

What Drives Routine Vaccine Availability at Health Facilities?

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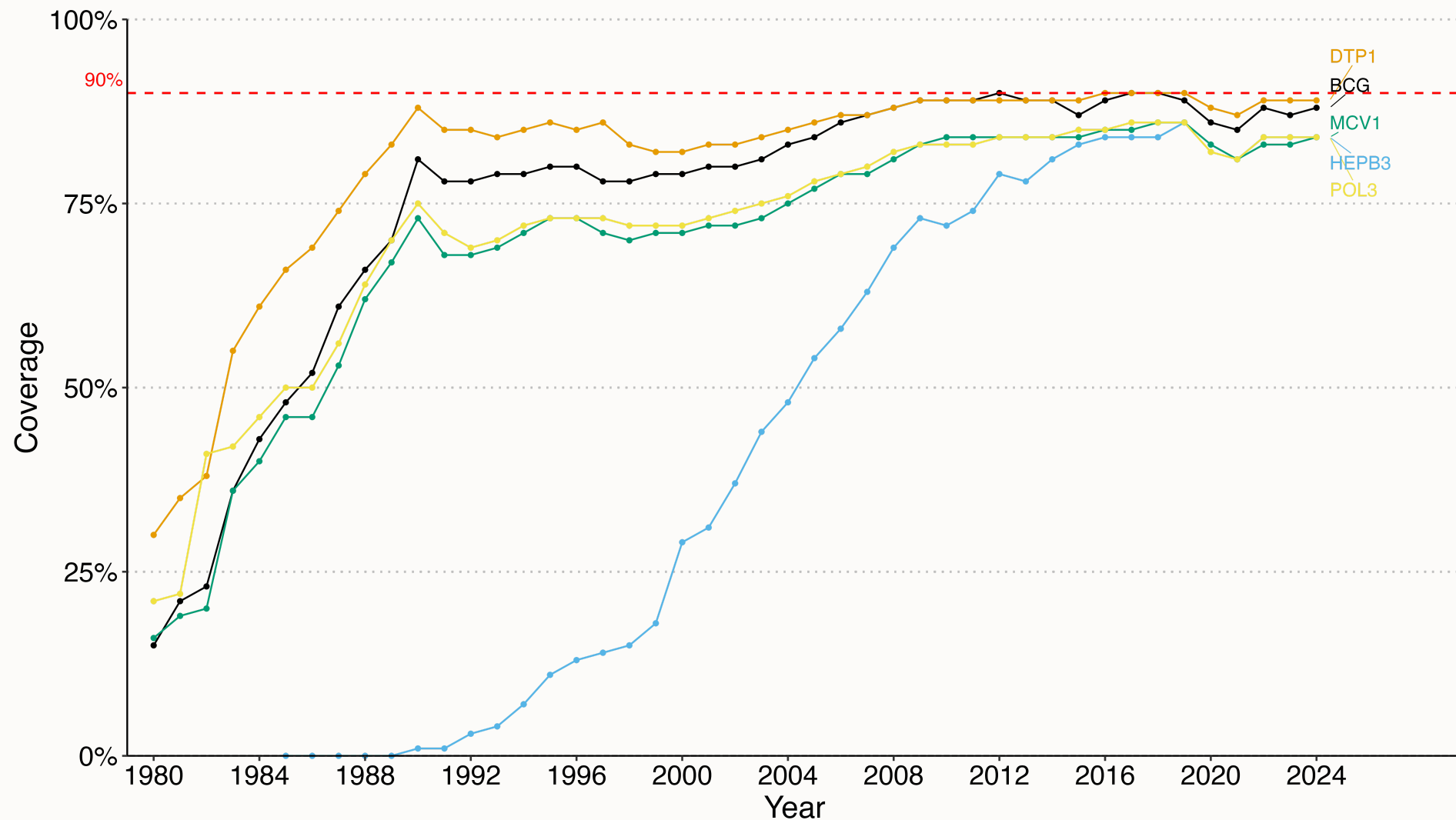


