Is There Enough Vaccine to Eradicate Measles? An Integrated Analysis of Measles-Containing Vaccine Supply and Demand

Running head: vaccine supply and measles eradication

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Abstract: 150 words.
Body: 3,835 words
Abstract

Responding to regional advancements in combating measles, the World Health Organization called for an assessment of the feasibility of eradication, including whether sufficient vaccine supply exists. Interviews with international health officials and vaccine-makers provided data for a detailed model of worldwide demand and supply for measles-containing vaccine (MCV). The study projected global MCV demand through 2025 with and without a global eradication goal. The study found that 5.2 billion cumulative MCV doses must be administered in 2010-2025 to maintain current measles programs, while 5.9 doses would likely be needed with a 2020 eradication goal; demand could rise to 7.5 billion in an upper-bound eradication scenario. These volumes are within existing and planned MCV-manufacturing capacity, though there are risks. In some markets, capacity is concentrated: supply-chain disruptions could reduce supply or increase prices. Mitigation strategies, such as building inventory and signing long-term contracts, and further coordination with manufacturers should be evaluated.

[Keywords: Measles-containing vaccine, MCV, eradication, supply, demand]
Introduction

Remarkable progress has been made in the fight against measles in the past 10 years. The Americas Region of WHO has stopped transmission of indigenous measles viruses and, since November 2002, is experiencing only small outbreaks linked to importations from abroad. The African, European, Eastern Mediterranean, and Western Pacific Regions of WHO have established measles elimination goals and substantially reduced measles cases and deaths, but continue to experience outbreaks and report an incidence that is in excess of elimination levels. The South-East Asia Region continues to strive towards achieving a 90% reduction in measles mortality by the end of 2010. All told between 2000 and 2008, estimated global measles mortality has decreased by 78%.

At the May 2008 Meeting of the Executive Board (EB) of the World Health Assembly (WHA) a request was made to WHO to examine the feasibility of global measles elimination, including programmatic, economic, political, and biological factors; impact on healthcare systems; and potential risks to the vaccine supply [1]. This current study was designed to answer four questions:

• What is the likely global demand for MCV under current programs for controlling measles?
• How might demand change with a 2020 eradication goal?
• Would aggregate manufacturing capacity, for each vaccine type—monovalent measles (M), measles-rubella (MR), and mumps-measles-rubella (MMR)—be sufficient to support a global eradication effort?
• Are there any risks associated with MCV supply that warrant further evaluation?

This study, completed in September 2009, focused on the 2010–2025 time frame and considered the global demand implications of setting a 2020 measles eradication goal, the vaccine capacity needed, and the potential supply risks. This paper summarizes those findings and compares the resources required for eradication against baseline immunization activities already instituted or planned.
Methods

Demand projections

WHO recommends the provision of 2 doses of MCV to all children either through routine immunization systems or nationwide campaigns (also known as supplemental immunization activities or SIAs) [2]. With these WHO recommendations as a guide, we developed a set of demand projections through a series of interviews conducted during the winter and summer of 2009 with 39 experts: WHO officials from each regional office and select countries and Supply Division personnel from the United Nations Children's Fund (UNICEF), as well as authorities on global measles disease burden, epidemiology and control. With these stakeholders, the project team first identified key demand drivers—the set of immunization activities currently employed or that may be needed in the future. The team first worked with experts to project future MCV demand in the absence of a global eradication goal. Here, respondents provided data on each demand driver, including trends in immunization activity coverage rates as well as SIA requirements, planned or potential shifts in delivery strategies, and vaccine product mix (e.g., moving from M to MR). This information was tabulated country by country.

