The Quality of Anthropometric Data and Investigator Roles in India's National Family Health Survey

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Extended Abstract:

Introduction

The quality measures of the demographic and health survey data are brought into focus to improve the estimates of health measures. It is necessary to analyse the achievement of nutritional targets mentioned under Sustainable Development Goals (SDG) (1). As data quality is concerned, anthropometric data is vulnerable to errors and results into biased estimates. A sizeable share of malnourished children is concentrated in the low and middle income countries (2). To design the interventions for malnourishment, a highly reliable and valid estimation of the anthropometric measures is required. Large scale health surveys famously known as Demographic and Health Survey (DHS) (National Family Health Surveys in India) are the major source of such information. The longitudinal nature of the survey has helped to track malnourishment across countries, however, the confidence in the progress estimated with these data sets is yet questionable due to various reliability and validity issues.

One of the major indicators of health burden that is required to be addressed in case of India before 2030 is malnourishment. Malnourishment is measured by stunting (height for age- HAZ- < 2 SD of population median) and wasting (weight for height- WHZ <2SD or >2SD of the population median, respectively) among under five children (3). More than one third of the stunted lives in India (4), and has the highest wasting rate in the globe (5). The prevalence of malnourishment varies to a great extent across states, and shows a critical cluster of districts with such burden in India. The diverse demographics of the country and large sample size of the survey can pose a challenge to gather accurate and reliable estimates within a stipulated time duration. Despite several guidelines issued by the DHS, errors are found to affect the quality of the data which is often generated during study designs, executions and data entry processes. Unreliability and biasness in sample surveys often become reasons of despair despite rigorous training imparted before the survey, and monitored and evaluated during the survey. The survey can result into errors majorly from survey designing procedure and survey investigators. As a result, different data quality issues are aroused which include the implausibility of biological issues, digit preferences, and high variation in the data sources (6). The Emergency Monitoring Assessment (EMA) and Standardized Monitoring and Assessment of Relief and Transitions (SMART) also select those indicators and further, it creates composite indices for evaluating the anthropometric data quality in the survey (7). This argument is relevant to measure the overall data quality across populations and geographies. The multistage procedure of data collection techniques can result into errors; therefore, it requires intense monitoring at the surveyor's end. Underestimation or over-estimation of the estimates portrays false ideation of the overall situation of the population (8). The errors are generated not just at the researcher's or investigator's level, several other cultural, social and political factors also influence the measures of demographic and anthropometric factors. Anthropometric measures are sensitive to age, height and weight reporting bias. Social desirability and recall bias are few confounding factors that result into reporting errors of age of children, age at marriage of women, age of first sexual debut, age of union etc. (8). Moreover, regions that are less developed have a higher likelihood of misreporting and hence, the quality of data deteriorates significantly (9,10).

The recent estimates from NFHS-5 at the national level show a declining trend in stunting and wasting outcomes among children in India. A cluster of states is bearing a high burden of malnourished children along with that they represent poor development outcomes. Despite an overall decline in stunting, around 280 districts have shown an increase in childhood stunting between NFHS4 and NFHS5 (11). The sensitivity of the estimates must be highlighted in that context when those data sets are used for important programmes and policy formulation. Previous studies on anthropometric measures using NFHS data have shown a substantial difference in the estimation of undernourishment among children due to the difference in reporting across age cohorts. They have further highlighted the role of data investigators while conducting the survey (12). Data quality of certain sections in the survey schedule which are long, technically complicated and time consuming are avoided while interviewing the respondents to cover a higher number of households (13). Understanding the nature of errors committed by the investigators in such a large-scale survey is a matter of interest for future improvements. The educational performance of the community or population is a matter of concern for the quality of survey responses mentioned by Borkotoky & Unisa in 2014. Therefore, a certain pattern can be observed in the data set while measuring the item-wise quality of the data.

To explain the data quality issues in the surveys in India, it also needed to highlight the importance of vital registrations. Age-appropriate measures often thrive under the correctness and sensitivity of the public health matter. In that context, an accurate measurement of nutritional progress in the country is questionable. Various anthropometric data collection surveys are conducted regularly to monitor the children's health status. Differences in nutritional indicators are often observed in these surveys within the same population. This calls for monitoring the quality of anthropometric data to address the issue of over and underestimation of nutritional indicators among children under five. Data quality issues arising due to errors in the method of data collection must be thoroughly checked. This analysis would not only portray the level of malnourishment in the regions/ states but also compare intra-state variations in the quality of anthropometric outcomes in India over two time points. A robust assessment has been performed to measure HAZ and WHZ along with the performance of survey teams while conducting the survey.

Methods

Data Source

The study has used unit level data from National Family Health Survey (NFHS)- 4 conducted in 2015-16 and NFHS-5 conducted in 2019-21. In NFHS4- nearly 0.6 million households, 2.8 million persons and 0.7 million eligible women aged 15-49 years by 789 field teams (14 field agencies) were covered across the nation using a stratified two-stage sampling procedure. And in NFHS 5 (2019-21), the number of households covered are 0.6 million, 0.7 million eligible women along with 0.1 million men and data collected by 1061 field teams (17 field agencies). It is important to mention that to cover such a large sample size, survey implementation design of NFHS includes phase wise collection of data and division of bigger states into smaller clusters. (14). Each team consisted of one field supervisor, three female interviewers, one male interviewer, two health investigators, and a driver. All DHS questionnaires (In India it is NFHS) were thoroughly reviewed by ICF international review board under standard protocol for ethical consideration.

Data quality Indicators

To measure the quality of anthropometric indicators in the survey, the study has identified 8 indicators for Height for Age (HAZ) and 5 indicators for Weight for Height (WHZ) measurement considering the suggestions from WHO/ UNICEF Anthropometric data quality working group and research studies (15,16). Eight indicators were used to calculate composite index of HAZ are: 1) Date of birth completeness, 2) Completeness of anthropometric measurement, 3) Digit preference for height, 4) Digit preference for age, 5) Absolute difference in HAZ by MOB, 6) Biologically impossible value, 7) Dispersion of HAZ, 8) Inappropriate height measurement. Five indicators used to calculate composite index of WHZ are: 1) Completeness of anthropometric measurement, 2) Digit preference for height, 3) Biologically impossible value, 4) Dispersion of WHZ, 5) Inappropriate height measurement.

Definition of indicators:

Date of birth completeness

The percentage share of children 0-59 months of age who have at least completed information on month and year of birth is used to measure the Date of Birth Completeness. The missing information about the day of birth was imputed while calculating the HAZ and WHZ using the WHO anthro-package (17).