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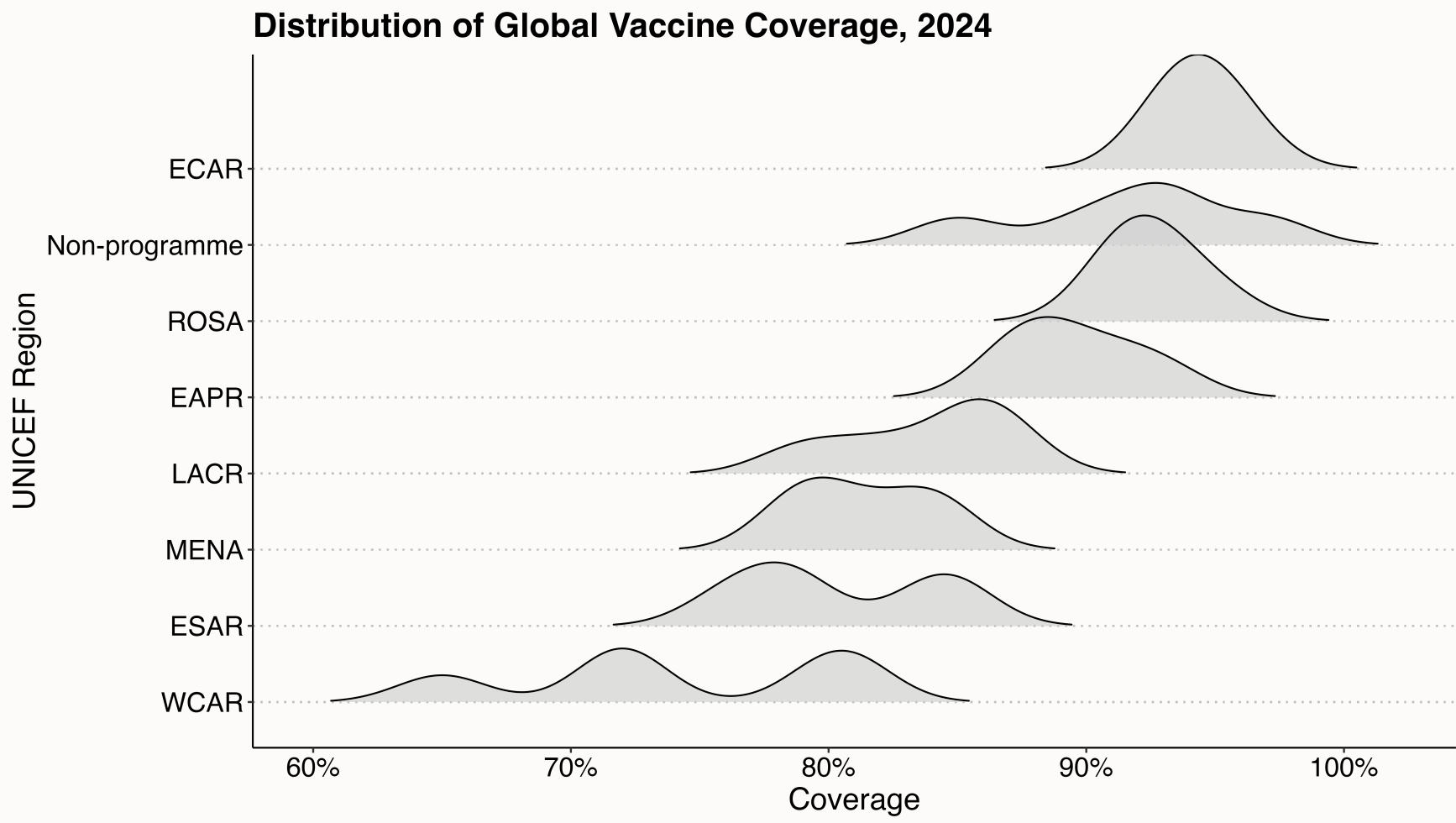
Vaccines are among the most effective public-health interventions



Vaccines are among the most effective public-health interventions



Coverage disparities exist within and between regions



19.9

Million

Missed
vaccines

13.5

Million

Zero-dose

4.9

Million

Under-five
mortality

Having the vaccine is not enough

A vaccine only saves a life if it reaches the child.

