-area

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estimates (*e.g.*, district-wise, block-wise, etc.) for VAD and/or its associated outcomes. Such data are largely lacking at present, which precluded the analysis of the trends and relationship between VAS coverage and child health outcomes at a more granular level (*e.g.*, by districts/blocks). This is a limitation of the current study. Efforts to bring about targeted improvements in VAS coverage may still be relevant and crucial for supporting child health in India in locations where VAD continues to be rampant. Availability of such granular information would facilitate the development of a practicable framework through which a targeted VAS approach and its intended benefits may be realized. It would also help in rationalizing the allocation of the country's resources (which are finite) and ensure that the interventions are not superfluous but focused upon areas in need. In our association analysis, we could not assess the scenario during the latest NFHS-5 (2019-21) since the VAS data available from that period pertained only to children aged 9-35 months. We were also unable to assess the time-lagged impacts of VAS on childhood mortality, since the spacing between the various NFHS rounds were not uniform and due to the limited availability of NFHS-5 data. Further, we were unable to take into account the vitamin A requirements that were met by the consumption of natural food items rich in vitamin A and products commercially fortified with vitamin A (such as oil, milk, etc.), since these aspects were beyond the scope of the NFHS workflow. These were other limitations of our study.

Conclusion

This study provides a nationwide overview about the coverage of childhood vitamin A supplementation in India over the years (2005-06 to 2019-21) and its relationship with childhood mortality. We documented an overall increase in the coverage of childhood VAS in the country over the years. However, nearly 40% of the eligible children in the age group of 9-59 months and 30% of the eligible children in age group of 9-35 months were found to miss their VAS dosage in recent times. Besides, there were disparities in coverage, when examined by individual states/UTs. As a region, northeast India had the poorest VAS coverage. The state/UT-wise mortality rates among children aged 1-5 years across India varied inversely as a function of the VAS coverage values. However, this reciprocal relationship has become less pronounced over the years, indicating a shrinking role of VAS in offering protection against childhood mortality.

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Authorship: Trishna Bora: Data curation, Formal Analysis, Investigation, Visualization, Writing – original draft. Kaustubh Bora: Data curation, Formal Analysis, Investigation, Methodology, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing.

