



Moving targets, missing data: why children on the move remain invisible to immunization surveillance systems

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Background: An estimated ~14.5 million children globally remain zero-dose (ZD), meaning they have not received any routine vaccinations. ZD children are disproportionately concentrated in hard-to-reach populations, including mobile groups such as refugees and nomadic pastoralists. Mobility driven by conflict, climate variability, food insecurity, and livelihood pressures produces complex, circular population movements. However, most immunization surveillance systems are designed for sedentary populations, leading to systematic exclusion of children in mobile settings.

Methods: We conducted a scoping review following PRISMA-ScR guidelines to synthesize evidence on geospatial modelling of childhood vaccination coverage in low- and lower-middle-income countries (LLMICs). Six databases were searched, and data were extracted on study characteristics, covariates, modelling approaches, and the incorporation of mobility sensitive data. Findings were synthesized thematically, with a focus on how population mobility is represented in immunization surveillance. **Results:** We included 102 studies across 68 countries, identifying 931 covariates used in spatial modelling of childhood vaccination coverage. Only 7.7% of the covariates represented hard-to-reach or migration contexts and just 11% of the studies incorporated routine health information systems that could support continuous surveillance of mobile populations. Only three studies explicitly focused on migrant populations, and 11 examined conflict- or displacement affected settings. Migration was rarely modelled as a dynamic process; instead, it was treated as a source of uncertainty rather than a determinant of immunization status.

Conclusion: Current immunization modelling approaches remain optimized for static populations, systematically missing children on the move. Integrating mobility-aware surveillance systems is essential to reduce persistent inequities in ZD vaccination coverage.