Completeness of anthropometry measurement

The percentage of children aged 0-59 months with complete height and weight data is known as anthropometric completeness. The data was considered incomplete when participants refused to participate, were not present, or if data was not measured because of another reason mentioned in the survey (16).

Digit Preference for height and age

Digit preference can be understood as the preference of selecting a particular digit more frequently than others. Index of dissimilarity was used to measure the digit preference of height and age in the study. The index is calculated as the sum of the half of absolute differences between observed and expected percentage (18). The preference for certain digits would suggest lack of care by the interviewer while collecting the data, or by the investigator or data entry personnel by rounding off or smoothing the last digits of the age to a preferable number (19). In the analysis, we have not used digit preference for weight of the respondent because it is recorded for the 100^{th} decimal place but available till tenth place. The index of dissimilarity was calculated as (18).

Index of dissimilarity = ∑ abs (actual percentage-expected percentage)/2 ------------- (1)

For the digit preference of height, the digit to the right of the decimal place was used. For age digit preference, we used heaping at 6 months of age interval, as supported by literature (16,19).

Absolute difference in HAZ by Month of birth (MOB)

Age of the children is misreported to adjust the initial or later months of the birth while reporting during investigation. The degree of bias in reporting MOB for each state was assessed by the absolute difference between the mean HAZ values for January and December(20). Sometimes, children who are born early in the years are assigned later birth months, or who born later are assigned earlier birth months, which misclassify the child's nutritional status (16), also called as calendar year artifact. If the gap between the HAZ by MOB is nearing zero then there are no chance of systematic errors in age reporting (19).

Biologically Implausible (flagged) values

Flagged cases are defined as biologically unreasonable values for a child of a particular age, and sex due to the measurement error. In our study using the anthro package,

We define the implausible value for HAZ to be greater than 6SD above or below, while for WHZ greater than 5SD above or below median z score of the reference population has been considered (21). The outliers are removed from the calculation. For instance, children of age less than 24 months were excluded from the study if their height was outside the range of 45-110 cm, and for length it was outside the range of 65-120 cm.

Standard deviation (SD) of HAZ and WHZ

After adjusting for the flagged values, the standard deviation was computed to describe the variation in HAZ and WHZ. The higher value of SD, generally 1.0 indicates data quality problem in the indices (21). A study based on 51 DHS countries has shown that SDs are relatively stable and did not vary much with the z score means(22), so can be considered as an indicator to measure data quality despite several limitation.

Height Inappropriateness

Height is another indicator that suffers measurement error. According to WHO, if the child age was between 9 and 24 months and was reportedly standing when height was measured, the height was considered to be measured inappropriately, similarly, for the child over age 2 years was measured while lying down may suffer biasness in measurement (21).

Statistical analysis

The stunting and wasting have been measured by utilizing WHO standard micro (2006) in the NFHS-4 data set. Defacto method is adopted in the survey to measure the members of age 0-59 months, who have slept the previous night in the household.

Each data quality indictor was calculated at the state level. After computation of all the variables, indicators were normalised across states. The normalisation was done to transform the data into direction which maximise the variance. So, we have used the normalisation as suggested by (23). The formula used for normalisation was:

$$NVij = 1- \frac{Best\ Xi - Observed\ Xij}{Best\ Xi - Worst\ Xi}$$

Further, principal component analysis (PCA) was used to generate composite data quality for HAZ and WHZ separately. PCA reduces data to lower dimensions, with the main goal to find the best summary of the data using limited principal components (PCs). (24,25). PCA was used to rank the quality of anthropometry data across states.

In addition, we have also used PCA to rank the teams using data quality indicators as performance measures. Indices values cannot be used to compare the outcome extensively, therefore, it was decided to keep ranking of the state. This approach can help to assess the performance of teams as move forward in the state. For this purpose, we have selected eight bigger states of India, Bihar, Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Uttar Pradesh, Madhya Pradesh, and Rajasthan on the basis of different malnutrition ranks in NFHS-4.

For study, we have ranked and measured the timing of the interview based on the HAZ and WHZ score. In NFHS, the FIs exclusively assigned to a region were assumed to be moving systematically from first to respective sets of the districts within a region, thereby each team covered a number of districts belonging to different sets in a region. So, the district set was constructed based on the clustering of the same teams that collected the data. For e.g., in the central region of Uttar Pradesh, the data collection process was carried out by 19 FI teams covering 18 districts. These districts were grouped into 5 sets consisting 3-5 adjoining districts of the region. All the FI teams are allocated to the districts in the first set for survey implementation. On completion of surveys in the first set, teams are assigned for data collection in the second or following set. All the analysis was done using SPSS 21.0, and MS Excel.

Ethics statement

NFHS survey has been conducted by the International Institute for Population Sciences (IIPS) under the aegis of MoHFW. The approval for NFHS-4, 5 was obtained from the Ethics Review Board of the IIPS, Mumbai, India and ICF International Review Board (IRB). In this survey, written consent was obtained from the participants before the commencement of the interview. Each participants' approval was sought, and then only interviews were conducted. Confidentiality was maintained as NFHS published gathered data with no identifiable information of the survey participants.

Results

The study presents the findings at the national and state level across two rounds of the NFHS to understand the quality of data. The descriptive statistics of the data quality at the national level is presented in Table 1. Improvement in the complete DoB, complete anthropometric measurements, digit preference for height, digit preference of age, implausible values of HAZ and implausible values of WHZ have shown a rise during NFHS4 to NFHS5. In contrary, absolute differences in mean HAZ by MoB, SD of HAZ, SD of WHZ and height inappropriateness have shown an increase in between these two rounds. Digit preference of height is 14.36 in NFHS5, shows a dip of one percentage point than NFHS4. While implausible values of HAZ declined by more than one percentage point from 3.41 to 2.28 (NFHS4 to NFHS5). SD of HAZ is 1.85% and height inappropriateness in found to be 5.6 in NFHS5.

