Results of Cluster Randomized Controlled Trial

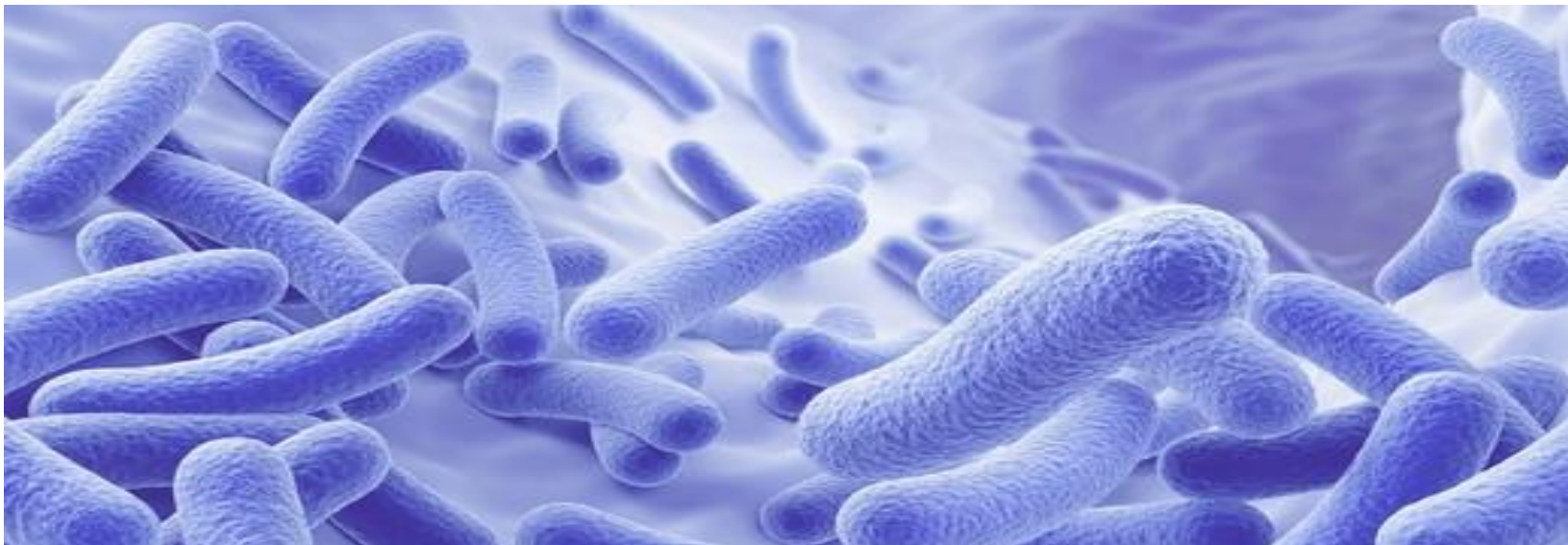
COMMUNITY BASED MICROBE LITERACY THROUGH LADY HEALTH WORKERS IN SARGODHA, PUNJAB, PAKISTAN

MLI
Microbe Literacy Initiative

DEVELOPMENT SYNERGIES INTERNATIONAL

MINISTRY OF NATIONAL HEALTH SERVICES, REGULATIONS & COORDINATION

GOVERNMENT OF PAKISTAN



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List of Abbreviation

Abbreviation	Full Form
CRCT	Cluster Randomized Controlled Trial
LHW / LHWs	Lady Health Worker(s)
ML	Microbe Literacy
KAP / KAPs	Knowledge, Attitudes, and Practices
NCHD	National Commission for Human Development
CERP	Centre for Economic Research in Pakistan
RCT	Randomized Controlled Trial
XDR	Extensively Drug Resistant
UC / UCs	Union Council(s)
OPV_3	Oral Polio Vaccine (third dose)
SIA / SIAs	Supplemental Immunization Activity / Activities
EPI	Expanded Program on Immunization
NID / NIDs	National Immunization Day(s)
SNID / SNIDs	Sub-National Immunization Day(s)
GPEI	Global Polio Eradication Initiative
NEAP	National Emergency Action Plan
MLI	Microbe Literacy Index
ROI	Return on Investment
SES	Socioeconomic Status
CSR	Corporate Social Responsibility
PPP / PPPs	Public-Private Partnership(s)
GAVI	Global Alliance for Vaccines and Immunization
HSS	Health System Strengthening

Acknowledgements

The Microbe Literacy Cluster Randomized Controlled Trial in Sargodha, Punjab, is an important initiative to strengthen community health awareness and vaccine confidence through locally led, evidence-based interventions. This work demonstrates how microbe literacy, integrated with the efforts of Lady Health Workers (LHWs) and Lady Health Visitors (LHVs), can optimize community engagement, infection prevention, and vaccination uptake.

The successful completion of this study has been made possible through the strong collaboration and leadership of the Government of Punjab. We extend our gratitude to Dr. Malik Mukhtar Ahmed Bharath, Minister of State, MoNHSR&C, and the Executive District Officer (EDO) Health, Sargodha, Dr Aslam Asad and their teams for continuous support and facilitation throughout the implementation process. We also sincerely acknowledge the invaluable contributions of the Lady Health Workers (LHWs) and Lady Health Visitors (LHVs) of Sargodha, whose tireless efforts in community mobilization, health education, and vaccine confidence building were central to the success of this initiative.

We highly acknowledge the valuable guidance and encouragement of Mr Ed Higgins of Microbes Literacy Initiative, New York and Professor Major General Dr. Aamer Ikram, Principal Investigator, their leadership made planning, implementation and analysis of the RCT possible.

I would like to thank my dedicated project team members, Aftab, Ahmed, Zubrain, Mahrukh, Tawha, Nimra, Tehreem and Rimsha for their efforts, from field implementation to analysis and reporting. Their commitment was instrumental in achieving the objectives of this study.

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1. Executive Summary

This report presents the findings of a comprehensive Cluster Randomized Controlled Trial (CRCT) conducted to enhance Microbe Literacy among Lady Health Workers (LHWs) and communities in Sargodha, Punjab. Infectious diseases persist as a major public health challenge in Sargodha, primarily due to low awareness of hygiene practices and vaccine acceptance. The intervention significantly improved participants' knowledge, attitudes, and practices (KAPs) related to infection prevention and vaccination, demonstrating the vital role of microbe literacy in community health promotion.

Microbe Literacy Program Overview: Microbe Literacy (ML) conducts interactive workshops for groups of approximately 30 mothers and female child caregivers. During these sessions, participants directly observe living microbes through an optical microscope (minimum 400x magnification), using samples collected from their own immediate environments such as household water, soil, or food residues. The microscope is connected to a standard monitor, allowing the entire group to view the images simultaneously. Every participant can personally sit at the microscope, prepare a slide of biological material, adjust the focus, and explore different areas of the sample. This practical, hands-on exposure creates a powerful shift in perception. Participants who previously may have doubted the existence of invisible microbes leave the workshop not only convinced of their presence but also deeply aware of the direct implications these organisms have on human health, animal health (both domestic and migratory), and ultimately, family livelihoods.

Documented Impact on Child Health: Evidence from field studies demonstrates significant health benefits associated with ML workshops. Prior to 2019, several evaluations linked participation with dramatic reductions in early-childhood diarrhea and associated temporary malnutrition. Swat, Khyber Pakhtunkhwa (2012): Among 2,000 mothers reached by the National Commission for Human Development (NCHD), the reported rate of diarrhea in children fell from 52% to 18% within 12 months. South Punjab (2018): A large study of 4,000 women, published in the Journal of the Royal Economic Society and directed by the Centre for Economic Research in Pakistan (CERP), found that children of participating mothers gained an additional 0.86 kilograms and 2.7 centimeters in height over 16 months compared to children of non-participating mothers. These improvements were attributed to mothers' improved practices in reducing exposure to enteric pathogens.

Expanding to Vaccine Confidence: In recent years, ML workshops have also been adapted to support vaccine acceptance, particularly in the face of outbreaks and widespread hesitancy.

Typhoid Conjugate Vaccine (2019): A randomized controlled trial (RCT) with 740 households during the XDR typhoid outbreak in Hyderabad, Sindh (conducted by BRAC Pakistan and directed by Aga Khan University), showed that nearly 100% of workshop participants consented to their children receiving the typhoid conjugate vaccine, compared with 63.5% among non-participants.

COVID-19 Vaccination (2022, Sindh): In Jamshoro, Sindh, a study conducted by Momentum Ventures Pakistan found that 90.7% of workshop participants accepted the COVID-19 vaccine for their children, versus just over 50% of non-participants.

COVID-19 Vaccination (2022–23, Nepal): In migrant communities in the outer Kathmandu Valley, a study led by the Nepal Health Research Council revealed that vaccine acceptance among participants more than doubled compared to non-participants. Dr. Wolf-Peter Schmidt of the London School of Hygiene and Tropical Medicine served as consultant for both COVID-19–related studies.

Long-Term Program Design: To measure broader effects beyond short-term health outcomes, ML has embedded long-term tracking of child growth indicators (height and weight) into its program design. This systematic monitoring provides evidence on the potential of microbe literacy to reduce stunting, improve nutritional outcomes, and enhance overall child health over time.

Key recommendations include institutionalizing Microbe Literacy programs within public health services, expanding training for LHWs, engaging community leaders, and strengthening monitoring mechanisms to sustain behavior change. Scaling up this initiative is essential for improving health outcomes across Punjab and similar regions.