These data were transferred into a proprietary Microsoft Excel–based model to allow the project team to evaluate the impact of MCV demand drivers and develop a picture of future MCV demand in the “base case,” without a global eradication goal. These data were merged with other country-level inputs, including population data (e.g., size of birth cohort, age/sex bands) and historical information on coverage rates, SIAs, and type of vaccine used [3]. For the purposes of projecting future coverage rates, all countries were grouped using their historical coverage rates into three categories (see Table 1): High (defined as countries whose coverage rates exceeded 90% for the last three years, n=123);

* Campaigns or SIAs are generally carried out using 2 approaches. An initial, nationwide catch-up campaign targets all children aged 9 months to 14 years; it has the goal of eliminating susceptibility to measles in the general population. Periodic follow-up campaigns then target all children born since the last campaign. Follow-up campaigns are generally conducted nationwide every 2–4 years and target children aged 9–59 months; their goal is to eliminate any measles susceptibility that has developed in recent birth cohorts and to protect children who did not respond to the first measles vaccination.
Growth (countries whose rates are still below 90% but have increased over the last three years, n=24); Plateau (countries whose rates are still below 90% and have not increased meaningful over the last three years, n=48). In the base case scenario, we assumed coverage rates for countries in the High and Plateau categories would continue at a three year average of each country’s historical rates. For those countries in the Growth category, we assumed each country’s coverage rate would continue to rise according to a logarithmic regression calculated separately for each country (typical $R^2$ was greater than 90%).

Once base case demand had been projected country by country and globally, the team conducted follow-up interviews with 22 of the 39 experts to explore the conditions necessary to eradicate measles by 2020. Each respondent provided data on the incremental country-specific immunization activities they felt would be required. These findings were incorporated into the model and served as the basis for developing eradication-demand projections. To model coverage rate growth under elimination, the project team constructed an s-curve with a peak value of 95% through consultation with select members of the expert panel. Each country’s starting position on the curve was determined using its current coverage rates. Generally speaking, those countries with current routine immunization coverage rates greater than 90% were projected to reach 95% in 3 years; those with rates around 80% were projected to reach 95% in 7 years; those with rates less than 70% were projected to reach 95% in 10 years.

**Supply capacity**

To evaluate worldwide MCV supply, the project team first engaged the UNICEF Supply Division, WHO, and industry experts to pinpoint existing and potential sources of MCV. The team then canvassed secondary sources (e.g., WHO prequalification submissions, intellectual property Web sites and databases including WIPO and Google Patents, and vaccine literature referencing MCV suppliers [4]) to form a more robust list. Once a comprehensive supply base had been identified, the team interviewed 10 current and potential MCV manufacturers to map overall supply dynamics. In particular, these discussions focused on defining existing capacity levels, estimating planned or potential capacity changes over the next 10–15 years, and identifying critical decision points related to those capacity changes. To complement direct manufacturer dialogues and build a more holistic perspective, the project team reengaged the representatives from the UNICEF Supply Division and WHO.
As a final step, the team segmented the global market and mapped demand against relevant or accessible supply. This segmentation was necessary because MCV sources do not necessarily serve all segments of demand (for example, some national suppliers serve their domestic markets exclusively and do not export). With this map complete, the team assessed potential supply gaps and risks within each demand segment. For reasons of confidentiality, and because some markets are served by so few suppliers, this report does not cover manufacturing capacity at the segment level.

**Results**

*Global demand segmentation.* Global demand falls naturally into five segments, each characterized by its dominant vaccine type and/or vaccine-supply modality (Tables 2 and 3). This paper will generally report demand at the segment level.

- **Developed World**, primarily high-income countries in North America and Europe, using MMR vaccines (containing Jeryl Lynn or Jeryl Lynn–like mumps strains) from large, multinational manufacturers.
- **Self-Suppliers**, middle- and low-income countries obtaining their vaccines almost exclusively from domestic manufacturers (which may or may not be government controlled or sponsored). In some cases (as in Brazil, Pakistan, and Indonesia), a single manufacturer may supply all of a country’s MCV. In other countries (such as China and India), several manufacturers or manufacturing sites provide vaccine supplies. Countries in this segment may use M, MR, and/or MMR vaccines.
- **Rest of World MMR**, primarily middle-income countries in the Americas and Eastern Mediterranean WHO regions, obtaining MMR (with non–Jeryl Lynn–like mumps strains) from WHO prequalified manufacturers.
- **Rest of World M**, UNICEF-supplied middle- and low-income countries using M monovalent vaccine obtained from WHO prequalified manufacturers.
Without eradication, vaccine demand will decrease slightly and flatten out. The mix of vaccine types will remain essentially static.

