# BITS Pilani, Hyderabad Campus

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Project Report
Area of study - Children

# Prevalence of Malnutrition among Children under-5 in India

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**Abstract**

This study aimed to determine the prevalence of malnutrition in children under 5 in India and identify the associated constructs, including birth spacing, mother's nutritional status, mother's education, and socio-economic factors. We have used the KR dataset from National Family and Health Survey (NFHS 3,4,5) for developing the reports and analysing the constructs identified. The findings suggest that interventions aimed at improving maternal nutrition, birth spacing, and education and addressing socio-economic factors could effectively reduce malnutrition in children under 5 in India. The report consists of background, conceptualization, dimensional modelling, and BI reports for analysis by stakeholders and decision-makers. KPI development is done on the basis of five constructs using group Analytical Hierarchy Processing (AHP) technique and even DAX queries, discussed in the conceptualization section. Relevant facts and dimensions tables and their attributes have been identified in the dimensional modelling section. PowerBI tool will be used for data analysis and visualization to help the decision-makers.

Key Terms- Data Warehouse, Key Performance Index(KPI), Dimensional Modeling, Analytical Hierarchy Processing(AHP), BI reports.

# 1 Introduction

Malnutrition among children under the age of 5 is a significant public health issue in India. Despite the country's economic growth in recent years, malnutrition remains widespread, with high rates of underweight, stunted, and wasted children. This issue has far-reaching implications, affecting not only children's physical growth and development but also their cognitive development and future economic prospects. The prevalence of malnutrition in India is affected by several factors, including poverty, lack of access to healthcare and education, poor sanitation, and inadequate nutrition education. In this context, several studies have been conducted to understand the prevalence of malnutrition among children under the age of 5 in India and its associated risk factors. The following review of recent studies aims to shed light on the current state of malnutrition among children under 5 in India and identify potential interventions to address this pressing issue.

According to the National Family Health Survey (NFHS) conducted in 2019-20, the prevalence of malnutrition among children under the age of five in India is 34.7%. This is a significant decrease from the previous survey conducted in 2015-16, which reported a prevalence of 38.4%. However, the issue of malnutrition among children in India remains a serious concern, with many children still suffering from stunted growth, being underweight, and wasting.

The NFHS is a comprehensive household survey conducted by the Indian government to collect information on various health and social indicators, including malnutrition among children. However, exploring and using this data can be difficult for various reasons.

Firstly, the NFHS is a massive dataset, with information collected from over 700,000 households across India. This makes it challenging to navigate and analyze the data effectively, especially for those without a statistics or data analysis background.

Secondly, the data is often presented in complex tables and graphs, which can be overwhelming for typical decision-makers in public health who may not have experience with data visualization tools.

Thirdly, there is often a lack of awareness and understanding of the importance of using data to inform decision-making among policymakers and program managers in India. This can lead to a lack of interest in exploring and utilizing the NFHS data to address children's malnutrition.

To enhance data utilisation, especially for exploration by typical decision-makers in public health, it is crucial to simplify the presentation of data and provide user-friendly interfaces for data exploration. This can be achieved by creating dashboards and interactive tools that allow users to explore the data easily and visualize the information meaningfully. It is also important to provide training and capacity-building programs for policymakers and program managers on the importance of using data to inform decision-making. This can help create a culture of data-driven decision-making and increase the demand for data and evidence-based policies and programs.

Finally, there is a need for increased collaboration between researchers, policymakers, and program managers to ensure that the NFHS data is being used effectively to address the issue of malnutrition among children in India. By working together, stakeholders can develop evidence-based policies and programs that significantly impact the lives of millions of children in India.

Data exploration is an essential step in any data analysis process. It involves analyzing and visualizing the data to discover patterns, trends, and insights to help businesses make informed decisions. In recent years, significant advancements in tools and technologies have made data exploration easier and more efficient. However, these powerful tools require a dimensional model used in data warehousing, for which businesses must identify the necessary parts of the nfhs datasets and model them as fact and dimension tables to simplify data exploration and analysis. While this process can be complex, the benefits of creating a dimensional model are significant, including improved data quality, faster query performance, and more accurate insights.

Exploring and using data on the prevalence of malnutrition among children under 5 in India can be challenging due to several factors. Firstly, the data is often scattered across multiple sources and can be difficult to access and interpret. Secondly, the data may not always be up-to-date or comprehensive, making it challenging to draw accurate conclusions or develop effective interventions. Additionally, the data quality may vary across different regions or states, making it challenging to compare and analyze trends at a national level.

To enhance the utilization of data on the prevalence of malnutrition among children under 5 in India, it is essential to focus on improving data collection, analysis, and dissemination. Efforts can be made to streamline data analysis and reporting processes, making it easier for decision-makers to access and use the information.

The powerful tool we will use for data exploration is Microsoft Power BI. Power BI is a data visualization tool allowing users to create interactive dashboards and visualizations. Power BI is designed to work with data warehouses and supports the use of dimensional models. By connecting Power BI to a data warehouse with a dimensional model, users can easily explore data and create compelling visualizations.

In our work, we've used the KR Children dataset of NFHS. Four constructs, namely: Socio-Economic factors, Birth Spacing, Mother's Health and Mother's Education, were selected, and their respective attributes were extracted from the dataset. Also, the relationship between the constructs was identified based on a literature survey. Then the fact and dimension tables were constructed, dimensional modeling was done, required measures were calculated using Stata commands and added to the fact table, relevant scores for constructs were calculated using AHP, then the visualizations to be shown were decided upon and were designed using PowerBI desktop.

# 2 Background

The prevalence of malnutrition among children under the age of five in India is a significant public health concern. Several studies have explored the factors associated with malnutrition in this population, including succeeding birth interval (SBI), maternal education, household income, and access to healthcare.

A study by Bose et al. (2013) investigated the relationship between SBI and malnutrition among under-five children in India. The authors found that children born within 24 months of their previous sibling had a higher risk of malnutrition compared to those born after 36 months. The study also found that the mother's age at first childbirth and education level were significant predictors of malnutrition in children. [1]

Another study by Karmakar and colleagues (2022) examined the determinants of malnutrition among under-five children in India. The study found that household income, the mother's education, and access to healthcare services were significant factors associated with malnutrition. Children living in households with lower income and mothers with lower levels of education were found to be at a higher risk of malnutrition. [2]

In a third study, Chakraborty et al. (2021) explored the factors associated with malnutrition among children under five in India. The study found that the prevalence of malnutrition was higher in rural areas compared to urban areas and that access to healthcare services was a significant factor associated with malnutrition. The authors also found that children from households with a lower socioeconomic status were at a higher risk of malnutrition. [3, 4]

Finally, a study by De et al. (2013) examined the factors associated with malnutrition among under-five children in West Bengal, India. The study found that maternal education, household income, and access to healthcare services were significant predictors of malnutrition in children. The authors also found that children living in households with a lower socioeconomic status had a higher risk of malnutrition. [5]

In conclusion, several factors contribute to the high prevalence of malnutrition among children under the age of five in India. Interventions aimed at improving these factors can help reduce the prevalence of malnutrition among children under the age of five in India.

We identified the business processes, which are the operational activities being modelled as creating data visualizations such as charts and producing reports to be used by business decision-makers. We declared the grain (lowest level of information) as the child's malnutrition status by mother's demographics, birth spacing and socio-economic factors. We also defined the dimension tables to contain the descriptive entities of the data and identified the facts as the numeric measurements that resulted from our business process.

# 3 Methodology

Conceptualisation, dimensional modelling, and report design are three important steps in developing a data warehouse and reporting system.

Conceptualisation: Conceptualisation identifies the business requirements, data sources, and metrics that will be used to create a data warehouse. This step involves working closely with stakeholders to define the project's scope and identify the key performance indicators (KPIs) that will be used to measure success. The goal of conceptualisation is to create a high-level view of the data warehouse, including the data sources, data transformations, and data models that will be used to support reporting and analysis.

Dimensional Modeling: Dimensional modeling creates a logical data model optimised for reporting and analysis. This step involves identifying the key business processes and entities and then defining the dimensions and measures that will be used to analyse these processes. The key concept in dimensional modelling is the fact table, which contains the metrics that will be analysed. The dimensions are used to slice and dice the data in the fact table, allowing users to analyse the data from different perspectives. The relationships between the fact and dimension tables are established through a set of keys, which are used to join the tables together. This creates a star or snowflake schema, a visual representation of the dimensional model. Dimensional modeling is widely used in business intelligence and data warehousing applications, as it provides a flexible and efficient way to store and access large amounts of data.

Report Design: Report design is creating reports that present the data in a clear and actionable way. This step involves working with stakeholders to identify the types of reports needed, the data included in the reports, and the visualisations used to present the data. The goal of report design is to create reports that are easy to understand and that provide insights that can be used to drive business decisions. This may involve creating dashboards, charts, and tables highlighting key metrics and trends.

Developing a data warehouse and reporting system involves iterative cycles of conceptualisation, dimensional modelling, and report design, with each step building on the work done in the previous step. By following this process, organisations can create a robust reporting system that provides valuable insights and supports data-driven decision-making.

## 3.1 Conceptualisation

To briefly understand the reasons behind the malnutrition in children under age 5, we have identified the following constructs:

Birth Spacing Vs Child Malnutrition:

Several studies have shown a relationship between birth spacing and child malnutrition. A shorter birth spacing (less than two years) has been associated with a higher risk of malnutrition in children. This is because a shorter interval between pregnancies can lead to maternal depletion of nutrients, which can then affect the development and health of the subsequent child.

Additionally, a shorter birth spacing may lead to more competition for resources (such as food and attention) among siblings, resulting in poorer nutritional outcomes for younger children. On the other hand, longer birth intervals (more than three years) have been associated with better nutrition outcomes in children.

It's worth noting that birth spacing is just one of many factors that can contribute to child malnutrition. However, optimizing birth spacing can be an important strategy for reducing the risk of malnutrition in children. [1, 2]

Mother's Demographics Vs Child Malnutrition:

The mother's age at the time of the child's birth can be a factor that affects the child's risk of malnutrition. However, the relationship between these two factors is complex and can vary depending on several other factors.

Several studies have shown that younger mothers (below 20 years of age) and older mothers (above 35 years of age) may have a higher risk of giving birth to malnourished children. Younger mothers may lack knowledge and resources for adequate child care, while older mothers may have a higher risk of pregnancy complications, which can affect the child's health and development. [6]

However, it's important to note that these relationships are not always consistent and can depend on other factors such as maternal education, income, and access to healthcare. For example, a younger mother with better education and resources may have better knowledge and skills for adequate child care, reducing the risk of malnutrition. [7]

Furthermore, maternal age is just one of many factors that can affect the child's risk of malnutrition. Other factors, such as the child's birth weight, the nutritional status of the mother and the socioeconomic factors of the household, can also play a significant role.