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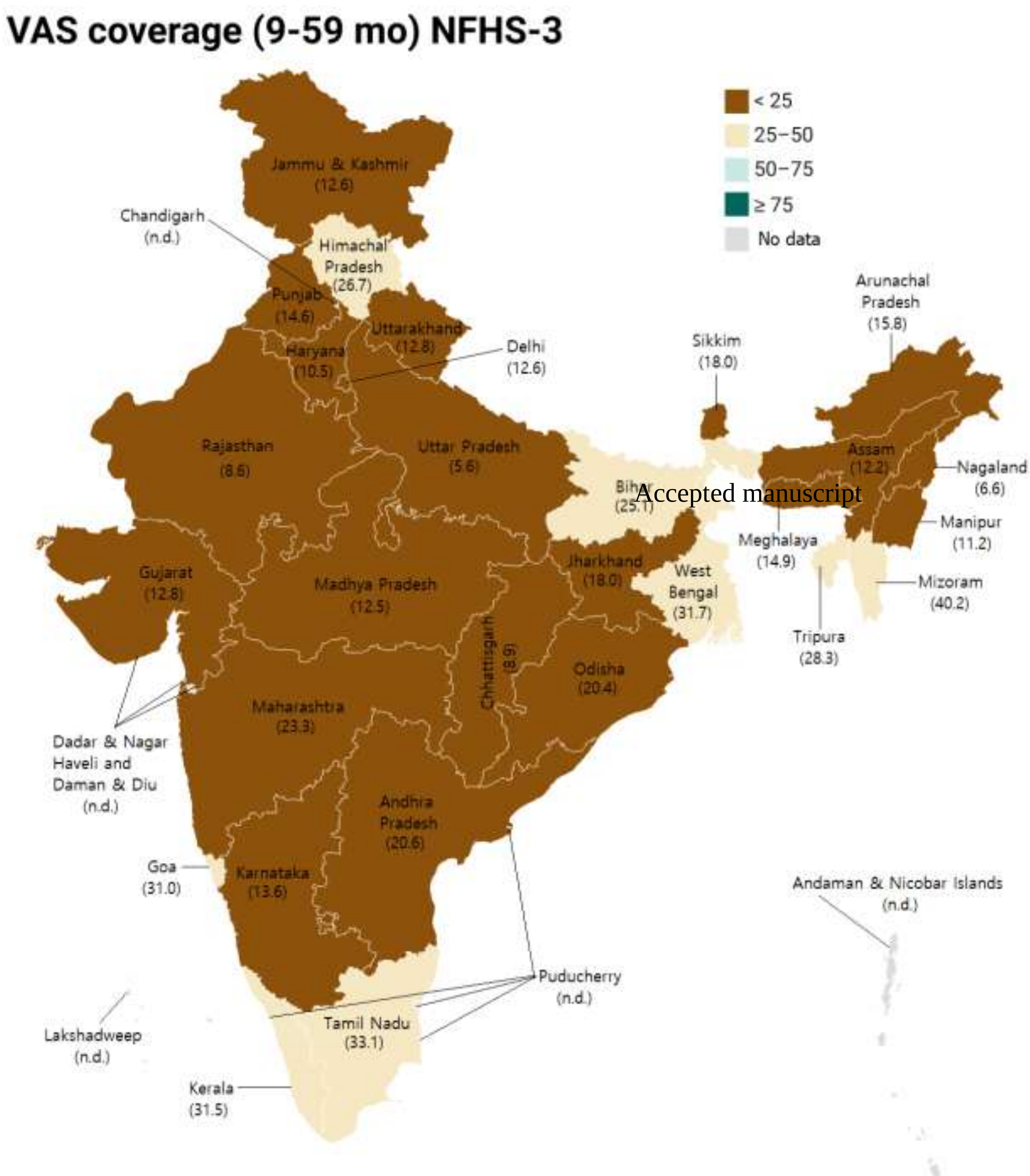
Figure 1. Coverage of vitamin A supplementation (VAS) in Indian children, shown by states/union territories, during different rounds of the National Family Health Survey (NFHS): (A) Children aged 9-59 months during NFHS-3 (2005-06); (B) Children aged 9-59 months during NFHS-4 (2015-16); (C) Children aged 9-35 months during NFHS-4 (2015-16); and (D) Children aged 9-35 months during NFHS-5 (2019-21).

(A)