As catch-up SIAs wind down in the absence of an eradication goal, annual MCV demand will likely decrease and remain relatively flat. This will still be the case even with several regions continuing to pursue measles elimination or control strategies. Cumulative vaccine demand from 2010 through 2025 will total about 5.2 billion doses. In this scenario, the overall vaccine mix will likely change little (see Table 4).

The number of catch-up SIAs will drop significantly. Since 2000, catch-up SIAs have significantly increased aggregate global demand—particularly for M monovalent. Many countries have conducted large-scale catch-up SIAs, primarily targeting birth cohorts aged 15 years or less. According to the advisory panel, only a few countries, including India, China, Egypt, and Japan, are conducting catch-up SIAs or planning them for the near future. With few large-scale catch-ups on the horizon, most future MCV demand will stem from routine and follow-up immunization activities (i.e., MCV1 and MCV2) dictated by region-specific control or elimination strategies. Immunization activity coverage rates are projected to improve modestly, but the concomitant increase in vaccine demand will not balance the drop resulting from the end of catch-up SIAs across multiple countries.

A minimal shift from M to MR is likely. The advisory panel identified a small set of countries expected to transition from M to MR over the next 10 years. Combined, these 8 nations (including 18 states in India) represent an annual birth cohort of approximately 10 million. This group—predominantly in the South-East Asia and Western Pacific WHO regions—already have, or will soon achieve, MCV1 coverage rates that suggest adoption of MR\textsuperscript{\dagger}. For these countries, the adoption decision is driven by an assessment of local rubella disease burden and desire to address it. The decision is not very sensitive to the availability of donor funding for rubella vaccine costs; most of the expected adopting countries are eligible for assistance from the Global Alliance for Vaccines and Immunisation (GAVI). In transitioning to MR, these countries are expected to follow current WHO and regional policy recommendations, conducting rubella catch-up SIAs targeting women of childbearing age.

\textsuperscript{\dagger} We assumed countries will transition from M to MR or MMR when they obtain MCV1 coverage of greater than 80 percent for at least three consecutive years.
age and school-age children. Any broader MR adoption appears unlikely. The panel indicated that many GAVI-eligible countries in the African WHO region are still assessing their rubella disease burdens. Several still need to establish the necessary surveillance infrastructure. These countries will also require several years to complete their assessments and increase current MCV coverage rates to sufficient levels. As a result, these countries are not expected to transition to MR during 2010–2025, even if donor funding is available.

A very minimal shift from M or MR to MMR is likely. The study panel identified two countries in the Eastern Mediterranean WHO region that are expected to transition from M to MMR over the time period. The incremental annual birth cohort is less than 1 million children. These countries are, however, expected to conduct catch-up SIAs using MR vaccine. Broader adoption of MMR in lower-income countries appears unlikely: many lack mechanisms to track mumps disease burden, and their health authorities hesitate to use the highly reactogenic mumps strains currently offered by UNICEF (Leningrad-Zagreb or Urabe). More widespread adoption would only occur if a less reactogenic mumps strain (e.g., Jeryl Lynn or Jeryl Lynn–like) became available at prices significantly below current market levels.

Eradication is expected to raise MCV demand by ~700 million doses.

With a global eradication goal, the study forecasts that from 2010 through 2025 cumulative MCV demand will be 5.9 billion doses, a 13.5 percent increase over the base case. Global eradication would affect several key demand drivers (see Table 5). The anticipated increase in demand would, however, be overwhelmingly driven by the potential need for additional catch-up SIAs.