In summary, while maternal age can be a factor that affects the child's risk of malnutrition, it's important to consider other factors and address them comprehensively to reduce the risk of malnutrition in children. [3]

Socio-economic factors Vs Child's Malnutrition:

Socio-economic factors can have a significant impact on a child's risk of malnutrition. Children who live in poverty or come from low-income families are more likely to suffer from malnutrition than those from more affluent households. There are several reasons for this:

Lack of access to nutritious food: Low-income families often cannot afford healthy food, such as fresh fruits and vegetables, lean proteins, and whole grains. Instead, they may rely on cheap, calorie-dense foods high in fat, sugar, and salt but low in nutrients. [8, 9]

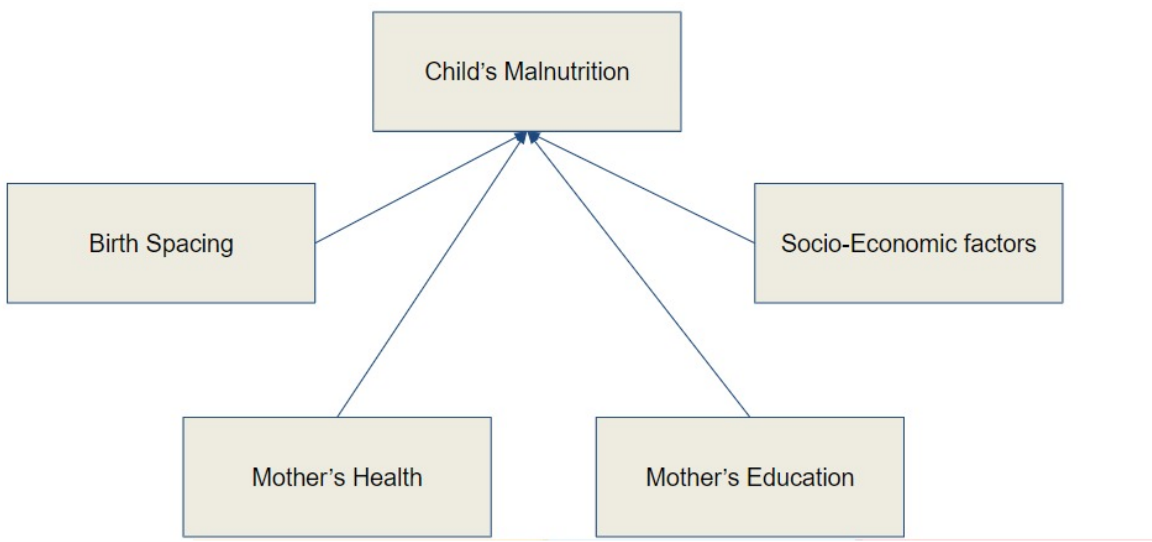
Limited access to healthcare: Families who live in poverty may not have access to healthcare or may be unable to afford medical care for their children. This can make it difficult to identify and treat malnutrition. [10]

Poor living conditions: Children who live in overcrowded or unsanitary conditions are more likely to contract infectious diseases that can lead to malnutrition. They may also be exposed to environmental toxins impairing their growth and development. [11, 12]

Lack of education: Parents who lack education may not understand the importance of proper nutrition or know how to prepare healthy meals. This can contribute to poor dietary habits and malnutrition.

In summary, socio-economic factors play a significant role in a child's risk of malnutrition. Addressing these factors, such as improving access to nutritious food, healthcare, and education, is critical to preventing and treating malnutrition. [5, 13]

**Figure 1:** Constructs identified




## 3.2 Dimensional modeling

Based on the above literature and the data available,

The following attributes are identified for Birth Spacing:

- Total children ever born: This measure tells us the total number of children ever born in the respondent's family, including the deaths.
- Preceding birth interval (months): The preceding birth interval (PBI) refers to the length of time between the birth of one child and the conception of the next child in a family.
- Succeeding birth interval (months): The succeeding birth interval (SBI) refers to the length of time between the birth of one child and the birth of the next child in a family.
- Birth order number: This measure tells us the index number of the child that is born, used for calculating the average birth interval.

The following attributes are identified for Mother's Education:

- Highest educational level: This measure records the value of the respondent's educational level. This typically has the values such as “No education”, ”Primary”, ”Secondary”, and ”Higher”.
- Highest year of education: The respondent's highest education is recorded in accordance with the highest educational level.
- Education in single years: This measure indicates whether the respondent's education is consistent.
- Educational attainment: This attribute primarily talks about the status of the respondent's educational level. It takes values like “No education”, ”Incomplete primary”, ”Complete primary”, ”Incomplete secondary”, ”Complete secondary”, and ”Higher”.

The following attributes are identified for Mother's Health:

- Height/Age standard deviation: This records the stunted measure of the respondent (mother).
- Weight/Height standard deviation (DHS): This records the wasted measure of the respondent(mother).
- Body mass index: This measure can be analyzed, and conclusions can be drawn if the respondent is under, overweight and obese.

The following attributes are identified for Socio-Economic Factors:

- Wealth index combined: This states the combined wealth index of the family. It includes categories like poorest, poorer, middle, richer, and richest. It is a direct measure of the economic status of the family.
- Religion: It records the religion of the respondent and family and can be used as the slicer for the report in the Power BI.

- Belong to a scheduled caste, a scheduled tribe, or other backward class: It records if the respondent and the family belong to sc/st/bc and further this can be used as the slicer in the report.
- Type of place of residence: It includes the following categories: rural and urban.

The following attributes are identified for Child's Malnutrition: [14]

- sex of the child: The sex of the child is recorded and is used as one of the slicers in the report.
- Height/Age standard deviation (new who): This measure gives the stunted value of the child.
- Weight/Height standard deviation (new who): This measure indicates the wastage in the child.
- Weight/Height standard deviation (new who): This measure classified the child as under, overweight and normal.

Based on this, the score of malnutrition for the child is calculated. [3, 15]

The grain of this project is Child's malnutrition status by mother's health and education, birth spacing and socio-economic factors.

For our analysis, we have chosen Star Schema. We simply have one Fact Table (with foreign keys and some explicitly-calculated numerical values) connected with many Dimension Tables (foreign keys referencing primary keys). The figure below shows the Star Schema we have applied to our Intelligence Reports.

**Figure 2:** Star Schema

## 3.3 Design of reports

**Slicers:**

The data is sliced and filtered based on the sex of the child, wealth index, place or type of residence, caste, religion, and state. These filters allow the users to view the data based on specific demographics and geographical locations.

**KPI Development:**

The following KPIs and scores were used for different constructs used in the visuals in PowerBI. Some new measures and columns were created using Stata expressions from the data present in the dataset.

- Child Malnutrition:

  Stunting is a condition where a child's height-for-age is significantly below the expected level for their age. This can be caused by chronic malnutrition and can have long-term effects on physical and cognitive development. The child's height is measured and compared to the WHO Child Growth Standards to determine their stunting level. Stunting levels are classified as follows:

  Severe: $height - for - age < -300$

  Moderate: $height - for - age < -200$

  Not Stunted: $height - for - age \geq -200$

  Wasting is a condition where a child's weight for height is significantly below the expected level for their height. This is often caused by acute malnutrition or illness and can be life-threatening if not treated promptly. The child's weight and height are measured and compared to the WHO Child Growth Standards to determine their wasting level. Wasting levels are classified as follows:

  Severe: $weight - for - height < -300$

  Moderate: $weight - for - height < -200$

  Not Wasted: $weight - for - height \geq -200$

  Underweight is a condition where a child's weight-for-age is significantly below the expected level for their age. This can be caused by malnutrition or illness and can have long-term effects on physical and cognitive development. The child's weight is measured and compared to the WHO Child Growth Standards to determine their underweight level. Underweight levels are classified as follows:

  Severe: $weight - for - age < -300$

  Moderate: $weight - for - age < -200$

  Overweight: $weight - for - age > 200$

  Not Underweight: $-200 \leq weight - for - age \leq 200$

  These classifications can be used to analyze and understand the prevalence and severity of child malnutrition in different populations and regions. We have calculated the relative weights for the stunting, wasting and underweight using the AHP technique. A score is assigned for malnutrition based on these weights. [Refer Figure10]

The Stata commands for this construct are as follows:

```
. gen childMalScore = 0.64*stunted+0.28*wasted+0.073*underweight

. replace stunting = "severe" if stunting <= -300

. replace stunting = "moderate" if stunting <= -200

. replace stunting = "not stunted" if stunting > -200

. replace wasting = "severe" if wasting <= -300

. replace wasting = "severe" if wasting <= -200

. replace wasting = "not wasted" if wasting > -200

. replace underweight = "severe" if underweight <= -300

. replace underweight = "moderate" if underweight <= -200

. replace underweight = "not underweight" if underweight <= 200

. replace underweight = "overweight" if underweight > 200
```

- Socio-Economic Factors:

  The weights for different attributes of the wealth index are calculated using the AHP technique and a separate column is made for the same. [Refer Figure11]

  The Stata commands for this construct are as follows:

```
. gen socioEcoScore

. replace socioEcoScore = 0.035 if wealthIndex == "poorest"

. replace socioEcoScore = 0.067 if wealthIndex == "poorer"

. replace socioEcoScore = 0.134 if wealthIndex == "middle"

. replace socioEcoScore = 0.26 if wealthIndex == "richer"

. replace socioEcoScore = 0.5 if wealthIndex == "richest"
```

- Mother's Education:

  Mother's education score is a composite measure that takes into account the highest level of education attained by the mother and her educational attainment. The individual scores for each sub-criterion are determined using AHP and then added together to obtain the final mother's education score. The higher the mother's education score, the higher her level of education and attainment.

The scores are as follows:

No Education: 0.05 (for Education Level Score) and 0.025 (for Education Attainment Score)

Incomplete Primary: 0.043 (for Education Attainment score)

Primary Education: 0.15 (for Education Level Score) and 0.055 (for Education Attainment Score)

Incomplete Secondary: 0.15 (for Education Attainment score)

Secondary Education: 0.17 (for Education Level Score) and 0.16 (for Education Attainment Score)

Higher Education: 0.63 (for Education Level Score) and 0.49 (for Education Attainment Score) [Refer Figure12, 13]

The Stata commands for this construct are as follows:

```
. gen eduLevelScore, eduAttScore

. replace eduLevelScore = 0.05 if eduLevel == "no education"

. replace eduLevelScore = 0.15 if eduLevel == "primary"

. replace eduLevelScore = 0.17 if eduLevel == "secondary"

. replace eduLevelScore = 0.63 if eduLevel == "higher"

. replace eduAttScore = 0.025 if eduAtt == "no education"

. replace eduAttScore = 0.043 if eduAtt == "incomplete primary"

. replace eduAttScore = 0.055 if eduAtt == "complete primary"

. replace eduAttScore = 0.15 if eduAtt == "incomplete secondary"

. replace eduAttScore = 0.16 if eduAtt == "complete secondary"

. replace eduAttScore = 0.49 if eduAtt == "higher"

. gen mothersEduScore = eduLevelScore + eduAttScore
```

- Mother's Health:

  Stunting, wasting and BMI are given respective weights with the help of the AHP technique [Refer Figure14]. The corresponding score for the mother's health is calculated based on these weights. The classification for stunting and wasting is similar to that of a child's stunting and wasting. BMI levels are classified as follows:

  Underweight: $BMI\_SD < -2$

  Normal: $BMI\_SD < 1$

Overweight: $BMI\_SD < 2$

Obese: $BMI\_SD \geq 2$

The Stata commands for this construct are as follows:

```
. gen bmi_zscore = bmi − median_bmi / SD_bmi

. gen motherHealthSocre = 0.22*stunted+0.095*wasted+0.68*bmi_zscore

. replace bmi_zscore = "underweight" if bmi_zscore < −2

. replace bmi_zscore = "normal" if bmi_zscore < 1

. replace bmi_zscore = "overweight" if bmi_zscore < 2

. replace bmi_zscore = "obese" if bmi_zscore >= 2
```

- Birth Spacing:

  Birth spacing is measured in birth interval months as preceding birth interval, succeeding birth interval and marriage to first birth interval. We followed a rule-based approach to classify the birth spacing and calculate the score for this construct.