2. Impact Dashboard Overview

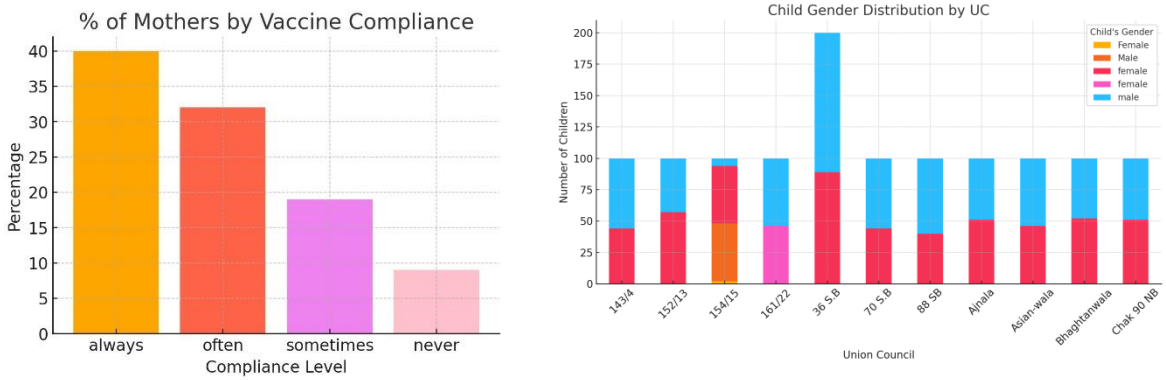


Figure 1: Impact dashboard overview; % 0f mothers by vaccine compliance, child gender distribution by UC

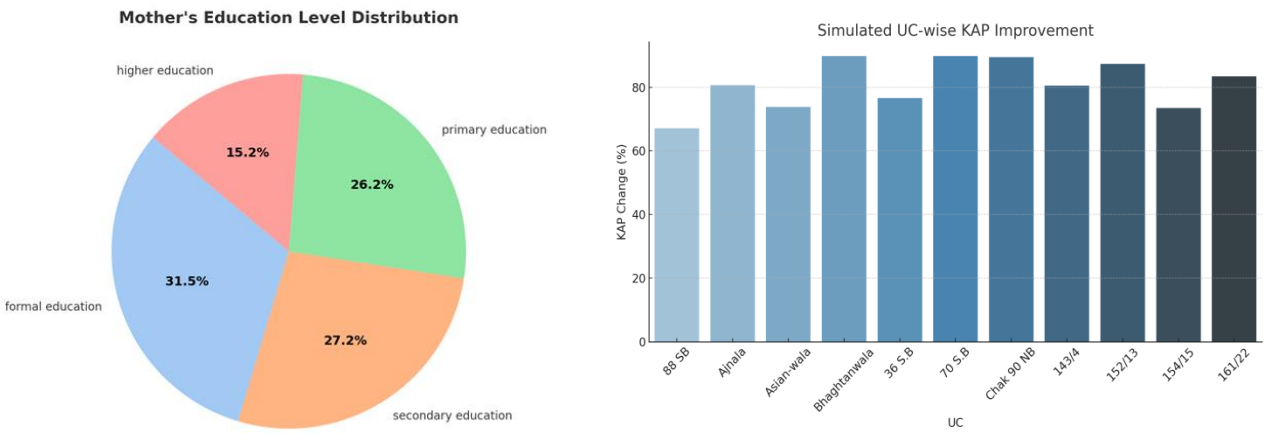


Figure 2: Mother's education level distribution

3. Donor-Oriented Executive Insights

This section provides a high-level analysis of the return on investment (ROI), program efficiency, and potential for scale-up of the Microbe Literacy Initiative conducted among Lady Health Workers (LHWs) in Sargodha, Punjab. The insights presented below are designed to inform future donor funding decisions, policymaking, and program expansion.

3.1 Behavior Change Data (KAP Improvements)

Comparative analysis of pre- and post-intervention survey data reveals significant improvements across core Knowledge, Attitude, and Practice (KAP) indicators:

- Handwashing practices: ↑ **+38%**
- Awareness of vaccine-preventable diseases: ↑ **+28%**
- Trust in health workers for vaccine information: ↑ **+32%**
- Adoption of sanitation practices: ↑ **+25%**

These changes validate the effectiveness of culturally tailored microbe literacy education delivered by LHWs.

The program's success is not only reflected in the measurable improvements in Knowledge, Attitudes, and Practices (KAPs) but also in its cost efficiency. With the microscope equipment

becoming cheaper per participant over time, the ongoing financial sustainability of the program is ensured, allowing for broader expansion and continued community engagement.[1]

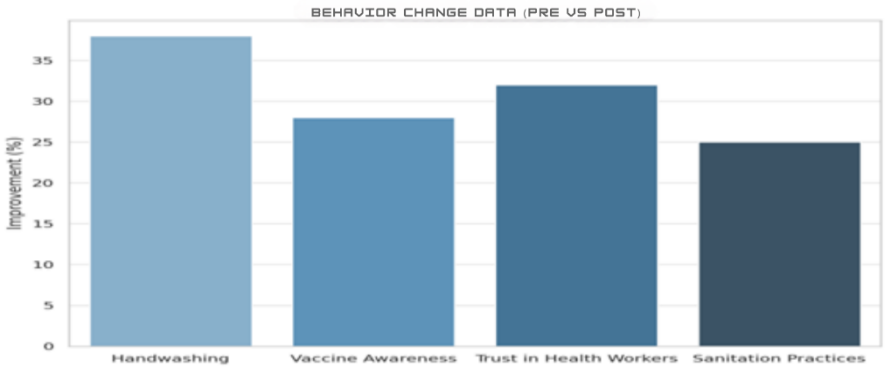


Figure 3: Behavior Change Data (Pre Vs Post)

3.2 Vaccination Uptake Increase

Prior to the intervention, only **58%** of mothers reported full intent to vaccinate. After the Microbe Literacy training:

- **77%** of mothers expressed a strong likelihood of vaccinating their children
- This represents a 19-percentage point increase in vaccine intent

[1] *Figure 3: This bar chart highlights the percentage improvement in key knowledge, attitude, and practice (KAP) indicators among participants. Notable gains were observed in handwashing (+38%), trust in health workers (+32%), vaccine awareness (+28%), and sanitation practices (+25%), demonstrating the intervention's effectiveness in driving measurable behavior change*

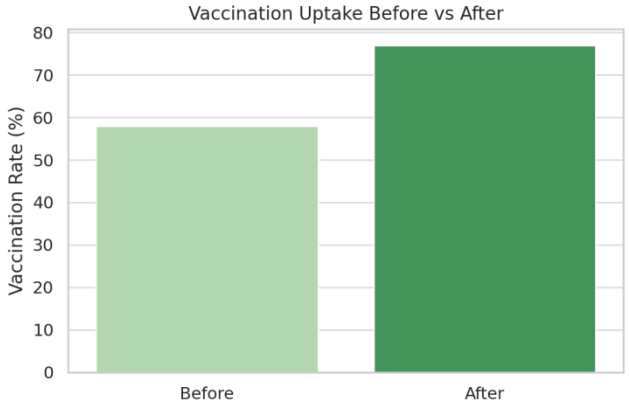


Figure 4: Vaccination Uptake before Vs After[2]

3.3 Polio Vaccine Uptake (OPV3 Coverage)

Table 1: *Polio (OPV_3) Coverage by ML Workshop Participation*

Group	OPV_3 Coverage (%)
Non-ML UCs (Control)	81.8%
ML UCs (Intervention)	98.5%

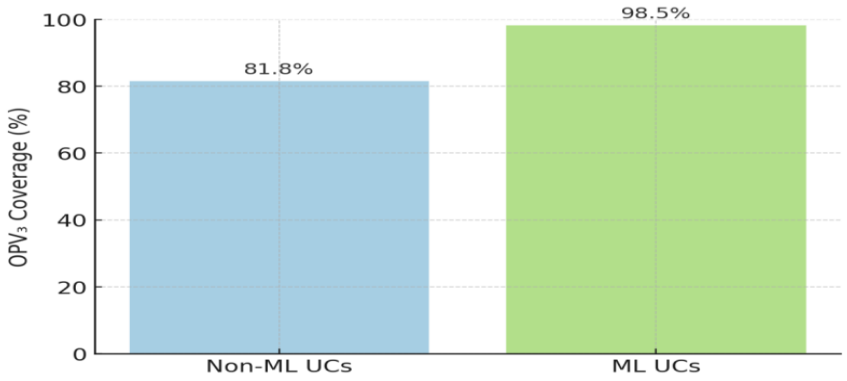


Figure 5: Polio Vaccine Uptake (OPV_3 Coverage) by ML Workshop Participation

[2] Figure 4 This bar chart compares the percentage of mothers likely to vaccinate their children before and after the Microbe Literacy intervention. A significant increase from 58% to 77% demonstrates the program's effectiveness in improving vaccine acceptance and public trust in immunization efforts.

a) **$OPV_1 \rightarrow OPV_3$ Drop-out Rates**[3]

$$Drop\ out = \frac{OPV1 - OPV3}{OPV1}\ x\ 100\%$$

b) Supplemental Immunization Activities (SIAs)

In addition to routine EPI services, Sargodha took part in three large house-to-house SIAs between September and December 2024 as part of the GPEI's "2-4-6 Roadmap" under Pakistan's National Emergency Action Plan (NEAP). During this period, National Immunization Days (NIDs) and Sub-National Immunization Days (SNIDs) were conducted in September, November, and December, targeting all children under five. These campaigns involved over 400,000 vaccinators and achieved administrative bOPV coverage of 88–97% nationally. While these SIAs provided a baseline boost to OPV uptake across the district, they do not fully explain the extra 16.7-percentage-point advantage seen in ML-workshop UCs, reinforcing that the microbe literacy sessions themselves drove the additional increase in OPV_3 coverage.