Overall demand and vaccine mix is minimally sensitive to differing MCV1 and MCV2 delivery strategies. Based on consistent feedback from the advisory panel, the study team assumed that eradication in all countries would require two MCV immunization doses per child. WHO and UNICEF personnel at the regional and country level would universally target a strategy of two routine doses (MCV1/MCV2) with 95 percent coverage rates. Based on current coverage rates, realization of this delivery strategy would require 115 countries to increase their coverage rates, some quite rapidly. Given this, some respondents suggested attaining sufficiently high coverage rates may be more effective via a hybrid strategy: routine MCV1 with periodic follow-up supplemental immunization

‡ The 18 Indian states are not expected to conduct rubella catch-up campaigns.
activities (SIAs), targeting those age 9 to 59 months. This strategy would alleviate potential programmatic challenges in achieving very high coverage rates with two routine doses. In particular, the respondent panel identified 47 countries [5] that, for programmatic reasons, might pursue this alternative delivery strategy, attaining 80 percent coverage via MCV1 and 95 percent coverage through follow-up SIAs. These high-priority countries are expected to use M monovalent vaccine. Under this method, respondents foresaw less change from the base case, with these countries intensifying the current strategy of routine MCV1 and follow-up SIAs leading up to and beyond the 2020 target.

Regardless of the delivery strategy used, these changes would have only modest impact on cumulative MCV demand as well as vaccine mix. The two-routine-dose method would increase cumulative MCV demand from 2010 to 2025 by ~400 million doses, a 7.7 percent increase from base-case demand. The rapid increase in MCV1 coverage rates and greater use of routine MCV2 would reduce the size and frequency of follow-up activity, muting demand volatility. The rapid rise in MCV1 coverage rates could also accelerate the expected transition of countries from M to MR (i.e., base-case MR adopters). Respondents, however, reiterated that outside the small pool of base-case adopters, further MR switching is unlikely due to the same reasons cited earlier (e.g., need for necessary surveillance infrastructure to assess disease burden). Under the alternative scenario (routine MCV1 / SIA-based MCV2), cumulative demand would differ little from the base case, totaling approximately 5.2 billion doses. Both approaches would yield very similar demand: the differences were small enough that the rest of this analysis utilizes the routine MCV1/MCV2 forecast (i.e., in both the expected and upper-bound eradication scenarios).

Eradication could require additional catch-up SIAs targeting older age groups to eliminate remaining pockets of susceptibility. The expert panel discussed the need for expanded or repeat catch-up SIAs, above those already planned in the base case. Respondents universally indicated that India is the most likely candidate for such SIAs, while the need outside of India is less certain.

In India, expanded catch-up SIAs could increase cumulative 2010–2025 MCV use by ~300 million doses (beyond those planned under their current control strategy), a 5.8 percent increase over the base case. This might be necessary, for example, to eliminate susceptibility in slightly older cohorts due to previous low immunization coverage rates. As such in the eradication demand scenario, we assumed India would expand its planned catch-up SIAs from the current target of 17
states to all 35 states. The specific birth cohorts targeted would vary by state and depend on historical coverage rates and disease transmission dynamics. Based on advisory panel input, we assumed 10 states, representing 60% of the population, would perform catch-up SIAs targeting those 15 years old or younger. The remaining 25 states, representing 40% of the population, would perform catch-up SIAs targeting those 20 years old or younger. The 18 states expected to transition to MR vaccine for routine immunization would also use MR vaccine in catch-up SIAs and the remaining 17 states would use M monovalent vaccine.

In an upper-bound eradication scenario, demand could climb an incremental 1,600 million doses.

As stated above, only additional catch-up SIAs have the potential to drive significant fluctuations in demand, and pervasive adoption of expanded or repeat catch-up SIAs is not widely anticipated outside of India. If broadly implemented, however, they could increase cumulative MCV demand by up to ~1,600 million doses, an increase of 30.7 percent over the base-case. Some respondents see need for expanded or repeat catch-up SIAs in a few countries, including China, to address pockets of lingering susceptibility in migrant populations and/or older age cohorts. Should they prove necessary, such programs would increase 2010–2025 MCV demand by ~600 million doses over the base case (with 90 percent or more of the incremental demand in China). Others hypothesized that the high-priority countries could require additional catch-up SIAs to eradicate measles. At the suggestion of these other advisory panel members and for the purpose of the upper-bound eradication scenario, we assumed all 47 high-priority countries would conduct additional catch-up SIAs targeting 15- to 29-year-olds. In this extreme case, cumulative MCV demand would increase another ~1,000 million doses.