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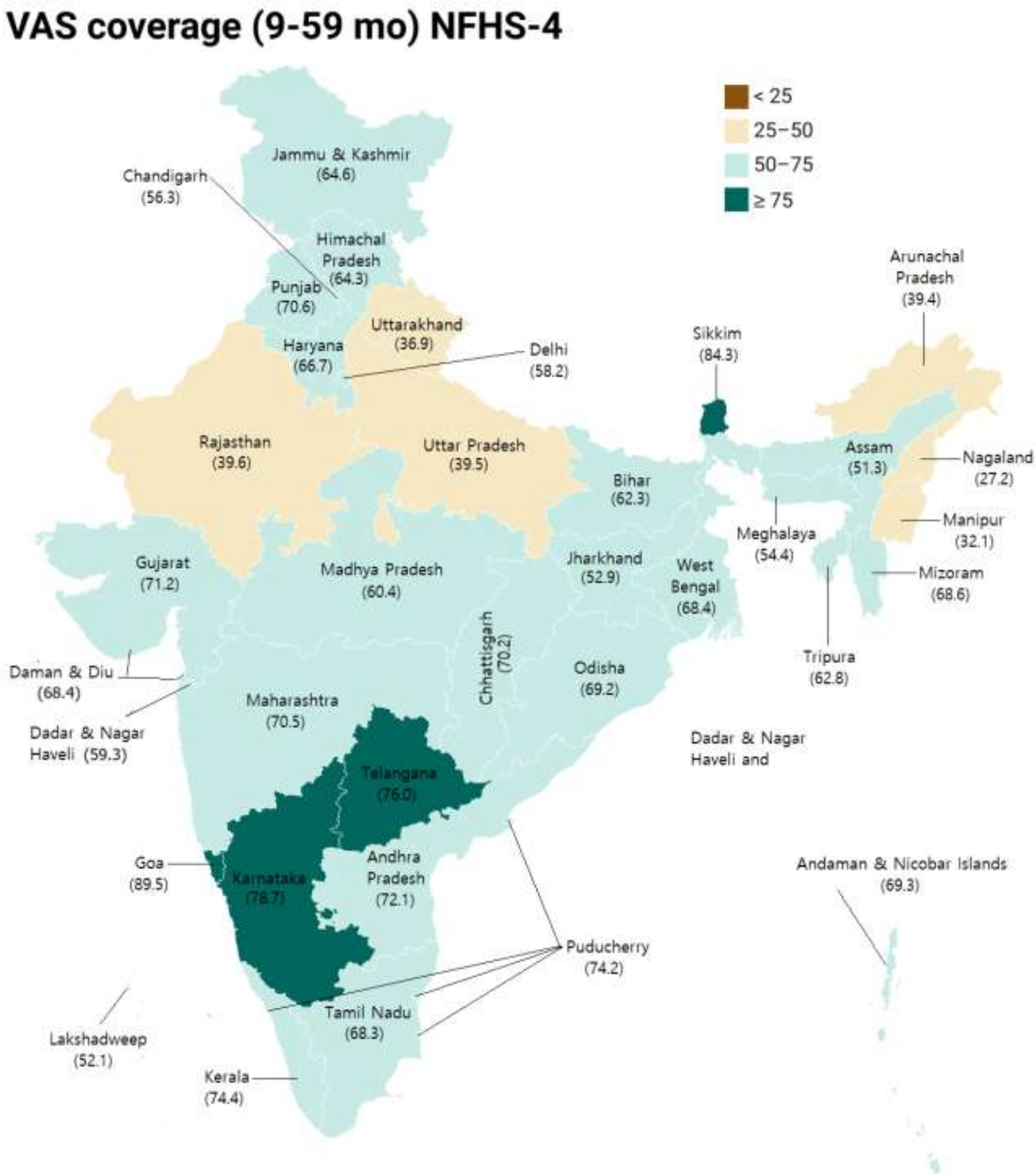
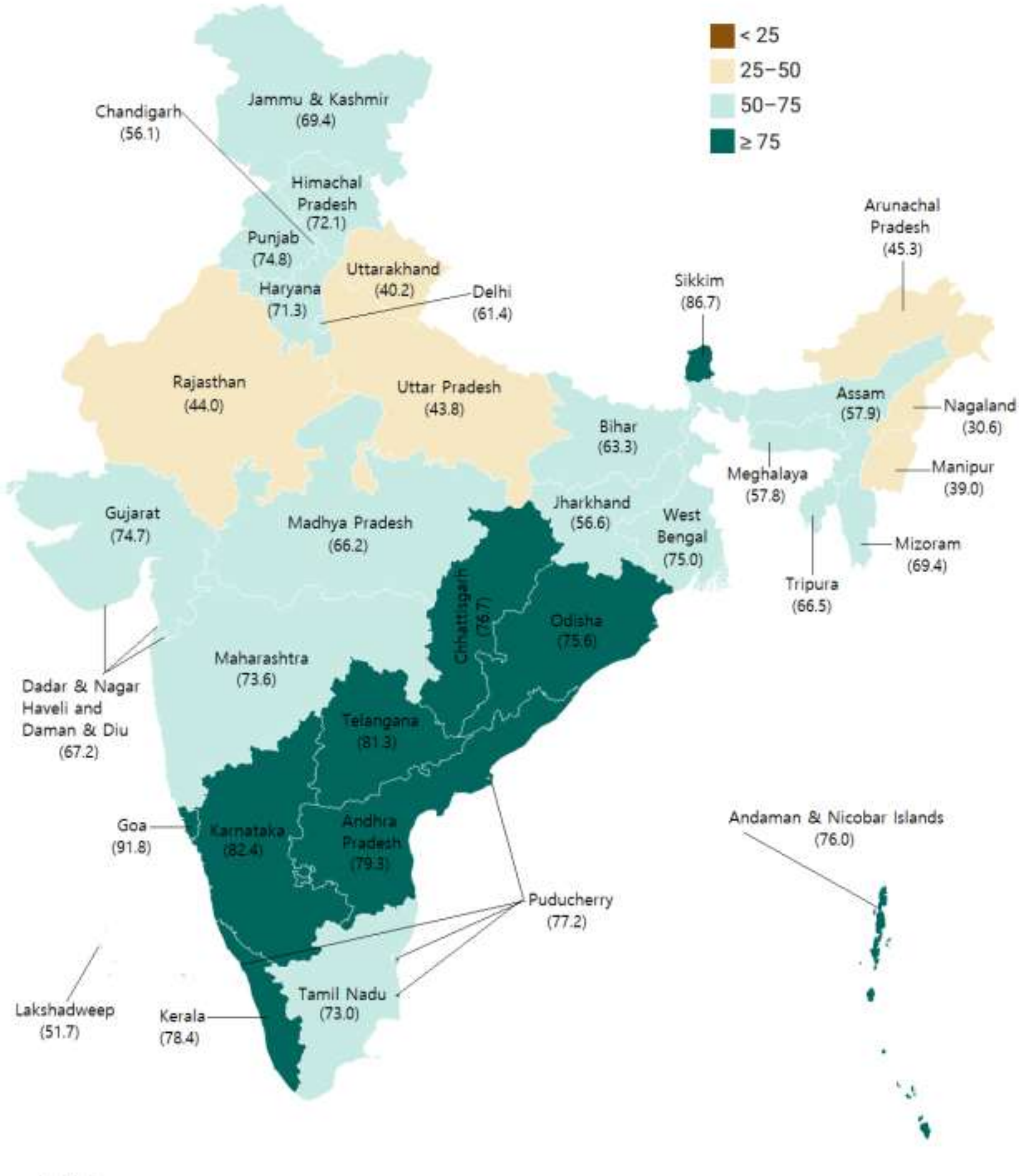
(B)