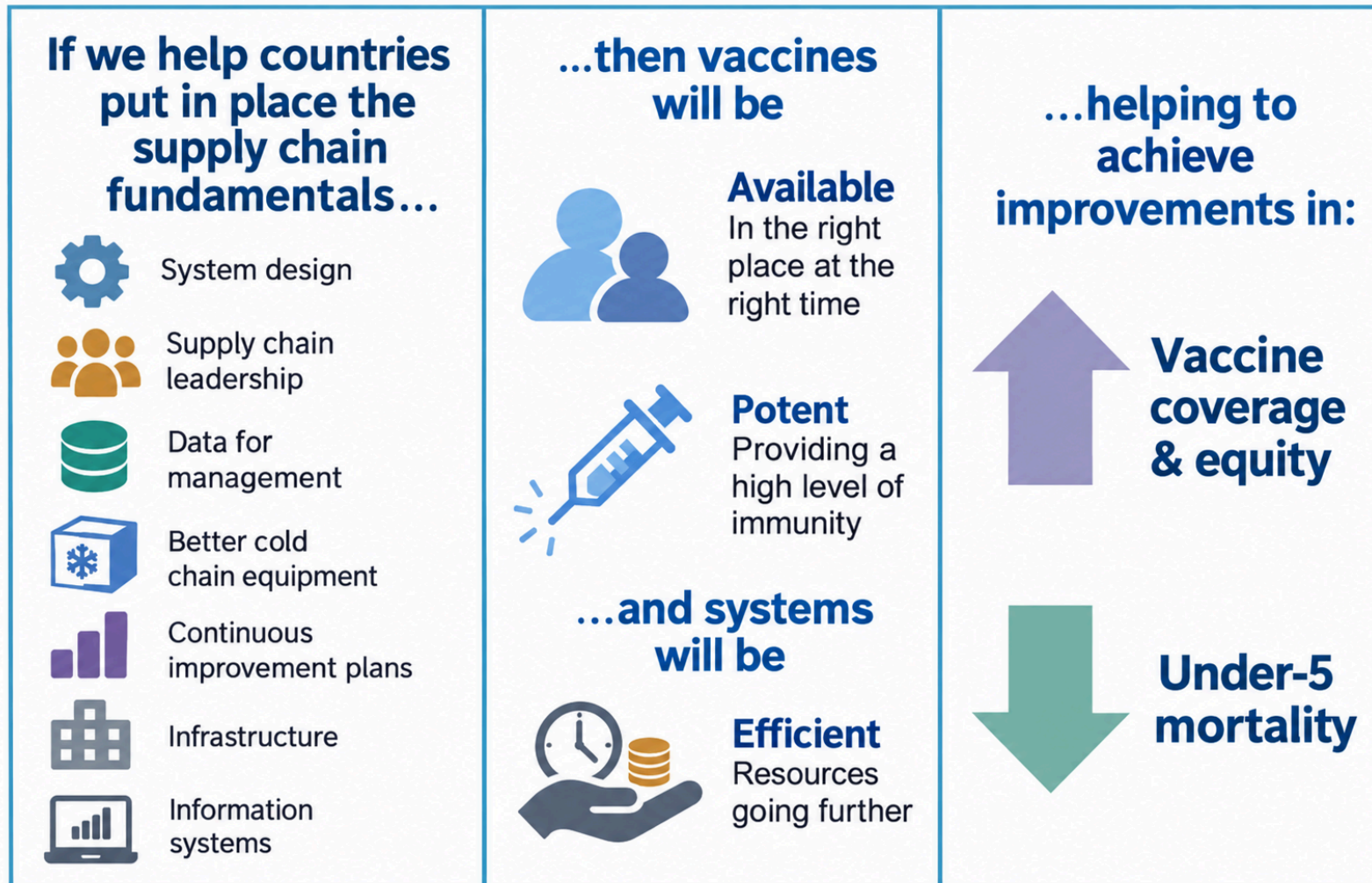


What could have gone wrong?

The child arrives. But the vaccine is not available. Why?



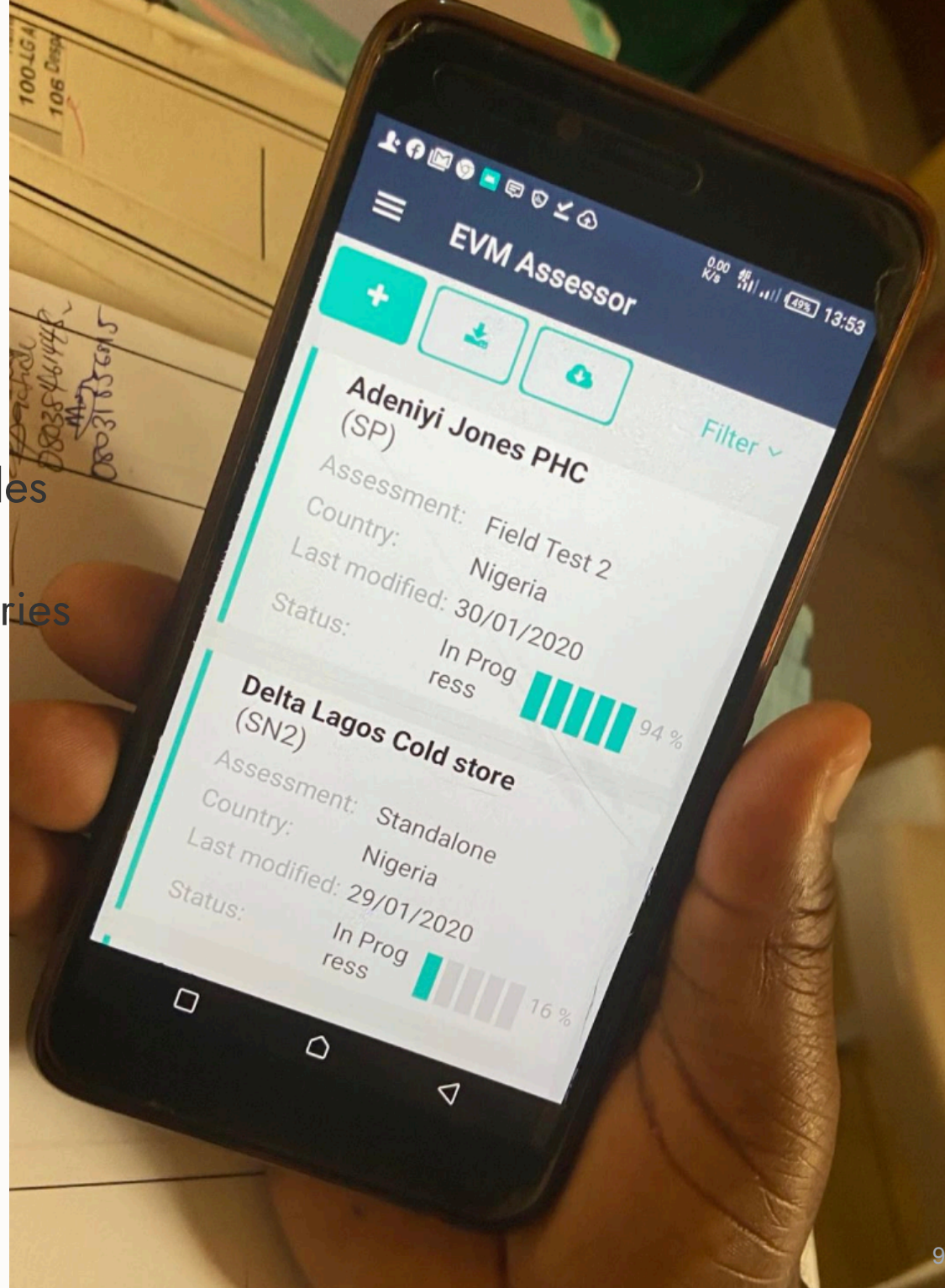
The supply chain connects vaccines to health outcomes



