DOSE PER CONTAINER PARTNERSHIP

DPCP SNAPSHOT

MODELING TO SUPPORT DECISION-MAKING FOR 5-DOSE MEASLES-RUBELLA ROUTINE VACCINATION IN ZAMBIA

MODELING ZAMBIA'S DPC CHANGE

As part of the Dose per Container Partnership (DPCP), the HERMES Logistics Modeling Team used computer simulation modeling to analyze the different effects of tailoring measles-rubella (MR) vaccine in 5-dose and 10-dose vials to different scenarios in Zambia's routine immunization program. The scenarios differentiated between rural and urban location by both district and health facilities, outreach and fixed immunization sites, and by session size. These scenarios were also applied in two different contexts: with healthcare workers (HCWs) adhering to the governmental policy of opening an MR vial for even a single child, and the more common practice of HCWs only opening an MR vial when at least five children are present in order to use at least half the vial. Key findings include the following:

- Replacing 10-dose MR with 5-dose MR at all health facilities led to the largest reduction in open vial wastage, particularly when HCWs follow the policy to open a vial for every child compared to when HCWs wait until more children are present.
- Shifting to 5-dose MR vials requires procuring fewer MR doses and introduces cost savings for vaccine procurement in the policy-following context.
- Shifting to 5-dose MR vials can increase the number of MR doses administered (as a proxy of coverage), especially in the context of HCWs waiting to open a vial. While this shift marginally increases the constraint of cold chain requirements during transport, there was minimal impact on cold chain space at the district and facility level (~0.3% additional liters). This transport constraint could be mitigated by different approaches, such as altering delivery intervals, transport routes, or using different vaccine carriers.
- Tailoring 5-dose vials to be used only at rural health facilities or by session sizes with fewer than an expected five or ten children is the most beneficial in terms of providing a balance between reducing MR wastage, improving availability of MR at the health facility from a supply chain perspective, and slightly improving availability of all vaccines by reducing cold chain equipment utilization.

THE TAKEAWAY

The results of the modeling show that switching to 5-dose MR in Zambia can reduce wastage and increase the number of doses administered to varying degrees in the different scenarios of 5-dose in all facilities, tailoring to urban or rural districts or facilities, and particularly beneficial if tailoring

DPCP: EXAMINING THE EFFECTS OF MULTIDOSE VACCINE PRESENTATIONS

The widespread use of multidose vaccine containers in low- and middle-income countries' immunization programs is assumed to offer benefits and efficiencies for health systems, such as reducing the purchase price per vaccine dose and easing cold chain requirements.

Yet the broader impacts on immunization coverage, costs, and safety are not well understood. It is also unclear what processes governments typically go through to determine their choices about DPC, and what information decision-makers have or use when determining DPC.

To add to the limited evidence base on this topic, the Dose Per Container Partnership, or DPCP, is undertaking a series of activities to explore current decision-making on DPC options and better understand the relationship between DPC and immunization systems, including operational costs, timely coverage, safety, product costs/wastage, and policy/correct use.

to session size. These results can be generalized to other countries, but they all must be considered within the larger decision-making framework to guide DPC considerations. Important factors in that framework include the country context (e.g. existing cold chain constraints, or average vaccine session sizes), HCW behavior and willingness to open a vial for every child, and the practical feasibility of implementing the scenarios, such as tailoring vial size to session size.

THE RESEARCH

Computer simulation modeling explains how the different components and processes interact in a complex system. It is useful to assess how a change in one interaction within a system will affect other components of the system. It can help predict those effects and identify the best mix of components and processes in order to use time, effort and resources most effectively and efficiently in order to drive evidence-based decisions.