Table 2 and Table 3 gives a detailed distribution for selected indicators across states during NFHS4 and NFHS5 in India. Completeness of date of birth has improved in all the states. The values range from 100% in Sikkim to 95.6% in Telangana and Karnataka in NFHS4 and from 99.7% in Rajasthan to 100% in several states of India. Completeness of anthropometric measures has shown an overall improvement except for Sikkim where it dips more than 10% points. The value for completeness of anthropometric measure remains as high as 99.7% in Chhattisgarh to 80.1% in NCT Delhi in NFHS4, and 99.8% in Ladakh to 86.9% in Sikkim in NFHS5. The digit preference for height performed poorer from NFHS4 to NFHS5. The range for index of dissimilarities for digit preference for height ranges from 8.5%(Manipur) to 22.5% (Arunachal Pradesh) in NFHS4 and from 11.3% (Rajasthan) to 23.9% (Lakshadweep) in NFHS5. The index of dissimilarities for digit preference for age at 6-month intervals have shown an improvement in two rounds. In NFHS4, the value ranges from 0.3% in Andhra Pradesh and NCT Delhi to 1.4% in Goa and in NFHS5, the value ranges from 0.3% in Assam to 7.2% in Sikkim. The quality of the stunting and wasting values has shown to be declining from NFHS4 to NFHS5. The standard deviations in stunting (HAZ) and wasting (WHZ) are shown an increase in most of the states. The SD of HAZ shows a range from 0.8 in West Bengal to 9.3 Arunachal Pradesh in NFHS4 and from one in Andhra Pradesh to 11.5 in Arunachal Pradesh in NFHS5. The SD of WHZ shows a range from 0.7 in Telangana and Andhra Pradesh to 7.9 in Andhra Pradesh in NFHS4 and from 0.8 in Andhra Pradesh to 10.1 in Lakshwadeep in NFHS5. Looking at the value for absolute difference in mean HAZ by month of birth depicts that in NFHS4 the range varies from 0 in several states to 1.3 in Chhattisgarh and in NFHS5 the range varies from 0 in Himachal Pradesh and West Bengal. The height inappropriateness defines the measurement criteria from height or length according to the age groups of the children that show an increase in NFHS5. Bihar has the highest value (7.8 and 8.8) in NFHS5 and NFHS4, respectively.

Figure 1 and 2 show the distributions for ranking of the states of India for HAZ and WHZ respectively. The ranking of the states is found to be changing across NFHS rounds. In southern states, data quality in stunting has declined for Andhra Pradesh, Karnataka, and Kerala; in northern states, Haryana and Himachal have shown a decline and northeast, west, central and eastern regions most of the states have shown improvement in the ranking for HAZ. For WHZ, among southern states, only Andhra Pradesh has shown a huge decline in ranking from 19 to 30 but Telangana has shown improvement in ranking from 26 to 19. In northern India only Himachal Pradesh, in North Eastern Manipur, Meghalaya, Nagaland, Tripura, in most of the Central and Eastern states have shown an increase in the ranks explaining the decline in the data quality for WHZ indices.

Further looking into the performance of the investigators by the timing of interview in the survey finds that for both the stunting and wasting the investigators performed worst in the beginning of the survey but performed best at the end of the survey in NFHS5 and middle of the survey in NFHS4. Figure 3, shows the performance of the teams in selected districts by its rank across the team sets for NFHS4. The last set of investigators in Bihar and West Bengal has performed better explaining improvement in the skills due to proper observations and monitoring throughout the survey. While investigators in selected Southern States have not performed better toward the end of the survey. Only Rajasthan performed best in the last set of the survey however it does not show a sustained improvement in the teams' performance while collecting the age or anthropometric data. Surveyors collected data in the UP west region has done better than other two regions. Moreover, at the end of the survey in the western region the surveyor performed better than the initial set of surveys. For Madhya Pradesh, the investigators in the western region have performed better overall than eastern regions and it progress through the survey rounds the quality of data collection has improved as the rank got better at the end. To mention in brief, different survey agencies have worked in different regions of UP and MP in NFHS4.

Discussion:

This study presents a comprehensive assessment of anthropometric data quality of children under age group of 5 years utilizing two latest rounds of NFHS dataset in India. It measures the perspective of the investigators' bias in the survey for measuring vital data points of children growth. Programmes and policies focused on addressing anthropometric failure require data quality measures. It prioritizes the necessity for monitoring the field data across survey teams within and across the survey teams and estimation of the change in the data quality in the survey. The salient findings of the study are following- 1) a prominence in digit preference especially for height among children is observable in the survey. The extent of digit preference varies substantially across states in India, 2) states in north-eastern regions and few southern states of India are performing low on the anthropometric data quality measures, and 3) the timing of the interview during the survey period matters significantly to the anthropometric data quality in the survey.

Completeness of anthropometric measures is very high found in the surveys, however, few states show marginally low completeness of the selected data. The major reason for this could be an inadequate capacity to implement the skill of interrogation after training among investigators or an absence of children or their mothers during surveys. Sometimes mothers could not remember the appropriate date of birth of the child, which may be associated with their educational status. The study finds a larger digit preference for height present among children along with a substantial difference across states. The issues of measurement of height are dependent upon two fundamental factors, firstly, who is measuring it and how it is being measured. Study supports that there is a mean difference of 1.2 cm +- 1.6 cm (SD) observed in the anthropometric indicators when measured by medical practitioners in comparison to nurses who are trained in the anthropometric measurement(26) . That means that chances of variation in the anthropometric data measurement could be due to a potential change in the surveyors' skills. Hence, variation in measurement in inter and intra-team members can bring forth a change. For recumbent measurement for children below 24 months, it is essential to maintain the anatomical posture such as dorsal side of the knee should be touching the surface and the Frankfurt plane should be maintained as per the direction given in the. The surface of ground and along with the thickness of hair of children to measure the height can be a vital parameter that determines the quality of the anthropometric data collected (27). Our study finds that several north-eastern states are showing a higher digit preference for height. Other hilly states show a higher score for that index. We can't deny the role of and training given to investigators for the measurement processes and difficulties of measuring very young children (12). Studies also capture reasons like the seasonal variations, diurnal height of the children, length vs. height measurement issues, one versus two legs recumbent length measurement related discrepancy, mentioning of wrong date of births of child etc. have the potential to distort the stunting and wasting estimates in the surveys(28). An increase in the random imposed height distribution such as upto 2.5 cm vis a vis SD of random imposed error 500 gm can result into 5.6% severe wasting among children (29).