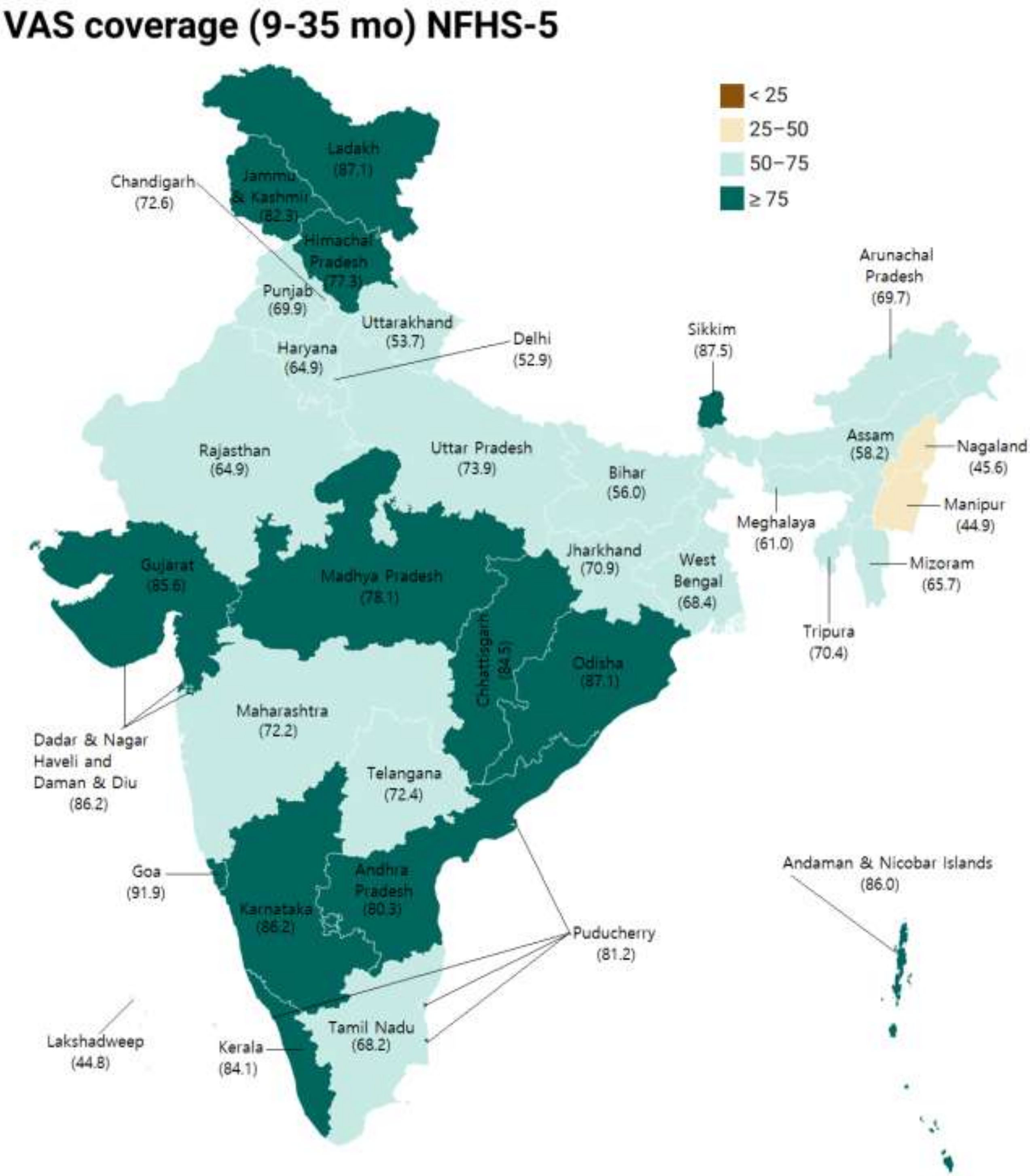
https://doi.org/10.1017/S0007114525104017 Published online by Cambridge University Press