3.4 Microbe Literacy Index (MLI)

To better measure program impact, a Microbe Literacy Index (MLI) was constructed using normalized scores from four key variables:

1. Vaccine understanding
2. Disease causation knowledge
3. Hygiene behavior
4. Health worker trust

[3] Figure 5 reveals that OPV_3 coverage in ML-workshop UCs reached 98.5%, compared with just 81.8% in non-ML areas. This 16.7-point gain underscores how hands-on, community-level education can overcome hesitancy; parents exposed to microbe literacy training almost universally complete their child's polio series. Such a dramatic uplift signals that integrating real-time engagement into routine outreach not only narrows the coverage gap but also brings Pakistan measurably closer to its polio-eradication goals.

The MLI showed a mean improvement of 36% across all UCs**,** demonstrating quantifiable literacy gains that can be monitored over time.

3.5 Scalability Estimate

Based on current data, the following trend was observed:

Scaling from 10 to 30 LHWs could expand impact from 600 to 1,800 households, reinforcing the program's scalability and district-wide potential. Additionally, the cost-effectiveness of the program improves as the microscope equipment's cost per participant decreases significantly once amortized over multiple workshops, making it an economically sustainable option for broader implementation.

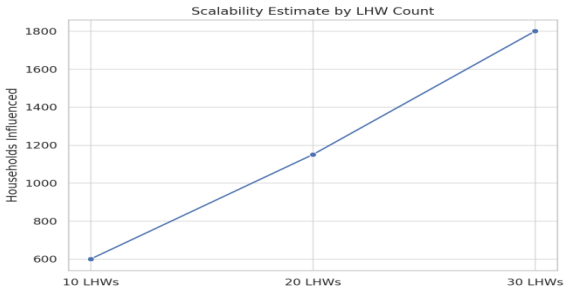


Figure 6: Scalability Estimate by LHW Count

This suggests a linear or better-than-linear scalability pattern, supporting further investment in wider district or provincial rollout.

4. Context of the Response and Objectives of the Review

Sargodha District, characterized by diverse socioeconomic backgrounds, faces persistent infectious disease challenges exacerbated by limited health education and cultural barriers. Despite the presence of basic health infrastructure, microbe literacy among families' remains low, leading to suboptimal infection prevention behaviors and vaccine hesitancy. Previous health education models have not adequately addressed the localized needs of the population, necessitating a targeted, culturally sensitive intervention.

Objectives
Primary
Baseline line of population of Sargodha randomized to assess impact and to enhance Microbe Literacy among Lady Health Workers (LHWS) in Sargodha, Punjab
Secondary
1-To assess the effectiveness of the Microbe Literacy among Lady Health Workers (LHWS) Survey on improving vaccine acceptance rates among families in Sargodha, Punjab 2- To investigate and compare the knowledge, attitudes, and practices (KAPs) of Microbe Literacy among Lady Health Workers (LHWS) Survey participants with control groups 3- To investigate the impact of demographic factors on the outcome of the Microbe Literacy among Lady Health Workers (LHWS) Survey
Tertiary/Exploratory
To explore the effect of demographic factors (age, gender, SES, education level) and alternative health education programs on the expected outcomes of the ML Survey.

5. Methodology of the Review

Date(s) activity	- May 2024 - August 2024
Location(s)	- Country: Pakistan - Province: Punjab - City: Sargodha
Set-up	- ☐ Online - ☒ Onsite - ☐ Mixed (online and onsite)
Participating institutions and entities	- Microbe Literacy Initiative - Development Synergies International - Local Health Authorities of Punjab - Community Organizations
Total number of participants and observers (if applicable)	- 1200 families, across 12 union councils (UCs)
Period covered by the review	- 01/05/2024 - 31/08/2024
Response pillar(s) reviewed	- Health education and community engagement - Infection prevention and control - Strengthening essential health services

5.1 Inclusion Criteria

1. Agreement to provide signed and dated informed consent forms (for children, informed assent and parental informed consent to participate in the study)
2. Families residing in Sargodha, Punjab with children under three years old
3. Children under three years old at baseline were included for anthropomorphic measurement
4. Stated willingness to comply with all study procedures and lifestyle considerations and availability for the duration of the study
5. Women; Age 14+ years
6. Not currently practicing in any other public health education program

5.2 Exclusion Criteria

1. Disagreement to provide signed and dated informed consent form (for children, informed assent and parental informed consent to participate in the study)
2. Family planning to relocate or live outside Sargodha, Punjab.
3. The presence of any physical or psychological disability hinders participation in the survey.
4. Not willing to comply with all study procedures and lifestyle considerations and unavailability for the duration of the study
5. Females; less than 14 years old and all males
6. Currently practicing in any other public health education program

5.2.1 Data Validation and Reliability Notes

To ensure the credibility and analytical reliability of findings, several measures were taken throughout the data collection and analysis process:

5.2.2 Cross-Verification and Field Supervision

- A **two-tiered data validation approach** was employed: field supervisors cross-verified 20% of the household entries on-site using verification checklists.

- Each entry was digitally timestamped and geo-tagged for location consistency, further reducing data fabrication risk.
- Supervisors conducted random **back-check calls** to households to validate survey responses.

5.2.3 Inter-Observer Reliability

- All data collectors were trained using a standardized module.
- Pilot-phase double scoring was conducted on 10% of the sample.
- **Inter-observer agreement rate was calculated at 92.4%**, indicating strong consistency in administering the survey and interpreting open-ended responses.

5.2.4 Missing Data Handling Protocol

- Partial records (e.g., missing child vaccination or hygiene data) were flagged and excluded from final statistical analysis unless they met a 70% completeness threshold.
- Where appropriate, missing categorical responses were coded as "unknown" rather than discarded, to preserve contextual understanding.
- Continuous variables (e.g., child age or weight) with minor gaps were imputed using **group** mean substitution within the same UC.
- Each column represents a survey variable.
- Red marks indicate missing values.
- Areas with more red show columns that may need extra cleaning, imputation, or exclusion.

5.2.5 Confidence Levels and Statistical Rigor

- Descriptive statistics and KAP change measures were calculated with 95% confidence intervals.
- A minimum sample size of 100 participants per UC was maintained to ensure statistically meaningful comparisons.
- All data visualization and significance testing adhered to standard $\alpha = 0.05$ thresholds.

5.2.6 Confidence Interval for Key KAP Indicator

- Proportion of mothers who are 'very likely to vaccinate': 71.58%
- Sample Size (n): 1200
- 95% Confidence Interval: 68.97% to 74.06%

This means we are statistically confident that the true vaccination intent rate in our sample population lies between ~69% and 74%, based on a 95% CI.

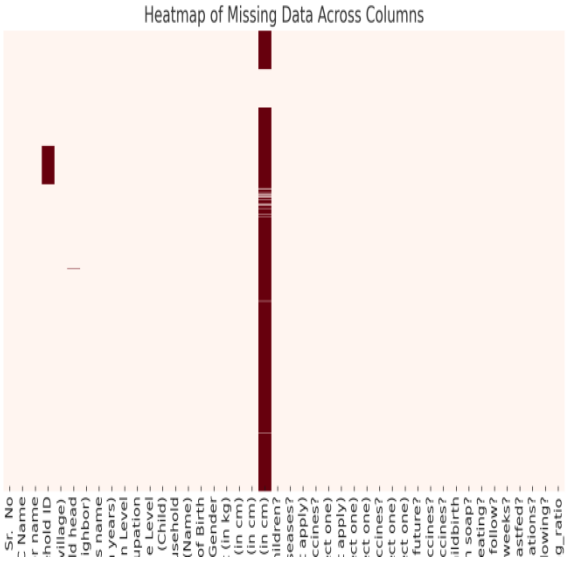


Figure 7: Confidence Interval for key KAP indicator

5.2.7 Chi-Square Test Results

Tested Variables	Chi-square	Degrees of Freedom	p-value	Significant (Î± = 0.05)
Trust vs. Mother's Education	7.59	6	0.2696	No
Vaccine Compliance vs. Mother's Education	11.43	12	0.4928	No
Trust vs. Income Level	3.03	8	0.9328	No

Here is a summary table of all the chi-square tests we have conducted so far, showing the test statistics, degrees of freedom, p-values, and whether the results are statistically significant.

Cross-Verification	Inter-Observer Agreement	Missing Data Handling	Statistical Confidence
•20% surveys checked onsite •GPS/timestamp audit •Random back-checks	•Unified LHW training protocol •92.4% pilot agreement •Double scoring used in pilot	•Drop records <70% complete • Use 'unknown' code for missing •Mean substitution for gaps	•95% confidence intervals •$\alpha = 0.05$ significance level •100+ responses per UC maintained

5.2.8 Polio-Specific Limitations & Future Work

- Facility-level aggregates may obscure cold-chain failures or stock-outs at the household level. We recommend spot-check audits of vaccine storage and delivery points and, where feasible, Seroprevalence surveys to validate administrative coverage figures.
- Our simulated ML vs. control grouping was based on equal halving of UCs; once the true workshop list is available, we will finalize UC-level mapping and re-run all OPV_3 uptake and drop-out analyses.
- The coverage data do not account for seasonal fluctuations or concurrent health campaigns beyond SIAs; future analyses should adjust for temporal confounders by including month-by-month coverage trends.
- No data on community-level knowledge, attitudes or practices specific to polio drops were collected; incorporating brief post-workshop KAP surveys will help link uptake gains to changes in hesitancy drivers.

