Layer 2: Child Risk Map - ADIEWS

Notebook: `06_layer2_child_risk.ipynb`
Status: Complete
Framework: Child Documentation Gap & Temporal Lag Analysis

Overview

Layer 2 identifies districts where children (ages 5-17) are systematically under-documented relative to adults, revealing welfare access barriers. The framework combines proportional analysis, temporal lag detection, and migration context to quantify child documentation risk.

Core Methodology

Child Documentation Risk Framework

Three-Pillar Assessment: 1. **Child Share Analysis**: Proportion of updates involving children 2. **Temporal Lag Detection**: Delay between adult and child update peaks 3. **Risk Scoring**: Composite metric integrating share, lag, and volatility

Risk Formula:

```
Child Risk Score = (100 - Child_Share_Pct) × 0.6 +
                   (Lag_Index × 10) × 0.3 +
                   (Volatility_Imbalance) × 0.1
```

Key Metrics

1. Child Share Percentage

Definition: (Child Updates / Total Updates) × 100

Statistic	Value	Interpretation
Mean Child Share	9.48%	Average district: ~1 in 11 updates is child
Median Child Share	8.84%	Half of districts below 8.84%

Statistic	Value	Interpretation
Low Share Districts (<5%)	206 (19.5%)	One-fifth critically underserving children
High Share Districts (>20%)	18 (1.7%)	Only 18 districts achieve equitable coverage

Child Share Distribution:

Range	Districts	% of Total	Status
0-5% (Critical)	206	19.5%	Severe child neglect
5-10% (Below Average)	598	56.6%	Moderate underperformance
10-15% (Average)	216	20.5%	Approaching equity
15-20% (Good)	18	1.7%	Strong child focus
20%+ (Excellent)	18	1.7%	Benchmark districts

Lowest Child Share Districts (Top 10):

Rank	District	State	Child Share %	Adult Updates	Child Updates	Risk Score
1	**Washim**	Maharashtra	0.5%	8,456	42	50.9 (HIGH)
2	**Buldana**	Maharashtra	0.8%	12,234	98	58.1 (HIGH)
3	**Bid**	Maharashtra	0.9%	15,678	141	55.3 (HIGH)
4	**Gondia**	Maharashtra	1.6%	9,234	148	53.2 (HIGH)
5	**Yavatmal**	Maharashtra	1.8%	19,456	350	50.1 (MOD-ERATE)
6	**Karaikal**	Pondicherry	2.4%	6,789	231	54.4 (HIGH)
7	**Panch Ma-hals**	Gujarat	3.6%	8,234	296	55.9 (HIGH)
8	**South An-daman**	A&N Is-lands	2.8%	3,456	97	49.9 (MOD-ERATE)
9	**Ahmadnagar**	Maharashtra	3.3%	36,523	1,205	25.8 (LOW)

Rank	District	State	Child Share %	Adult Updates	Child Updates	Risk Score
10	**Solapur**	Maharashtra	2.7%	47,202	1,274	27.3 (LOW)

Maharashtra Concentration: 7 of bottom 10 in Maharashtra (overlap with Layer 1 migration zones)

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2. Temporal Lag Analysis

Definition: Month offset between adult peak and child peak

Lag Detection Metrics: | Metric | Value | |——–|——-| | **Districts with Positive Lag** | 65 (6.2%) | | **Districts with Adult Spike** | 966 (91.5%) | | **Districts with Child Response** | 949 (89.9%) | | **Districts with Peak Mismatch** | 142 (13.4%) |

Lag Interpretation: - **Lag = 0**: Child and adult peaks synchronous (expected pattern) - **Lag = 1-2**: Child updates follow adult updates with 1-2 month delay (mild concern) - **Lag ≥ 3**: Significant documentation delay (structural barrier)

Highest Lag Districts:

District	State	Lag (Months)	Adult Peak	Child Peak	Risk Score
Dadra & Nagar Haveli	D&NH	3	Oct 2025	Jan 2026	51.5
Shahjahanpur	UP	3	Sep 2025	Dec 2025	50.6
Gondiya	Maharashtra	3	Oct 2025	Jan 2026	50.1
Washim	Maharashtra	2	Nov 2025	Jan 2026	50.9
Buldana	Maharashtra	2	Oct 2025	Dec 2025	58.1

Lag Causes (Hypothesized): 1. **Administrative delay**: Parents enroll self first, children later 2. **School-cycle dependence**: Child updates tied to academic year 3. **Awareness gap**: Parents unaware of child enrollment importance 4. **Access barriers**: Separate processes/centers for child enrollment

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3. Child-Adult Ratio

Definition: Average child updates per adult update per record

Statistic	Value
Mean Ratio	0.116
Median Ratio	0.000
75th Percentile	0.143
Maximum	1.083

Ratio Distribution: - **0.00** (Zero Child): 53.5% of all records - **0.01-0.10**: 26.8% - **0.11-0.20**: 14.2% - **0.21-0.50**: 4.7% - **0.50+**: 0.8% (outliers)

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4. Child Risk Score (Composite)

Formula Components: - **60% Weight**: 100 - Child Share % (under-representation penalty) - **30% Weight**: Lag Index × 10 (temporal delay penalty) - **10% Weight**: Volatility Imbalance (instability penalty)

Risk Level Classification:

Risk Level	Score Range	Districts	% of Total	Intervention
CRITICAL	70-100	0	0.0%	Immediate action
HIGH	50-70	9	0.9%	Urgent intervention
MODERATE	30-50	93	8.8%	Enhanced monitoring
LOW	0-30	954	90.3%	Standard operations

High Risk Districts (All 9):

Rank	District	State	Risk Score	Child Share	Lag	Migration Pattern
1	Buldana	Maharashtra	58.1	0.8%	2	High In-Migration
2	Panch Mahals	Gujarat	55.9	3.6%	2	Seasonal Migration
3	Bid	Maharashtra	55.3	0.9%	2	Seasonal Migration
4	Karaikal	Pondicherry	54.4	3.4%	2	Seasonal Migration

Rank	District	State	Risk Score	Child Share	Lag	Migration Pattern
5	Gondia	Maharashtra	53.2	1.6%	2	Seasonal Migration
6	Dadra & Nagar Haveli	D&NH	51.5	12.2%	3	Seasonal Migration
7	Washim	Maharashtra	50.9	0.5%	2	Seasonal Migration
8	Shahjahanpur	UP	50.6	7.9%	3	High In-Migration
9	Gondiya	Maharashtra	50.1	5.8%	3	High In-Migration

🗺️ Geographic Patterns

State-Level Child Share Analysis

Top Performing States (Child Share >12%):

State	Avg Child Share	Districts	Best District
Tamil Nadu	14.2%	46	Tiruvarur (52.0%)
Kerala	13.8%	14	Thiruvarur (45.6%)
Karnataka	12.5%	53	Bangalore (18.9%)
Andhra Pradesh	11.9%	45	Visakhapatnam (16.2%)

Underperforming States (Child Share <8%):

State	Avg Child Share	Districts	Worst District
Maharashtra	6.8%	53	Washim (0.5%)
Gujarat	7.2%	39	Panch Mahals (3.6%)
Uttar Pradesh	7.5%	89	Shahjahanpur (7.9%)
Bihar	8.1%	47	Purnia (5.4%)

Correlation with Migration Patterns

Risk by Migration Type:

Migration Pattern	Avg Risk Score	Districts	Interpretation
High In-Migration	25.14	162	New migrants deprioritize child docs
High Churn	23.86	92	Instability disrupts child enrollment
Seasonal Migration	23.76	597	Circular migration hinders follow-up
High Out-Migration	23.50	20	Economic stress limits engagement
Stable Population	22.66	185	Baseline (controlled comparison)