(C)

VAS coverage (9-35 mo) NFHS-4



(D)



[Values within parentheses against the state name indicates the corresponding VAS coverage value, expressed in percentage. The state of Andhra Pradesh was bifurcated into the states of ‘Andhra Pradesh’ and ‘Telangana’ in June 2014. The state of Jammu & Kashmir was reorganized and bifurcated into the two union territories of ‘Jammu & Kashmir’ and ‘Ladakh’ in August 2019].

Figure 2. Boxplots illustrating subnational heterogeneities in vitamin A supplementation (VAS) coverage across India during the 2019-21 reporting period, according to (A) Geographical region, (B) Sociodemographic index (SDI), and (C) Developmental category.

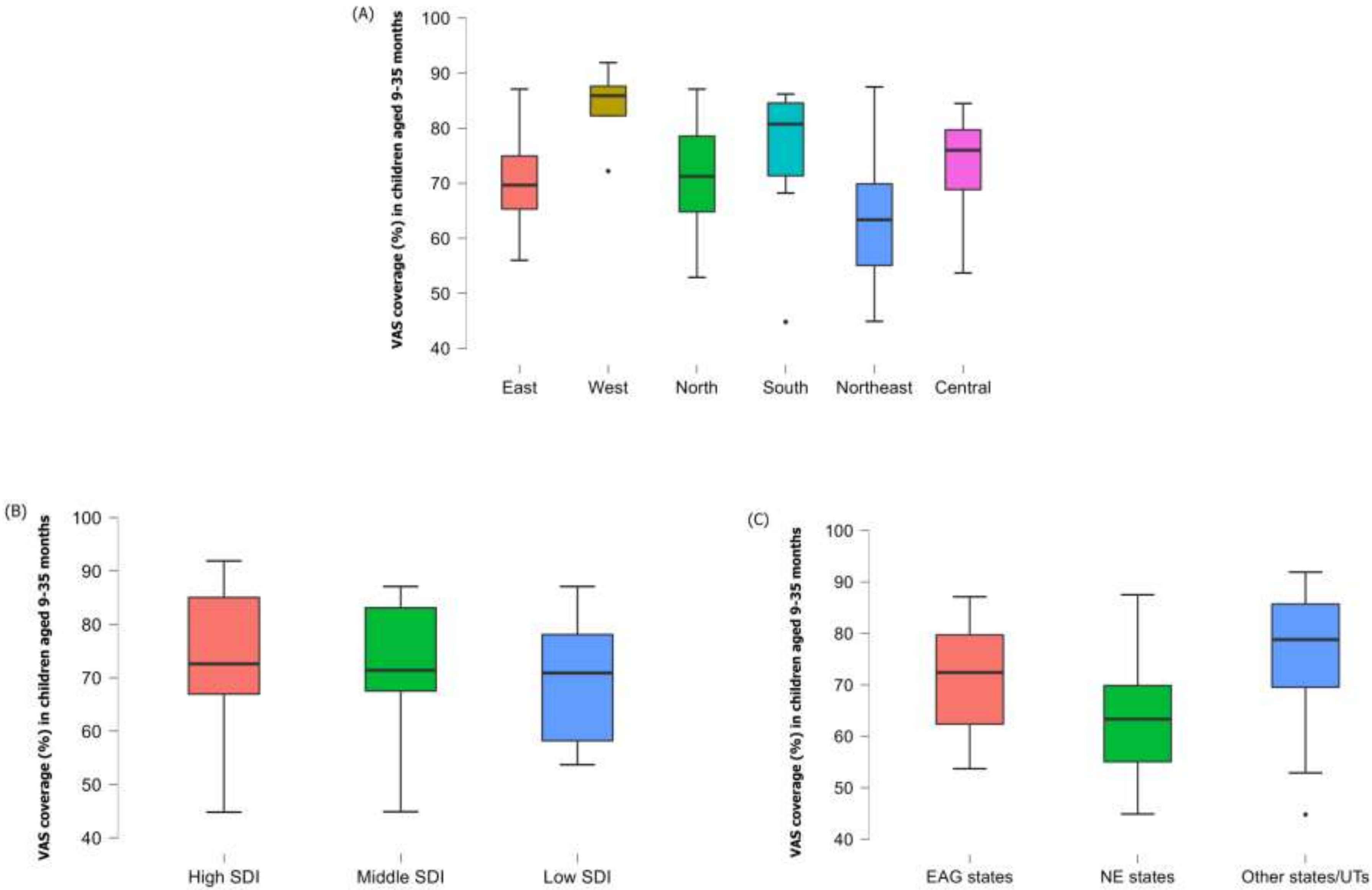


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Figure 3. Scatter plot showing the association between vitamin A supplementation (VAS) coverage and child mortality rates across the states and union territories of India.