  In the process of combining the available information in the above-said columns, we consider the preceding birth interval or succeeding birth interval if either is available. If both are available, we consider the maximum of preceding and succeeding birth intervals; if neither is present, we consider the marriage to the first birth interval.

  The final birth interval level is classified as short for 5 to 17 months, normal for 18 to 60 months, and long for greater than 60 months.

  The corresponding weights for short, normal and long are calculated using the AHP technique and the score for birth spacing is calculated accordingly. [Refer Figure15]

  The Stata commands for this construct are as follows:

```
. gen finalBirthInt

. replace finalBirthInt = precedingBirthInt if
  succeedingBirthInt == .

. replace finalBirthInt = succeedingBirthInt if
  preceedingBirthInt == .

. replace finalBirthInt = max(precedingBirthInt,succeedingBirthInt)
  if finalBirthInt == .

. replace finalBirthInt = marriageToFirstBirth if
  finalBirthInt == .

. gen finalBirthIntScore = 0.068*finalBirthInt if
  finalBirthInt >= 5 and finalBirthInt < 17
```

```
. replace finalBirthIntScore = 0.78*finalBirthInt if
  finalBirthInt >= 18 and finalBirthInt < 60

. replace finalBirthIntScore = 0.154*finalBirthInt if
  finalBirthInt > 60
```

Some key challenges in Dimensional Modeling that we addressed are:

- Initially created all dimension tables first using MS Excel for simplicity, but later learned to build Dimension Tables and construct Star Schema directly using Power BI.
- Applying Bi-Directional Mapping to/from the Fact Table to District dimension so that we are able to slice the data appropriately.
- Learning about Stata commands so that we are able to explicitly calculate helper numeric attributes to develop KPIs in our Intelligence Reports.

**Visualizations:**

This project uses a variety of visualizations to display the data, including maps, stacked column charts, pie charts, donut charts, and area charts. These visualizations provide different ways to view the data and highlight specific trends and patterns.

Map Visualization: The map visualization is used to display the data geographically, allowing users to view the data at the state or district level.

Stacked Column Chart: The stacked column chart is used to display the distribution of different variables, such as the proportion of children who are stunted, wasted, or underweight based on different demographic factors.

Pie and Donut Charts: The pie and donut charts are used to display the percentage breakdown of different variables, such as the proportion of children who are stunted or wasted based on different demographic factors.

# 4 Dimensional model and Report design

**Table 1:** Fact table and attributes

| ***Item*** | ***Attributes*** |
|---|---|
| Birth Spacing | marriage to first birth interval(months), preceding birth interval (months), succeeding birth interval (months), Final Birth Interval, Birth Int Score, finalBirthIntervalLevel (fk), Birth order number, Total children ever born |
| Mother's Education | educational Level Score (fk), educational attainment score (fk), mother education score |
| Mother's Health | Stunted sd, motherstuntingLevel(fk), Wasted sd, motherwastingLevel(fk), Bmi, Bmi z score, bmiLevel (fk), mother Health Score |
| Socio-Economic factors | Wealth index combined (fk), Religion (fk), Caste (fk), Residence (fk), state (fk) |
| Child's Malnutrition | child malnutrition score,Stunted sd, stuntingLevel (fk),wasted sd, wastingLevel (fk), underweight sd, underweightLevel (fk), sex of child (fk) |
| Identification number | ID (pk) |

**Table 2:** Confirmed dimension tables and attributes.

| ***Dimension Table*** | ***Attributes*** |
|---|---|
| Mothers stunting | **motherstuntingLevel key**, motherstuntingLevel |
| Childs stunting | **stuntingLevel key**, stuntingLevel |
| Wealth Index | **Wealth key**, wealth index combined |
| Edu Attainment | **educational attainment key**, educational attainment score |
| Edu Level | **educational Level Key**, educational Level Score |
| Religion | **Religion key**, Religion |
| State | **State key**, State |
| Caste | **Caste key**, Caste |
| Residence | **Residence key**, residence |
| BMI | **bmiLevel key**, bmiLevel |
| Underweight | **underweightLevel key**, underweightLevel |
| Sex | **Sex key**, sex |
| Mothers wasting | **motherwastingLevel key**, motherwastingLevel |
| Childs wasting | **wastingLevel key**, wastingLevel |

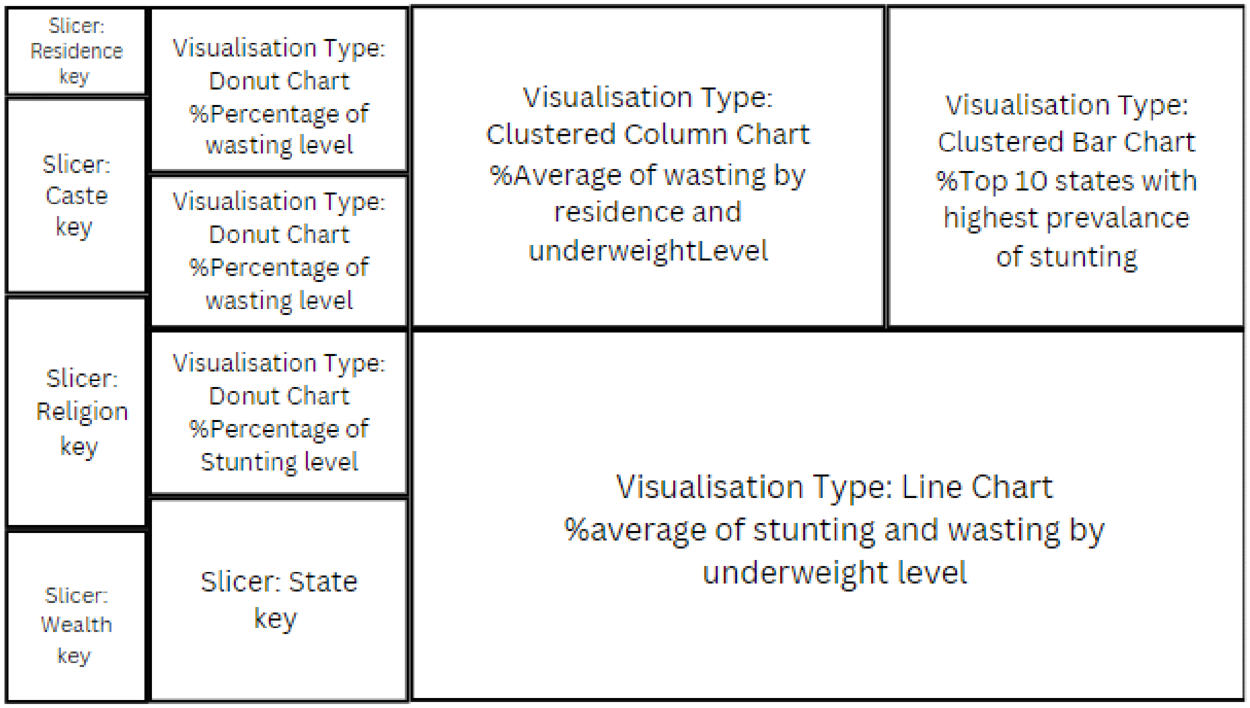
The truth table is connected to the dimension tables via a ”many to one” cardinality which refers to the relationship between two tables where one table contains multiple rows that can match a single row in the other table. ”many to one” relationship is defined between these tables by specifying that the truth table has a foreign key column that references the dimension table’s primary key column. This establishes the relationship between the tables and allows you to create visualizations that show the truth table numeric data by their key values.

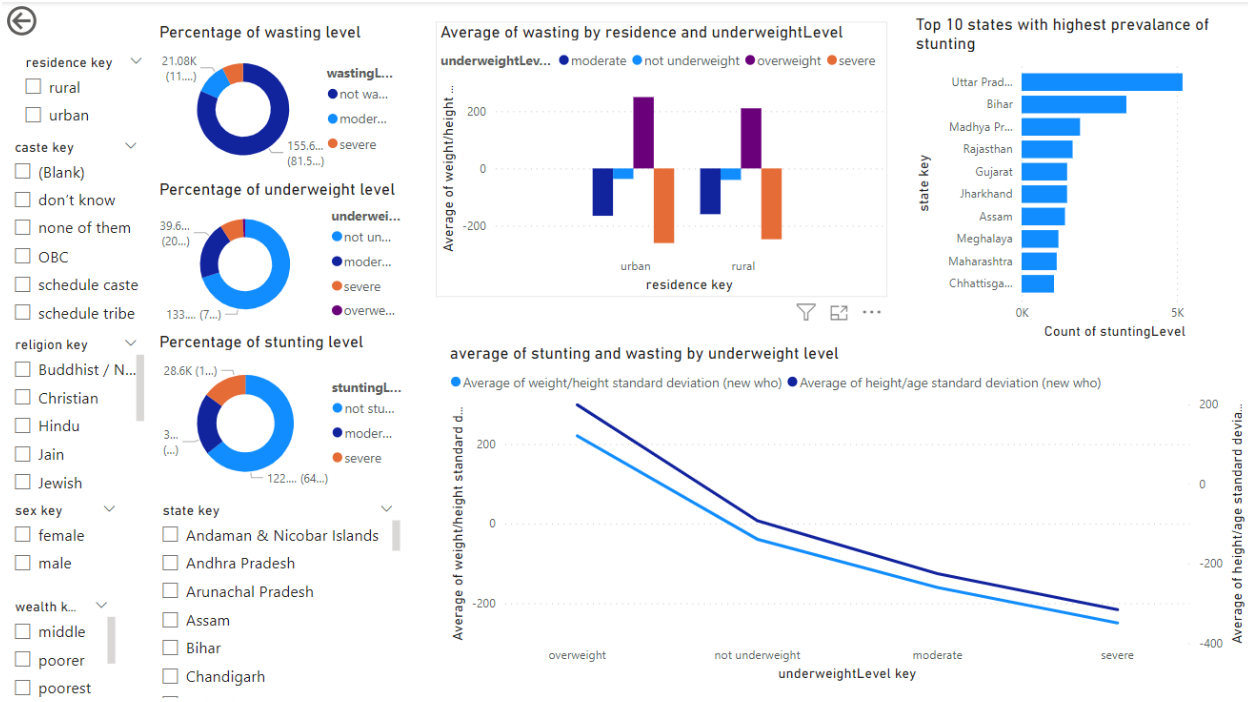
Cross-filter direction is a setting that defines the relationship between two tables in a data model. When you create a relationship between two tables, you can specify the cross-filter direction to control how filtering works between the tables.