A global initiative to improve immunisation supply chain

A national planning process endorsed and supported by WHO and UNICEF

Effective Vaccine Management (EVM) provides materials and tools needed to monitor and assess vaccine supply chains and help countries improve their supply chain performance.



EVM Framework

The **EVM** assessment framework defines the way in which vaccine supply chain systems are assessed.

It is organised by:

- **Questions:** are asked to assess whether a requirement has been met.
 - **Requirements:** the attributes that a well-functioning immunisation supply chain must have.
 - **Requirements** could be inputs, outputs or performance measures.
 - **Criteria:** the operational or management functions that health facilities must perform.
 - **Categories:** the necessary inputs, outputs and performance of health facilities.
- Assessments from 82 countries between 2019 and 2026.
 - 1286 potential questions
 - over 4000 health facilities
 - 900 requirements, 19 criteria and 8 categories
 - Scores range from 0 to 5.

Data - Scores

Show  entries

Search:

[illegible]

Showing 1 to 10 of 29 entries

Previous

1

2

3

Next

EVM creates an analytical opportunity

 EVM already tells us **where requirements are being met**.

But we want to go one step further:

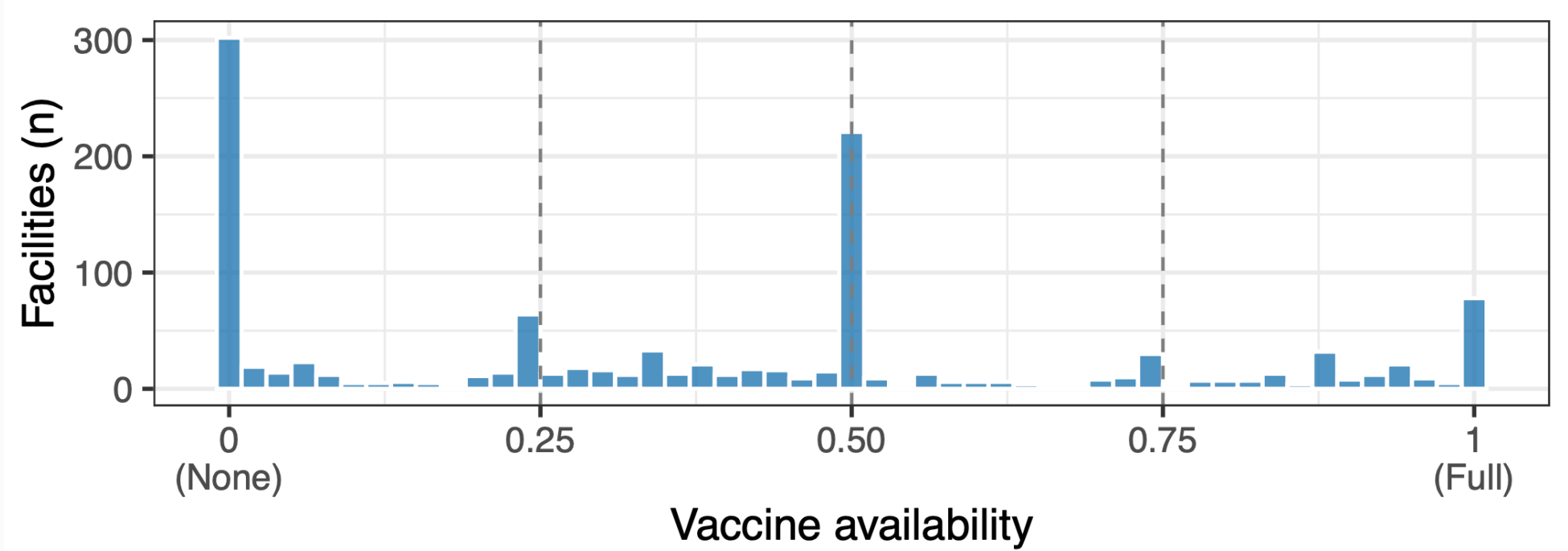
Which requirements are associated with higher/lower vaccine availability?