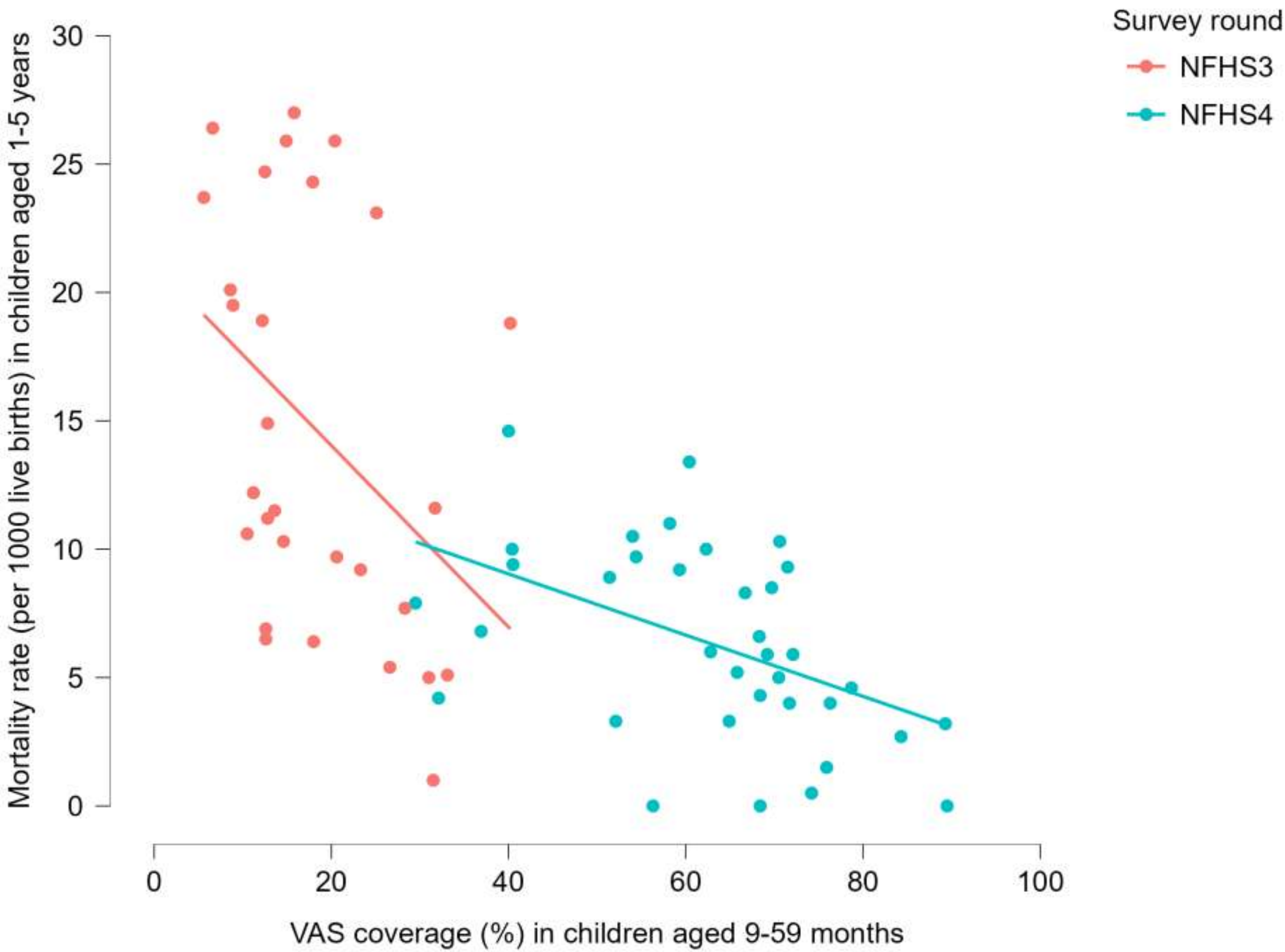

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Table 1. Coverage of vitamin A supplementation among children in India, as estimated during the different rounds of the National Family Health Survey.

Target population	VAS coverage by survey rounds			NFHS-5 *vs* NFHS-4		NFHS-4 *vs* NFHS-3	
	NFHS-3 (2005-06)	NFHS-4 (2015-16)	NFHS-5 (2019-21)	Coverage difference*	Coverage ratio†	Coverage difference*	Coverage ratio†
Children							
9-35 months age	-	64.5%	71.2%	6.7%	1.1	-	-
9-59 months age	18.6%	60.5%	-	-	-	41.9%	3.3

Abbreviations: VAS, vitamin A supplementation; NFHS, National Family Health Survey.

* Coverage difference was calculated as the absolute difference in VAS coverage between the given survey round and the preceding survey round.

† Coverage ratio was calculated as the ratio of VAS coverage during a given survey round to that during the previous survey round.

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Table 2. Results of multivariate regression analysis, examining the factors influencing mortality rate in children aged 1-5 years.

Model particulars	**NFHS-3 (2005-06)**			**NFHS-4 (2015-16)**		
Independent Variables †	***β***	**95% CI**	***P*-value**	***β***	**95% CI**	***P*-value**
VAS coverage	0.03	-0.19, 0.25	0.81	-0.01	-0.09, 0.08	0.94
HCR	0.49	0.09, 0.36	< 0.01	0.57	0.07, 0.24	< 0.01
BCG coverage	0.13	-0.17, 0.35	0.49	0.14	-0.66, 0.79	0.85
DPT1 coverage	-0.29	-0.83, 0.43	0.52	0.35	-0.89, 1.23	0.75
DPT2 coverage	0.08	-1.10, 1.20	0.93	0.75	-1.32, 1.99	0.68
DPT3 coverage	-0.51	-0.96, 0.37	0.37	-1.48	-1.50, 0.45	0.28
MCV coverage	0.14	-0.33, 0.56	0.59	0.05	-0.27, 0.33	0.84
Model characteristics	R^2 = 0.79, R^2-adjusted = 0.72			R^2 = 0.65, R^2-adjusted = 0.54		

Abbreviations: NFHS, National Family Health Survey; VAS, vitamin A supplementation; HCR, head count ratio; BCG, Bacillus Calmette–Guérin; DPT, diphtheria-pertussis-tetanus; MCV, measles containing vaccine; β, regression coefficient (standardized); CI, confidence interval; R^2, coefficient of determination.

† The primary independent variable (predictor) that we considered was VAS coverage, whose effect upon the outcome of interest (mortality rate in children aged 1-5 years) was examined in the regression model. The estimates were adjusted for other covariates, *viz*., HCR and coverage for various childhood vaccines namely BCG, DPT1, DPT2, DPT3 and MCV.

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