Drawing on the DPCP implementation research in Zambia, the HERMES Logistics Modeling Team[1] built a computer simulation model to validate and complement the different options for 10-dose and 5-dose MR vial presentations within the Zambian health system in order to look at the interaction and trade-offs between the six system components. Data in the model included health facility target population and location, cold chain equipment, transport system and distribution frequency, the vaccine schedule and session frequency, and costs related to distribution of vaccines through the supply chain, including personnel costs for logistics and vaccine procurement costs.[2]

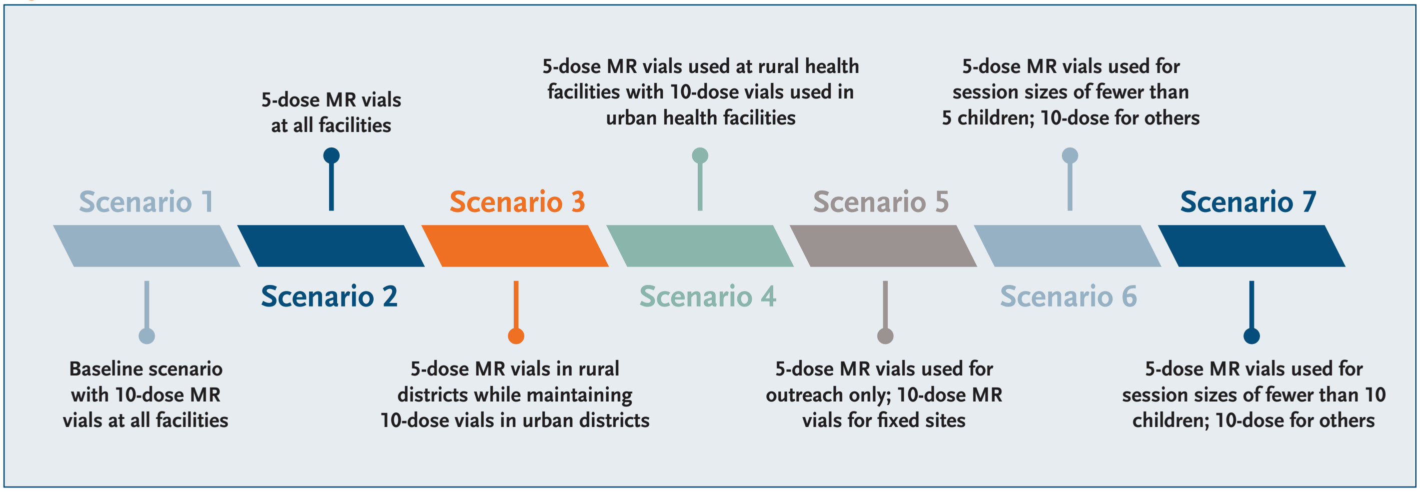
One of the important findings from the Zambia implementation research, and much of the impetus for creating the DPCP, is that HCWs are often reluctant to open a 10-dose vial of unpreserved lyophilized vaccines such as MR for only a few children due to concern over high open vial wastage as these must be discarded six hours after reconstitution or at the end of the vaccination session. The research showed that on average HCWs will wait until at least 5 children present before opening a 10-dose vial of MR. Using that finding, the model was applied in two different contexts: with HCWs adhering to the governmental policy of opening an MR vial for even a single child, and the more common practice of opening an MR vial when enough children are present to use at least half the vial.

The model was built to answer a few questions related to the trade-offs of the system components, when compared to the current use in Zambia of 10-dose MR vials. The scenarios reflect HCW reality and decisions they have to make related to opening a vial or not, as well as the "what if" scenarios of how to reduce the burden on HCW for that decision while strengthening the overall health system. **Figure 1** shows the scenarios that were included.

The model was built on data from the immunization program (facilities and storage sites, target population, cold chain space, vaccine distribution practices, and related costs), and assumptions included the HCW behavior of waiting for children to present before opening a vial. Full details can be found in the complete report.

The results of any modeling can provide insight into a system, yet a decision maker must still weigh those results within the context of the broader country dynamics, the assumptions built into the model, and based on priorities, reality, and feasibility of change. For example, the model doesn't consider that some children will not present at an immunization session due to inaccessibility or other reasons. Or the model might show one scenario is the best in

Figure 1: The 7 scenarios included in the model



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1 The HERMES team has done extensive modeling on supply chains for many countries. More information and links to publications can be found at http://hermes.psc.edu/.