All told, 5.9–7.5 billion doses of MCV could be required to pursue a global eradication goal, which would constitute an increase of 700 million to 2,300 million doses over the base case (13.5–44.2 percent higher).

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§ The specific timing of these campaigns was undefined; assumed to be spread evenly over 2015–2020.
Global production capacity could meet the demands of eradication.

Projected MCV supplies would be sufficient to meet both the expected and upper-bound vaccine demands of an eradication program, though supply risks exist in some segments.

Figure 1 shows year-by-year demand for each type of vaccine in each of the five global supply-modality segments. Considering the high stakes of global eradication, it is necessary to evaluate MCV supply using two criteria: the ratio of capacity to demand (requiring an understanding of the manufacturer landscape, current and potential capacities, and each manufacturer’s market) and the risks to the stability of supply, both in terms of physical capacity and price.

Developed World. Overall supply risk: low. Though only two suppliers serve this segment, their available capacity is more than sufficient to support the 2020 eradication goal. One supplier currently controls most of the manufacturing capacity, but the secondary player could add capacity for equal output.

Self-Suppliers. Overall supply risk: low to moderate. By definition, in-country manufacturers are expected to meet domestic demand. Many vaccine makers in this segment, especially those in populous countries, already have sufficient capacity to meet the range of MCV demand required under the 2020 eradication goal. Elsewhere, in-country manufacturers expect to scale-up and/or stage supply (stockpile supplies in advance) as needed. The situation requires careful monitoring, especially in areas supplied by a single source.

Rest of World MMR. Overall supply risk: moderate. Two suppliers serve the segment, and their combined capacity far outstrips the expected demands of eradication. One supplier currently holds the vast majority of capacity, but with projected demand levels, the second supplier could play a relatively equal role, reducing supply and pricing risks. Because of the current overcapacity, however, it is possible that these manufacturers would decide to rationalize some supply.

Rest of World MR. Overall supply risk: moderate. The two suppliers serving this segment have capacity greater than the demand expected under eradication. The evolution of this segment depends heavily on further MR adoption. Further, one manufacturer controls most of the capacity in this segment and would serve a significant share of increasing demand. This is particularly the case if additional countries move from M to MR for standard immunization, and in doing so, undertake large-scale rubella catch-up SIAs. As demand evolves, existing suppliers could alter capacity and new suppliers could consider entering this market. Further dialogue is needed with both existing and
potential suppliers to better define these potential actions and understand their decision-making criteria.

Rest of World M. Overall supply risk: low to moderate. Three suppliers serve this segment, with supply historically very concentrated in a single manufacturer. This dominance has created concerns about supply stability. The major manufacturer was the only one with sufficient capacity to meet the surge in monovalent M demand resulting from catch-up SIAs conducted in many countries from 2002–2007. At the same time, there was concern that one of the other manufacturers might exit the market, exacerbating supply risks. Fortunately, all three suppliers of monovalent M have taken actions that improved the supply outlook. The dominant supplier has taken several steps to minimize the probability and the impact of a supply disruption—creating redundancy and diversity in its supply chains, increasing the number of its production facilities, and increasing inventories of bulk and filled product. Further, the supplier thought to be at risk of exiting the market is likely to stay. All told, the segment’s overall annual capacity has the potential to expand from ~400 million to ~500 million doses within the next two to four years. These levels would be more than sufficient to support global eradication scenarios. In the expected eradication scenario, all three suppliers could play approximately equal roles, minimizing risk. Sufficient capacity would still exist to supply the upper-bound eradication scenario, but the dominant supplier would take on a larger role.