The quality of data for stunting and wasting can be measured by the implausible values. More than 1% of the implausible value indicates the data quality issue in the survey (17). Implausible or flagged value for the wasting is higher than the stunting. It might arise due to analytical problems such as dropping off the observations having very poor nutritional status. The measurement error of the investigators can be understood in such context. Here also, the percentage share for biologically implausible values for stunting and wasting varies greatly with an increase in the values over two rounds across states in India. Systematic reporting of birth is less erroneous at the national level found in the study. Standard deviations of HAZ and WHZ score across states depicts that a substantial heterogeneity exists in the population. Unable to follow the height or length measurement protocols results into such height inappropriateness. It has also been mentioned by other researchers that centimetres marks are larger on the height board, therefore, many investigators round off the score for their ease of measurement (30). In addition, there is always a chance of biological or physical error in the measurement as the children wear heavy clothes during winter, diapers, or their bladder, bowel remains full and stomach is not empty at the time of measurement. Moreover, higher length discrepancy in measurement over height measurement can distort the data quality of anthropometric outcomes (31)

An increase in the digit preference for height and age in most of the states during NFHS4 and 5 raises a serious concern. It suggests that despite intensive training imparted to the surveyors, there is a decline in the quality of data collection, especially, in the initial stage of the survey. A decline in the data quality explains for increasing randomness in the height, weight and age data. However, the study substantiates that there is an improvement in the data quality for extreme values for height and weight. It suggests that in the NFHS5 of the survey, the training of the investigators for the anthropometric data quality has been given fruitfully and also extreme malnourishment cases are declining gradually among population. Our study finds that an absolute mean difference in mean HAZ by month of birth has increased from NFHS4 to NFHS5 since there is an overall increase in the estimates across states. That explains a growing pattern of shift in the date of birth from December to January, hence, an underreporting of the age among children by the respondents. The standard of measurement for SD of anthropometric measures, which should lie between 0.8 to 1.2 at a single time point across a sectional survey. This is found to be deferring in both rounds of the survey. Most of the states are showing SD which is higher than 1.2. It throws a light on the quality of the investigators as well. A study has already marked the role of team level factors and the ratio of multiple child households and team size for higher SD for stunting (31). PSUs with high loads find it more troublesome to capture the height and weight measures among population. States like Andhra Pradesh, Odisha, Tamil Nadu, Punjab and West Bengal can be explained due to larger multiple-child household sizes.

The state-wise differences observed in the study suggest understanding the persistent heterogeneity in the demographic, socio-economic and most importantly, in nutritional outcomes (32). Child growth failure can be substantially different across the regions of India, which is dependent upon genetic factors and exposed vulnerability. DHS also mentions that SD of stunting can be higher than SD of wasting since stunting requires a precise measurement for height/ length and ages. The report has elucidated that a change in one month in age reporting of very small children gives more biased estimates in the Z score of children than children in the older age groups (33). Looking deep into the outcome of the states across its region in terms of HAZ and WHZ quality, the paper depicts that the teams in the north-eastern regions are performing remarkably low in anthropometric measurements. States in northern and southern regions have high variability in the stunting and wasting outcomes. Surveyors' fatigue may explain the quality of the data collected in NFHS. NE states have varied terrains and heterogenous communities which may increase the challenge to collect data within a predefined time. Due to long sets of questionnaires, quality of the data may be compromised along with anthropometric measurement which needs to follow certain protocols. It is often found that states with better education report better in the survey (34). Though, Kerala is showing a better outcome in HAZ and WHZ, however, state such as Karnataka has a higher ranking in terms of overall data quality. States in the central and eastern regions carry a higher burden of malnourishment. Though, the anthropometric data quality analysed in these states explains a good quality of data than respective other states. This indicates that a focus has been given to the investigators right from survey implementation to the collection of data. The falling rate of undernourishment could be a reason for poor reporting of the anthropometric data in the survey (35). Therefore, the data collection needs to be thoroughly monitored.

A team wise performance of the measurement of HAZ and WHZ also depicts that in the middle of the survey period teams are performing best in NFHS4 while it is the last phase of the survey where teams are performing better in NFHS5 round. The underlying reasons show that at the initial phases of the survey, investigators are in the learning stage while in the end phases fatigue is one of the main reasons for poor performance (30). However, this pattern showed a change in the pattern as NFHS5 shows a sustained improvement in the data quality towards the end of survey. An in-depth analysis of the team performance of the investigators in the southern states like Tamil Nadu, Karnataka, and Andhra Pradesh finds that a sustainable improvement of the team performance in the rank of HAZ, despite the overall ranking of the states in the HAZ outcome differs greatly. This can prompt that population wise heterogeneity in the measurement can be a cause of concern. The study protocol should be sensitive to these observations and can modify the training and monitoring from time to time. States in the eastern regions of India show a stable ranking in terms of HAZ and WHZ scores. An exclusive analysis of the performance of investigators in the states of West Bengal and Bihar shows a gradual improvement in the performance of the teams. While, in a bigger state like Uttar Pradesh finds that a large difference in the performance of teams across subregions of the state. Performance of the team in the western UP has been better and more stable, than that of the other two regions. Homogenous population in the survey along with consistent team performance. The same can be found in the state of Madhya Pradesh, since two teams led by different survey agency are performing quite differently in the state. Different survey teams work in different clusters. To improve the performance and to reduce fatigue, survey investigators were taken to the movie hall to watch cinemas (PI, NFHS). Therefore, this kind of practice can be adapted by the surveys to reduce the load and improve the data quality in the survey. It is necessary to assess the heterogeneity in the measurement among clusters in the larger states. This suggests developing a framework for the teams for a better understanding of the training programmes and its effectiveness while the survey is going on. It also suggests a stronger monitoring of the teams during surveys. Since, the different agencies are involved in the data collection procedure, thus, it may affect the performance of the teams. It is recommended to provide training to the investigators keeping in mind the initial challenges and fatigue at the later stage of the survey. Studies on NFHS data quality have argued the role of public and private field agencies in the surveys. Private organizations are motivated to maximize profit, which in turn hampers the survey quality (36). Hence, a checklist must be followed while selecting the field agencies for the surveys. Technical support must be given appropriately, challenges must be reviewed from time to time and interview quality must be constantly scrutinized in phases so that specific interventions can be planned out efficiently.

It is essential to associate the gender, education, wealth indices, change in the count of districts, age wise distribution of the children in the districts of the states and so on with the team performance while analysing the data quality issues. The study needs to analyse the anthropometric data quality indicators among children in the age groups below 24 months and 24-59 months as it has unique characteristics in terms of growth and measurement processes and protocols. This gives a comprehensive understanding of the data quality as it considers multiple indicators for the assessment. We don't analyse whether children are showing extreme values for height was placed on the central values to reduce the biases of the study sample or not. The study is limited to show weeks spent in a cluster of PSUs, number of teams involved and team size- those have determined the survey loads to an extent.