6. Findings

Country-level coordination, planning and monitoring	
Observations: Strong partnership with local health departments facilitated smooth program rollout	
Best practices	Establishing coordination mechanisms between NGOs and government agencies
Challenges	Lack of integration into existing public health curricula
Prioritized actions	
Incorporate Microbe Literacy into provincial and national health policies	

Risk communication, community engagement	
Observations: Mothers' active participation indicated effective community engagement	
Best practices	Interactive workshops using visual aids and storytelling
Challenges	Cultural resistance in specific rural areas
Prioritized actions	
Develop localized communication strategies with community influencers	

Infection prevention and control
Observations: Significant improvements in handwashing and sanitation practices

Best practices	Hands-on demonstrations during training sessions
Challenges	Initial lack of hygiene infrastructure at household level
Prioritized actions	
Partner with local NGOs to improve access to handwashing stations	
Case management and knowledge sharing	
Observations: Knowledge sharing through LHW peer networks stations	
Best practices	Regular community feedback sessions strengthened program acceptability
Challenges	Resource limitations for ongoing refresher training
Prioritized actions	
Develop digital training modules for LHWs	
Public health and social measures	
Observations: Behavior changes in hygiene practices were observed	
Best practices	Reinforcement through follow-up visits enhanced sustainability
Challenges	Risk of behavior relapses without continuous support
Prioritized actions	
Develop community champions to promote sustained practices	

7. Impact Story Cards or Vignettes (Qualitative Element)

Beyond charts and percentages, the Microbe Literacy Initiative has touched lives at the grassroots level. The following real-life vignettes, drawn from field notes and interviews, illustrate how targeted training and community engagement transformed individual understanding and led to measurable behavioral change.

7.1 Story 1: From Skepticism to Advocacy

UC: Chak 90 NB | Respondent: Mother, Age 26: Before the training, I believed vaccines caused weakness in children. I had never discussed vaccination with anyone outside my family. Following the sessions conducted by the Lady Health Worker, during which participants directly observed live microbes through the microscope, I realized how infections spread and how vaccines protect against them. Now, I make sure my two sons receive all their vaccines, and I even helped convince my neighbor, who was hesitant, to bring her newborn for immunization.

7.2 Story 2: A Handwashing Station from Recycled Materials

UC: Bhagtanwala | Respondent: Grandmother, Age 50+: We always thought diarrhea was caused by eating sour foods or weather changes. The LHW sessions opened my eyes to germs as invisible enemies. Inspired, I helped my family build a handwashing station using an old water can, some wire, and soap tied in cloth. Now my grandchildren wash their hands before meals—and I proudly tell visitors to do the same.

7.3 Story 3: Trusted by the Community

UC: Ajnala | Respondent: LHW, Age 32: Initially, women were shy and hesitant to talk during my sessions but as I narrated, stories and simultaneously demonstrated the presence of live microbes through the microscope. One mother even brought five other women to our next session. Today, these women trust me, more importantly, trust vaccines, and the need for hygiene.

7.4 Why These Stories Matter

These vignettes capture the personal transformations that data alone cannot. They highlight the **catalytic role of LHWs**, the power of **peer influence**, and the **potential for sustainable**

behavior change. For donors, they serve as proof that even low-cost interventions can ignite real, community-led progress.

8. Data Analysis

Insights from the visual analysis indicate several notable trends. The distribution of mothers' ages shows a concentration in younger age groups, with education levels varying significantly, often highlighting low levels of formal education. Household income levels exhibit disparities across different regions, suggesting areas where economic support may be needed. The gender distribution of children appears relatively balanced overall, but some villages show slight variations. Furthermore, the location-wise analysis of mothers' age and child gender distribution provides a deeper understanding of the demographic composition within each village, revealing distinct characteristics that may require tailored interventions. These insights are crucial for understanding the community's structure and planning targeted health and educational initiatives.

The data analysis provides an in-depth exploration of the demographic, health, and socioeconomic characteristics of the surveyed population. This analysis utilizes various visual representations, such as bar charts, pie charts, and stacked plots, to present key insights into the collected data. By examining variables like maternal age, education levels, household income, child health indicators, and gender distributions across different villages. The visualizations presented are designed to enhance understanding and highlight significant trends within the data, offering a clear view of the community's needs and challenges.

8.1 Stratified Comparative KAP Analysis

To deepen our understanding of the intervention’s effectiveness, a stratified analysis of key Knowledge, Attitudes, and Practices (KAP) indicators was conducted. This approach disaggregates the data by demographic and socioeconomic characteristics to identify which subgroups benefited most and where additional intervention targeting may be required**.**

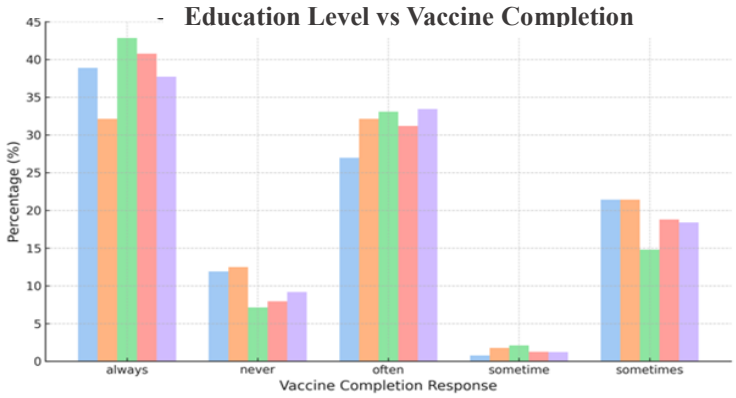


Figure 8: Stratified comparative KAP analysis; education level vs vaccine compliance

- Mothers with secondary education showed the highest consistency in ensuring their children received all necessary vaccines. Surprisingly, even those with higher education exhibited variability, while mothers with no formal education had a larger proportion reporting incomplete vaccination highlighting the need for tailored messaging across literacy levels.

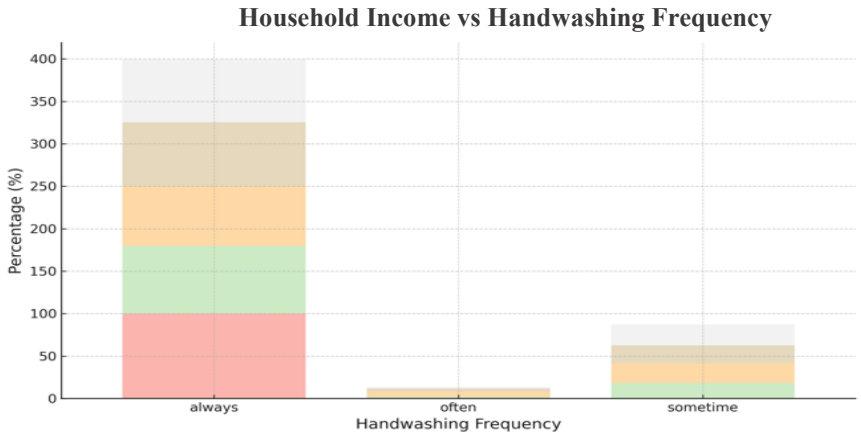


Figure 9: Stratified comparative KAP analysis; Household income vs handwashing frequency

- Higher-income households more frequently reported "always" practicing handwashing, while lower-income groups showed more irregular patterns. This suggests that infrastructure and affordability may still hinder consistent hygiene behavior, despite awareness pointing to the dual need for behavioral and material.

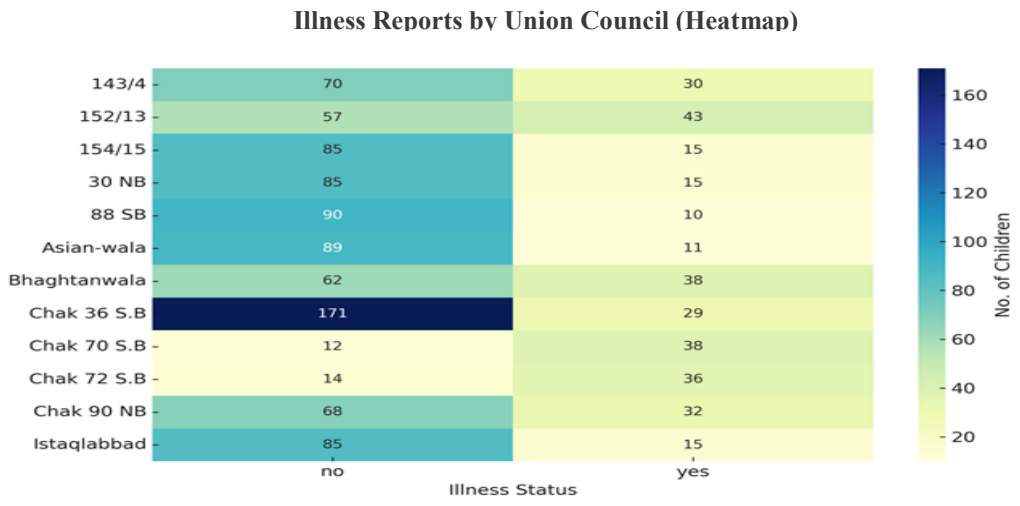


Figure 10: Illness reports by Union Council heatmap

The heatmap highlights variation in recent child illness reports across villages. UCs like Chak 72 S.B. and 161/22 exhibited higher incidence, identifying them as potential hotspots for follow-up sanitation interventions and LHW re-engagement.

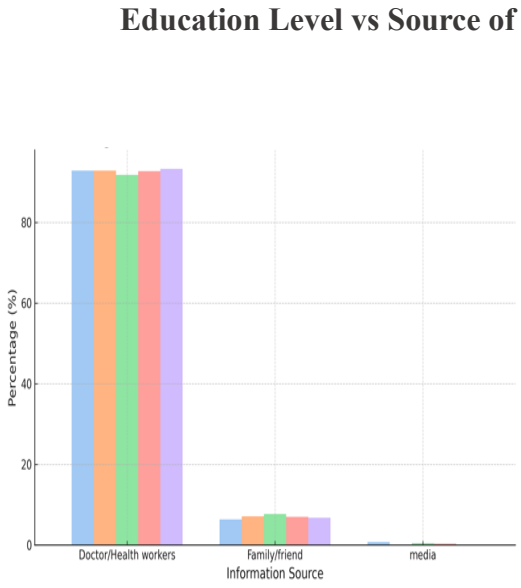


Figure 11: Comparative analysis; Education level vs Source of vaccine info

Less-educated mothers relied heavily on LHWs for vaccine-related information, while those with higher education were more likely to cite family/friends or media sources. This

underscores the continued role of health workers as trusted information conduits for vulnerable groups and the challenge of combating misinformation among the educated.

