



Research priorities for accelerating progress toward measles and rubella elimination identified by a cross-sectional web-based survey [☆]



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ABSTRACT

Background: In 2012, the World Health Assembly endorsed the Global Vaccine Action Plan (GVAP) that set a target to eliminate measles and rubella in five of the six World Health Organization (WHO) regions by 2020. Significant progress has been made toward achieving this goal through intensive efforts by countries and Measles & Rubella Initiative (M&RI) partners. Accelerating progress will require evidence-based approaches to improve implementation of the core strategies in the Global Measles and Rubella Strategic Plan. The M&RI Research and Innovation Working Group (R&IWG) conducted a web-based survey as part of a process to identify measles and rubella research priorities. Survey findings were used to inform discussions during a meeting of experts convened by the M&RI at the Pan American Health Organization in November 2016.

Methods: The cross-sectional web-based survey of scientific and programmatic experts included questions in four main topic areas: (1) epidemiology and economics (epidemiology); (2) new tools for surveillance, vaccine delivery, and laboratory testing (new tools); (3) immunization strategies and outbreak response (strategies); and (4) vaccine demand and communications (demand). Analyses were stratified by the six WHO regions and by global, regional, or national/sub-national level of respondents.

Results: The six highest priority research questions selected by survey respondents from the four topic areas were the following: (1) *What are the causes of outbreaks in settings with high reported vaccination coverage?* (epidemiology); (2) *Can affordable diagnostic tests be developed to confirm measles and rubella cases rapidly and accurately at the point of care?* (new tools); (3) *What are effective strategies for increasing coverage of the routine first dose of measles vaccine administered at 9 or 12 months?* (strategies); (4) *What are effective strategies for increasing coverage of the second dose given after the first year of life?* (strategies); (5) *How can communities best be engaged in planning, implementing and monitoring health services including vaccinations?* (demand); (6) *What capacity building is needed for health workers to be able to identify and work more effectively with community leaders?* (demand). Research priorities varied by region and by global/regional/national levels for all topic areas.

Conclusions: Research and innovation will be critical to make further progress toward achieving the GVAP measles and rubella elimination goals. The results of this survey can be used to inform decision-making for investments in research activities at the global, regional, and national levels.

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1. Introduction

The Global Vaccine Action Plan (GVAP), endorsed by the World Health Assembly (WHA) in 2012, established a global goal to achieve elimination of measles, rubella, and congenital rubella syndrome (CRS) by 2020 in five of the six World Health Organization (WHO) regions [1,2]. Additionally, as of September 2013, all WHO regions have set regional goals to achieve measles elimination by 2020, and three have established a goal for rubella elimination [3]. The Measles & Rubella Initiative (M&RI), led by the American Red Cross, the United Nations Foundation, the U.S. Centers for Disease Control and Prevention (CDC), the United Nations Children's Fund (UNICEF), and WHO, established the Global Measles and Rubella Strategic Plan, 2012–2020 [2]. The plan contains targets aligned with the GVAP and outlines five implementation strategies for achieving measles and rubella elimination goals: (1) achieve and maintain high levels of population immunity by providing high vaccination coverage with two doses of measles- and rubella-containing vaccines; (2) monitor disease using effective surveillance and evaluate programmatic efforts to ensure progress; (3) develop and maintain outbreak preparedness, respond rapidly to outbreaks, and manage cases; (4) communicate and engage to build public confidence and demand for immunization; and (5) perform the research and development needed to support cost-effective operations and improve vaccination and diagnostic tools [2].

Significant progress has been made toward achieving measles and rubella elimination through intensive efforts by various countries and M&RI partners. Global reported measles cases declined from 853,479 in 2000 to 173,330 in 2017, a decrease of 80% [4]. During this same period, the annual number of estimated measles deaths decreased by 80%, from 545,174 to 109,638 [4]. Estimated coverage with the routine first dose of measles-containing vaccine (MCV1) increased from 72% in 2000 to 85% in 2010 globally, and plateaued at 84–85% during 2010–2017; the number of countries with $\geq 90\%$ MCV1 coverage increased from 84 in 2000 to 118 in 2017 [5]. The number of countries providing the recommended routine second dose of measles-containing vaccine (MCV2) increased from 97 in 2000 to 160 in 2016 [6]; estimated MCV2 coverage increased from 15% in 2000 to 67% in 2017 globally [5]. During 2000–2017, estimated rubella-containing vaccine coverage increased globally from 22% to 52%, and the number of rubella cases reported globally declined 97% from 670,894 in 2010 to 22,361 in 2016 [5,7].

The Region of the Americas verified elimination of measles in May 2016 and rubella in September 2015 [8], but a recent measles outbreak in Venezuela led to reestablished endemic measles because of the sustained transmission of measles virus for >12 months [4]. In 2018, the outbreak continued with more than 6,300 confirmed measles cases and 70 measles deaths. The other five WHO regions have made progress but will require further efforts to achieve measles and rubella elimination goals. In 2016, a midterm review of the Global Measles and Rubella Strategic Plan (2012–2020) concluded that the plan's core strategies were sound and recommended that countries continue to work toward elimination goals with a focus on strengthening their immunization systems and improving implementation of the core strategies. The review concluded that full implementation of the strategies had been impeded by inadequate country ownership and global political will and emphasized the need to invest in innovation [9,10].