Discussion: A Way Forward

In aggregate, projected near-term M, MR, and MMR manufacturing capacity would be sufficient to meet projected demand in the event of a 2020 eradication goal. The primary supply risk is the concentration of manufacturing capacity, which poses concerns over the certainty of supply and the long-term stability of price. The degree of concentration does vary across demand segments and vaccine types (i.e., M, MR, and MMR) and in total, represents a low to moderate global risk to requisite supply.

It is important for countries and the community at large to assess their supply-risk tolerance with and without the eradication goal. Depending on that threshold and the perceived risks, stakeholders could pursue several risk-mitigating options. They might, for example, stockpile inventory at strategic points in the supply chain. This buffer stock would reduce the impact of supply disruption (e.g., a manufacturing facility problem) or an unexpected surge in demand (e.g., a large measles outbreak). More work is needed to determine appropriate inventory levels, locations, and financing mechanisms.
To address price stability risk, stakeholders might enter into long-term supply contracts, committing to set volumes at set prices. This would create greater cost transparency in an effort to secure sufficient advance financing. Moreover, to address both supply certainty and pricing risks, “self-supply” manufacturers could be encouraged to export products, temporarily or long-term. Many of these suppliers would first need to obtain WHO prequalification for their products, and the amount actually available for export would depend on domestic needs. In addition, the cost of vaccine from these sources is not entirely known and should be investigated further.

No matter the course of action, it will be important to continually refine forecasts of demand related to global eradication and establish mechanisms for quickly communicating forecast changes to existing and potential manufacturers. Adequate warning will give them enough time to act (e.g., make capacity adjustments) and ultimately ensure that supply and demand are well matched.

**Acknowledgements and Funding**

The Bill & Melinda Gates Foundation, in close collaboration with WHO and UNICEF, commissioned Oliver Wyman, an international management consulting firm, to evaluate potential future global supply and demand for measles-containing vaccines.

The insights and conclusions from this work are intended to help inform policy and stakeholder decision-making. To date, a summary of the work has been shared with the measles program partners and the WHO Executive Board.

The study team at the measles program partners and Oliver Wyman would like to thank the individuals, public institutions, and companies that provided data, insights, and expert opinions during the course of this project.

Douglas McCormick, D. McCormick Associates (dmcc@dmccormick.com) helped prepare this manuscript for publication.
Figures & Tables

Figure 1. Annual worldwide estimated vaccine demand 2010–2025 by segment and vaccine type: base-case demand, eradication program demand, upper-bound eradication demand.

Table 1. Base Case Coverage Rate Segments: Country composition.
Table 2. Vaccine Segments: Number of countries, birth cohort, GDP per capita.
Table 3. Vaccine Segments: Country composition.
Table 4. Future global demand drivers in the absence of a global eradication goal.
Table 5. Future global demand drivers with a 2020 global eradication goal.
5 WHO Executive Board. “Global Elimination of Measles: Report by Secretariat, April 16th 2009.”
Figure 1. Annual worldwide estimated vaccine demand 2010–2025 by segment and vaccine type: base case demand, eradication demand, upper-bound eradication demand.

Source: Oliver Wyman analysis
1. Average demand per year is the simple average of annual demand from 2010 to 2015 by vaccine product type (M, MR, and MMR)
2. Peak demand in any given year is the highest annual demand experienced over the 2010 to 2015 period by vaccine product type
3. Cumulative MCV demand is the summation of annual demand across all vaccine product types from 2010 to the date listed on the x-axis
<table>
<thead>
<tr>
<th>Segment</th>
<th>Countries</th>
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<tr>
<td><strong>High</strong></td>
<td>Albania, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Barbados, Belarus, Belgium, Belize, Bhutan, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Canada, Channel Islands, Chile, China, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Grenada, Guam, Guatemala, Guyana, Honduras, Hong Kong SAR, Hungary, Iceland, Iran, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Latvia, Libyan Arab Jamahiriya, Lithuania, Luxembourg, Macao SAR, Macedonia, Malaysia, Maldives, Malta, Mauritius, Mexico, Micronesia, Moldova, Mongolia, Montenegro, Morocco, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Nicaragua, North Korea, Norway, Occupied Palestinian Territory, Oman, Panama, Peru, Poland, Portugal, Puerto Rico, Qatar, Romania, Russia, Rwanda, Saint Lucia, Saint Vincent and the Grenadines, Saudi Arabia, Serbia, Singapore, Slovakia, Slovenia, South Korea, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, United Republic of Tanzania, United States of America, United States Virgin Islands, Uruguay, Uzbekistan, Viet Nam</td>
</tr>
<tr>
<td><strong>Plateau</strong></td>
<td>Afghanistan, Algeria, Burkina Faso, Cameroon, Democratic Republic of the Congo, Djibouti, Ethiopia, Guinea, Indonesia, Kenya, Madagascar, Mauritania, Myanmar, Nepal, Pakistan, Réunion, Samoa, Senegal, Solomon Islands, Sudan, Timor-Leste, Togo, Western Sahara</td>
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</table>