We focus on **Service Point (SP) facilities**

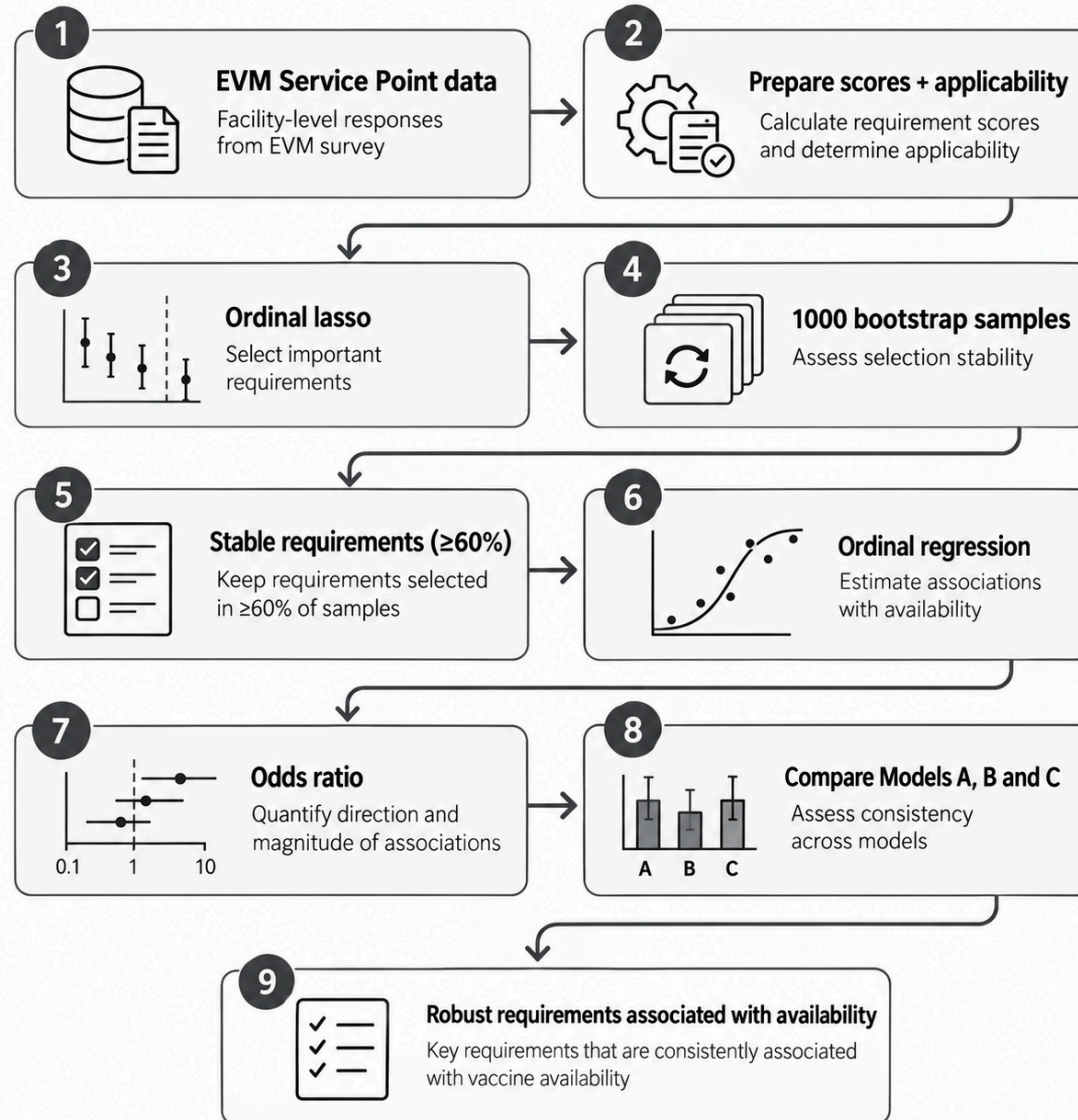
- **Outcome:** Vaccine availability (AV)
- **Independent variables of interest:** The facility's **EVM requirements**.
- **Context:** **Country** and **target population** are used as adjustments rather than treated as the requirements of interest.