Mapping of the states in terms of anthropometric measures such as stunting and wasting and reported date of birth has been done in this study. Anthropometric data quality on separate indicators has been assessed across the state along with the performance of the survey teams has been followed. It is clearly understood that agencies working in certain regions of the state need much more proactive steps to improve the data quality in the survey. Monitoring and evaluation of the data quality have been maintained during the survey, however, emphasis must be given to the phases of data collection in large scale surveys. The difference in the data quality goes beyond the simple understanding of measurement error and dearth in training. Allocation of budget, motivation, and admiration for better data quality must be promoted while conducting a large-scale survey.

Data availability

NFHS is the anonymous, publicly available dataset, and is accessible upon request from the DHS Program at https://dhsprogram.com/data/available-datasets.cfm.

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Table 1: Summary Statistics of teams performance in each quality indicator for HAZ, and WHZ, India, NFHS-2015-21

	NFHS-4 (2015-16)	NFHS-5(2019-21)
Complete DOB	99.01	99.92
Complete anthropometric measurements	98.46	96.57
Digit Preference height (%)	15.19	14.36
Digit Preference Age(%)	0.78	0.62
Implausible values HAZ	3.41	2.28
Implausible values WHZ	4.70	4.20
Absolute Difference in mean HAZ by MOB(%)	0.28	1.92
SD of HAZ(%)	1.77	1.85
SD of WHZ(%)	1.40	1.50
Height inappropriate	4.99	5.60

Table 2: Summary statistics of Data quality indicators for HAZ and WHZ for states of India, NFHS-4, 2015-16

State	Completeness Of Date Of Birth, %	Completeness Of Anthropometry Measurement, %	Digit Preference For Height, Index Of Dissimilarity, %	Digit Preference For Age At 6-Mo Intervals, Index Of Dissimilarity, %	Biologically Implausible ("Flagged") Values For HAZ, %	Biologically Implausible ("Flagged") Values For WHZ, %	Absolute Difference In Mean HAZ By Month Of Birth (December Vs. January), Of HAZ, Z Score	SD Of HAZ, Z Score	SD Of WHZ, Z Score	Height Inappropriately Measured
Andhra Pradesh	96.7	94.5	14.7	0.3	6.1	6.3	0.3	0.9	0.7	5.69
Arunachal Pradesh	96.8	92.0	22.5	0.5	10.8	12.1	0.3	9.3	7.9	5.64
Assam	99.1	96.2	16.2	0.9	5.6	6.7	0.3	2.2	1.8	4.44
Bihar	99.2	99.4	12.0	0.5	2.8	3.2	0.3	1.6	1.1	8.79
Chhattisgarh	99.8	99.7	15.7	1.0	1.3	2.3	1.3	1.9	1.7	1.86
Goa	99.7	99.6	18.2	1.4	2.3	6.9	0.8	2.6	2.1	4.45
Gujarat	97.3	96.9	15.5	0.5	4.8	7.0	0.3	1.6	1.2	5.03
Haryana	99.5	98.9	13.9	0.6	3.6	5.5	0.4	2.1	1.8	6.5
Himachal Pradesh	98.7	97.5	13.0	1.3	4.0	4.7	0.0	2.4	2.1	2.66
Jammu And Kashmir	99.7	98.4	12.8	0.9	4.5	5.5	0.2	3.7	3.0	5.67
Jharkhand	99.7	98.9	14.0	0.4	3.2	5.6	0.3	2.3	1.8	5.86
Karnataka	95.6	98.6	19.4	0.8	5.0	7.3	0.5	1.7	1.4	7.29
Kerala	99.4	98.9	9.6	0.7	3.8	5.6	0.1	1.3	1.1	4.83
Madhya Pradesh	98.8	99.4	14.5	0.7	2.6	3.6	0.3	2.1	1.6	5.19
Maharashtra	97.5	97.6	13.4	1.0	4.7	7.2	0.2	1.3	1.0	4.63

Manipur	99.8	98.9	8.5	0.4	1.6	2.4	0.0	4.8	4.1	1.79
Meghalaya	99.7	98.9	20.3	0.4	3.9	5.6	0.1	4.5	3.6	3.62
Mizoram	98.8	98.9	18.4	1.0	3.9	4.3	0.2	7.6	6.0	5.41
Nagaland	99.4	98.9	15.4	1.1	8.9	10.2	0.3	6.4	5.1	2.77
NCT of Delhi	96.0	80.1	17.8	0.3	21.0	22.2	0.6	1.2	1.0	2.31
Odisha	98.7	99.0	12.9	0.5	3.1	3.8	0.2	1.9	1.6	4.38
Punjab	99.9	99.2	12.9	0.5	2.0	3.4	0.3	1.7	1.5	1.9
Rajasthan	99.8	99.2	11.4	1.0	2.1	3.8	0.2	1.8	1.5	2.48
Sikkim	100.0	98.3	21.1	1.2	3.6	3.5	0.0	7.8	6.9	2.42
Tamil Nadu	99.3	99.6	14.6	0.8	4.2	5.6	0.0	1.4	1.2	6.24
Telangana	95.6	93.2	17.8	1.2	7.6	7.7	0.4	0.9	0.7	3.17
Tripura	99.4	96.3	16.7	1.3	4.5	6.5	0.0	2.5	2.1	5.53
Uttar Pradesh	99.5	99.3	12.7	0.6	2.3	2.9	0.2	1.6	1.2	5.02
Uttarakhand	99.4	98.3	17.0	0.9	3.6	6.2	0.3	3.2	2.6	3.38
West Bengal	99.6	97.2	13.0	0.8	3.8	4.4	0.1	0.8	0.8	6.16

Table 3: Summary statistics of Data quality indicators for HAZ and WHZ for states of India, NFHS-5, 2019-21

