ISO 9001: 2015 certified
IFAKARA HEALTH INSTITUTE
research | training | services

POLICY BRIEF

>> Number 024-016 | August 2024

Supply chain management of rabies post-exposure vaccines in Tanzania

Kennedy Lushasi | Martha Lucas | Joel Changalucha | Katie Hampson | Sambo Maganga | Eleanor Rees | Camille Barker | Nai Rui Chng

>> EXECUTIVE SUMMARY

1. **Demand for post-exposure prophylaxis (PEP) is highly variable:** bite patient presentations vary considerably by month and district, posing challenges for supply chain management.
2. **The WHO recommended intradermal (ID) regimen is more efficient**: The intramuscular (IM) regimen (Essen) uses more vials than the ID 1-week regimen. ID vaccination also buffers against surges in PEP demand.
3. **Decentralization improves vaccine access but is logistically challenging**: Decentralizing vaccines reduces vial sharing opportunities, increasing vial use, but ID vaccination remains more efficient than IM. A balanced approach is needed to optimize vaccine accessibility without overburdening the system.
4. **Restocking criteria can meet vaccine demand**: modelling indicates that restocking volumes and alert thresholds can meet local demand and prevent stockouts accounting for realistic delays in restocking. Monitoring can be used to adapt restocking criteria in response to changes from new policies or control measures.

>> BACKGROUND

Rabies is a major public health challenge in Tanzania, causing around 800 preventable deaths annually due to poor access to effective (PEP) and limited dog vaccination.(1) The disease is primarily transmitted through dog bites, with the risk of human infection high in areas with inadequate dog vaccination coverage. Supply chain inefficiencies and financial barriers prevent many bite victims from receiving timely PEP to prevent the onset of rabies, especially in rural areas.(2,3)

The inclusion of human rabies vaccines in Gavi, the Vaccine Alliance's 2021 Vaccine Investment Strategy(4) presents an exciting opportunity to prevent human rabies deaths and catalyze rabies control.

Gavi's support would make human rabies vaccines free of charge and promote adoption of dose-sparing ID regimens. ID vaccination allows multiple patients to be immunized from a single vial, reducing vaccine use as well as requiring fewer visits for patients. This approach aligns with the World Health Organization's (WHO) recommendations(5) and could significantly improve vaccine access in Tanzania.

When considering integrating rabies vaccines into national immunization programs, it is critical to optimize the vaccine supply chain. As an emergency vaccination, rabies vaccine demand is expected to differ from the more stable demand of routine childhood immunizations. Therefore, the supply chain needs tailoring to be resilient and ensure accessibility and consistent availability of these lifesaving vaccines.

Our research developed models informed by data collected between June 2018 and December 2023 from districts implementing Integrated Bite Case Management (IBCM) in Tanzania to provide insights into best practices for managing rabies vaccines.

"When considering integrating rabies vaccines into national immunization programs, it is critical to optimize the vaccine supply chain. As an emergency vaccination, rabies vaccine demand is expected to differ from the more stable demand of routine childhood immunizations.

"While decentralization may enhance access, it leads to higher vaccine consumption

>> RESULTS

Variable demand for PEP

Demand varies considerably across districts and over time, **Figure 1A**. In some districts, such as Liwale, monthly bite cases ranged from 0 to 7 (average 0.9), while in higher-throughput districts like Ulanga, cases ranged from 0 to 50 (average 12.6).

Our analysis revealed that even though low-throughput areas generally report fewer cases, they experience sudden surges, sometimes up to ten times the average number of cases. These surges highlight the need for a flexible and responsive supply chain robust to these fluctuating demands.

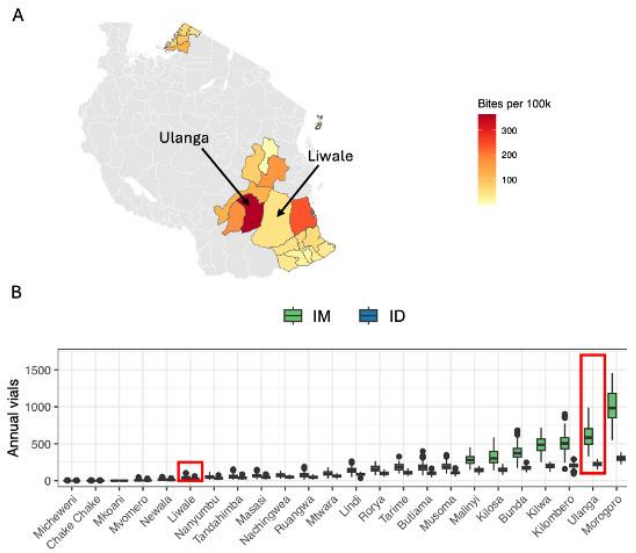


Figure 1. A) Spatial heterogeneity in bite patient incidence across IBCM districts in Tanzania. B) Predicted annual vial needs for IBCM districts under the Essen4 IM and 1-week ID regimens. Each boxplot represents the distribution of vial use across 1000 simulations.