Despite the substantial progress in increasing coverage of measles and rubella vaccines and in reducing the burden of measles and rubella, there are a number of unanswered questions on how to implement the strategies most effectively and efficiently to accelerate measles and rubella elimination. The M&RI Research

and Innovation Work Group (R&IWG) is a group of experts appointed by the M&RI for their recognized expertise in measles and rubella that works with government agencies, implementing partners, and academic institutions to monitor and coordinate research, and prioritize research areas for focus [11]. The R&IWG conducted a survey of scientific and programmatic experts to identify measles and rubella research questions considered high priority for accelerating elimination efforts. Experts were invited to complete the survey using a list of contacts compiled by the R&IWG from established measles and rubella committees, previous measles and rubella meetings, and input from measles and rubella implementing partner focal points. The survey results were presented at a meeting of 40 experts with measles and rubella elimination effort experience from all six WHO regions, held at the Pan American Health Organization (PAHO) in Washington, D.C. in November 2016 where deliberations and recommendations on research priorities were made [12]. The survey results were used as critical inputs for the M&RI comprehensive research prioritization process, but were just one of several data sources that informed the M&RI research agenda-setting meeting [13].

2. Methods

2.1. Study design and recruitment

A cross-sectional web-based survey was conducted by asking experts on measles and/or rubella about research priorities for achieving disease elimination goals. Before conducting the survey, CDC and the M&RI held an hour-long webinar on October 17, 2016, discussing measles and rubella elimination goals and research priorities. The webinar was promoted through global measles and rubella networks; it was recorded and posted on the M&RI website [14]. After the initial webinar, invitations to complete the survey were emailed to 774 experts in the field of measles and rubella, based on a list of experts compiled by the R&IWG with input from M&RI partners. The email recipients were asked to forward the survey invitation to other appropriate persons working on measles and rubella, in order to increase participation and inclusivity and ensure that we received responses from a variety of individuals working in measles and rubella at the country and local levels. The survey was open for completion during October 17–November 4, 2016. Reminder emails were sent to non-responders and to individuals who began the survey but only partially completed it.

2.2. Survey questions

A list of research questions was generated by the R&IWG based on findings from previous research prioritization activities published by Goodson et al. [15] and presented by Moss et al. in a report to the Strategic Advisory Group of Experts (SAGE) on Immunization Working Group on Measles and Rubella [16]. The research questions were categorized into four research topic areas: (1) epidemiology and economics; (2) new tools for surveillance, vaccine delivery, and laboratory testing; (3) immunization strategies and outbreak response; and (4) vaccine demand and communications. The survey presented the list of research questions and asked respondents to rate each question's significance (highly significant, moderately significant, low significance, not significant) and urgency (as soon as possible, by 2020, not essential by 2020) in order to achieve global and regional measles and rubella elimination goals (Supplemental Table). From the list of research questions, respondents were also asked to select the three research questions they considered of highest priority to achieve measles and rubella global and regional elimination goals. Additionally,

respondents were asked to add key research questions they thought were missing from the list in open fields on the survey and to rank those questions with regard to significance and urgency.

2.3. Statistical analysis

For each research question, we calculated the proportion of respondents who selected the question as one of their three highest priorities to achieve the measles and rubella global and regional elimination goals, by dividing the number of people who selected the research question as a high priority by the number of respondents who answered that question. Analyses were stratified in two ways: (1) the primary WHO region that each respondent reported they worked in, and (2) by global, regional, or national/sub-national level of the respondents' work.

3. Results

3.1. Demographics

A total of 207 individuals responded to the web-based survey during October 17–November 4, 2016, including 145 (70%) who answered all questions in the survey, and 18 (9%) who partially completed the survey and whose responses were included for the questions they answered. The analysis excluded 44 (21%) individuals who provided demographic data only but did not answer any of the questions on research priorities. The survey respondents' immunization experience was from all six WHO regions (Table 1). Respondents were categorized by primarily working at the global ($n = 39$), regional ($n = 30$), or national/sub-national ($n = 73$) level (the remaining 21 respondents were not categorized and were not included in analyses stratified by level). Respondents worked for Ministry of Health/Government (27%), WHO (25%), CDC (14%), academic setting/university (8%), UNICEF (7%), John Snow, Inc. (4%), American Red Cross (2%), or as an independent immunization consultant (3%). Almost half (48%) had worked on measles and/or rubella for ≥ 10 years, 28% for 5–9 years, 19% for 1–5 years, and 5% for < 1 year. The primary area of respondents' expertise was reported as both measles and rubella (44%), routine immunization service delivery (25%), measles only (11%), rubella only (2%), or other (18%). The most common primary scopes of work (respondents could select more than one area) were epidemiology (51%), routine immunization service delivery (50%), field surveillance (44%), outbreak response (43%), campaigns (41%), vaccine delivery (28%), and research (28%). Smaller numbers said that they worked in communications (15%), health behavior (5%), economics (5%), and mathematical modeling (2%).