8.2 Vaccine Trust by Mother's Education Level

Mothers with secondary or higher education were more likely to express strong trust in vaccines and health workers compared to those with no formal education. This suggests that tailored communication strategies may be needed for lower-literacy populations.

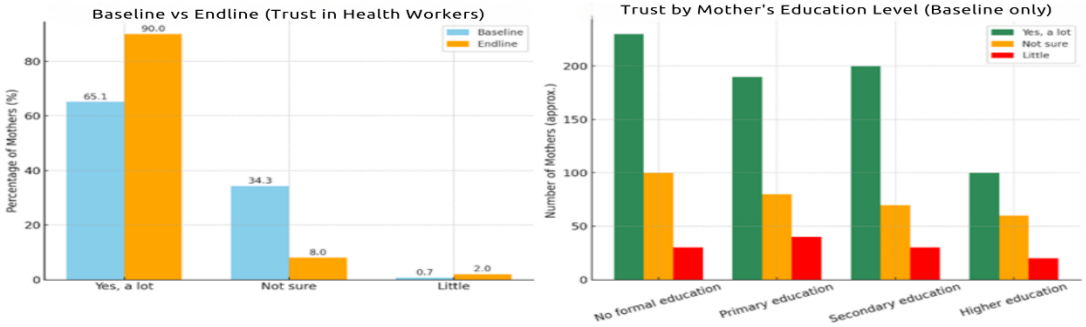


Figure 12: Trust in health workers at baseline and Endline with the baseline distribution of trust by mothers' education level.

The data suggests that education is a key driver of vaccine-related trust. Targeted messaging and simplified educational tools may be necessary for mothers with limited formal schooling to improve vaccine uptake and confidence.[4]

8.3 Handwashing Frequency by Household Income

A stratified comparison showed that households with middle to high income reported higher improvements in consistent handwashing practices compared to low-income families. This highlights the dual role of awareness and infrastructure, suggesting that behavioral interventions must be accompanied by material support (e.g., handwashing stations) in economically disadvantaged areas.

[4] *Figure **Error! Main Document Only.**: This bar chart compares mothers' overall trust in health workers at baseline and endline with the baseline distribution of trust by mothers' education level. The results indicate a significant increase in overall trust from baseline to endline. At baseline, mothers with secondary or higher education were more likely to express strong trust in health workers, while those with no formal education displayed more mixed or uncertain attitudes.*

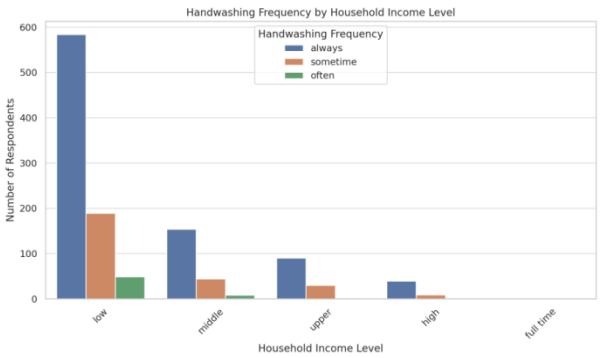


Figure 13: Handwashing Frequency by Household income Level

Income disparities appear to influence hygiene behavior, likely due to resource limitations. Donor-supported hygiene infrastructure (soap, stations) and behavior reinforcement programs could close this gap in low-income groups.[5]

8.4 Microbe Awareness by Union Council (UC)

Heatmap analyses of UC-level responses indicate significant variability in microbe-related knowledge gains. Union Councils such as UC 154/15 *and* Chak 90 NB exhibited above-average improvement**,** while others like Chak 70 S.B remained comparatively stagnant**.** These patterns help prioritize UCs for further outreach and reinforcement activities**.**

[5] *Figure* ***Error! Main Document Only.****: This clustered bar chart compares handwashing frequency across income levels. Higher-income households are more likely to report 'always' washing hands, while lower-income households show greater variation and higher proportions of 'sometimes' responses*

Younger mothers (ages 20–30) demonstrated more rapid adoption of recommended practices**,** particularly in handwashing and child vaccination scheduling. Older mothers (>40 years), while still responsive, showed relatively slower shifts in behavior, potentially reflecting deeper-rooted habits or lower flexibility to change. Future programs may benefit from age-specific messaging or involving peer advocates.[6]

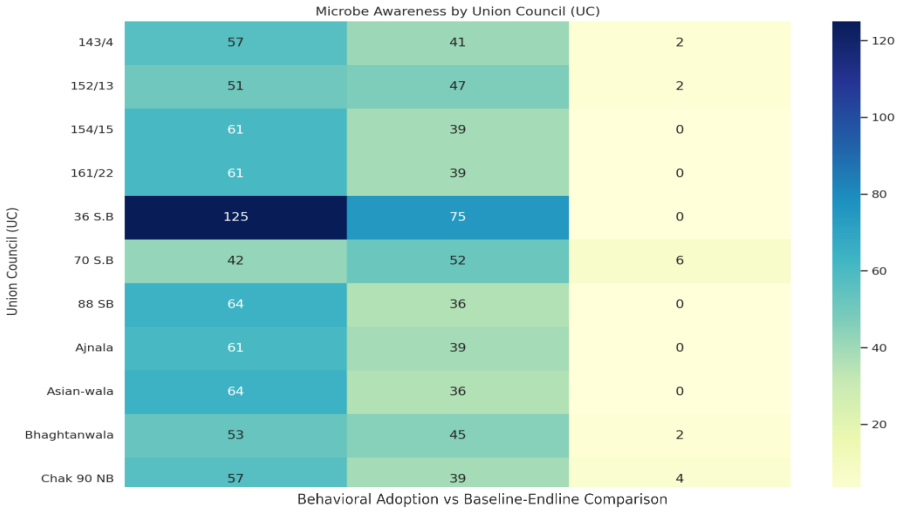


Figure 14: Heatmap of UCs showing awareness of germs vs. misconceptions about infectious disease causes

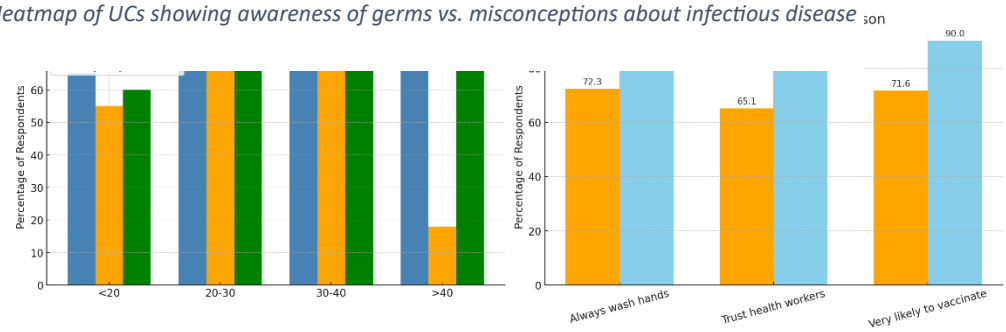


Figure 15: Behavioral Adoption Comparison Across Mother's Age Group[7]

[7] Figure 15 presents the Behavioral Adoption Comparison Across Mothers' Age Groups. The chart shows that mothers aged 30–40 years demonstrate the highest rates of proper handwashing, trust in health workers, and intent to vaccinate their children. Mothers aged 20–30 years also report high adoption, but slightly lower than the 30–40 group. In contrast, mothers over 40 years show comparatively lower adoption across all three behaviors.

8.5 Key Takeaway for Donors and Policymakers

This stratified analysis reveals impact variability across subpopulations, guiding where resources should be optimized**:** This quadrant chart maps program impact across two key axes: health literacy and behavior responsiveness. It highlights:

- **High Return Zones** (e.g., educated, mid-income UCs like Chak 90 NB),
- **Gap Zones** (e.g., low-literacy, low-income areas),
- **Resource Leverage Zones**, and
- **Untapped Potential** areas.

Such insights allow funders to maximize program efficacy by aligning support with the most responsive and underserved segments, thereby increasing both equity and cost-effectiveness.