Vaccine demand under different regimens

Comparing the Essen4 IM versus the abridged 1-week ID regimens shows that the IM regimen requires significantly more vials than the ID regimen, especially in districts with higher bite incidence. For example, in Ulanga, the IM regimen would require around 650 vials annually, while the ID regimen would only require around 250, **Figure 1B**.

The difference is primarily due to fractional doses of ID vaccination, which enable vial sharing among patients. This makes the ID regimen not only more resource-efficient but more resilient during demand surges, as it can stretch limited supplies further.

Impact of decentralization

Decentralizing vaccines can improve accessibility, particularly for remote or underserved populations. However, our analysis shows that decentralization increases vial use under ID vaccination due to reduced opportunities for vial sharing. For example, in a high-throughput district like Ulanga, maintaining a centralized system (one facility in a district) requires approximately 250 vials annually, but under moderate decentralization (four facilities), this requirement increases to about 300 vials, and with high decentralization (eight facilities), to around 400 vials, **Figure 3**.

Therefore, while decentralization may enhance access, it leads to higher vaccine consumption yet remains more efficient than IM. More critically the logistics of decentralization (cold chain, health worker training etc.) need consideration with a balanced approach necessary to optimizes accessibility and efficiency yet ensure feasibility.

"Our analysis revealed that even though low-throughput areas generally report fewer cases, they experience sudden surges, sometimes up to ten times the average number of cases.

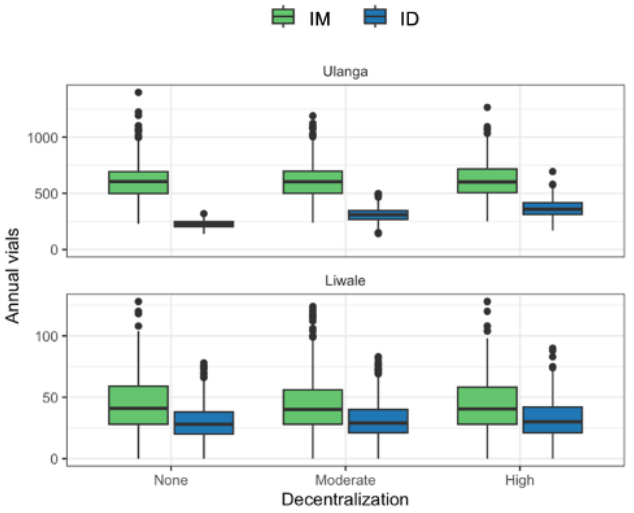


Figure 2. Annual vial requirements for low and high throughput districts under different decentralization scenarios. Different levels of decentralization are shown (None = 1 facility per district, Moderate = 4 facilities per district, High = 8 facilities per district) and the vaccination regimen used (*Essen4 IM* and 1-week *ID*).

Appropriate restocking values and alert thresholds

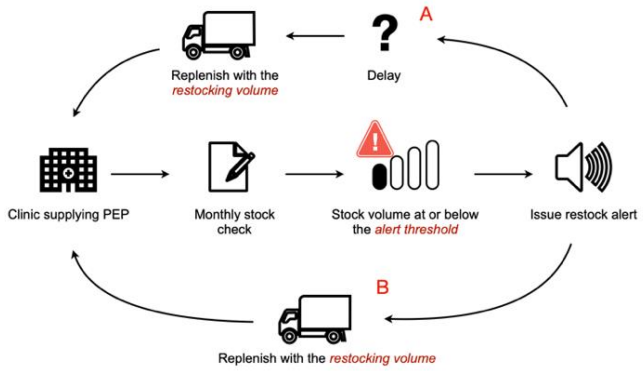
Stock management criteria also need to be designed to prevent stockouts given the variability in vaccine demand and that also are logistically feasible in terms of the likely frequency of restocking required (**Figures 3 & 4**).

Analyses showed that in low-throughput areas implementing the 1-week ID regimen, a restocking volume of 50 vials with an alert threshold of 20 vials can suffice to prevent stockouts under ideal conditions with prompt restocking.

However, when there is a 1-month delay in restocking, these thresholds need adjusting upwards, potentially to 80 vials (restocking volume) with a 40-vial alert threshold, to maintain vaccine availability. The restocking volume needs to be correspondingly higher in high-throughput districts using the ID regimen (Figures 3 & 4).