State	Completeness Of Date Of Birth, %	Completeness Of Anthropometry Measurement, %	Digit Preference For Height, Index Of Dissimilarity, %	Digit Preference For Age At 6-Mo Intervals, Index Of Dissimilarity, %	Biologically Implausible ("Flagged") Values For HAZ, %	Biologically Implausible ("Flagged") Values For WHZ, %	Absolute Difference In Mean HAZ By Month Of Birth (December Vs. January), Of HAZ, Z Score	SD Of HAZ, Z Score	SD Of WHZ, Z Score	Height Inappropriately Measured
Andaman & Nicobar Islands	100.0	99.4	18.0	6.5	2.5	5.0	0.2	5.9	4.9	4.4
Andhra Pradesh	100.0	95.2	14.4	2.3	1.5	2.7	0.1	1.0	0.8	5.2
Arunachal Pradesh	99.9	98.3	14.8	2.0	2.8	5.8	0.2	11.5	9.6	5.9
Assam	100.0	97.7	17.1	0.3	2.8	5.8	0.3	2.6	2.2	5.5
Bihar	99.9	96.3	14.9	0.8	2.2	3.6	0.2	1.6	1.2	7.8
Chhattisgarh	100.0	96.7	14.7	1.5	2.2	4.3	0.5	2.3	1.9	4.4
Dadra & Nagar Haveli	100.0	97.0	19.2	0.9	2.0	2.7	0.5	5.1	3.8	5.7
Goa	100.0	94.4	11.4	1.7	1.4	2.4	0.6	2.5	1.9	4.4
Gujarat	99.9	98.0	16.1	1.0	2.5	5.2	0.2	2.0	1.6	5.7
Haryana	100.0	95.0	15.4	1.6	1.5	2.2	0.3	2.1	1.7	4.0
Himachal Pradesh	100.0	97.5	17.8	2.0	1.8	4.1	0.0	3.1	2.7	3.1
Jammu & Kashmir	100.0	97.8	17.0	2.3	4.4	8.1	0.7	4.2	3.6	4.2
Jharkhand	100.0	97.1	18.2	1.9	2.5	4.7	0.3	2.2	1.8	5.0
Karnataka	99.9	95.5	14.8	1.1	3.1	6.1	0.2	1.8	1.4	7.5

Kerala	100.0	96.8	11.9	2.2	1.6	3.7	0.4	1.3	1.1	5.1
Ladakh	100.0	99.8	17.9	2.0	5.6	9.2	0.6	10.1	8.6	3.3
Lakshadweep	100.0	97.8	23.9	1.3	1.8	8.8	0.4	9.0	10.1	3.2
Madhya Pradesh	99.9	94.5	15.1	0.8	1.7	3.2	0.4	1.9	1.5	4.6
Maharashtra	99.9	96.1	15.7	0.4	2.8	5.2	0.3	1.4	1.1	6.6
Manipur	100.0	99.0	13.2	3.0	1.7	2.0	0.4	4.4	3.4	4.9
Meghalaya	99.9	98.1	16.4	1.7	1.6	2.9	0.5	5.0	3.9	4.7
Mizoram	99.8	97.6	12.9	2.2	2.9	3.7	0.2	7.3	6.0	5.0
Nagaland	100.0	99.3	15.3	2.2	1.6	3.5	0.9	7.8	5.9	3.7
NCT Of Delhi	100.0	92.7	17.0	1.2	1.3	3.2	0.4	1.8	1.4	3.4
Odisha	100.0	98.0	12.8	1.6	1.2	3.2	0.3	1.8	1.6	3.9
Puducherry	100.0	99.0	19.1	4.5	1.5	2.1	0.6	3.8	3.3	7.0
Punjab	99.9	95.4	15.8	2.5	1.4	1.9	0.2	1.9	1.7	4.4
Rajasthan	99.7	97.7	11.3	1.5	2.3	4.3	0.3	1.8	1.4	4.8
Sikkim	100.0	86.9	17.1	7.2	2.0	12.1	0.6	7.2	5.9	6.4
Tamil Nadu	100.0	97.6	14.7	1.6	2.3	4.2	0.2	1.3	1.1	5.5
Telangana	100.0	93.3	15.7	1.2	3.4	6.5	0.5	2.4	1.8	7.2
Tripura	99.8	98.8	18.3	2.8	2.2	5.7	0.5	3.6	3.2	4.6
Uttar Pradesh	99.9	96.5	14.5	1.1	2.3	4.2	0.4	1.7	1.3	5.2
Uttarakhand	99.9	92.2	17.1	1.8	1.3	2.2	0.1	2.6	2.1	4.5
West Bengal	100.0	98.1	14.8	2.5	2.4	4.1	0.0	1.1	0.9	4.9

Figure 1 : Ranking of Indian states based on HAZ data quality indicators India, NFHS-2015-21