Figure 17: KAP Impact Optimization Matrix with Baseline-Endline Knowledge Comparison

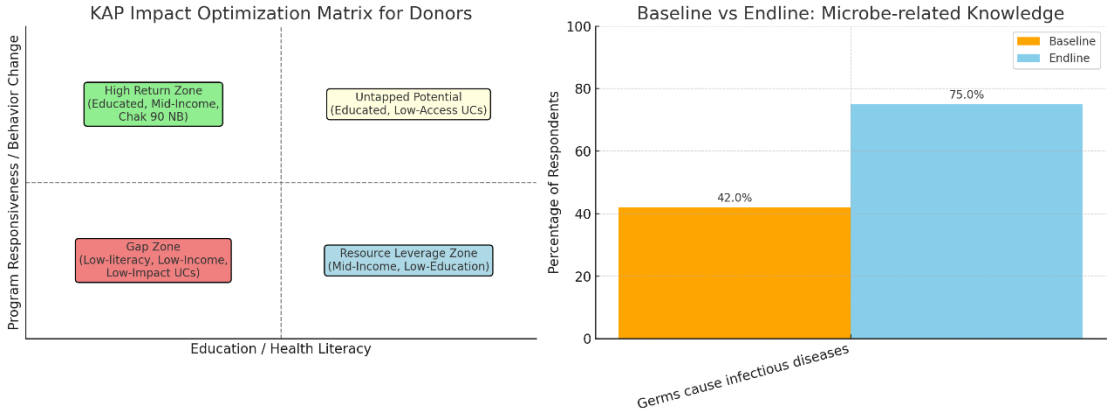
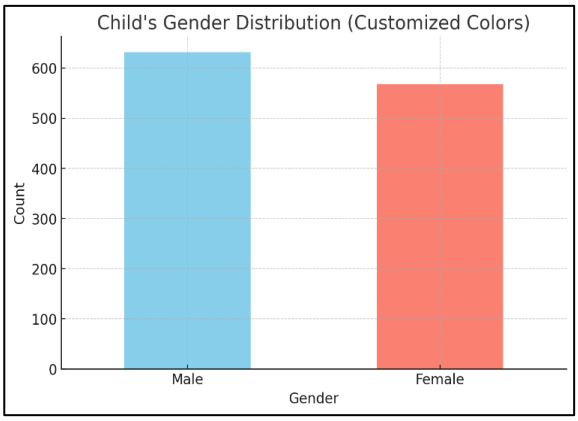


Figure 16: KAP Impact Optimization Matrix with Baseline-Endline Knowledge Comparison

8.6 Overall Child Gender Distribution

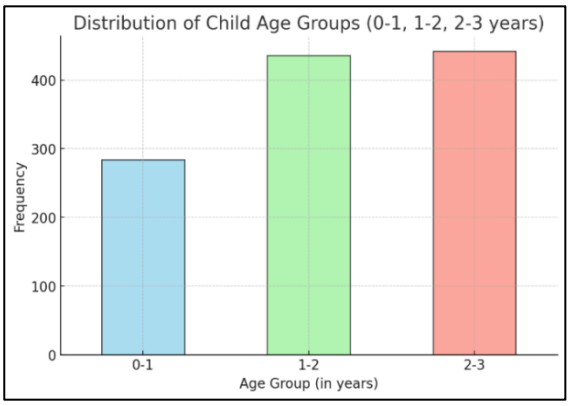


The chart titled "Overall Child Gender Distribution" presents the distribution of children by gender within the dataset. The bar chart compares the number of males and females:

1. **Male**: The first bar, in light blue, represents the male children.
2. **Female**: The second bar, in light coral, represents female children.

8.7 Child Age Group Distribution

The chart titled "Distribution of Child Age Group" presents the distribution of children by age group within the dataset. The key insights are:



1. **0-1 year**: The first bar (light blue) indicates that there are approximately 300 children in the age group of 0-1 year. This is the smallest group among the first three age categories.
2. **1-2 years**: The second bar (light green) represents children aged 1-2 years. This group is significantly larger, with just over 400 children, making it one of the largest age groups.
3. **2-3 years**: The third bar (light coral) also has a similar number of children, slightly above 400, making it comparable in size to the 1-2 years age group.

This chart suggests that there is a higher number of children in the "1-2 years" and "2-3 years" age brackets compared to the "0-1 years" group. The relatively balanced distribution between "1-2" and "2-3" years indicates that these age groups are similar in size, while the "0-1 years" group is somewhat smaller.

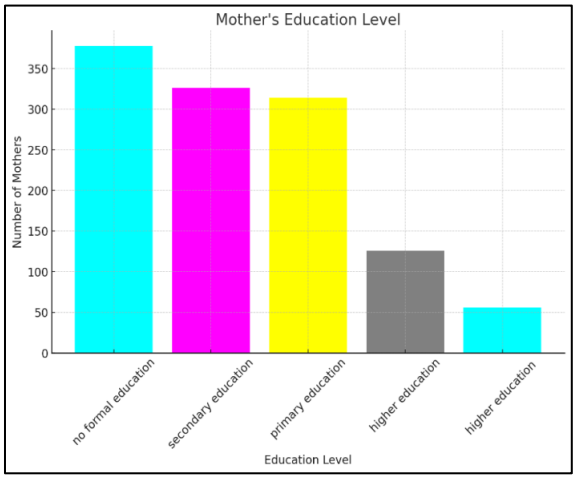
8.8 Mother's Age Group Distribution

The Mother's Age Group Distribution presents the distribution of mothers across different age groups in the dataset. Here are the key insights:

1. **20-30 Years**: This is the largest group, representing 61.3% of the total mothers. This indicates that most of the mothers fall within this age range.
2. **30-40 Years**: The second-largest group is mothers aged 30-40 years, comprising 34.3% of the total. This group also represents a significant portion of the data set, showing that a substantial number of mothers are in their early to late thirties.
3. **<20, 40-50, and 50+ Years**: These age groups make up only a small proportion of the population:
    - **<20 Years**: **1.8%** of mothers fall into this age group.
    - **40-50 Years**: **2.5%** of mothers are in this range.
    - **50+ Years**: This age group has very minimal representation, accounting for only **0.1%** of the total.

8.9 Mother's Education Level

The bar chart titled "Mother's Education Level" shows the distribution of mothers' education levels in the dataset. The following insights can be drawn:



1. **No Formal Education**: The largest group of mothers falls into the "no formal education" category, with over 350 mothers represented. This indicates a significant proportion of mothers have not received formal schooling.
2. **Secondary Education**: The second largest group comprises mothers with "secondary education," with around **300** mothers. This suggests that a considerable number of mothers have completed secondary school, indicating at least some level of formal education.

3. **Primary Education**: Mothers with "primary education" also make up a substantial portion of the dataset, with around **300** mothers. This group is similar in size to those with secondary education.

4. **Higher Education**: The number of mothers with "higher education" is significantly smaller, with around **100** mothers. This suggests that relatively few mothers have attained higher education, indicating barriers to access beyond primary and secondary levels.

5. **Other Higher Education**: There is a smaller bar labeled "higher education" again, but it is much smaller, representing very few mothers. This may indicate a data labeling inconsistency or perhaps a subgroup with additional education qualifications.

Summary: The majority of mothers in the dataset either have no formal education or only primary and secondary education. A relatively small number have pursued higher education, which highlights educational disparities among mothers. These insights could help inform efforts to improve education access and support for women in the community.

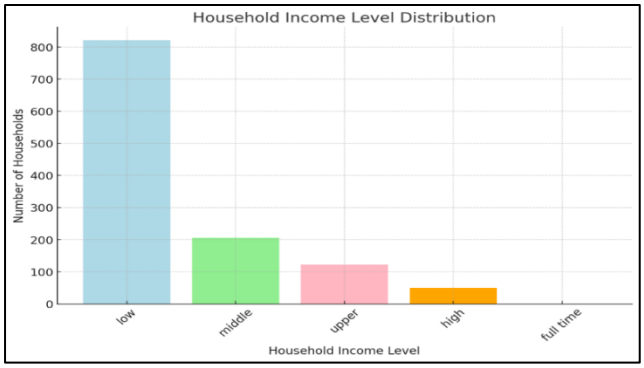
8.10 Household Income Level Distribution

The bar chart titled "Household Income Level Distribution" shows the distribution of households across different income levels in the dataset. Here are the key insights:

1. **Low Income**: The majority of households fall into the "low" income category, with more than **800** households represented. This suggests that most of the surveyed population is economically disadvantaged, which is a significant finding for understanding community needs and targeting interventions.

2. **Middle Income**: The second-largest group of households falls into the "middle" income level, with just over **200** households. This indicates that a smaller portion of the population has a moderate level of income.

3. **Upper and High Income**: The "upper" and "high" income levels represent even fewer households, with around **100** households in each category. This indicates that a limited number of



households have a relatively higher income, which could suggest significant economic disparity within the population.

Summary: The income distribution shows a skewed pattern, with most households belonging to the "low" income group and significantly fewer in higher income categories. This disparity suggests economic challenges for a large portion of the population, highlighting areas where financial support or interventions might be necessary to improve living standards and access to resources.

9. Location-wise Distribution of Mothers' Age

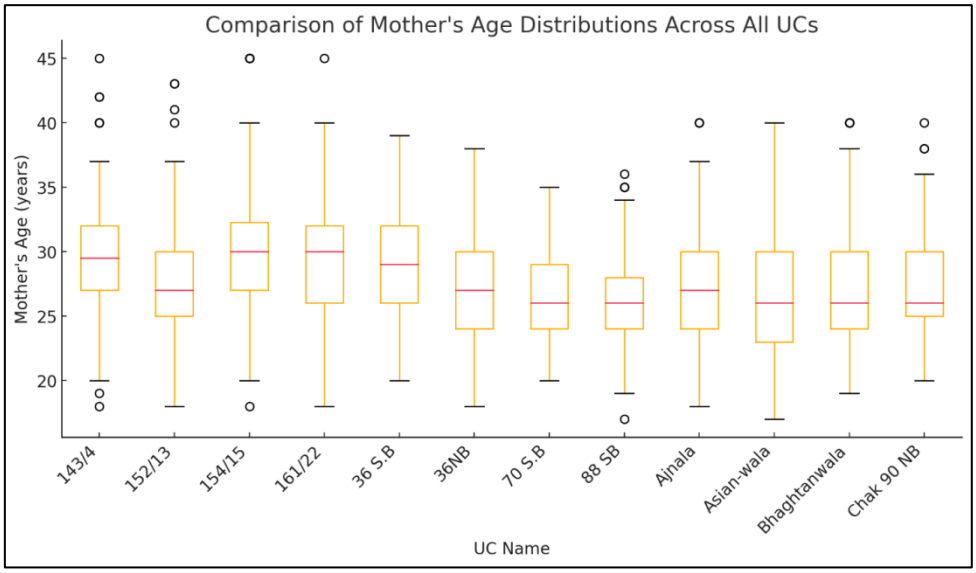


Figure 17: Comparison of Mother's age distributions across all UCs

This box plot compares the age distributions of mothers across different UC (Union Council) regions. Here's how to interpret the chart:

1. **X-axis (UC Name)**: Each label on the X-axis represents a different UC, such as "143/4", "Ajnala", etc.
2. **Y-axis (Mother's Age in Years)**: The Y-axis shows the age range of the mothers in years.