3.2. Epidemiology and economics (Fig. 1)

The epidemiology and economics research question selected by the largest percentage (46%) of respondents as a high priority was: "What are the causes of outbreaks in settings with high reported vaccination coverage?" This question was most frequently listed by respondents in the African Region (AFR), the Region of the Americas (AMR), the European Region (EUR), and the Western Pacific Region (WPR). Respondents working at the national or sub-national level, in particular, selected this question as high priority. The second most selected (34%) research question in this category was: "What are the epidemiologic characteristics of measles (e.g., incidence, age distribution, case fatality ratios) in various settings in priority countries?" This question was identified particularly in the Eastern Mediterranean Region (EMR), where 63% of respondents selected it as a high priority. It was a high priority for respondents

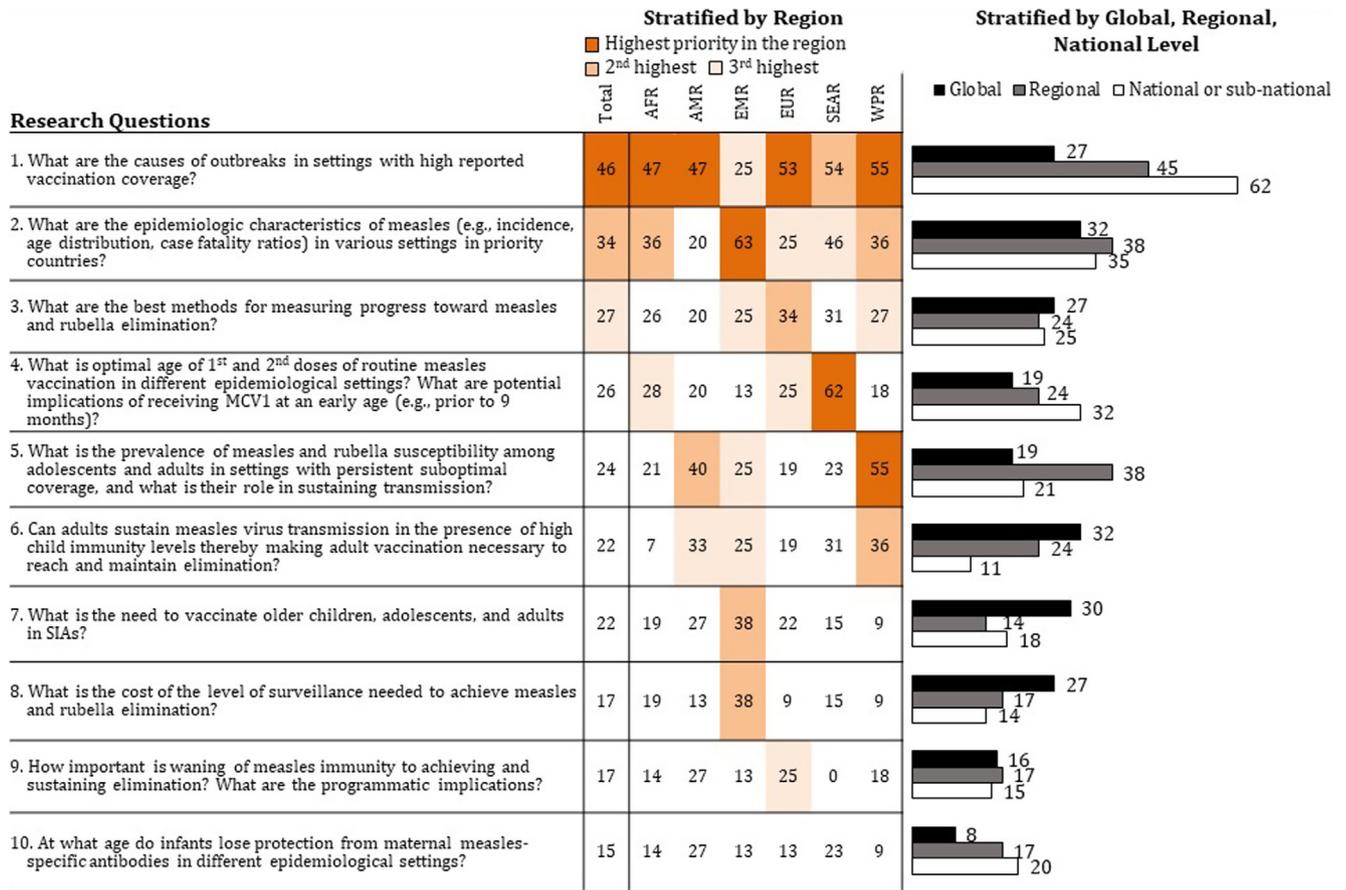
across global, regional, and national levels. The third most frequently chosen (27%) research question in this category was the following: "What are the best methods for measuring progress toward measles and rubella elimination?" This question was a high priority for 20–34% of respondents across all regions and across global, regional, and national levels.