Availability is categorized and ordered

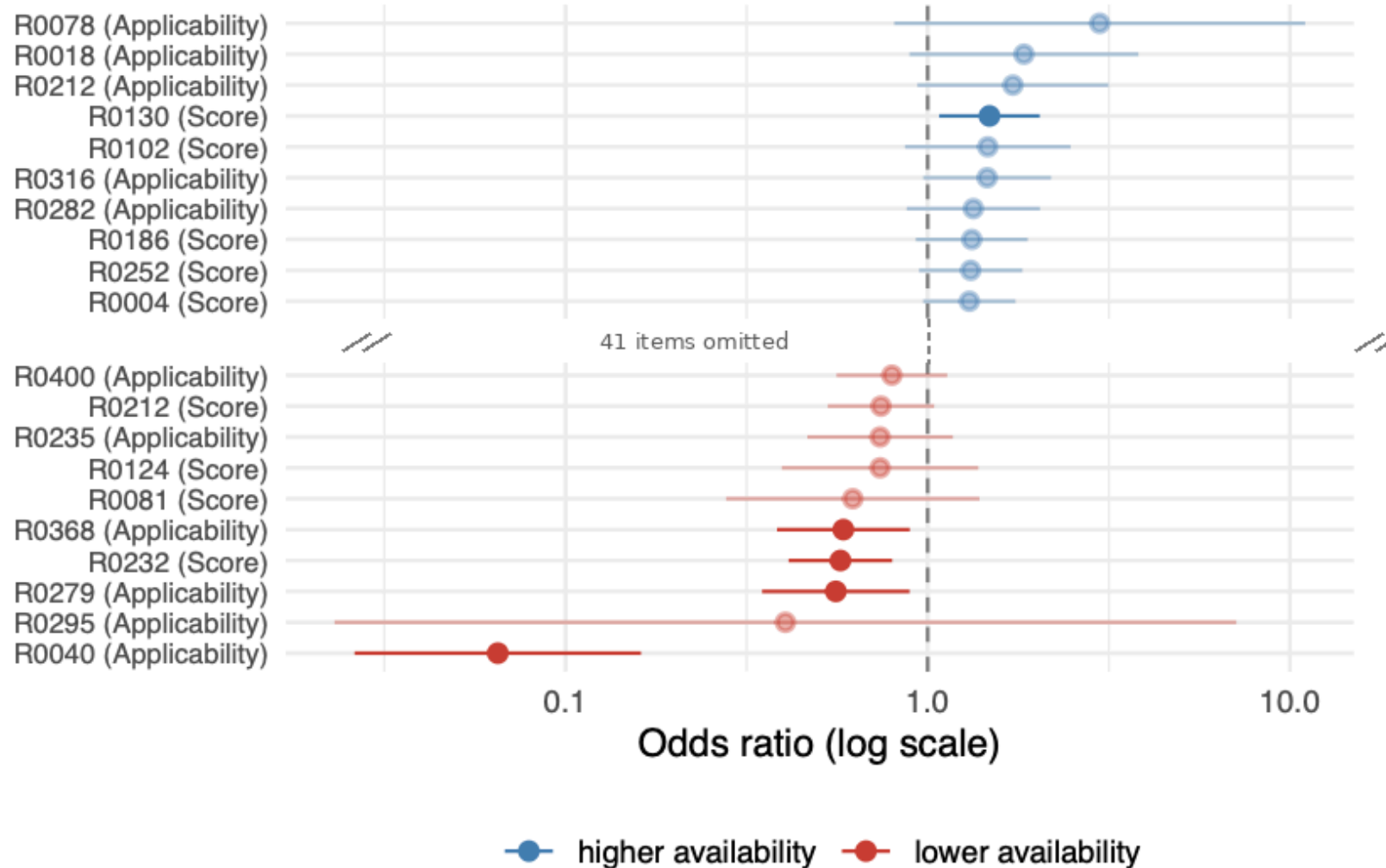
Band	Availability
1 — None	$AV = 0$
2 — Critical	$0 < AV \leq 0.25$
3 — Low	$0.25 < AV \leq 0.50$
4 — Moderate	$0.50 < AV \leq 0.75$
5 — Good	$0.75 < AV < 1$
6 — Full	$AV = 1$