Source: Oliver Wyman analysis.
<table>
<thead>
<tr>
<th>Segment</th>
<th>Number of Countries</th>
<th>Birth cohort (2008)</th>
<th>GDP per capita¹ (US$, 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed world</td>
<td>22</td>
<td>9.2 M</td>
<td>$45.2 k</td>
</tr>
<tr>
<td>Self-supply</td>
<td>12</td>
<td>57.6 M</td>
<td>$3.0 k</td>
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<tr>
<td>Rest of world MMR</td>
<td>81</td>
<td>15.5 M</td>
<td>$9.3 k</td>
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<tr>
<td>Rest of world MR</td>
<td>5</td>
<td>2.3 M</td>
<td>$1.9 k</td>
</tr>
<tr>
<td>Rest of world M</td>
<td>75</td>
<td>45.7</td>
<td>$1.2 k</td>
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Source: UN Population Division, World Bank, Oliver Wyman analysis
1 Weighted average, excludes 3.5% of global birth cohort for which World Bank data not available
<table>
<thead>
<tr>
<th>Segment</th>
<th>Countries</th>
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<tbody>
<tr>
<td>Developed world</td>
<td>Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States of America</td>
</tr>
<tr>
<td>Self-supply</td>
<td>Brazil, China, Croatia, Czech Republic, Hong Kong SAR, India, Indonesia, Iran, Japan, Macao SAR, Pakistan, Slovakia</td>
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<tr>
<td>Rest of world MMR</td>
<td>Albania, Argentina, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Barbados, Belarus, Belize, Bolivia, Bosnia and Herzegovina, Brunei Darussalam, Bulgaria, Channel Islands, China, Colombia, Costa Rica, Cuba, Cyprus, Dominican Republic, Ecuador, El Salvador, Estonia, French Guiana, French Polynesia, Georgia, Grenada, Guadeloupe, Guam, Guatemala, Guyana, Honduras, Hungary, Israel, Jamaica, Kazakhstan, South Korea, Kuwait, Kyrgyzstan, Latvia, Lebanon, Libyan Arab Jamahiriya, Lithuania, Malaysia, Malta, Martinique, Mauritius, Mexico, Micronesia, Moldova, Montenegro, Netherlands Antilles, New Caledonia, Nicaragua, Oman, Panama, Paraguay, Peru, Poland, Puerto Rico, Qatar, Romania, Russian Federation, Saint Lucia, Saint Vincent and the Grenadines, Saudi Arabia, Serbia, Singapore, Slovenia, Suriname, Macedonia, Trinidad and Tobago, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United States Virgin Islands, Uruguay, Uzbekistan, Venezuela</td>
</tr>
<tr>
<td>Rest of world MR</td>
<td>Fiji, Mongolia, Philippines, Samoa, Tonga</td>
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Source: WHO historical immunization data; Oliver Wyman analysis.
Table 4: Future global demand drivers in the absence of a global eradication goal