In the South-East Asia Region (SEAR), the most frequently chosen research question (62%) was "What is the optimal age of 1st and 2nd doses of routine measles vaccination in different epidemiological settings? What are potential implications of receiving MCV1 at an early age (e.g., prior to 9 months)?" In WPR and AMR, the second most frequently chosen research question (55% and 40% of respondents, respectively) was "What is the prevalence of measles and rubella susceptibility among adolescents and adults in settings with persistent suboptimal coverage, and what is their role in sustaining transmission?" In EMR, the following questions were selected frequently (38% each): "What is the need to vaccinate older children, adolescents, and adults in SIAs," and "What is the cost of the level of surveillance needed to achieve measles and rubella elimination?" The research question, "Can adults sustain measles virus transmission in the presence of high child immunity levels, thereby making adult vaccination necessary to reach and maintain elimination," was the most frequently selected question for respondents working at the global level (32%) and the second most chosen for respondents working in WPR (36%). Three economics research questions were presented in the survey as potential priorities. The economic research question selected most frequently (17%) was "What is the cost of the level of surveillance needed to achieve measles and rubella elimination?" Survey respondents also provided new epidemiology and economics research questions that they thought were missing from those listed in the survey [17].

3.3. Surveillance, vaccine delivery, and laboratory testing (Fig. 2)

The surveillance, vaccine delivery, and laboratory testing research question selected by the largest percentage (68%) of respondents as a high priority was: "Can affordable diagnostic tests be developed to rapidly and accurately confirm measles and rubella cases at the point of care?" This question was selected most frequently by respondents across global, regional, and national levels, and in all regions except for EMR and WPR (ranging from 67% in AMR to 77% in SEAR, and up to 84% among those working at the regional level). The second most frequently selected (60%) research question in this category was: "Can vaccine safety, effectiveness, and/or coverage be improved by developing more thermo-stable vaccines, advanced vaccine vial temperature monitors, self-reconstituting vials, or by alternative delivery methods (e.g., needle-free injection devices, aerosol, dry powder inhalation, microneedles)?" This question was particularly important in WPR, where it was selected by the largest percentage of respondents (80%). It was chosen as a high priority question by a majority of respondents across global, regional, and national levels. The third highest (42%) priority research question in this category was "What is the effectiveness of 2 or more doses of measles-containing vaccine for achieving elimination in high birth rate, densely populated settings in developing countries?" This question, that is related to better understanding basic reproduction number (R_0) values and herd immunity thresholds in various settings, was selected as high priority by large proportions of survey respondents in SEAR (69%) and EMR (57%), in particular. It was also chosen as high priority among a majority of experts working at the national or sub-national level (52%).

Two additional research questions were selected by more than one-quarter of respondents as high priority. The question "What is the most appropriate method for determining level of population immunity in developing countries?" was selected by 26% of all respondents, by 60% of WPR respondents, and by 36% of regional



Numbers shown are the percentages of respondents who selected each question as a top priority

Fig. 1. Epidemiology and economics research priorities, Measles & Rubella Initiative web-based survey, 2016 (n = 157). Note: Other epidemiology and economics research questions that were selected by fewer respondents as a priority: What are the best methods to estimate the threshold population size and susceptible density required to sustain measles and/or rubella virus transmission in various settings? (11%); What is the economic burden of measles outbreaks in low- and middle-income countries? (11%); What are the best methods for measuring disease burden of measles and rubella? (8%); What is the epidemiology of rubella/CRS in developing countries with different birth rates? (8%); What is the prevalence of measles virus susceptibility among human immunodeficiency virus (HIV)-infected adults in high HIV-prevalence settings and does this depend on coverage of highly active antiretroviral therapy (HAART)? (4%); What is the economic burden of CRS at global, regional and national levels? Does the economic burden differ for low- and middle-income countries? (3%).

level respondents. The question “What are valid performance indicators for measles and rubella case-based surveillance in different settings?” was selected by 28% of all respondents and by 39% of global level respondents. Survey respondents provided new key surveillance, vaccine delivery, and laboratory testing research questions that they thought were missing from those listed in the survey [17].