2 Data collected by the Centre for Infectious Disease Research in Zambia (CIDRZ) was used for this activity and complemented by data collected through DPCP implementation research. Vaccine cost provided by UNICEF.

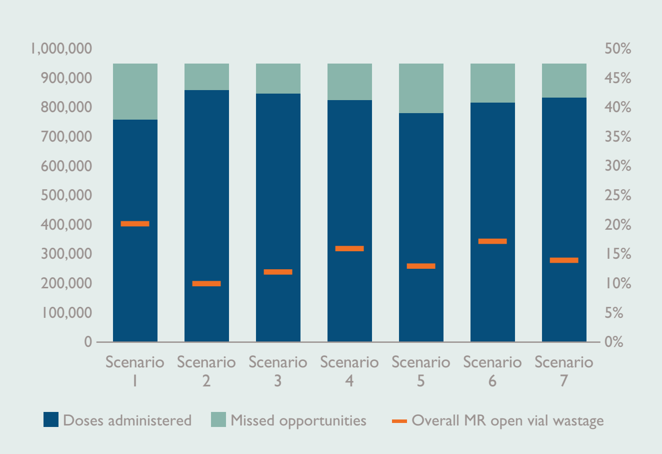
terms of increasing timely coverage and reducing costs, but it may not be feasible to implement in reality.

THE FINDINGS

Coverage. As a proxy for immunization coverage, the modeling results indicate the number of MR doses administered and the number of missed opportunities for MR for each scenario. As one would expect, in the common 'practice' context (where HCWs wait to open a vial so that no more than half of the doses would be wasted), having 5-dose MR vials at all sites instead of 10-dose vials increases the number of doses administered by 13% for that particular scenario. The impact of that change varies among the scenarios, from increasing doses administered by 3% in the outreach scenario, 11% when focusing on 5-dose vials being available throughout rural districts, and 7% more doses administered when tailoring 5-dose MR to session sizes with fewer than five children. The trend is similar for missed opportunities, with the greatest reduction found with 5-dose vials used everywhere (decreasing missed opportunities by 51%). In the governmental 'policy' context (where HCWs open a vial for even a single child), the change in doses administered and missed opportunities among each scenario is minimal, as is to be expected as a vial is opened for every child.

Wastage. In the governmental 'policy' context, open vial wastage is inherently higher as HCWs open a vial for even a single child, and in the 'practice' context, HCWs wait until enough children are present in order to use at least

Figure 2: MR doses administered, missed opportunities, and wastage rate in the common 'practice' context and changes with the different scenarios.



In the practice scenario where HCWs wait to open a vial until many children are present, the model showed that using 5-dose vials instead of 10-dose would decrease missed opportunities to vaccinate by 51%.

half the vial. As such, when testing the different scenarios using 5-dose MR vials, the reduction in wastage is greatest in this policy context, although wastage still declines in the common 'practice' context as well. The greatest reduction is seen when 5-dose MR vials are used everywhere in both policy and practice contexts (see **Table 1**).

Table 1: Wastage rate by scenario

		'Policy'	'Practice'
Scenario 1	10-dose MR scenario	50%	20%
Scenario 2	5-dose MR scenario	29%	10%
Scenario 3	5-dose MR rural district	34%	12%
Scenario 4	5-dose MR rural facility	39%	16%
Scenario 5	5-dose MR outreach	45%	13%
Scenario 6	Session size <5, 5-dose MR	42%	17%
Scenario 7	Session size <10, 5-dose MR	38%	14%