The analytical workflow



Results



Results

Code	Category	Name	Enc	OR (95% CI)	p	Direction
R0078	C2.2.1	The facility's vaccine transportation vehicles have suffi...	Applicability	2.98 (0.81–11.02)	1.01e-01	higher availability
R0018	C1.2	Windows have locks or grills.	Applicability	1.84 (0.89–3.82)	9.91e-02	higher availability
R0212	C3.2	The vaccine receipt form has the field: Freeze indicator ...	Applicability	1.72 (0.94–3.16)	8.05e-02	higher availability
R0130	C2.3	The bins are colour coded for different types of waste.	Score	1.48 (1.08–2.04)	1.61e-02	higher availability
R0102	C2.3	The facility has at least one functional needle cutter pe...	Score	1.47 (0.87–2.48)	1.55e-01	higher availability
R0316	C5.3	The facility has SOPs for packing insulated containers.	Applicability	1.46 (0.97–2.19)	6.81e-02	higher availability
R0282	C4.3	Responsible staff know that warm-packs should not be pack...	Applicability	1.34 (0.88–2.04)	1.79e-01	higher availability
R0186	C3.2	The vaccine stock record form has the field: VVM status	Score	1.32 (0.93–1.89)	1.22e-01	higher availability
R0252	C4.2	Responsible staff are trained how to forecast vaccine and...	Score	1.31 (0.95–1.83)	1.03e-01	higher availability
R0004	C1.1	The facility has a reliable internet connection.	Score	1.30 (0.97–1.75)	7.68e-02	higher availability
R0109	C2.3	The needle pit is not subject to flooding.	Applicability	1.27 (0.77–2.10)	3.54e-01	higher availability
R0156	C3.2	The form is graphical.	Score	1.23 (0.86–1.76)	2.62e-01	higher availability
R0306	C5.3	The facility has SOPs for vaccine temperature monitoring ...	Score	1.21 (1.05–1.40)	8.41e-03	higher availability
R0316	C5.3	The facility has SOPs for packing insulated containers.	Score	1.16 (1.06–1.26)	8.33e-04	higher availability
R0112	C2.3	The incinerator has two or more combustion chambers.	Score	1.13 (0.98–1.30)	8.51e-02	higher availability
R0211	C3.2	The vaccine receipt form has the field: VVM status of vac...	Score	1.13 (1.01–1.26)	3.86e-02	higher availability
R0120	C2.3	Waste handlers are equipped with protective eyewear.	Score	1.12 (0.99–1.27)	8.06e-02	higher availability
R0309	C5.3	The facility has SOPs/guidelines for routine maintenance ...	Score	1.09 (1.00–1.19)	4.54e-02	higher availability
R0208	C3.2	The vaccine receipt form has the field: Signature of pers...	Score	1.09 (0.99–1.20)	7.25e-02	higher availability
R0037	C1.2	Storage buildings have functional certified fire extingui...	Score	1.08 (0.99–1.17)	7.32e-02	higher availability
R0136	C3.1	iSC staff have work mobile phones.	Score	1.07 (0.97–1.19)	1.74e-01	higher availability
R0269	C4.3	Responsible staff can correctly read a 30DTR.	Score	1.07 (1.00–1.13)	3.58e-02	higher availability
R0238	C4.1	Adequate staff are assigned to monitor vaccine temperatures.	Score	1.06 (0.99–1.15)	1.09e-01	higher availability
R0358	C6.1	Staff are paid in full and on time.	Score	1.06 (1.00–1.13)	4.24e-02	higher availability
R0017	C1.2	External doors have locks.	Score	1.06 (0.98–1.14)	1.31e-01	higher availability
R0095	C2.2.2	Insulated containers comply with WHO or national specific...	Score	1.05 (0.94–1.18)	3.93e-01	higher availability
R0245	C4.1	Two or more members of staff are assigned to manage vacci...	Score	1.03 (0.96–1.11)	3.92e-01	higher availability

Agreement across models is the robust core

A requirement that changes direction or disappears across specifications should be treated more cautiously.

Code	Category	Name	Enc	OR (A)	OR (B)	OR (C)	Direction	In n models
R0005	C1.1	The facility receives at least eight hours of grid electr...	Applicability	0.85	0.84	0.97	lower availability	3/3
R0004	C1.1	The facility has a reliable internet connection.	Score	1.17	1.30	1.28	higher availability	3/3
R0037	C1.2	Storage buildings have functional certified fire extingui...	Score	1.08	1.08	1.08	higher availability	3/3
R0017	C1.2	External doors have locks.	Score	1.05	1.06	1.05	higher availability	3/3
R0040	C2.1.1	The facility has sufficient positive cold storage capacit...	Applicability	0.04*	0.07*	0.08*	lower availability	3/3
R0062	C2.1.1	Vaccine refrigerators/freezers have functioning voltage r...	Score	0.82	0.83	0.83	lower availability	3/3
R0102	C2.3	The facility has at least one functional needle cutter pe...	Score	1.52	1.47	1.51	higher availability	3/3
R0130	C2.3	The bins are colour coded for different types of waste.	Score	1.43*	1.48*	1.50*	higher availability	3/3
R0126	C2.3	Waste is stored in a segregated area.	Score	0.95	0.95	0.95	lower availability	3/3
R0136	C3.1	iSC staff have work mobile phones.	Score	1.04	1.07	1.06	higher availability	3/3
R0212	C3.2	The vaccine receipt form has the field: Freeze indicator ...	Score	0.67*	0.74	0.74	lower availability	3/3
R0211	C3.2	The vaccine receipt form has the field: VVM status of vac...	Score	1.13*	1.13*	1.15*	higher availability	3/3
R0208	C3.2	The vaccine receipt form has the field: Signature of pers...	Score	1.05	1.09	1.06	higher availability	3/3
R0187	C3.2	The vaccine stock record form has the field: Transaction ...	Score	0.95	0.93*	0.93*	lower availability	3/3
R0232	C4.1	At least one member of staff is responsible for forecasti...	Score	0.66*	0.57*	0.57*	lower availability	3/3
R0235	C4.1	Two or more members of staff are able to report iSC data.	Applicability	0.85	0.74	0.76	lower availability	3/3
R0238	C4.1	Adequate staff are assigned to monitor vaccine temperatures.	Score	1.06	1.06	1.05	higher availability	3/3
R0245	C4.1	Two or more members of staff are assigned to manage vacci...	Score	1.04	1.03	1.03	higher availability	3/3