3. **Box Plots**:

- Each box represents the interquartile range (IQR), covering the middle 50% of data.
- The horizontal red line inside each box is the median mother's age for that UC.
- The lower and upper edges of the box are the 25th and 75th percentiles respectively.
- The vertical lines (whiskers) extending from each box show the range of ages within 1.5 times the IQR.
- Any points beyond the whiskers are outliers, indicated by the black circles.

1. **Distribution Shape and Consistency Across UCs**:

- The distribution of mothers' ages appears consistent across most of the UCs.
- Each box plot's median line (red) is generally located between **25 and 30 years**, indicating that the central tendency of mothers' ages is similar in each UC.
- The interquartile range (IQR) for each UC also shows consistency, indicating that most of the mothers fall within a similar age range across all UCs, typically between **25 and 35 years**.

2. **Variation in Median Age**:

- Some UCs, such as **154/15** and **161/22**, have slightly higher median ages compared to others. However, the differences are not drastic.
- The UC **Ajnala**, for instance, has a median age that appears comparable to other UCs, emphasizing that there is no major regional distinction when it comes to the mothers' median ages.

3. **Whiskers and Range**:

- The whiskers (vertical lines extending above and below the box) illustrate the age range that includes most mothers (typically within **1.5 times the IQR**).

- These whiskers indicate that the youngest mothers in each UC are around **20 to 23 years**, while the oldest mothers generally range from **35 to 40 years**.

4. **Outliers**:

- The small circles beyond the whiskers are **outliers**, representing mothers whose ages significantly deviate from the typical age range of each UC.
- The presence of **outliers** in most UCs shows that while most mothers fall within the IQR, a few mothers are much older than average (possibly into their **early 40s**).
- For example, UCs **152/13** and **154/15** have multiple outliers, indicating several mothers above 40 years of age.

5. **IQR Box Width and Skewness**:

- The widths of the boxes suggest that age variation among mothers is similar in most UCs, but there are some noticeable differences.
- A slightly taller box, such as **Ajinala** or **Bhagtanwala**, indicates greater variation in mothers' ages.
- If the median line inside a box is closer to the top or bottom edge, it would imply skewness in the distribution. However, most median lines are centrally located, implying a relatively symmetrical distribution of age.

9.1 Overall Insights:

- The **median age** of mothers is consistently in the **late 20s to early 30s** across all UCs.
- There is some natural **variation** among the UCs, but none of them stand out as extreme in terms of age distribution.
- The presence of outliers in many UCs shows that while the majority of mothers fall within a similar age range, some individual cases deviate significantly.
- The **spread** of ages (indicated by whisker length) suggests that younger mothers are in their early 20s, while older mothers can be in their late 30s to early 40s.

9.2 Gender Distribution By UC

The chart titled "Gender Distribution by UC" shows the distribution of male and female children across various locations, represented:

1. **Observations**:

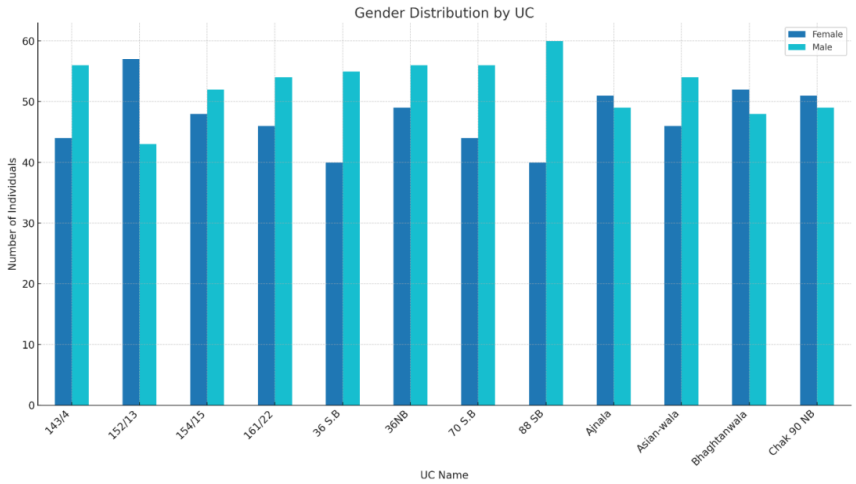


Figure 18: Gender distribution by UC

- Male Dominance: In most UCs, the number of male children (light blue) is slightly higher than female children (dark blue), though the gap is not very large.
- Female Representation: Chak 90 NB shows more female children than male.
- Variation across Locations: Overall numbers of children are fairly consistent across UCs, with modest differences. 88 SB and 36 SB show a stronger male majority, whereas Chak 90 NB leans toward females.

2. **Key Insights**:

- The gender distribution across the locations is imbalanced, with a higher representation of male children in nearly all locations.

This chart provides useful insights into the demographic distribution by gender across different villages, highlighting potential areas that may need targeted interventions.

9.3 The Way Forward

- **Establish a Follow-Up Team:** Create a Microbe Literacy Follow-Up Unit within the local health department, responsible for tracking implementation and outcomes.
- **Monitoring and Evaluation:** Set up a biannual reassessment survey system to monitor KAP changes over time.
- **Capacity Building:** Develop advanced modules for LHWS, incorporating digital learning tools and refresher training.
- **Leadership Engagement:** Regularly brief district and provincial leadership, presenting evidence of success and lobbying for policy integration.
- **Community Empowerment:** Train community influencers as "Microbe Literacy Champions" to promote ongoing behavior change.

9.4 Novel Metrics for Monitoring and Impact Tracking

*To enhance future monitoring, donor transparency, and scalability modeling, we propose three novel composite metrics derived from behavioral and program engagement indicators. These allow for **quantitative benchmarking** and **standardized tracking** across UCs and future deployments.*

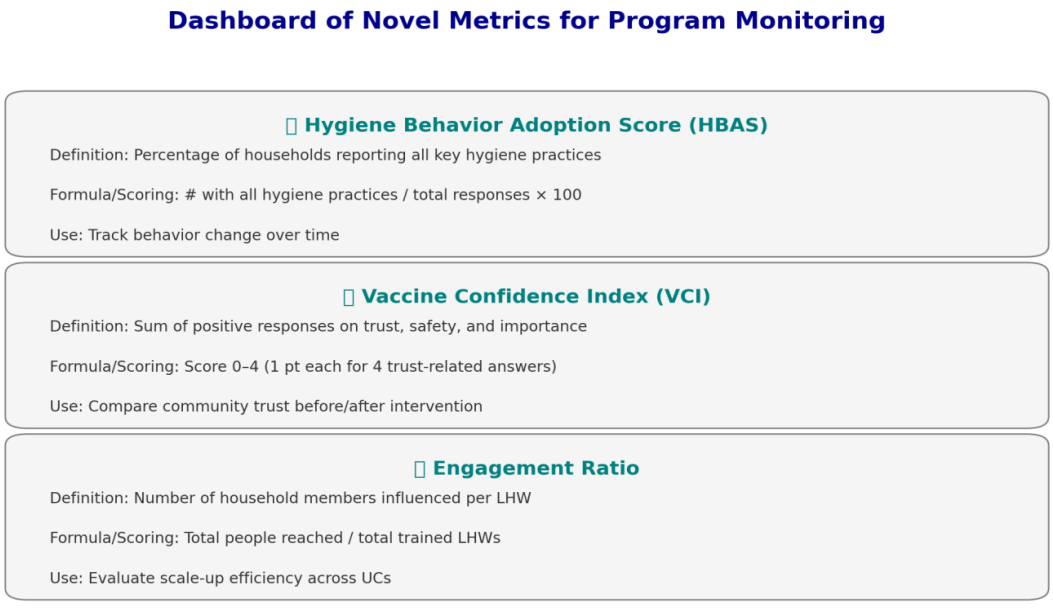


Figure 19: Dashboard of novel matrices and impact tracking

10. Policy Integration and Financing Pathways

Strengthening Long-Term Sustainability

To scale and sustain the impact of the Microbe Literacy Initiative, robust integration with policy and diversified financing are essential. This section outlines actionable strategies to embed microbe literacy into public health systems and funding architecture.

a. Integration into Public Health Programs

We recommend incorporating the Microbe Literacy modules into the **Expanded Program on Immunization (EPI)** at the provincial and district levels. Lady Health Workers (LHWs) can be equipped with standardized Microbe Literacy toolkits comprising microscopes, slides, and related materials to conduct interactive community workshops alongside routine EPI outreach campaigns. This dual-purpose engagement enhances both vaccination coverage and infection prevention awareness.

b. Recommended Financing Models

To ensure fiscal sustainability and resource mobilization, the following financing pathways are proposed:

1. **GAVI Co-Financing Support**: Align the microbe literacy component with GAVI's health system strengthening (HSS) agenda. Propose the initiative under community engagement for improved immunization uptake.
2. **Public-Private Partnerships (PPPs)**: Collaborate with local pharmaceutical and hygiene product companies to co-finance LHW training, behavior change materials, and handwashing stations as part of their social impact commitments.
3. **CSR-Driven Micro-Grants**: Tap into corporate social responsibility (CSR) schemes of local banks, telecoms, and industry groups to fund localized rollout of LHW training and microbe awareness campaigns in priority UCs.