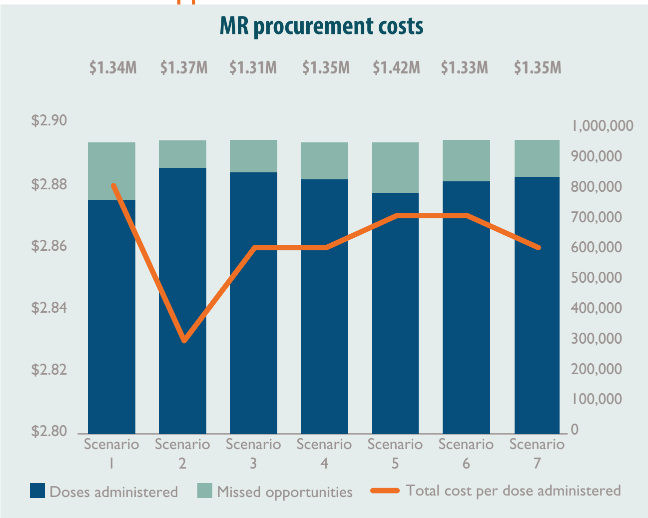
Costs. Even though the purchase price per dose of 5-dose MR ($0.82) is higher than the price per dose of 10-dose MR ($0.62), some cost savings are found through reducing vaccine wastage when using 5-dose MR at all locations in the 'policy' context (6% less spent on MR purchase cost). This reduces the overall quantity of the MR vaccine that is needed for the routine immunization program and takes into account the purchase cost per vial of 5-dose MR as $4.10 compared to $6.50 for a vial of 10-dose MR.

This is different in the 'practice' context where the same cost savings are not found. When using 10-dose vials everywhere, 2.14 million MR doses are needed for a year of routine service delivery; with 5-dose vials everywhere, only 1.67 million doses are needed, costing $32,890 USD more (see **Figure 3**) or 2.5% more than with 10-dose vials. However, the model indicates that almost 100,000 more children getting immunized with MR 5-dose, which is an important benefit to consider.

Total cost per dose administered considers the purchase cost of all vaccines in the schedule as well as the logistics costs required to distribute the vaccines throughout the supply chain. The analysis shows that logistics costs have minimal differences among all scenarios; the lowest cost per dose administered is found in the scenario with 5-dose vials everywhere ($2.83/dose administered compared to $2.88 for 10-dose vials), related to reaching a larger number of children with fewer missed opportunities and reduce wastage.

Supply chain. One of the outputs of the model measures vaccine availability for each scenario, both for MR as well as the overall supply chain with all vaccines, as an indicator of

Figure 3: In the 'practice' context, the total cost per dose administered of all vaccines tracked against the number of MR doses administered and missed opportunities. The cost of MR vaccines procured (provided across the top of the chart) must be weighed against fewer missed opportunities and doses administered.



space availability and/or constraints in the supply chain, both during transport and at fixed storage sites (health facilities, district stores, provincial and national stores). The model indicates an already-constrained supply chain in Zambia with the current system using 10-dose vials everywhere. In the 'policy' context, it shows 80% availability for all vaccines and 77% availability for MR. In the 'practice' context, more accurately reflecting reality, the overall vaccine availability using 10-dose vials is 79%, and MR availability is 62%. This indicates that only 62% of the MR vaccines that are needed at health facilities are actually available due to different constraints in the supply chain. In Zambia, the constraint in each of the contexts is found largely during transport, driven mostly by the fact that health workers use small vaccine carriers to collect vaccines on a monthly or quarterly basis, with a few transport routes using 4x4 trucks from province to district level constrained. Availability slightly improves with 5-dose MR at all facilities (71%), and when tailoring to rural districts (69%) or rural facilities (67%).

The scenarios with a positive impact on the supply chain where MR availability improves and the supply chain constraints are reduced are with 5-dose MR used at rural health facilities or when tailored to session sizes of either 5 or 10 children.

The model showed that transport for the Zambia supply chain is already constrained even with 10-dose MR, with availability of all vaccines at 79% and only 62% for MR. Availability slightly improves for the different scenarios modeled. The main constraint is from facilities going to collect vaccines from the district level using small vaccine carriers.