Insight: Migration exacerbates child documentation gaps (+1.5 to +2.5 points vs stable)

Statistical Validation

Predictive Model: Child Risk Score

Logistic Regression: High Risk (Yes/No) ~ Migration Pattern + Volatility + Child Share

Predictor	Odds Ratio	95% CI	p-value	Interpretation
Seasonal Migration	2.34	[1.89, 2.91]	<0.001	2.3× higher odds of high risk
High Volatility (σ >5000)	1.87	[1.45, 2.41]	<0.001	1.9× higher odds
Child Share <5%	8.45	[6.23, 11.48]	<0.001	8.5× higher odds (strongest)
Urban District	0.72	[0.56, 0.93]	0.012	28% protective effect

Model Performance: - **AUC-ROC**: 0.89 (excellent discrimination) -

Sensitivity: 86.3% (captures 86% of high-risk districts) - **Specificity**: 91.2% (low false positive rate)

📊 Visualizations Generated

File	Description	Key Insight
`layer2_child_share_analysis.png`	Distribution + geographic patterns	206 districts <5% share
`layer2_lag_detailed.png`	Temporal mismatch analysis	142 districts with peak mismatch
`layer2_risk_score_priority.png`	Composite risk ranking	9 high-risk districts
`layer2_high_risk_districts.png`	Priority intervention map	Maharashtra clusters

🎯 Policy Recommendations

Immediate Interventions (0-3 months)

For 9 High-Risk Districts:

1. **Mobile Aadhaar Camps**:
   - School-based enrollment drives (weekdays 3-5 PM)
   - Anganwadi integration (under-5s + 5-17 coverage)
   - Weekend camps in migration corridors
2. **Awareness Campaigns**:
   - “Child Aadhaar = School Access” messaging
   - Local language materials (Marathi, Gujarati, Hindi)
   - Community leader engagement
3. **Administrative Mandates**:
   - School admission conditional on Aadhaar (with grace period)
   - Mid-day meal linkage to enrollment
   - PDS ration card dependent on child documentation

Medium-Term Programs (3-12 months)

For 93 Moderate-Risk Districts:

1. **Systematic Lag Elimination**:
   - Simultaneous parent-child enrollment protocols
   - “Family Package” enrollment incentives

- Follow-up SMS reminders for child updates

2. **Infrastructure Upgrades**:
   - Child-friendly enrollment centers (play areas, short queues)
   - School-hour availability (4-6 PM slots)
   - Female staff for child comfort
3. **Data Integration**:
   - Link Aadhaar to UDISE+ (school database)
   - Cross-reference with immunization records
   - Identify undocumented children proactively

Long-Term Structural Reforms (12+ months)

1. **Policy Linkages**:
   - Make child Aadhaar mandatory for:
     - School enrollment/transfer certificates
     - Scholarship disbursement
     - Child welfare scheme benefits
   - Incentivize schools for 100% Aadhaar coverage
2. **Migration-Responsive Systems**:
   - Portable enrollment (enroll at source, update at destination)
   - Seasonal camp calendars aligned with agricultural cycles
   - Inter-state coordination for migrant families
3. **Zero-Gap Target**:
   - National goal: 95% child share in all districts by 2027
   - Quarterly monitoring dashboard
   - District-level performance incentives

Technical Notes

Assumptions

1. **Proportional Equity**: Ideal child share = % of population aged 5-17 (assumed ~15%)
2. **Temporal Sync**: Adult-child peaks should align (lag indicates barrier)
3. **Migration Causality**: Migration causes child gaps (not proven, but correlated)

Limitations

1. **No Age-Specific Targets**: Assumes uniform 15% child share (varies by district demographics)

2. **Lag Detection Sensitivity**: 10-month window limits multi-year lag detection
3. **Risk Score Weights**: Arbitrary 60-30-10 split (not empirically optimized)

Last Updated: January 2026
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