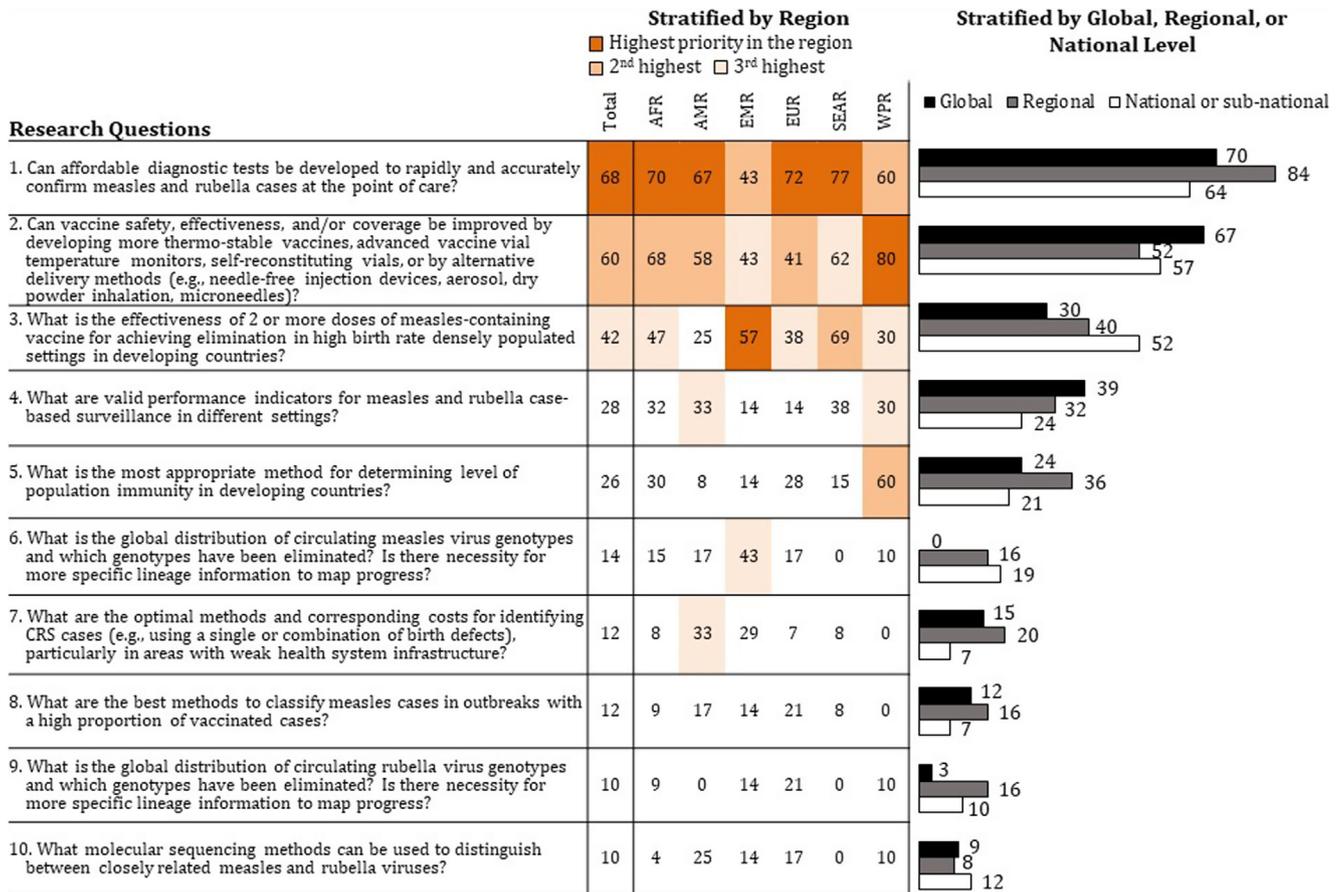
3.4. Immunization strategies and outbreak response (Fig. 3)

Two research questions pertaining to immunization strategies and outbreak response were selected by a majority (53% each) of respondents as high priority. The first question was “What are effective strategies for increasing coverage of the routine first dose of measles vaccine administered at 9 or 12 months?” The second question was “What are effective strategies for increasing coverage of the second dose given after the first year of life?” First dose coverage was selected particularly in AMR (67%), and second dose coverage was selected by more than two-thirds of respondents (70%) in WPR.

The second most frequently selected (46%) research question in this category was: “What are effective strategies for identifying and vaccinating geographic or culturally hard-to-reach populations (e.g., nomadic populations, migrants, refugees, and internally displaced persons) in various settings?” This question was chosen as high priority

by ≥38% of respondents across regions and by ≥43% of respondents across global, regional and national levels. It was the most frequently selected question in EUR (62%). The third most commonly selected (30%) research question in this category was “What are accurate, efficient, and novel methods for monitoring/verifying first- and second-dose measles vaccination coverage through routine immunization services and SIAs (e.g., serosurveys, coverage surveys, etc.)?” This question was selected as highest priority by 46% of survey respondents in SEAR. It was infrequently chosen as a high priority question by experts working at the global level (6%), but it was more frequently selected among experts working at regional or national/sub-national levels (43% and 38%, respectively).

Respondents from EMR and SEAR tended to select different research questions as high priority compared to respondents in the other regions. In SEAR, nearly half (46%) of respondents listed two research questions as high priority: “What are accurate, efficient, and novel methods for monitoring/verifying first- and second-dose measles vaccination coverage through routine immunization services and SIAs (e.g., serosurveys, coverage surveys, etc.)?”, and “What are the most cost-effective strategies for outbreak response immunization activities, including the timing of outbreak response immunization and selection of target populations?” EMR respondents most frequently (67%) selected the research question “What are effective strategies (e.g., house-to-house social mobilization) to maximize SIA



Numbers shown are the percentages of respondents who selected each question as a top priority

Fig. 2. Surveillance, vaccine delivery, and laboratory testing research priorities, Measles & Rubella Initiative web-based survey, 2016 (n = 144). Note: Other surveillance, vaccine delivery, and laboratory testing research questions that were selected by fewer respondents as a high priority: What are the technical requirements and epidemiologic utility of developing serologic assays to differentiate immunity acquired from exposure to wild-type viruses and immunity acquired from exposure to vaccine strains? (9%); Can tests be developed to accurately measure neutralizing antibodies to measles and rubella viruses, and provide results faster than the plaque reduction neutralization assay (PRNT)? (8%).

coverage in different epidemiological settings?" Respondents working at the regional level were particularly interested in this research question as well; 52% selected this question as high priority. Survey respondents provided new key research questions in the immunization strategies and outbreak response category that they thought were missing from those listed in the survey [17].