”Single” cross-filter direction means that filtering will flow in only one direction, from the table on the ”one” side of the relationship to the table on the ”many” side. This means that if you select a value in a field in the ”one” table, only the related records in the ”many” table will be displayed, but the selection in the ”many” table will not impact the ”one” table.

Layout Designs and Power BI reports for Single Constructs

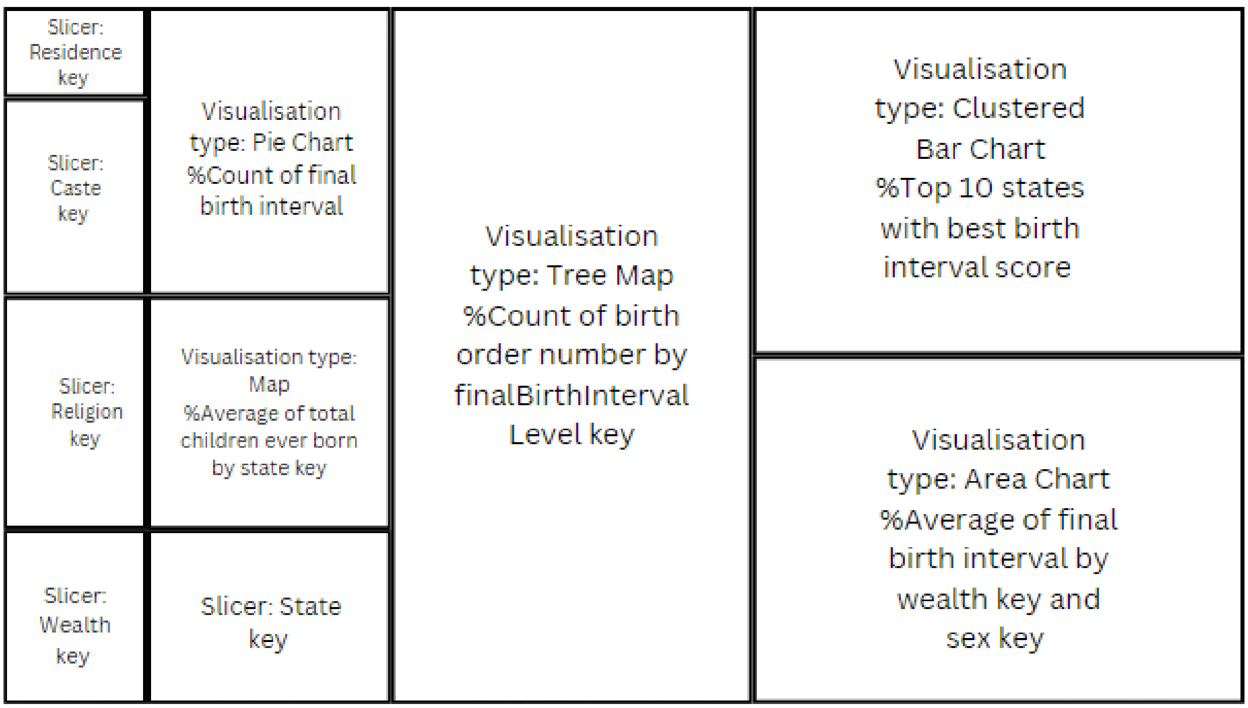
**Figure 3:** Child Malnutition

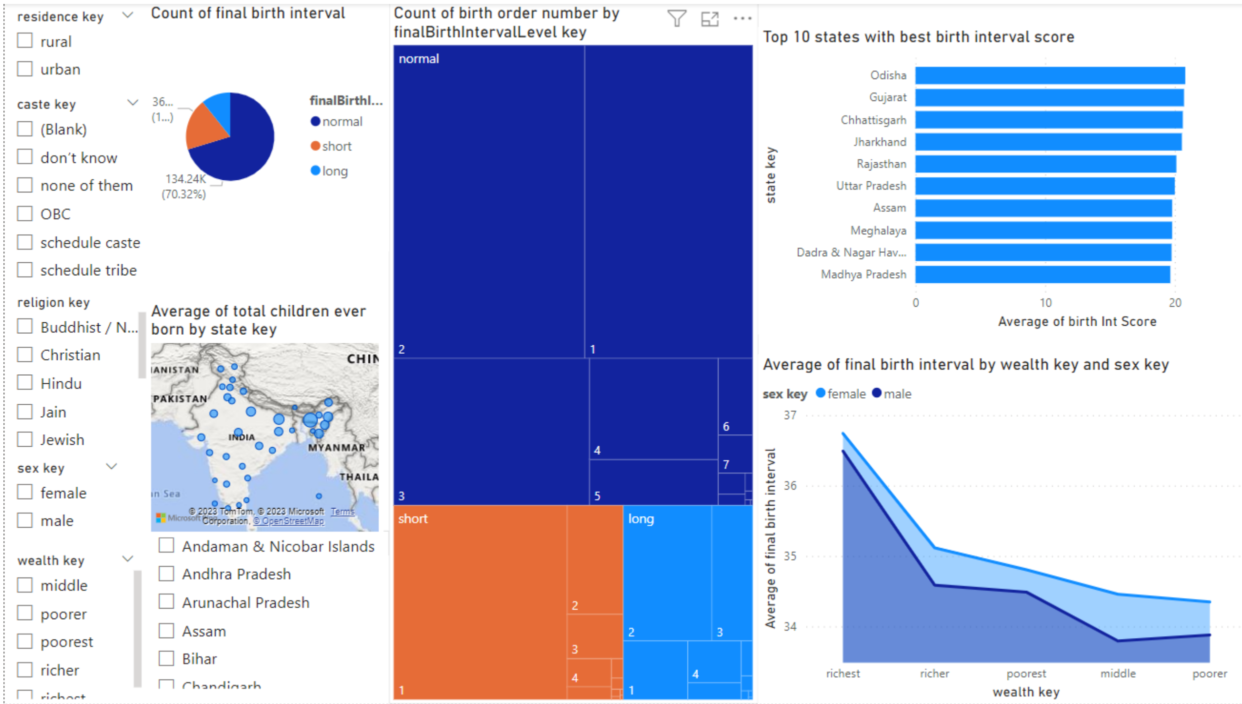





By providing information on the percentage of children who are wasting, underweight, and stunted, the report helps to identify the extent of the problem. This information can then guide interventions aimed at reducing malnutrition and its impact. The other charts can be used to identify trends and patterns in malnutrition and target specific populations and areas that require more attention and resources. Thus, the Power BI report is a valuable tool for understanding child malnutrition's prevalence and impact and guiding interventions to reduce the problem and its consequences.