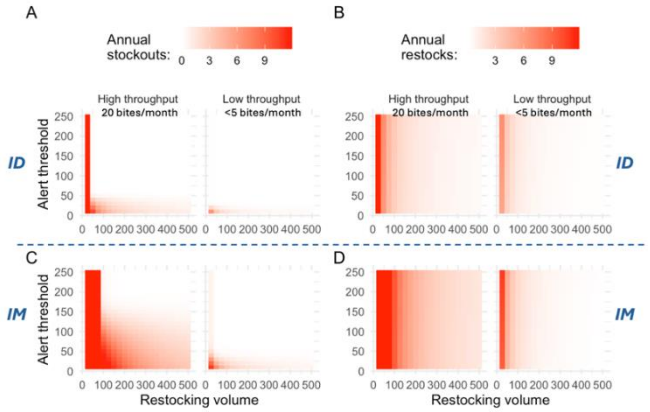
Figure 3. Post-exposure vaccine supply chain management scenario. Once a clinic raises an alert to be restocked, there could be A) a lag before restocking or B) prompt restocking.

Designing the national supply chain



A strategic approach is therefore necessary to design an effective robust supply chain for rabies vaccines. Given the variability in PEP demand, it is important to classify districts based on their throughput of bite patient presentations and apply appropriate restocking volumes and alert thresholds (**Table 1**).

With Gavi's investment in human rabies vaccines, an increase in healthcare-seeking behaviour is expected and, subsequently, greater PEP demand. Restocking volumes



and thresholds should therefore be monitored to track changes in bite patients and stock management practices adjusted accordingly.

Figure 4. Predicted annual stockouts and restocks under different stocking criteria. Panels show results for low vs high-throughput districts under a 1-month restocking lag for different restocking and alert values. Predicted stockouts per year in high (left) and low throughput (right) districts using A) ID vs C) IM. Predicted restocks in high (left) vs low throughput (right) districts under B) ID vs D) IM.

With Gavi's investment in human rabies vaccines, an increase in healthcare-seeking behaviour is expected

Table 1. Clinic stocking criteria to ensure vaccine availability under 1-week regimen. Minimum criteria are shown that do not result in any stockouts and assume a 1-month delay in restocking.

Mean monthly bite patients	Minimum restocking volume	Minimum alert threshold	Expected restocks per year (mean)	median
<5	80	40	2	2
<10	100	50	2	2
<20	110	60	3	3
<30	120	70	3	3
<50	150	100	3	3
<100	220	160	4	4

>> CONCLUSION

There is a strong case for adopting the 1-week ID regimen in Tanzania. This regimen conserves vaccines while maintaining efficacy and combined with optimized stocking practices and a strategic approach to decentralization, offers a robust framework for improving rabies prevention.

>> ACKNOWLEDGEMENTS

We extend our deepest gratitude to the invaluable partners who have supported our rabies research efforts at Ifakara Health Institute. Our heartfelt thanks go to The University of Glasgow for their exceptional technical support, which has been instrumental in advancing our research. Their expertise and guidance have significantly contributed to the success of our project. We are also profoundly grateful to The Wellcome Trust, for their generous funding. Their financial support has been crucial in enabling us to carry out this vital research and achieve our objectives.

Additionally, we wish to express our sincere appreciation to the President's Office – Regional Administration and Local Governments (PO-RALG) and the local government authorities. Their facilitation in providing access to frontline health and animal workers has been essential in executing our work effectively on the ground.

>> REFERENCES

1. Abela-Ridder B, Martin S, Gongal G, Engels D. Rabies vaccine stockpile: fixing the supply chain. Bull World Health Organ. 2016 Sep;94(9):635.
2. Hampson K, Ventura F, Steenson R, Mancy R, Trotter C, Cooper L, et al. The potential effect of improved provision of rabies post-exposure prophylaxis in Gavi-eligible countries: a modelling study. Lancet Infect Dis. 2019 Jan;19(1):102–11.
3. Changalucha J, Steenson R, Grieve E, Cleaveland S, Lembo T, Lushasi K, et al. The need to improve access to rabies post-exposure vaccines: Lessons from Tanzania. Vaccine. 2019 Oct;37(Suppl 1):A45.
4. Minghui R, Stone M, Semedo MH, Nel L. New global strategic plan to eliminate dog-mediated rabies by 2030. Lancet Glob Health. 2018 Aug;6(8):e828–9.
5. Nadal D, Bote K, Masthi R, Narayana A, Ross Y, Wallace R, et al. Rabies post-exposure prophylaxis delivery to ensure treatment efficacy and increase compliance. IJID One Health. 2023 Dec 1;1:100006.

>> **Corresponding Author:** Kennedy Lushasi, *klushasi@ihi.or.tz*