3.5. Vaccine demand and communications (Fig. 4)

The vaccine demand and communications research question selected by the largest percentage (53%) of respondents was: "How can communities best be engaged in planning, implementing and monitoring health services including vaccinations? What capacity building is needed for health workers to be able to identify and work more effectively with community leaders?" This question was selected by a majority of survey respondents in AFR (70%), EMR (50%), SEAR (62%), and WPR (50%). It was also chosen frequently by experts working at the regional and national levels (58% each), but less so by global level experts (39%).

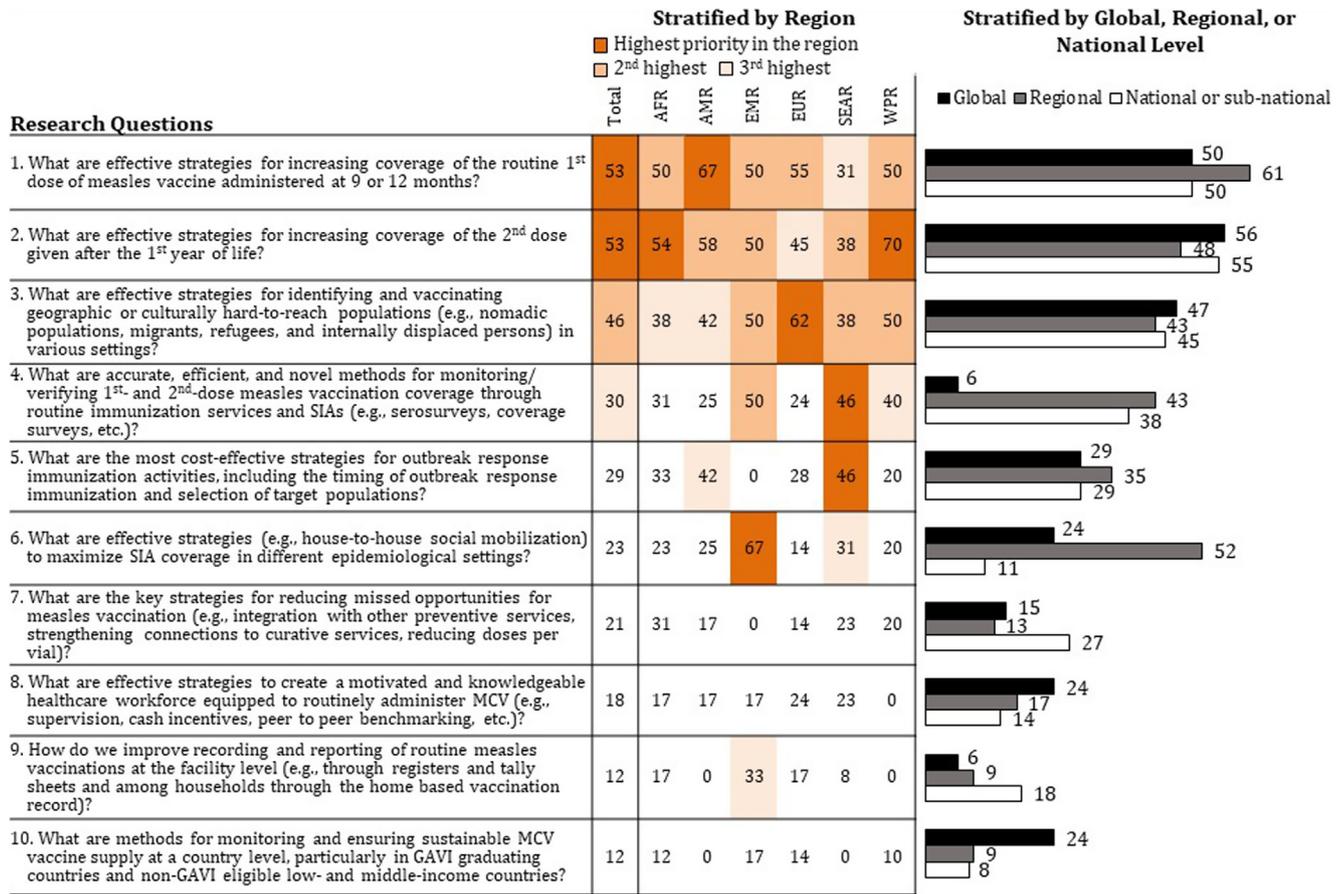
The second most commonly chosen (41%) research question in this category was "What are community attitudes and perceptions related to health services, immunizations, measles and rubella vaccination, and SIAs?" This question was selected by a majority of respondents in SEAR (62%) and by experts working at the national/sub-national level (52%). The third most frequently selected research question in this category was "What misconceptions and

attitudinal barriers exist among public and private sector health care providers regarding measles- and rubella-containing vaccines?" This question was selected by 37% of all survey respondents and by 50% and 62% of respondents from EMR and EUR, respectively.

There was more variation among respondents in prioritizing research questions in the vaccine demand and communications topic area than in the other research topic areas. Although the "community engagement" research question was selected as high priority by most respondents overall and was the most frequently cited research question by respondents in four regions (AFR 70%, EMR 50%, SEAR 62%, WPR 50%), respondents from three of those regions (EMR, SEAR, WPR) rated at least one other question a high priority with the same frequency. Respondents in AMR selected a different research question as highest priority (46%): "What are the most effective evidence-based strategies for measles and rubella vaccine acceptance?" Among global level respondents, the most frequently chosen (50%) question was "What are the best strategies to address information gaps or confidence gaps in measles and rubella vaccines in different settings?" Survey respondents provided new key vaccine demand and communications research questions that they thought were missing from those listed in the survey [17].