It is important to note that switching to 5-dose MR vials does not double the cold chain space required, as often is assumed. As the results of the model show, the trade-offs of reducing wastage and reaching more children actually improves MR vaccine availability, as mentioned above, and, in some cases, the use of the cold chain space.

Healthcare worker behavior. The model provides the 'policy' and 'practice' contexts in order to capture the impact on the system of HCW behavior and willingness to open a vial. There are, however, aspects that are more nebulous and were not modeled. Presumably, having 5-dose MR vials at health facilities would reduce the burden on the HCW to have to decide between some level of "acceptable" wastage and immunization coverage. Additionally, having both 5-dose MR and 10-dose MR in the system may allow for more tailoring of vaccine use at immunization sessions and targeted vaccine distribution, but the complexity of managing that throughout the supply chain were not modeled. These aspects must be considered within the country context by decision makers.

In places that have workarounds to reduce vaccine wastage while maintaining high and timely coverage, such as well-accepted days for immunization or strong mobilization for specific MR days, this change to 5-dose vials will have less of an impact on the system components but could relieve the burden of introducing and managing workarounds.

Applicability to other countries. Even though this model was built specifically for Zambia, there are generalizations that can be applied in other countries and their specific contexts when used within the larger decision making framework:

- The impact of changing to 5-dose MR vials will depend on the country context and the 'policy'/'practice' reality. In places that have workarounds to reduce vaccine wastage while maintaining high and timely coverage, such as well-accepted days for immunization or strong mobilization for specific MR days, this change to 5-dose vials will have less of an impact on the system components but could relieve the burden of introducing and managing workarounds.
- Changing to 5-dose MR will likely decrease vaccine wastage rates and reduce missed opportunities by encouraging HCWs to open smaller vials at immunization sessions even for a single child and also opportunistically on non-vaccination days—which should lead to a reduced quantity of vaccines to procure. Depending on the context, this could provide overall cost savings.
- Switching to 5-dose MR vials does not require a doubling of the cold chain space requirements, as is often assumed; space at the facility level is minimally impacted and can be assessed through different supply chain planning tools

already in use. Already constrained segments of the supply chain, such as transport or higher level storage sites, may experience additional constraints with DPC change, some of which can be addressed through different supply chain delivery intervals or transport options.
- Tailoring 5-dose MR vials to rural facilities or expected session sizes may provide some benefits. This option must be considered within the context of feasibility and the potential complexity for management.
- In the 'practice' scenario where HCWs wait until enough children are present to use at least half a vial, using smaller vial sizes relieves the burden of this decision on HCWs and can reduce missed opportunities to vaccinate as they are more willing to open a vial with reduced wastage.