**Figure 4:** Birth Spacing

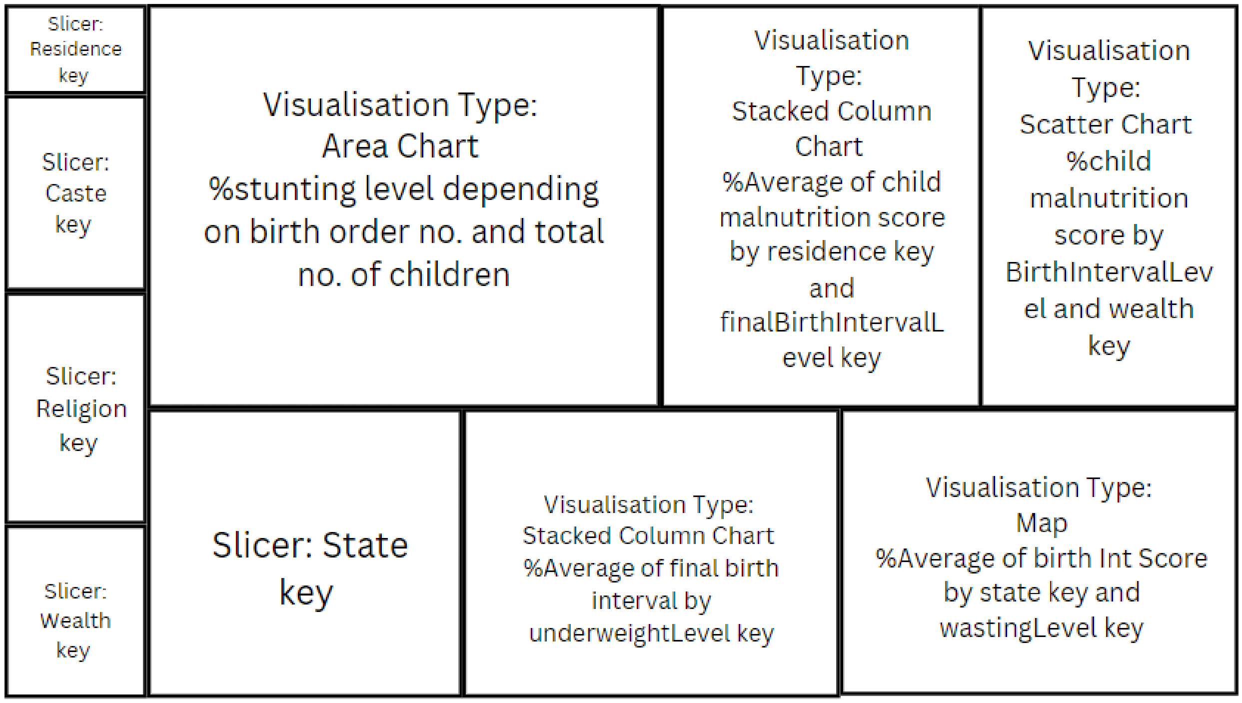


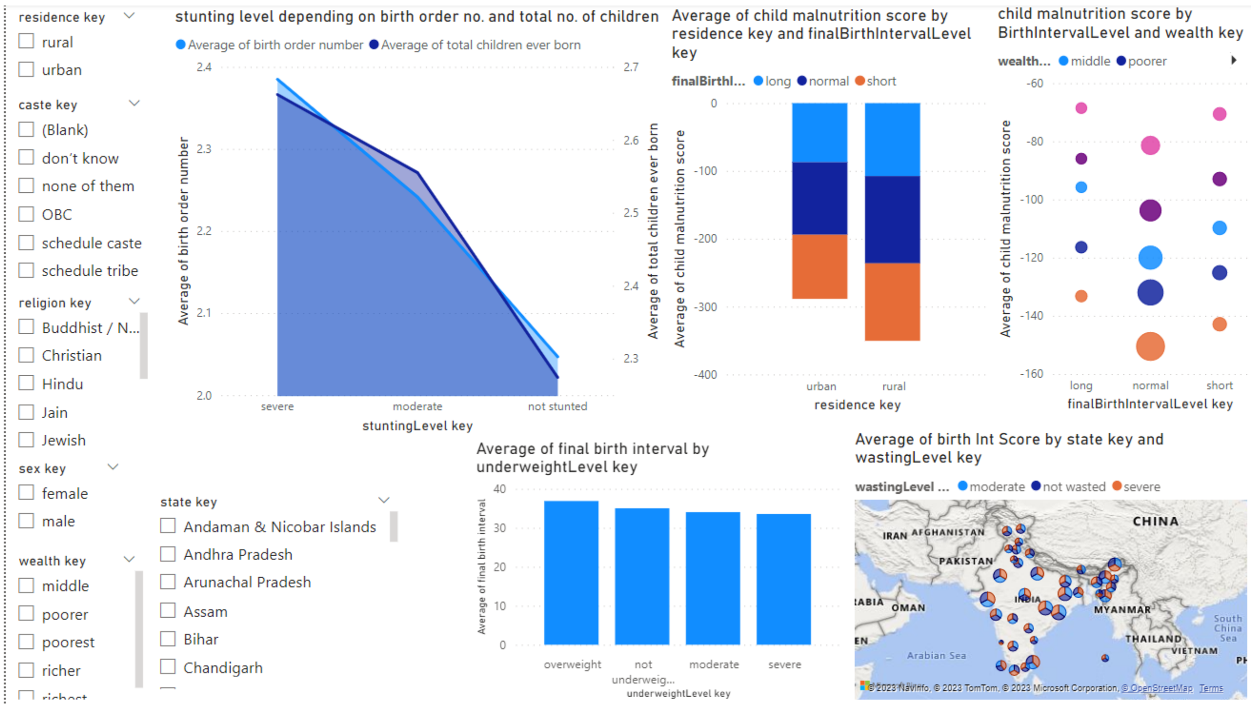



The report is important for understanding the prevalence, patterns, and determinants of birth intervals, critical for maternal and child health. The report provides information on the distribution of birth intervals, birth order, and geographic location, as well as the relationship between birth intervals and socio-economic status and gender. This information can identify areas of need and guide interventions aimed at improving birth spacing, maternal and child health, and reducing health disparities.

Layout Design and Power BI reports for Pairs of Constructs

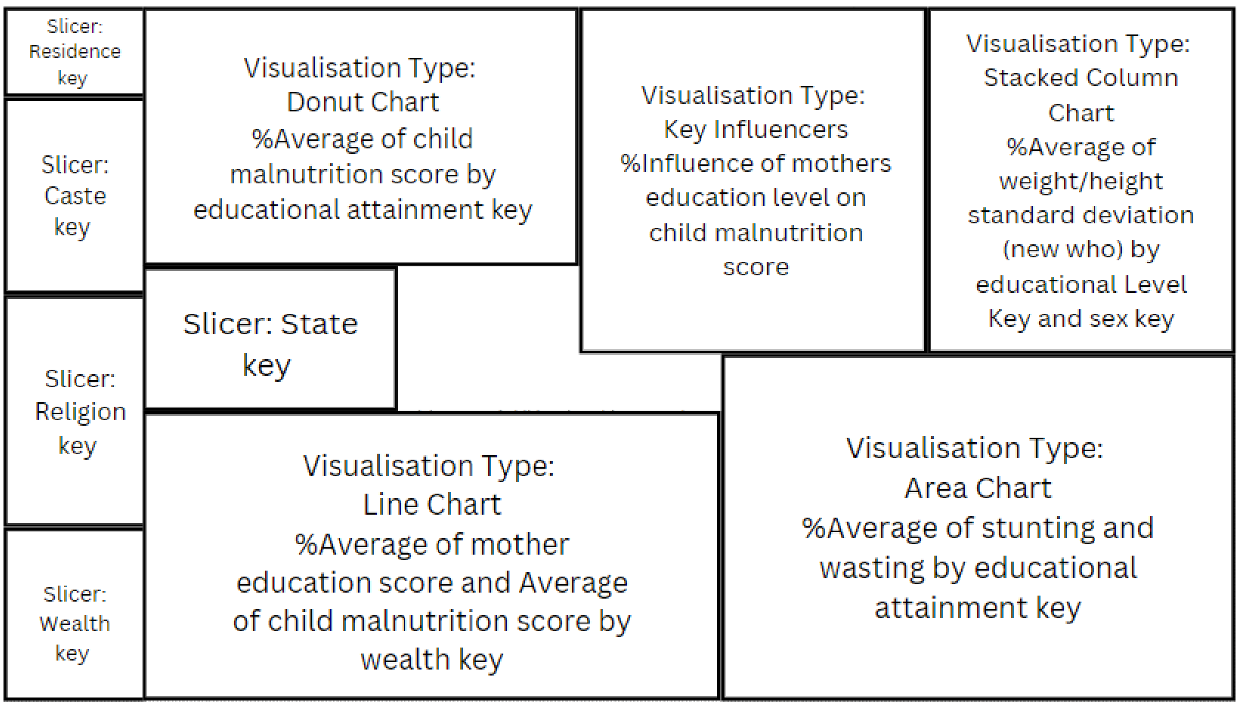
**Figure 5:** Child Malnutrition and Birth Spacing

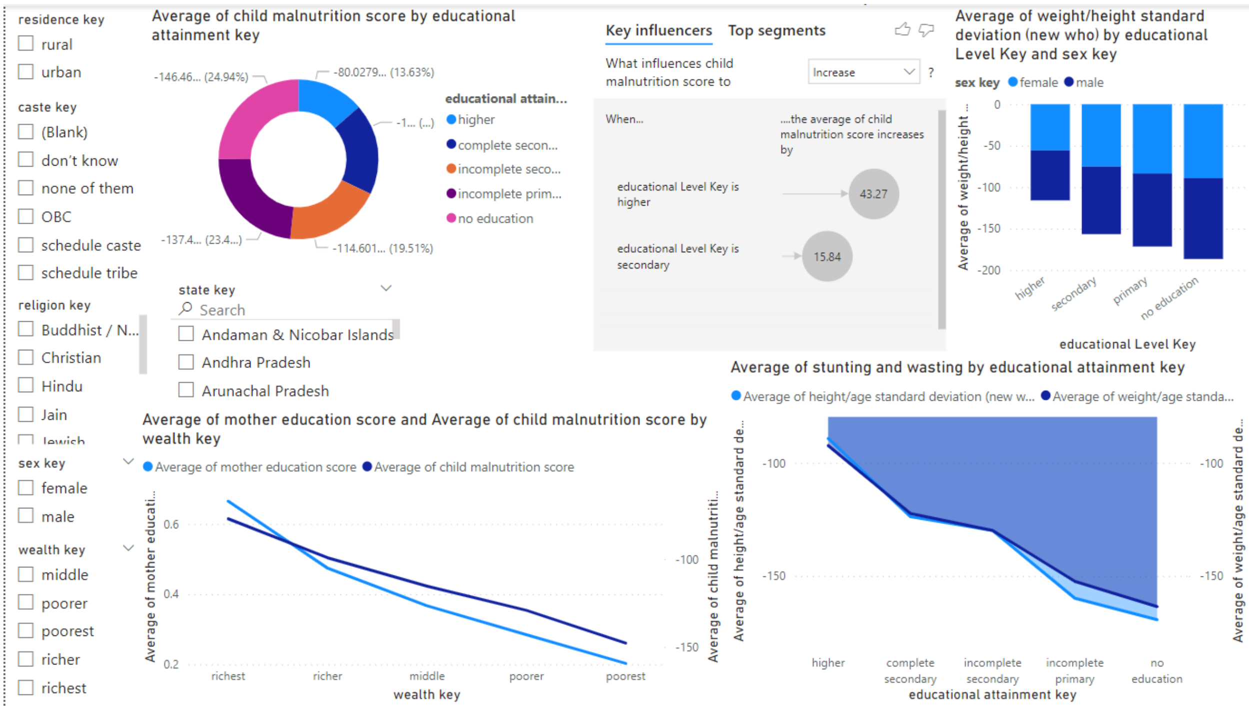





By combining information on birth intervals with information on child malnutrition, the report can provide a more comprehensive understanding of the factors contributing to children's malnutrition. This information can then guide interventions to improve maternal and child health outcomes, such as family planning programs promoting optimal birth intervals and nutrition programs targeting children and women at different reproductive cycle stages.

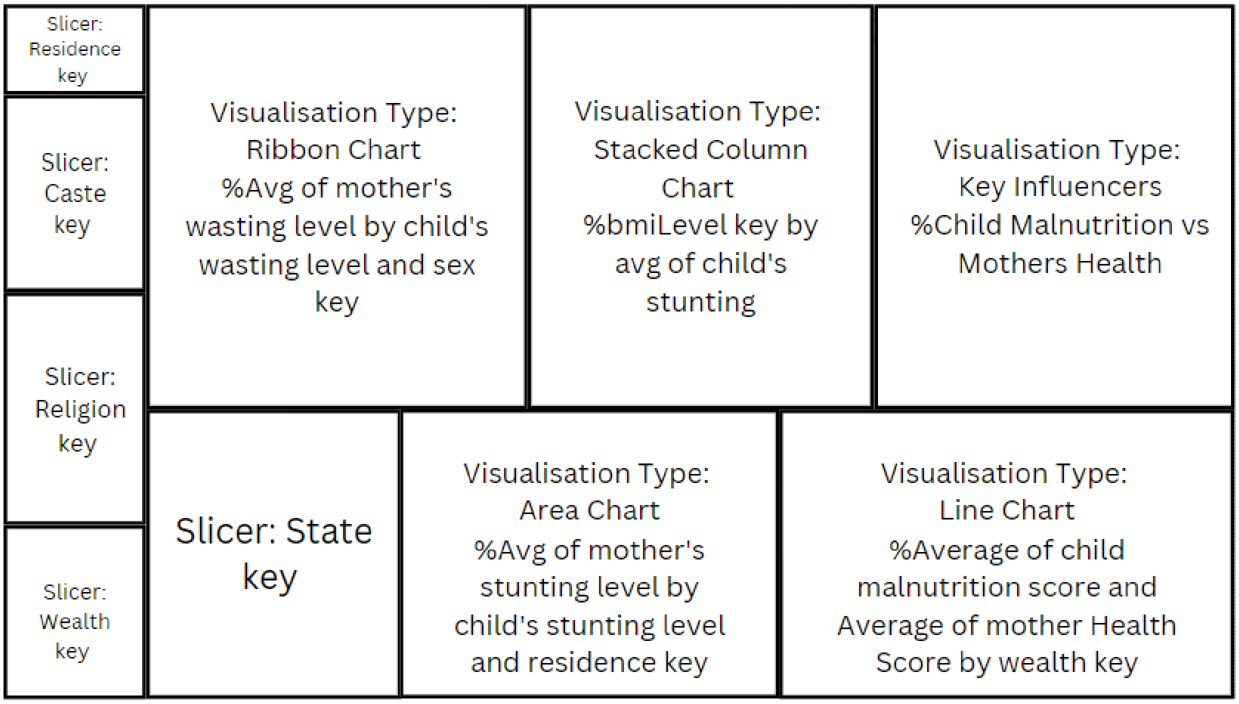
**Figure 6:** Child Malnutition and Mother's Education