4. Discussion

Research and innovation will be critical to accelerate progress toward achieving the GVAP goal to eliminate measles, rubella,



Numbers shown are the percentages of respondents who selected each question as a top priority

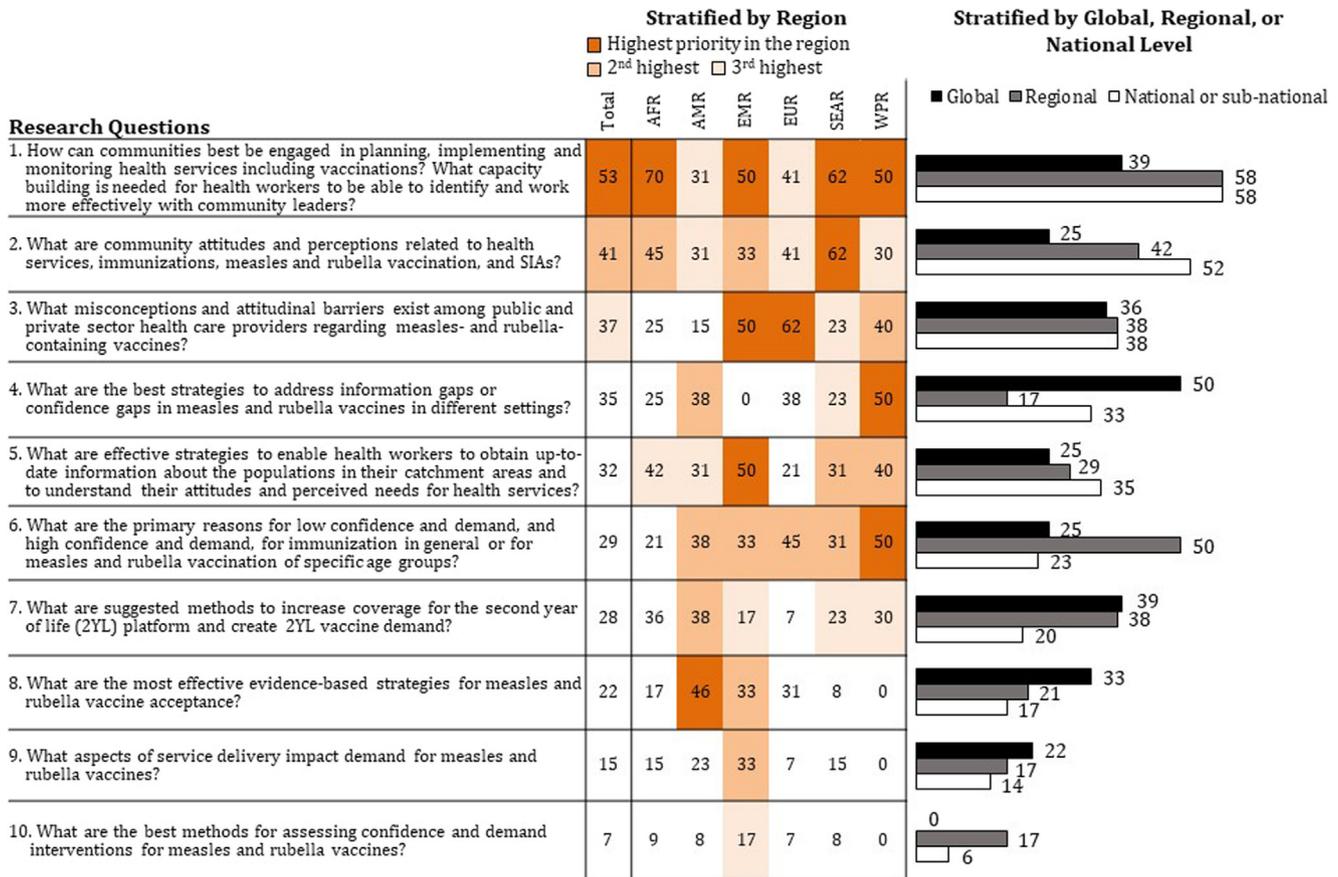
Fig. 3. Immunization strategies and outbreak response research priorities, Measles & Rubella Initiative web-based survey, 2016 (n = 142).

and CRS in five of the six WHO regions by 2020 [1,3]. It will be vital to continue to identify and prioritize research questions with the greatest potential impact on achieving elimination goals, and these will likely vary by region [15]. Previous research prioritization efforts for measles and rubella/CRS have been done by consensus among subject matter experts (SMEs) participating in collaborative meetings or by expert input through surveys [15,16]. The recent M&RI measles and rubella research prioritization process combined both approaches. The web-based survey described in this report provided results that were used during the November 2016 meeting of experts to inform discussions about research priorities in four main topic areas: (1) epidemiology and economics; (2) new tools for surveillance, vaccine delivery, and laboratory testing; (3) immunization strategies and outbreak response; and (4) vaccine demand and communications. Data from the survey were reviewed by SMEs in topic-based workgroups during the meeting, considered along with results from previous research prioritization activities, and used to identify research priorities for accelerating measles and rubella elimination. The findings from the collaborative meeting of experts are presented in an accompanying paper [13].