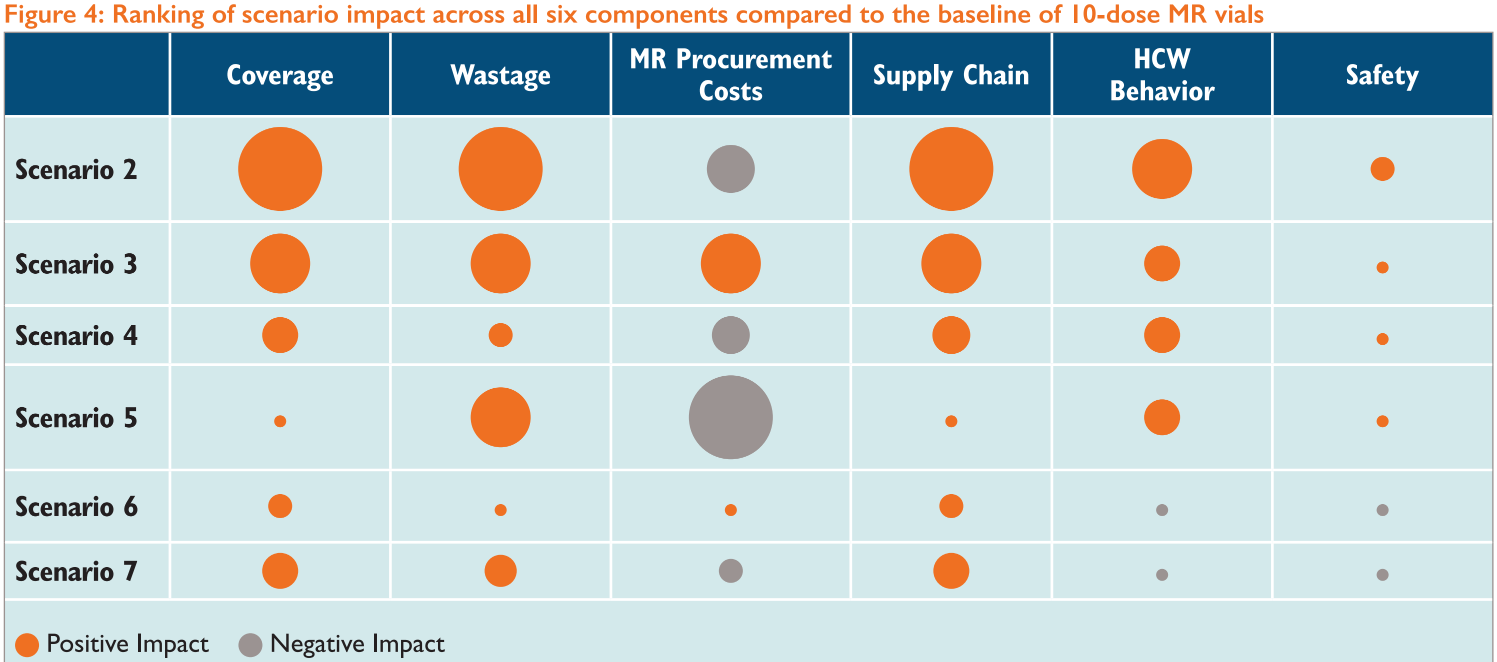
Applying the results. Modeling provides a framework which can help guide decisions, yet the modeling results must be considered in the country context and are also influenced by subjective factors.

Figure 4 is one representation of how to consider the trade-offs of the scenarios in the Zambia model and how to weigh the subjective factors. The scenarios are ranked in ascending order based on the percent differences compared to the baseline scenario. The size of the dot represents the degree of the impact compared to all scenarios. Green represents a positive impact; red represents a negative impact. The results of the modeling are the basis for the first four components in the figure (coverage, wastage, logistics cost per dose, and supply chain). The final two components, HCW behavior and safety, are more subjective.

For the assumptions around HCW behavior, there is a positive impact for a smaller vial size assuming HCWs will be more willing to open a vial; however, there is a negative impact when both 5-dose and 10-dose vials are available at the facility level as this still places the burden on the HCW to decide whether to open a vial or not; it also introduces a complexity into managing the supply chain.

For safety, there is an inherent risk of contamination of multi-dose vials. As such, there is a positive impact when smaller vial sizes are included in the model (i.e., reduced safety risk); yet there is a negative impact when both 5-dose and 10-dose vials are available at the facility level as there is a risk of confusing the two vials. ■

Figure 4: Ranking of scenario impact across all six components compared to the baseline of 10-dose MR vials



Note: Scenarios are ranked in ascending order based on percent differences compared to baseline. The size of impact is not reflective of the actual percentage difference between the scenario and baseline. The size of impact is based on how a scenario ranks compared to all scenarios.

JSI

This document was developed by JSI through the Dose Per Container Partnership (DPCP). The partnership is coordinated by JSI Research & Training Institute, Inc. in collaboration with colleagues from the Clinton Health Access Initiative, the HERMES modeling team and the International Vaccine Access Center (IVAC) through Johns Hopkins School of Public Health, and PATH. This material is intended to provide stakeholders evidence to guide informed, sustainable decisions on DPC when considering vaccine products and program design and may be used freely by all partners.

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