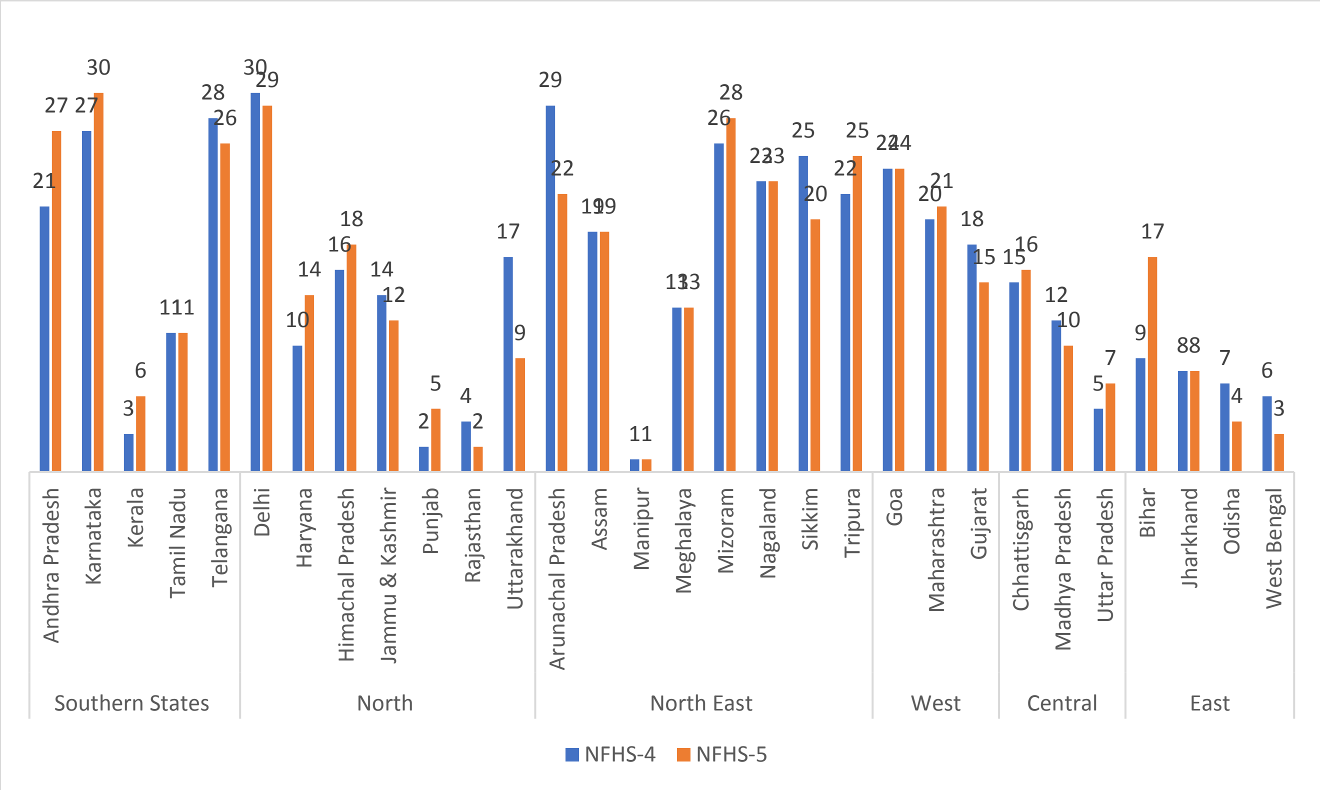


Figure 2 : Ranking of Indian states based on WHZ data quality indicators India, NFHS-2015-21

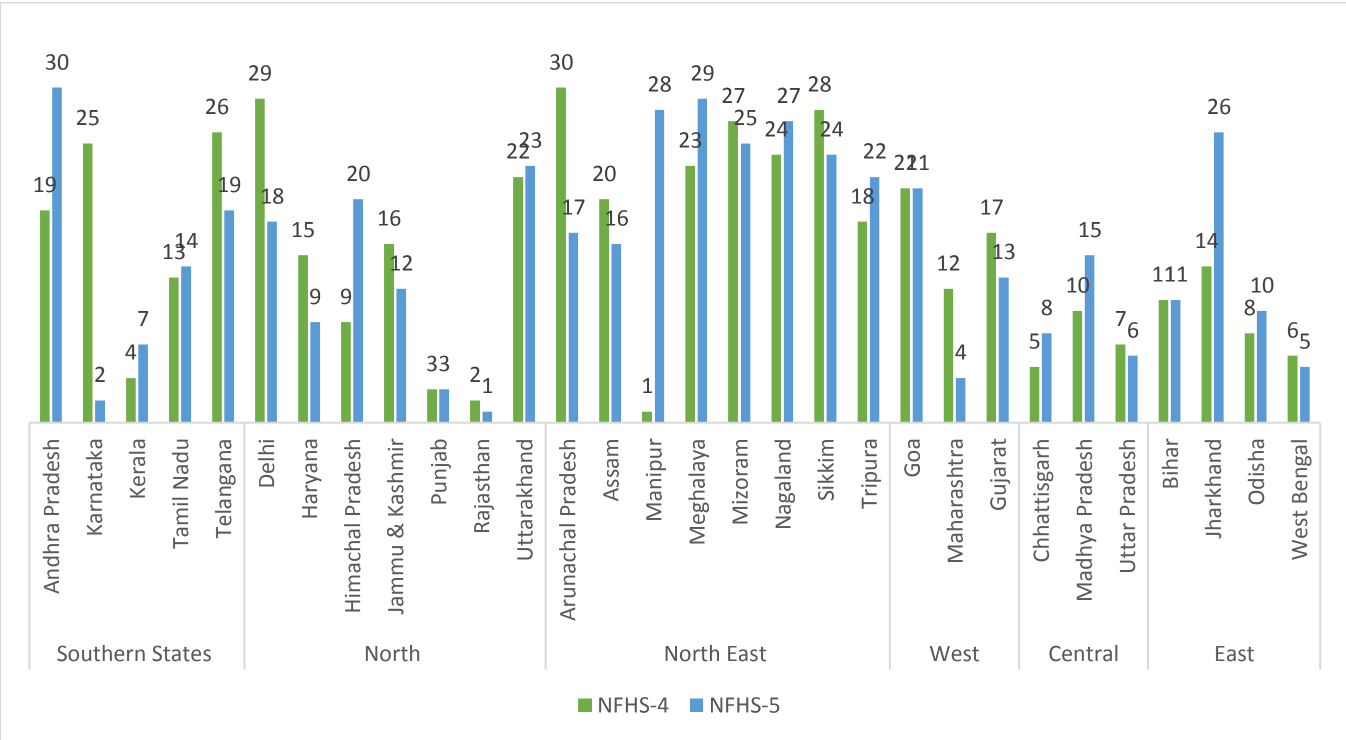
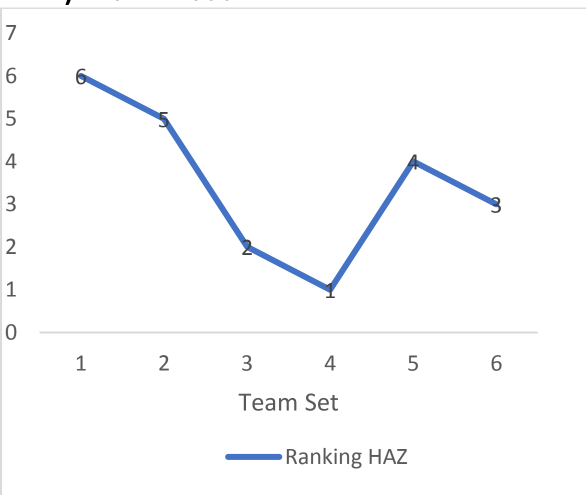


Table 3: Ranking of HAZ and WHZ data quality indicators by timing of the interview, NFHS-4, and 5

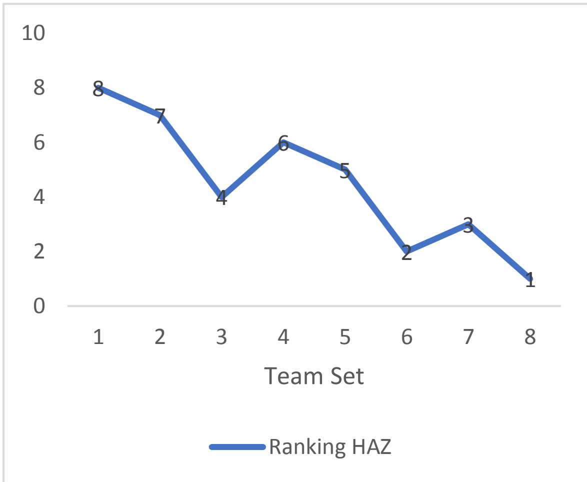
Timing of the interview	Ranking Index HAZ		Ranking Index WHZ	
	NFHS-4	NFHS-5	NFHS-4	NFHS-5
Beginning (First 3 months)	3	3	3	3
Middle (4-7 months)	1	2	1	2
End (8-12 months)	2	1	2	1