Across WHO regions and at the global, regional, and national/sub-national levels, there was considerable agreement by experts on measles and rubella research priorities. Overall, the research questions that were selected as high priority by the most survey respondents pertained to the development of new technologies to improve vaccination and diagnosis of disease. The priority research question listed by the most (68%) respondents addressed whether affordable diagnostic tests can be developed to confirm

measles and rubella cases rapidly and accurately at the point of care. Another high priority research question, chosen by 60% of all respondents, addressed whether vaccine safety, effectiveness, and/or coverage can be improved by developing more thermostable vaccines, advanced vaccine vial temperature monitors, self-reconstituting vials, or by alternative delivery methods (e.g., needle-free injection devices, aerosol, dry powder inhalation, microneedles).

In three of the research topic areas, there was agreement on the highest priority research questions by respondents from at least four of the six regions. However, there appeared to be some differences in priorities worth noting. Experts working at the global level more frequently cited questions related to strategies to address information gaps or confidence gaps for measles and rubella vaccines (50%), and the need for better understanding of the role of adults in sustaining virus transmission and the potential need for adult vaccination (32%). Experts working at the national or sub-national level appeared to place more priority on questions regarding the causes of outbreaks in high-coverage settings (62%); the effectiveness of vaccination in densely populated developing country settings (52%); and community attitudes and perceptions of health services, immunization, measles and rubella vaccination, and SIAs (52%). In the Americas, the only region that achieved elimination of both measles and rubella, but where a recent measles outbreak in Venezuela with sustained transmission of measles virus for >12 months led to reestablished endemic measles [4], experts were more concerned with questions related to evidence-based strategies for vaccine acceptance (46%) and susceptibility among adolescents and adults and their role in



Numbers shown are the percentages of respondents who selected each question as a top priority

Fig. 4. Vaccine demand and communications research priorities, Measles & Rubella Initiative web-based survey, 2016 (n = 144).

sustaining transmission (40%). The vaccine demand and communications topic area had more regional heterogeneity in priority questions than the other topic areas. Almost half of respondents reported working in measles/rubella programs for ≥ 10 years, so it is possible that compared with respondents with less time working in measles/rubella, they may have less independent perspective and their responses may favor incremental progress rather than more innovative research that could lead to more significant change.

The results of this survey should be viewed in light of some limitations. First, respondents to the survey were a convenience sample; 774 measles and rubella experts were identified by the R&IWG with input from M&RI partners and were directly invited to complete the survey, and invitees were asked to forward the survey invitation to other experts working on measles and rubella. We selected this sampling strategy in order to increase inclusivity and ensure that we received input from a variety of experts working in measles and rubella at the country and local levels who might not have been identified for the initial invitation list. This strategy helped to increase participation in the survey but the exact number of individuals who received a survey invitation was unknown; therefore, the survey response rate could not be calculated. Further, even with this sampling strategy it is possible that some measles and rubella experts did not receive a survey invitation, with a higher likelihood among those working at the local level. Comparing the invite list to the list of respondents, 30 individuals who completed the survey were not on the original invite list, so likely received a forwarded survey invite. The survey was conducted using the internet and in English, so individuals with

poor internet connection or in non-English-speaking settings were likely underrepresented among survey respondents. We received some non-English responses that were translated and included in the results; however, it is possible that other non-English speaking invitees did not participate in the survey due to a language barrier. Second, the list of research questions presented in the survey was developed by a group of M&RI experts. Although this list was intended to be comprehensive, it was likely biased by the experts' own knowledge and subjective priorities. Open-ended response questions were purposefully included in the survey to allow respondents to provide additional key research questions that were not already in the survey. Through open-ended responses, survey participants identified additional high priority research questions that were missing from those listed specifically in the survey. Although this was important information, not all survey respondents ranked these additional research questions, and quantitative analysis of these open-ended responses was not possible. However, this information was shared at the meeting of experts in November 2016 and considered during the comprehensive prioritization process. Third, the design and structural organization of the survey could have had an impact on the way respondents ranked priorities. For example, epidemiology topics and economics topics were categorized together, and so research questions from both topics were compared against each other in rankings. Thus, we found that in the epidemiology and economics topic area, research questions with the highest priorities were related to epidemiology, and three research questions related to economics were ranked as lower priority. Similarly, some questions were composites which combined multiple innovations in the same

question. This style of question may have increased the likelihood of ranking these questions more highly compared with a question on a single topic area.

Global research priorities will continue to evolve with further progress toward achieving the GVAP goals and as countries and regions move closer toward measles and rubella elimination. This is evident in the Americas, which had achieved elimination, and whose respondents have different priorities than other regions. Periodic assessments of research priorities through future research prioritization processes will be critical to focus research projects and guide investments by stakeholders. Implementation of research to address the identified priorities will be instrumental in accelerating progress toward elimination and eventual eradication of measles and rubella. The R&IWG will estimate the scale of funds required, and identify potential sources of research funding opportunities and implementation partners to ensure that research and innovation activities provide the evidence that will be critical for setting policies and refining elimination strategies for success.

Conflict of interest

We declare that we have no conflict of interest.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2019.02.058>.

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