<table>
<thead>
<tr>
<th>Coverage rates&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Developed world</th>
<th>Self-supply</th>
<th>Rest of world MMR</th>
<th>Rest of world MR</th>
<th>Rest of world M</th>
</tr>
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<tbody>
<tr>
<td>&quot;No change; weighted average remains constant&quot;</td>
<td>&quot;Modest increase; weighted average increases by nearly 5%&quot;</td>
<td>&quot;Minimal increase; weighted average remains nearly constant&quot;</td>
<td>&quot;Minimal increase; weighted average remains nearly constant&quot;</td>
<td>&quot;Modest increase; weighted average increases by 3%&quot;</td>
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<tr>
<th>Immunization strategy&lt;sup&gt;2&lt;/sup&gt; (MCV1, MCV2)</th>
<th>&quot;No change; using routine MCV1 &amp; MCV2&quot;</th>
<th>&quot;Very limited change; one country expected to transition to routine MCV2&quot;</th>
<th>&quot;7 countries expected to transition to routine MCV2&quot;</th>
<th>&quot;No change&quot;</th>
<th>&quot;24 countries expected to transition to routine MCV2&quot;</th>
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<tr>
<th>Vaccine product mix</th>
<th>&quot;No change; remain using Jeryl Lynn or Jeryl Lynn-like MMR&quot;</th>
<th>&quot;Some states in India expected to go from M to MR for MCV2&quot;</th>
<th>&quot;No change; remain using non-Jeryl Lynn-like MMR&quot;</th>
<th>&quot;No change&quot;</th>
<th>&quot;Few countries in SEARO and WPRO expected to go from M to MR or MMR&quot;</th>
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<tr>
<th>Catch-up campaigns</th>
<th>&quot;None; campaigns complete&quot;</th>
<th>&quot;India, China, and Japan&quot;</th>
<th>&quot;None; campaigns complete&quot;</th>
<th>&quot;None; campaigns complete&quot;</th>
<th>&quot;None; campaigns complete&quot;</th>
</tr>
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</table>

Source: Expert interviews; Oliver Wyman analysis.
1. Weighted average expected change in MCV1 coverage rates from 2010 to 2020
2. Countries still expected to conduct follow-up SIAs upon accumulation of one full birth cohort of susceptibles
Table 5: Future global demand drivers with a 2020 global eradication goal

<table>
<thead>
<tr>
<th>Coverage rates</th>
<th>Developed world</th>
<th>Self-supply</th>
<th>Rest of world MMR</th>
<th>Rest of world MR</th>
<th>Rest of world M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All countries increase to 95% by 2020</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Immunization strategy(^c) (MCV1, MCV2)</td>
<td>No change; same as Table 4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Vaccine product mix</td>
<td>No change; same as Table 4</td>
<td>Same as Table 4; timing slightly accelerated</td>
<td>No change; same as Table 4</td>
<td>No change; same as Table 4</td>
<td>Same as Table 4; timing slightly accelerated</td>
</tr>
<tr>
<td>Catch-up campaigns</td>
<td>No change; same as Table 4</td>
<td>No change in Japan</td>
<td>Potential need for campaigns targeting older age groups and migrant populations</td>
<td>No change; same as Table 4</td>
<td>Potential need for campaigns targeting older age groups in high priority(^c) countries</td>
</tr>
</tbody>
</table>

Two scenarios (each modeled separately):
1. All countries increase MCV1 & MCV2 to 95% by 2020
2. High priority\(^c\) countries increase MCV1 to 80% and MCV2 to 95% by 2020; all other countries increase MCV1 and MCV2 to 95% by 2020

Two scenarios (correspond to the two coverage rate scenarios):
1. All countries transition to routine MCV1 and MCV2 by 2020
2. High priority\(^c\) countries continue with routine MCV1 and campaign-based MCV2; all other countries transition to routine MCV1 and MCV2 by 2020

Source: Expert interviews; Oliver Wyman analysis.

1. 47 countries identified as high priority in the WHO Executive Board report entitled “Global Elimination of Measles: Report by Secretariat”, April 16th 2009
2. Countries still expected to conduct follow-up SIAs upon accumulation of one full birth cohort of susceptibles
3. Assume a 95% coverage rate

*note: Each scenario is modeled separately.*