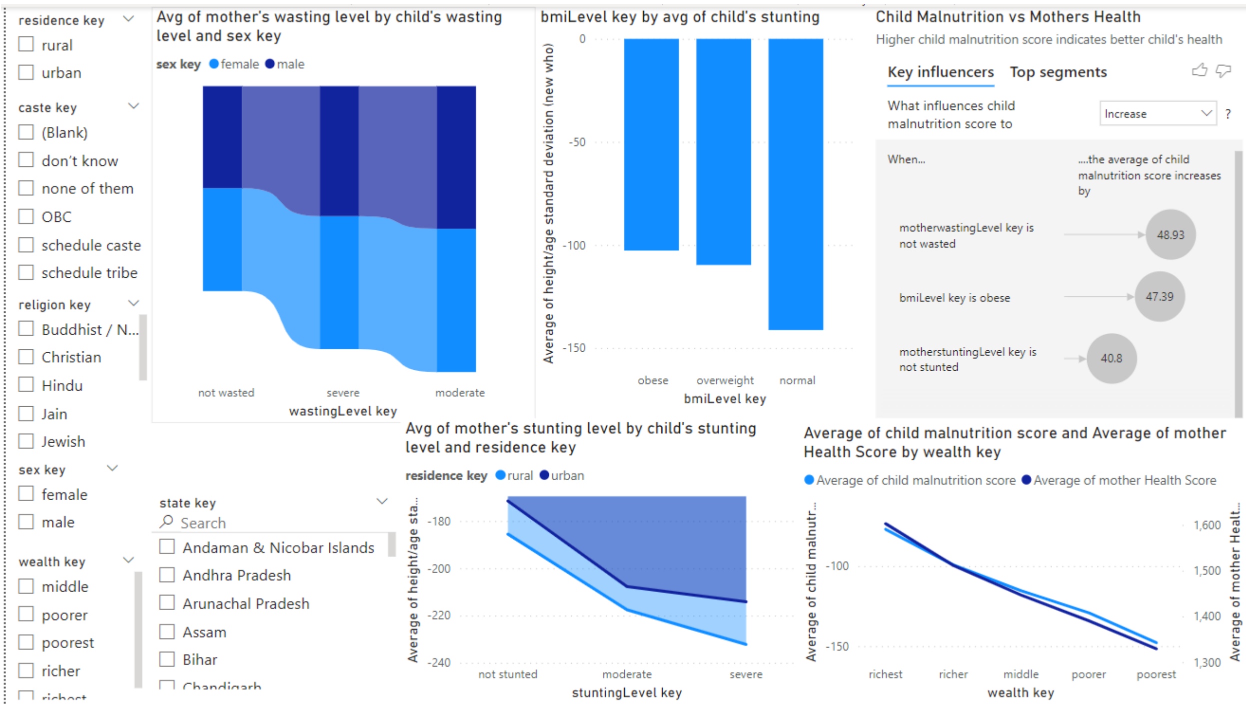





By comparing child malnutrition factors with maternal education level, the report can provide insights into the relationship between education and child health outcomes and identify potential targets for interventions to reduce the prevalence of child malnutrition. For example, programs that focus on improving maternal education, such as literacy programs and life skills training, can help empower women and improve their ability to make informed decisions about their health and their children's health.

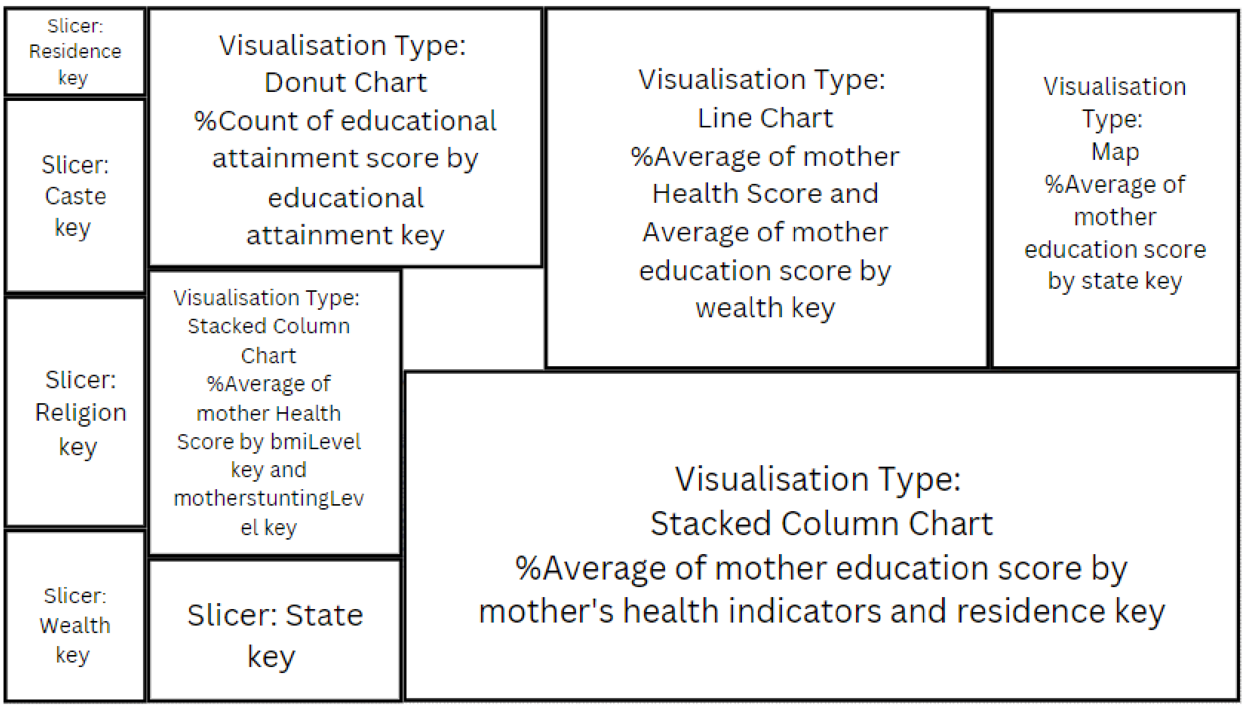
**Figure 7:** Child Malnutition and Mother's Health

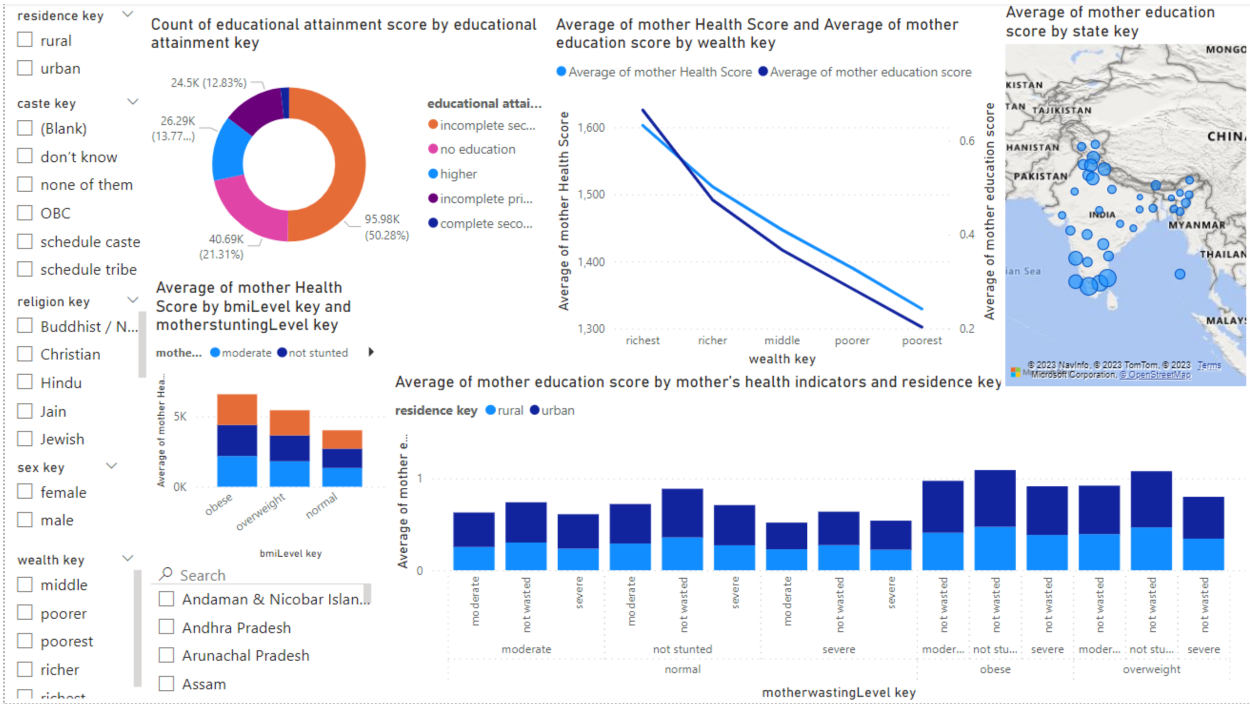





Maternal malnutrition and poor health status can significantly impact fetal growth and development, leading to poor birth outcomes and an increased risk of child malnutrition. By comparing maternal health factors with child malnutrition factors, the report can provide insights into the intergenerational cycle of malnutrition and identify potential targets for interventions to break the cycle.

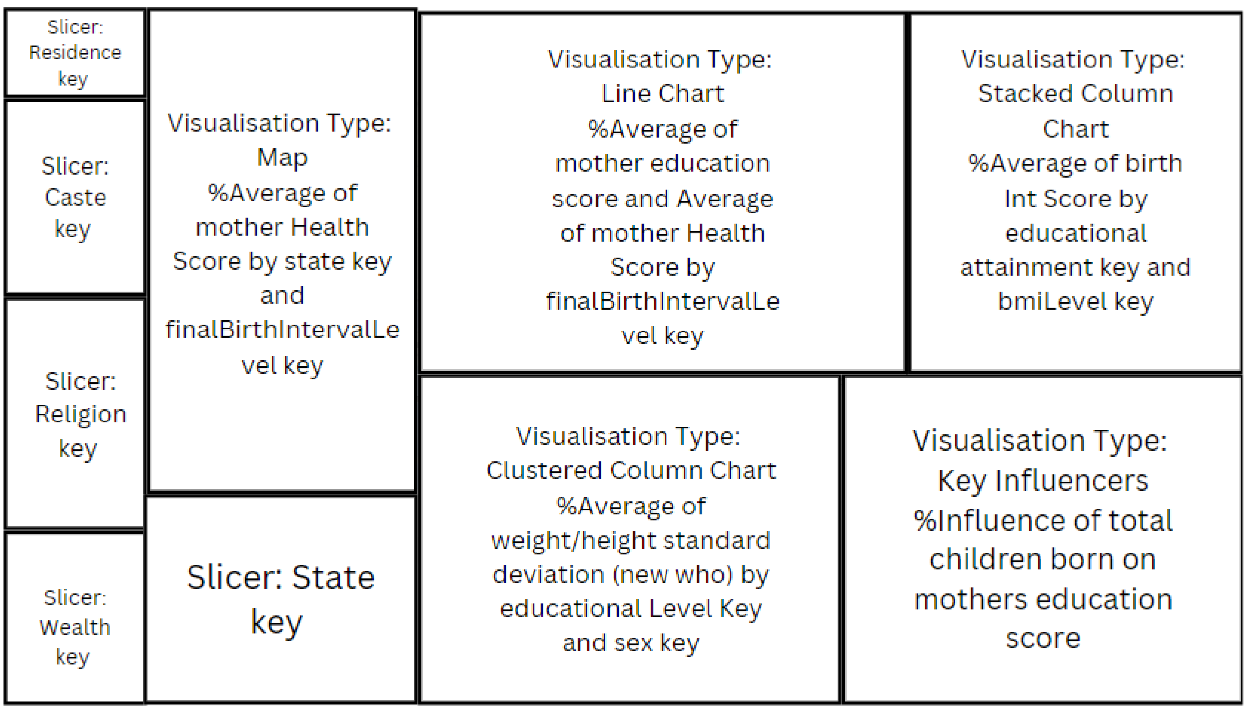
**Figure 8:** Mother's Demographics(Mother's Education and Mother's Health)