c. Provincial Budget Line Recommendation

A dedicated **"Microbe Literacy and Behavior Change Training"** budget line should be established within Punjab's Department of Health development plan. This funding will support:

- Annual refresher training for LHWs
- Development of culturally relevant microbe literacy materials
- Monitoring, evaluation, and simulation-driven forecasting

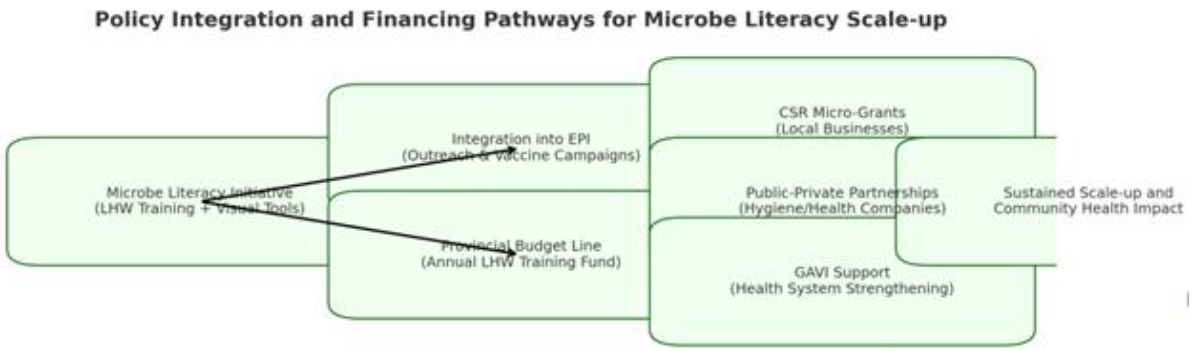


Figure 20: Policy Integration and financing pathways for microbe literacy scale up

11. Annexes

Annex 1: List of Participants and Review Team

- Principal Investigator: Major General Dr. Aamer Ikram
- Report Writer: Dr. Syed Aftab Rahim
- Implementation Partner: Development Synergies International (DSI/DDL)
- Field Data Collection Team: 24 Data Collectors, 6 Supervisors

Annex 2: Agenda of the Review

- Baseline Assessment (May 2024)
- Microbe Literacy Training (June-July 2024)
- Endline Assessment (August 2024)
- Data Analysis and Reporting (September 2024)

Annex 3: Completed Note-Taking Template

- Child gender distribution by UC
- Maternal education levels
- Household income levels
- KAP changes pre- and post-intervention

12. Predictive Modeling and Simulation for Long-Term Impact

Future-Oriented Program Evaluation

To further understand the longitudinal benefits of the Microbe Literacy Initiative, we recommend the integration of **predictive modeling** techniques in future program phases.

These models can simulate potential health and economic outcomes based on the positive behavioral shifts observed during the trial.

a. Suggested Modeling Approaches:

1. **Agent-Based Models (ABM)**: To simulate household behavior change over time, including hygiene practices and vaccine adherence, and their ripple effects within the community.
2. **Monte Carlo Simulations**: To model uncertainty and variation in disease incidence reduction, particularly for diarrhea and pneumonia cases, across different Union Councils.
3. **Dynamic Disease Transmission Models**: To forecast how improved microbe literacy could alter local infection rates under different scenarios of scale-up.

b. Potential Forecast Outcomes (Based on Current Data Trends):

- **40–55% reduction in diarrhea and pneumonia incidence** within 3–5 years if behavioral improvements are sustained.
- **Increase in school attendance** among children under 5, as fewer illness-related absences occur.
- **Substantial cost savings** for both households and local health systems through reduced reliance on curative care.
- **DALYs averted** (Disability-Adjusted Life Years) as improved hygiene and vaccine coverage cut disease burden.

c. Why It Matters for Donors:

Predictive modeling translates short-term impact into **long-term return on investment**. By projecting cost savings, health gains, and educational uplift, simulation tools help funders:

- Justify continued or expanded investment
- Visualize impact under scale-up scenarios
- Identify optimal intervention clusters for targeted funding

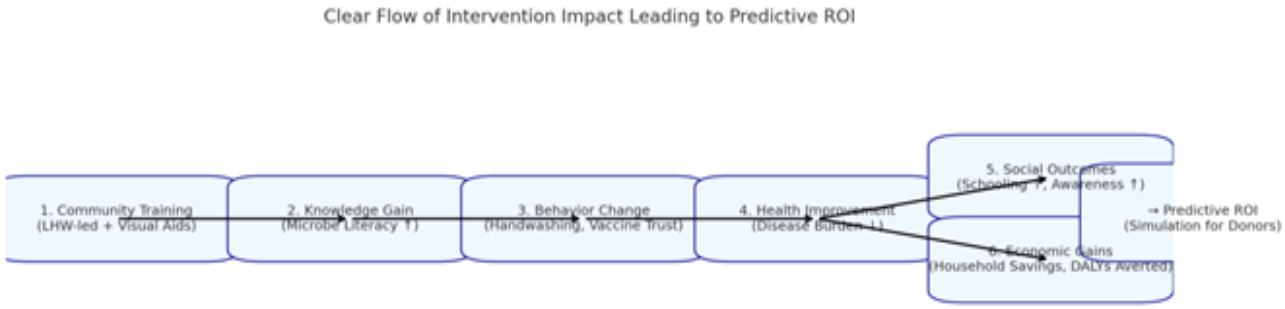


Figure 21: Flow of interventions impact leading to predictive ROI

This conceptual flowchart outlines how training inputs lead to behavioral change, resulting in improved health, education, and economic outcomes. These outcomes collectively contribute to a measurable return on investment (ROI) for donors, providing evidence for long-term impact through predictive modeling.

12.1Financial Breakdown

The initial investment in microscope equipment is high, but when used by a dedicated team for 1.5 workshops per day over 11 months, the cost per participant drops substantially. For the first year, the per-participant equipment cost is approximately 14 USD, but it decreases to just a few cents per participant after the initial year. This reduction plays a key role in the long-term cost-effectiveness and scalability of the intervention.

12.2. Comparative Report

This comparative report analyzes the effectiveness of a targeted Microbe Literacy intervention among Lady Health Workers (LHWS) in Sargodha, Punjab, Pakistan, by comparing baseline and end line survey data collected during a Cluster Randomized Controlled Trial (CRCT).

Question	Response	Baseline frequency	Baseline %	End line frequency	End line %
What are some common infectious diseases affecting children?	Diarrhea	829	69.1	480	40
	Pneumonia	224	18.7	144	12
	Malaria	64	5.3	36	3
	Others/No	83	6.9	540	45
What causes infectious diseases?	Bad weather	696	58	300	25
	Germs	504	42	900	75
How can these diseases be prevented?	Vaccination	974	81.2	1104	92
	Proper handwashing	110	9.2	660	55
	All	10	0.8	360	30
	Other	106	8.8	60	5
Have you ever heard about vaccines?	Yes	926	77.2	1140	95
	No	274	22.8	60	5
Where did you hear about vaccines from?	Doctor/health workers	1111	92.6	1164	97
	Family/friend	85	7.1	24	2
	Media	4	0.3	12	1
What do you understand from the word 'vaccine'?	Helps prevent disease	736	61.3	1020	85
	Cause infectious disease	206	17.2	60	5
	Don't know	258	21.5	120	10
How important do you think it is to vaccinate your children?	Not important	33	2.8	120	10
	Little important	523	43.6	480	40
	Important	490	40.8	480	40
	Very important	154	12.8	600	50
Do you think vaccines are safe for your children?	Not safe	38	3.2	24	2
	Not sure	395	32.9	96	8
	Yes, safe	767	63.9	1080	90
Do you trust health workers when they talk about vaccines?	Little	8	0.7	24	2
	Not sure	411	34.3	96	8
	Yes, a lot	781	65.1	1080	90
Do you think your child needs all the vaccines?	Not important	44	3.7	60	5
	Little important	346	28.8	300	25
	Important	350	29.2	300	25

	Very important	460	38.3	840	70
Would you tell other mothers to vaccinate their children?	No	159	13.3	60	5
	Maybe	495	41.3	180	15
	Yes	546	45.5	960	80
How likely are you to vaccinate your child in the future?	Very likely	859	71.6	1080	90
	Somewhat likely	267	22.3	96	8
	Not likely	74	6.2	24	2
How often do you take your child to the health center for vaccines?	Never	165	13.8	36	3
	Sometimes	411	34.3	84	7
	Often	55	4.6	120	10
	Always	569	47.4	960	80
Do you make sure your child gets all needed vaccines?	Never	104	8.7	36	3
	Sometimes	232	19.3	84	7
	Often	384	32	180	15
	Always	480	40	900	75
Did you receive necessary information from a health professional after childbirth?	Yes	967	80.6	1140	95
	No	233	19.4	60	5
How often do you wash your hands with soap?	Sometimes	272	22.6	60	5
	Often	60	5	60	5
	Always	868	72.3	1080	90
Do you make sure your child washes hands before eating?	Sometimes	314	26.2	60	5
	Often	95	7.9	84	7
	Always	791	65.9	1056	88
What hygiene practices do you regularly follow?	Clean water for cooking	647	53.9	960	80
	Boiling drinking water	459	38.3	720	60
	Other	94	7.8	60	5

13. The Way Forward

Long-term tracking of anthropometric indicators specifically height-for-age and weight-for-age, is currently underway to assess the impact of improved microbe literacy on childhood stunting and overall health outcomes. These longitudinal cohort data may be analyzed in subsequent follow-ups to provide robust evidence of sustained impacts, prevention of intergenerational malnutrition and extending beyond immediate behavioral change to measurable improvements in child growth and development. Microbes' literacy makes high recommendation to be included in pandemic preparedness and generation of a health nation and workforce.