Figure 3: Ranking of HAZ data quality indicators by the timing of the interview (denoted by team set) for eight states of India, NFHS-4

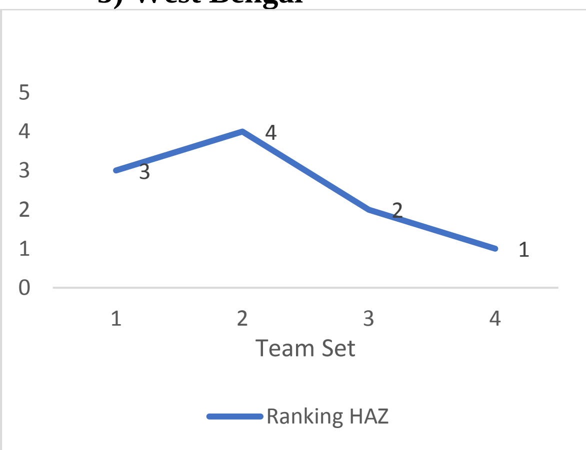
1) Tamil Nadu



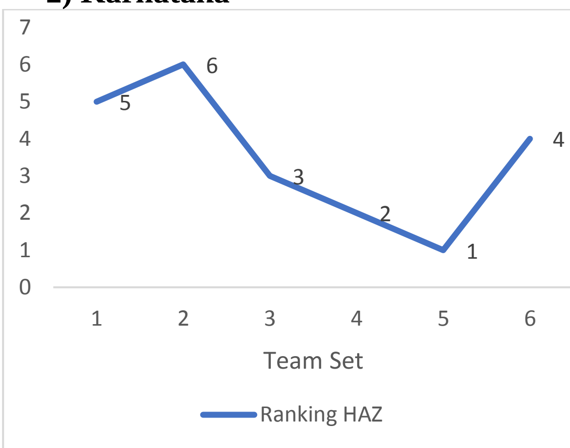
4) Bihar



5) West Bengal

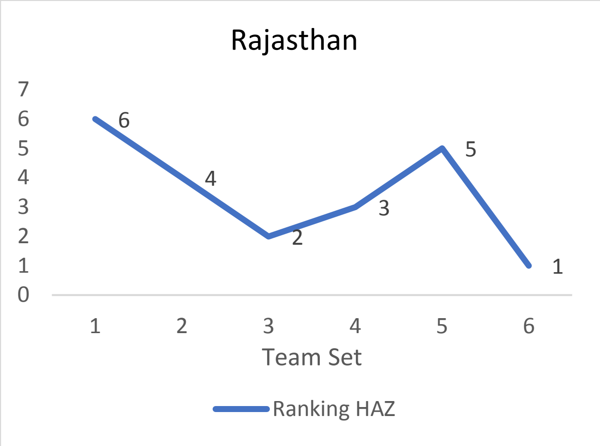


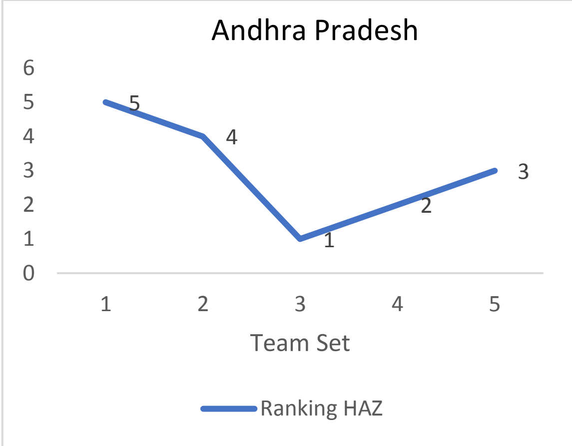
2) Karnataka



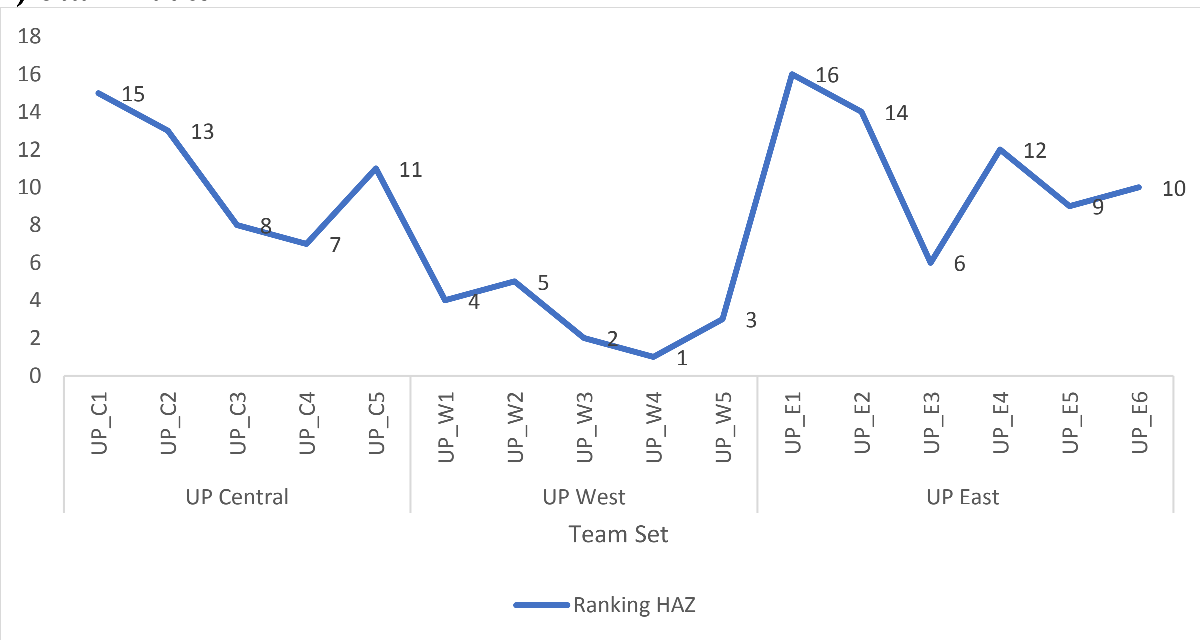
6) Rajasthan

3) Andhra Pradesh





7) Uttar Pradesh



8) Madhya Pradesh