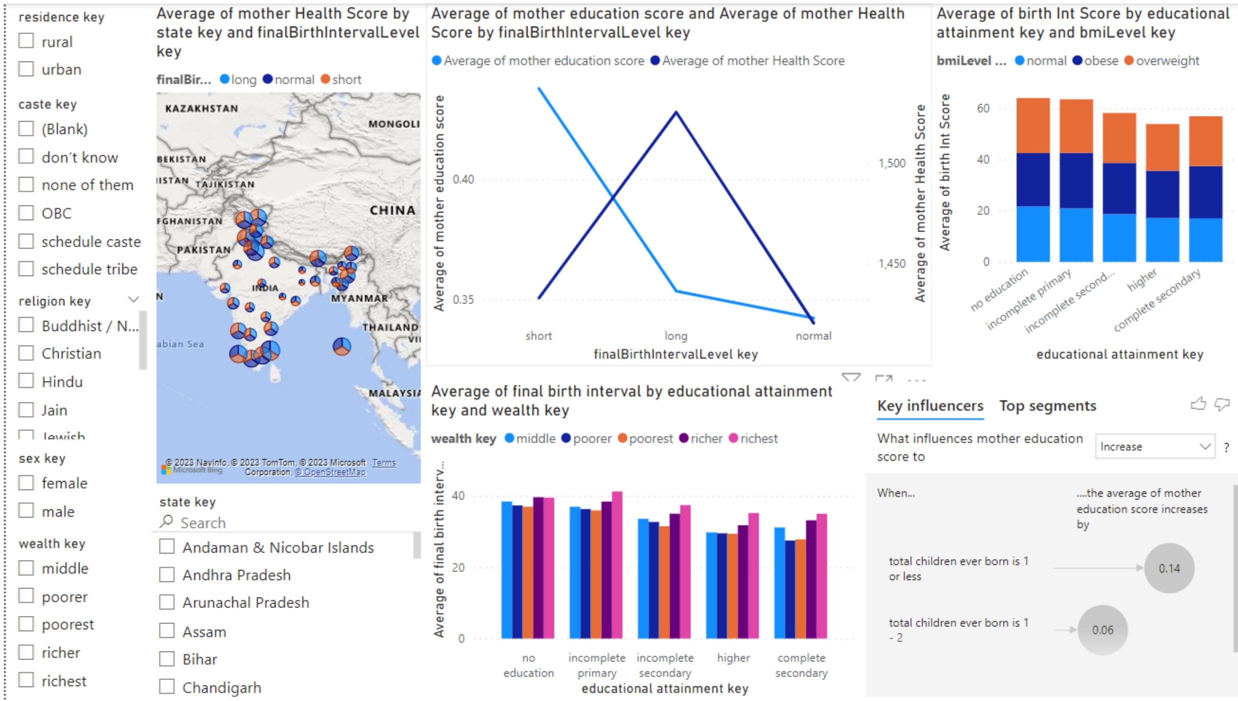





By comparing maternal health factors with maternal education level, the report can provide insights into the relationship between education and maternal health and identify potential targets for interventions to improve maternal and child health outcomes. For example, programs that focus on improving maternal education, such as literacy programs and life skills training, can help empower women and improve their ability to make informed decisions about their health and their children's health.

**Figure 9:** Mothers's Demographics and Birth Spacing






By comparing maternal demographics with birth spacing, the report can provide insights into the factors contributing to suboptimal birth intervals and identify potential targets for interventions to improve birth spacing and reduce the risk of child malnutrition. For example, programs focusing on improving maternal education, such as literacy programs and life skills training, can help empower women and improve their ability to make informed decisions about their health and family planning.

# 5 Discussion

The process of creating a data model involves three key aspects: conceptualisation, dimension modeling, and reporting. Each of these aspects has its benefits and limitations that should be taken into account when designing a data model.

**Benefits:**

- Conceptualisation:
  - Conceptualization helps in understanding the business problem or domain and its requirements better.
  - It helps in identifying and defining the key entities, attributes, relationships, and rules related to the business problem.
  - It helps in identifying gaps and inconsistencies in the data and domain knowledge, which can be addressed before the actual development of the solution.
- Dimensional Modeling:
  - Dimension modeling enables the creation of a robust and flexible data model that can support complex queries and analysis.
  - It facilitates the creation of a common vocabulary and structure for the data, which simplifies communication and understanding among stakeholders.
  - It enables the development of a scalable and optimized data model that can handle large volumes of data and support high-performance analytics.
  - It supports the integration of data from multiple sources and provides a unified view of the data, which can improve decision-making and insight generation.
- Reporting:
  - Reporting provides a mechanism for presenting data and insights in a clear and concise manner to support decision-making.
  - It enables stakeholders to monitor key performance indicators and track progress against goals and objectives.
  - It facilitates the identification of trends, patterns, and anomalies in the data, which can inform business decisions and actions.

**Limitations:**

- Conceptualisation:
  - Conceptualization can be time-consuming and requires significant effort to gather and analyze requirements and domain knowledge.

  - It can be difficult to capture all the nuances and complexities of the business problem in a conceptual model.
  - There can be differences in the interpretation and understanding of the business problem and its requirements among stakeholders.
  - Changes in the business problem or requirements can result in significant changes to the conceptual model, which can affect the development timeline and budget.

- Dimensional Modeling:

  - Dimension modeling can be complex and requires significant expertise in data modeling and database design.
  - It can be challenging to design and develop the data model, especially for large and complex data sets.
  - Dimension modeling may not be suitable for all types of data and analysis requirements.

- Reporting:

  - Reporting can be limited by the quality and availability of the data, which can affect the accuracy and reliability of the insights presented.
  - It is resource-intensive to design and develop effective reports, especially for complex data sets.
  - The interpretation of the data presented in reports can be subjective and dependent on the context and assumptions made.

The representative user evaluations of our report on the prevalence of malnutrition among children under-5 in India were obtained from NGOs and other organizations working in the field of child health and nutrition. Their feedback will help us understand the strengths and weaknesses of our report and provide insights into how we can improve our future work. Here are some evaluation comments:

- "The report provides a comprehensive analysis of the prevalence of malnutrition among children under 5 in India. Various visualisations and slicers make it easy to understand the data and identify trends in different demographic groups."
- "The inclusion of mother's education and health indicators is valuable to the report, as it highlights the importance of addressing maternal health and education to improve child nutrition outcomes."
- "The report could benefit from a more detailed analysis of the causes of malnutrition and recommendations for interventions. It would also be useful to include data on the availability and accessibility of healthcare and nutrition services in different regions."
- "The report is a valuable resource for policymakers and practitioners working in the field of child nutrition in India. It provides a comprehensive overview of the issue and highlights the need for a multi-sectoral approach to addressing malnutrition."

# 6 Findings

- Children in rural areas have a higher prevalence of underweight, while urban areas have a higher prevalence of overweight.
- Bihar and Uttar Pradesh have a marginally higher prevalence of stunting.
- Child malnutrition is significantly decreased when the mother is not wasted, obese, and not stunted.
- Child malnutrition is decreased when the mother is highly educated.
- Mothers with the highest health scores have long birth intervals.
- Mothers with high education scores have short birth intervals, and less educated mothers have more children.
- Longer birth intervals lead to more overweight children.
- Odisha, Gujarat, and Chhattisgarh have the best birth interval scores, while Goa, Andaman and Nicobar, and Sikkim have the lowest.
- People with urban residence and the richest wealth category have the best birth interval scores, child malnutrition scores, mother health scores, and mother education scores.
- More than 50% of the survey population has an incomplete secondary-level educational attainment.
- Kerala, Puducherry, and Tamil Nadu have the highest mothers' education scores, while Assam, Meghalaya, and Bihar have the lowest.
- Puducherry, Chandigarh, and Ladakh have the highest mother health scores, while Jharkhand, Bihar, and Chhattisgarh have the lowest.
- Meghalaya, Bihar, and Nagaland have the highest average of total children ever born, while Sikkim, Goa, and Tripura have the lowest.

# 7 Conclusions

Through our analysis of various BI reports on child malnutrition in India, we have gained valuable insights into the factors that contribute to the prevalence of child malnutrition and how we can work towards improving the health of children and mothers.

The reports have highlighted the significant differences in the prevalence of child malnutrition in rural and urban areas. Children in rural areas are more likely to be underweight, while children in urban areas are more likely to be overweight. Additionally, we found that Bihar and Uttar Pradesh have marginally higher prevalence rates of stunting than other states.

One of the most significant insights from our analysis was the strong link between the mother's health and the child's health. Our reports indicate that child malnutrition significantly decreases when the mother is not wasted, obese, or stunted. Furthermore, we found that child malnutrition is decreased when the mother is highly educated.

We also discovered that birth spacing is critical in reducing child malnutrition. Mothers with higher health scores tend to have longer birth intervals, while those with higher education scores tend to have shorter birth intervals. In contrast, less-educated mothers tend to have more children, which can increase the risk of child malnutrition.

By examining the relationship between mothers' health, education, birth spacing, and child malnutrition, we can identify areas for targeted interventions to improve child health outcomes. Our reports provide decision-makers with a comprehensive understanding of the factors contributing to child malnutrition and offer insights into allocating resources to address this critical issue.

However, there are some limitations to our analysis. We could not consider the effects of prenatal nutrition on child malnutrition as there was insufficient data available. Our dataset is mainly focused on children under the age of 5. We have limited information on the child's entire family except for the mother. Therefore, there may be other factors that contribute to child malnutrition that are not captured in our reports. Additionally, further research is needed to explore the education-mortality link in India to inform the development of effective healthcare policies and campaigns that address the needs of different communities and populations.

In conclusion, our BI reports offer valuable insights into the complex factors contributing to child malnutrition in India. By prioritizing the education and health of mothers and children, we can work towards improving the overall health and prosperity of communities in India and beyond.

