University of Cape Town

Mathematical Modelling of Infectious Diseases

Rubella Vaccination in South Africa: A Policy Brief

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Rubella Vaccination in South Africa: What Coverage, How Fast?

Policy Brief for Decision-Makers (October 19, 2025)

Executive Summary Rubella remains endemic in South Africa and causes preventable congenital rubella syndrome (CRS). An age/sex-structured SEIR model calibrated to national demography and WHO cases shows that introducing rubella-containing vaccine (RCV) with **high routine coverage and a one-time, wide catch-up** yields the largest CRS reductions over 10 and 25 years. Immediate roll-out at **routine** $\geq 90\%$ with a **catch-up of ages 1–14 years at 90%** dominates alternatives at 10 years and remains slightly better at 25 years. Low routine with modest catch-up can temporarily increase infections among women 15–44 (the "paradox") despite fewer total infections; this risk is avoided with high routine plus high catch-up. Our recommendation is therefore to **introduce now**, target $\geq 90\%$ **routine** in all districts, and deliver a **single national catch-up (1–14y) at 90%** using schools and primary care.

Background and Question Rubella's transmissibility is lower than measles yet sufficient to sustain endemic transmission without vaccination. Infection during early pregnancy can cause fetal death or lifelong disability due to CRS, making prevention a priority even when total case counts are modest.

Policy question. Should South Africa introduce RCV now, and if so, what combination of routine coverage and a one-time catch-up minimises CRS over 10 and 25 years while avoiding paradox risk?

What We Did (in brief) We implemented an age/sex-structured SEIR with annual births, ageing, and mortality (UN WPP 2024); routine MR at age 1; and an optional one-time catch-up (default 1–14y; 9m–9y variant tested). Female infections (15–44y) were mapped to CRS using trimester-weighted risks and a pregnancy-prevalence proxy derived from fertility-by-age. Magnitudes and trends were checked against WHO reported rubella cases (2012–2019) using literature-anchored transmissibility and reporting, with a single mean-level rescale shown for face validity. We also ran an *exploratory negative-binomial likelihood fit* to the annual case series but retained literature-anchored parameters for the headline policy results (full details in the technical report). We then explored $R_0 \in \{6, 7, 8\}$, routine 50–95%, catch-up 0–95%, and campaign timing (immediate, +1y, +2y, +3y).

Key Findings

- **High routine + wide, high-coverage catch-up delivers the biggest CRS reductions.** With a 90% catch-up done immediately, the *minimum* routine needed so that 25-year averted CRS is positive (vs. an 80% routine, no-catch-up baseline) is roughly: $\sim$ 55–60% at R_0=6; $\sim$ 50% at R_0=7; and $\sim$ 80% at R_0=8. In practice, targeting $\geq 90\%$ routine coverage eliminates paradox concerns and maximises benefits at both 10 and 25 years.
- **Timing matters.** Immediate campaigns yield larger 10-year gains and remain slightly better by 25 years than delaying 1–3 years when routine is high.
- **Paradox flag.** At low routine with modest catch-up, cumulative infections in females 15–44 can exceed baseline (temporary upward shift in mean infection age). This flag disappears at $\geq 90\%$ routine with a 90% catch-up (1–14y).

Recommendations 1) **Introduce now** with **routine** $\geq 90\%$ nationwide and a **one-time**

1–14y catch-up at 90%. Use schools as the backbone and primary-care/mobile teams to reach out-of-school and informal settlements.
2) **Do not introduce at low routine** unless paired with a broad catch-up. Where local R_0 approaches 8, secure at least $\sim 80\%$ routine or the catch-up benefit will be blunted.
3) **Act fast**: immediate campaigns produce larger 10-year reductions and still outperform delays by 25 years when routine is high.

Implementation Considerations

- *Delivery model.* Co-administer MR at 9–12 months in routine; deliver the one-time catch-up via schools (grades R–9) plus PHC outreach/mobile teams to reach out-of-school children and informal settlements.
- *Microplanning & doses.* Set ward-level targets; forecast doses as targets × coverage goal + 10–15% buffer; align session plans to minimise open-vial wastage (10-dose MR).
- *Cold chain & logistics.* Verify sub-district cold capacity and transport coolers; pre-position syringes and safety boxes; maintain weekly stock visibility (DHIS2 logistics).
- *People & training.* Brief vaccinators on screening/contraindications, AEFI reporting, and tally-sheet accuracy; assign supervisors (1 per 5–8 teams) with a simple daily checklist.
- *Equity.* Schedule extra days for low-coverage wards, evening/weekend sessions, and partner with NGOs/CBOs for migrant and informal-settlement outreach.
- *Communications.* Emphasise CRS prevention and MR co-benefits; simple consent flows in schools; pre-empt misinformation via radio and community leaders.

Monitoring & Risk Mitigation

- *Coverage.* Each week, districts will report routine and catch-up coverage by age band. An independent check in a 5–10% sample of sites will verify the administrative reports.
- *Equity.* We will monitor zero-dose and drop-out rates and the share of schools and facilities that achieve at least 90% coverage, with additional outreach scheduled where gaps persist.
- *Supply and quality.* Cold-chain alarms, stockout days for vaccine and consumables, and open-vial wastage will be reviewed weekly so that resupply or coaching can be triggered before sessions are missed.
- *Safety.* Adverse events following immunisation (AEFI) will be recorded and investigated, with any cluster reviewed within 48 hours and findings communicated promptly to providers and communities.
- *Epidemiology.* We will summarise rubella-like illness by age—especially in females aged 15–24—and compile suspected and confirmed CRS from sentinel sites to detect any unexpected shifts.
- *Pre-agreed triggers.* If any district's weekly coverage remains below 85% for two consecutive weeks, a surge team will support extra school and primary-care sessions. If female cases in the 15–24 age group rise above baseline (a paradox signal), a targeted mini catch-up and communications push will be undertaken. If an AEFI cluster is suspected, a rapid clinical review and lot audit will be conducted, with a focused pause if warranted.
- *Reporting cadence.* A one-page dashboard will be issued weekly during rollout, monthly for six months after the campaign, and once more at endline with a concise summary of coverage, equity, epidemiology, and safety.

Code & Reproducibility Full source and outputs: `https://github.com/Annie0619/disease_modelling_assignment/tree/main`.