What this tells WHO

Twenty-six requirements are associated with availability **consistently across all three models** (within-country, global, and without population).

The clearest, strongest signal — a red flag

- **Cold storage capacity (R0040)**. Facilities where this is *not applicable* — i.e. that **have no adequate cold storage** — have dramatically **lower** availability.

Requirements that go with *higher* availability

- **SOPs and temperature monitoring** — SOPs for temperature monitoring (R0306) and for packing insulated containers (R0316).
- **Record quality** — VVM-status field on the receipt form (R0211); staff can correctly read a 3ODTR (R0269).
- **Waste handling** — colour-coded waste bins (R0130).

Next steps

1. Model at the category level: Aggregate requirements into **EVM function-category scores** (cold storage, records, SOPs, staffing, funding...).
2. **Test for bottlenecks**: Use a decision tree to check if availability needs a **critical few** requirements *together*, not each alone.
3. **Review odd signals**: Investigate requirements pointing the *unexpected* way — likely proxies, not real effects.
4. **Toward causal evidence**: Repeated assessments over time , test whether *improving* a requirement raises availability.

References

- Effective Vaccine Management (EVM) Initiative
- UNICEF Immunization Data



Any questions or comments?



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Stage 1: Selecting the requirements

A **penalised ordinal (cumulative-logit) lasso** on all candidate requirements + population. Availability AV_i is one of six ordered bands.

$$\text{logit}(P(AV_i \geq k)) = \beta_{0k} + \sum_{j=1}^p \left(\beta_j R_{ij}^s + \gamma_j R_{ij}^I \right) + \delta \text{Pop}_i$$

Coefficients minimise the penalised likelihood:

$$\min \left\{ -\ell(\beta, \gamma, \delta) + \lambda \sum_{j=1}^p (|\beta_j| + |\gamma_j|) \right\}$$

- R_{ij}^s — score of requirement j (0–5)
- R_{ij}^I — applicability flag (1 = not applicable)
- Pop_i — $\log_{10}$ target population
- λ — penalty strength (tuned by cross-validation)

What it does

- The penalty forces most coefficients to **exactly zero**.
- Repeated on **1000 bootstrap resamples** → each requirement's *selection frequency*.
- Keep those selected in **$\geq 60\%$** → shortlist $\mathcal{S}$.
- **Country is not in Stage 1** (enters only in Stage 2).

Stage 2: Estimating the odds ratios

The shortlist $\mathcal{S}$ is re-fitted with an **unpenalised mixed** ordinal model, adding a **country random intercept** $u_{c[i]}$:

$$\text{logit}(P(\text{AV}_i \leq k)) = \theta_k - \sum_{j \in \mathcal{S}} (\beta_j R_{ij}^s + \gamma_j R_{ij}^l) - \delta \text{Pop}_i - u_{c[i]}$$
$$u_c \sim \mathcal{N}(0, \sigma_{\text{country}}^2)$$

Reportable effect size — the **odds ratio**:

$$\text{OR}_j = e^{\beta_j}, \quad 95\% \text{ CI} = e^{\beta_j \pm 1.96 \text{ SE}(\beta_j)}$$

- $\mathcal{S}$ — requirements kept from Stage 1
- $u_{c[i]}$ — **country random intercept**: each country its own baseline availability, drawn from a shared distribution
- $\sigma_{\text{country}}^2$ — between-country variance
- θ_k — the five band thresholds

Reading the OR

- $\text{OR}_j > 1 \rightarrow$ higher availability
- $\text{OR}_j < 1 \rightarrow$ lower availability
- Far from 1 = strong; interval excluding 1 = statistically clear

We ask the question three ways

Model B — Main

Across all facilities, which requirements are linked to availability?

Adjusts for **country context** and **target population**.

Model A —

Country check

When facilities are compared **within their own country**, which requirements still matter?

Removes the possibility that a requirement looks important simply because of its country.

Model C — Size

check

What happens when **facility size is not used**?

Checks whether findings are driven by target population.