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# A Appendix for AHP Calculations

**Figure 10:** AHP showing the weights for dimension table rows for Child Malnutition

**CR Value = 0.056 Reasonable Consistency**

**Pairwise comparisons**

| Item Numb | **Item Number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Item Description | Stunting | Wasting | Underweig | | | | | | | |
| 1 | Stunting | 1.00 | 3.00 | 7.00 | | | | | | | |
| 2 | Wasting | 0.33 | 1.00 | 5.00 | | | | | | | |
| 3 | Underweight | 0.14 | 0.20 | 1.00 | | | | | | | |
| 4 | | | | | 1.00 | | | | | | |
| 5 | | | | | | 1.00 | | | | | |
| 6 | | | | | | | 1.00 | | | | |
| 7 | | | | | | | | 1.00 | | | |
| 8 | | | | | | | | | 1.00 | | |
| 9 | | | | | | | | | | 1.00 | |
| 10 | | | | | | | | | | | 1.00 |
| 5 | Sum | 1.48 | 4.20 | 13.00 | | | | | | | |
| | | | | | | | | | | | |

**STANDARDIZED MATRIX**

| | | Stunting | Wasting | Underweig | | | | | | | | **Weight** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Stunting | 0.68 | 0.71 | 0.54 | | | | | | | | **64.3%** |
| 2 | Wasting | 0.23 | 0.24 | 0.38 | | | | | | | | **28.3%** |
| 3 | Underweight | 0.10 | 0.05 | 0.08 | | | | | | | | **7.4%** |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |

**Figure 11:** AHP screenshots showing the weights for dimension table rows for Wealth Index

**CR Value = 0.045** **Reasonable Consistency**

**Pairwise comparisons**

| Item Numb | **Item Number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Item Description | Poorest | Poorer | Middle | Richer | Richest | | | | | |
| 1 | Poorest | 1.00 | 0.33 | 0.20 | 0.14 | 0.11 | | | | | |
| 2 | Poorer | 3.03 | 1.00 | 0.23 | 0.20 | 0.14 | | | | | |
| 3 | Middle | 5.00 | 3.00 | 1.00 | 0.33 | 0.20 | | | | | |
| 4 | Richer | 7.14 | 5.00 | 3.03 | 1.00 | 0.33 | | | | | |
| 5 | Richest | 9.09 | 7.14 | 5.00 | 3.03 | 1.00 | | | | | |
| 6 | | | | | | | 1.00 | | | | |
| 7 | | | | | | | | 1.00 | | | |
| 8 | | | | | | | | | 1.00 | | |
| 9 | | | | | | | | | | 1.00 | |
| 10 | | | | | | | | | | | 1.00 |
| 5 | Sum | 25.26 | 16.47 | 9.46 | 4.70 | 1.78 | | | | | |

**STANDARDIZED MATRIX**

| | | Poorest | Poorer | Middle | Richer | Richest | | | | | **Weight** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poorest | 0.04 | 0.02 | 0.02 | 0.03 | 0.06 | | | | | **3.4%** |
| 2 | Poorer | 0.12 | 0.06 | 0.02 | 0.04 | 0.08 | | | | | **6.5%** |
| 3 | Middle | 0.20 | 0.18 | 0.11 | 0.07 | 0.11 | | | | | **13.4%** |
| 4 | Richer | 0.28 | 0.30 | 0.32 | 0.21 | 0.19 | | | | | **26.1%** |
| 5 | Richest | 0.36 | 0.43 | 0.53 | 0.64 | 0.56 | | | | | **50.6%** |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |

**Figure 12:** AHP screenshots showing the weights for dimension table rows for Highest educational level

**CR Value = -0.053** **Reasonable Consistency**

**Pairwise comparisons**

| Item Numb | **Item Number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Item Description | No Educati | Primary | Secondary | Higher | | | | | | |
| 1 | No Education | 1.00 | 0.20 | 0.17 | 0.14 | | | | | | |
| 2 | Primary | 5.00 | 1.00 | 0.25 | 0.20 | | | | | | |
| 3 | Secondary | 5.88 | 0.20 | 1.00 | 0.25 | | | | | | |
| 4 | Higher | 7.14 | 5.00 | 4.00 | 1.00 | | | | | | |
| 5 | | | | | | 1.00 | | | | | |
| 6 | | | | | | | 1.00 | | | | |
| 7 | | | | | | | | 1.00 | | | |
| 8 | | | | | | | | | 1.00 | | |
| 9 | | | | | | | | | | 1.00 | |
| 10 | | | | | | | | | | | 1.00 |
| 5 | Sum | 19.03 | 6.40 | 5.42 | 1.59 | | | | | | |

**STANDARDIZED MATRIX**

| | | No Educati | Primary | Secondary | Higher | | | | | | **Weight** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | No Education | 0.05 | 0.03 | 0.03 | 0.09 | | | | | | **5.1%** |
| 2 | Primary | 0.26 | 0.16 | 0.05 | 0.13 | | | | | | **14.8%** |
| 3 | Secondary | 0.31 | 0.03 | 0.18 | 0.16 | | | | | | **17.1%** |
| 4 | Higher | 0.38 | 0.78 | 0.74 | 0.63 | | | | | | **63.1%** |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |

**Figure 13:** AHP screenshots showing the weights for dimension table rows for Educational Attainment

| | CR Value = | 0.028 | | Reasonable Consistency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Pairwise comparisons** | | | | | | | | | | |
| Item Numb | **Item Number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | Item Description | No Educati | Incomplete | Complete F | Incomplete S | Complete S | Higher | | | | |
| 1 | No Education | 1.00 | 0.33 | 0.20 | 0.17 | 0.13 | 0.11 | | | | |
| 2 | Incomplete Primary | 3.03 | 1.00 | 0.25 | 0.17 | 0.14 | 0.13 | | | | |
| 3 | Complete Primary | 5.00 | 0.20 | 1.00 | 0.20 | 0.17 | 0.13 | | | | |
| 4 | Incomplete Secondary | 6.02 | 6.02 | 5.00 | 1.00 | 0.17 | 0.13 | | | | |
| 5 | Complete Secondary | 7.69 | 7.14 | 5.88 | 5.88 | 1.00 | 0.11 | | | | |
| 6 | Higher | 7.14 | 7.69 | 7.69 | 7.69 | 9.09 | 1.00 | | | | |
| 7 | | | | | | | | 1.00 | | | |
| 8 | | | | | | | | | 1.00 | | |
| 9 | | | | | | | | | | 1.00 | |
| 10 | | | | | | | | | | | 1.00 |
| 5 | Sum | 29.89 | 22.39 | 20.02 | 15.11 | 10.70 | 1.61 | | | | |

**STANDARDIZED MATRIX**

| | | No Educati | Incomplete | Complete F | Incomplete S | Complete S | Higher | | | | | **Weight** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | No Education | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | | | | | **2.5%** |
| 2 | Incomplete Primary | 0.10 | 0.04 | 0.01 | 0.01 | 0.01 | 0.08 | | | | | **4.4%** |
| 3 | Complete Primary | 0.17 | 0.01 | 0.05 | 0.01 | 0.02 | 0.08 | | | | | **5.6%** |
| 4 | Incomplete Secondary | 0.20 | 0.27 | 0.25 | 0.07 | 0.02 | 0.08 | | | | | **14.7%** |
| 5 | Complete Secondary | 0.26 | 0.32 | 0.29 | 0.39 | 0.09 | 0.07 | | | | | **23.7%** |
| 6 | Higher | 0.24 | 0.34 | 0.38 | 0.51 | 0.85 | 0.62 | | | | | **49.1%** |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |

**Figure 14:** AHP screenshots showing the weights for dimension table rows for Mother's Health

| | CR Value = | 0.051 | | Reasonable Consistency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Pairwise comparisons** | | | | | | | | | | |
| Item Numb | **Item Number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | Item Description | Stunting | Wasting | BMI | | | | | | | |
| 1 | Stunting | 1.00 | 5.00 | 0.33 | | | | | | | |
| 2 | Wasting | 0.20 | 1.00 | 0.14 | | | | | | | |
| 3 | BMI | 3.03 | 7.00 | 1.00 | | | | | | | |
| 4 | | | | | 1.00 | | | | | | |
| 5 | | | | | | 1.00 | | | | | |
| 6 | | | | | | | 1.00 | | | | |
| 7 | | | | | | | | 1.00 | | | |
| 8 | | | | | | | | | 1.00 | | |
| 9 | | | | | | | | | | 1.00 | |
| 10 | | | | | | | | | | | 1.00 |
| 5 | Sum | 4.23 | 13.00 | 1.47 | | | | | | | |

**STANDARDIZED MATRIX**

| | | Stunting | Wasting | BMI | | | | | | | | **Weight** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Stunting | 0.24 | 0.38 | 0.22 | | | | | | | | **28.2%** |
| 2 | Wasting | 0.05 | 0.08 | 0.10 | | | | | | | | **7.3%** |
| 3 | BMI | 0.72 | 0.54 | 0.68 | | | | | | | | **64.5%** |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |

**Figure 15:** AHP screenshots showing the weights for dimension table rows for Birth Interval

**CR Value = 0.067 Reasonable Consistency**

**Pairwise comparisons**

| Item Numb | **Item Number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Item Description | Short | Normal | Long | | | | | | | |
| 1 | Short | 1.00 | 0.11 | 0.33 | | | | | | | |
| 2 | Normal | 9.09 | 1.00 | 7.00 | | | | | | | |
| 3 | Long | 3.03 | 0.14 | 1.00 | | | | | | | |
| 4 | | | | | 1.00 | | | | | | |
| 5 | | | | | | 1.00 | | | | | |
| 6 | | | | | | | 1.00 | | | | |
| 7 | | | | | | | | 1.00 | | | |
| 8 | | | | | | | | | 1.00 | | |
| 9 | | | | | | | | | | 1.00 | |
| 10 | | | | | | | | | | | 1.00 |
| 5 | Sum | 13.12 | 1.25 | 8.33 | | | | | | | |

**STANDARDIZED MATRIX**

| | | Short | Normal | Long | | | | | | | | **Weight** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Short | 0.08 | 0.09 | 0.04 | | | | | | | | **6.8%** |
| 2 | Normal | 0.69 | 0.80 | 0.84 | | | | | | | | **77.8%** |
| 3 | Long | 0.23 | 0.11 | 0.12 | | | | | | | | **15.4%** |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
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The scores assigned during the AHP process (using the AHP tool) are semantic to the context. For example, to assign scores for Child Malnutrition (Stunting, Wasting, Underweight), scores for Stunting were the maximum compared to the other two types. Here, we mean to convey that Stunting will collectively contribute more towards Child Malnutrition as stunting can lead to an increased risk of chronic diseases.

Similarly, households with better wealth indexes have been assigned more weight than poorer households.

Again for educational level and attainment, the attribute "Higher" was given more importance compared to "secondary" or "complete primary" because a higher educational level contributes more to the education status.

BMI has been assigned more weight for the mother's health compared to stunting and wasting. For Birth Spacing, normal (18-60 months) is given more weightage followed by long(>60 months) and short(5-17 months) as both long and short intervals do not provide the child with the required nutrition.