Note: This report was used to solicit feedback from WHO's Strategic Advisory Group of Experts on Immunization (SAGE), and does not represent the final methodology, results, or views of any of the contributors. Final methods and results will be published in a peer-reviewed article, currently in preparation.

Partnering with regions and countries to identify priority pathogens for vaccine development

Immunization Agenda 2030 Monitoring and Evaluation – February 2023

Table of Contents

Abbreviations *2*

I. Executive Summary **2**

II. Report **8**

A. Introduction *8*
B. Survey versions *10*
C. Survey dissemination *11*
D. Survey responses *14*
E. Respondents *15*
F. Criteria weights *17*
G. Pathogen ranks *19*
H. Priority weights and sensitivity testing *21*
I. Respondent feedback *23*
J. Discussion *25*
K. Acknowledgments *27*

III. Annexes **28**

A. Annex A: Survey invitation *29*
B. Annex B: Responses per region and country *32*
C. Annex C: Individual criteria weights *33*
D. Annex D: Sensitivity testing datasets *35*
E. Annex E: Pathogen ranks and calculation method *38*
F. Annex F: Thematic analysis *47*

Abbreviations

African CDC	African Centers for Disease Control
AFRO	WHO Regional Office for Africa
AMR	Antimicrobial resistance
CHAI	Clinton Health Access Initiative
CSO	Civil society organization
DCVMN	Developing Country Vaccine Manufacturers Network
ExPEC	Extra-intestinal pathogenic *E. coli*
GAS	Group A streptococcus
GBD	Global Burden of Diseases Project
GVIRF	Global Vaccine and Immunization Research Forum
HIV-1	Human immunodeficiency virus 1
IA2030	Immunization Agenda 2030
IHME	Institute for Health Metrics and Evaluation
IFPMA	International Federation of Pharmaceutical Manufacturers Associations
InPEC	Intestinal pathogenic *E. coli*
IQR	Inter-quartile range
M&E	Monitoring and evaluation
MCDA	Multi-criteria decision analysis
MoH	Ministry of Health
NITAG	National immunization technical advisory group
NRA	National regulatory authority
PAPRIKA	Potentially All Pairwise Rankings of All Possible Alternatives
PAVM	Partnership for African Vaccine Manufacturing
PDVAC	Product Development for Vaccines Advisory Committee
R&D	Research and development
RITAG	Regional immunization technical advisory group
RSV	Respiratory syncytial virus
SAGE	WHO's Strategic Advisory Group of Experts on Immunization
SP7	Strategic Priority 7 of IA2030, "Research and Innovation"
TB	Tuberculosis
WG	Working Group
WHO	World Health Organization
YLDs	Years lived with disability

I. Executive Summary

Immunization Agenda 2030: A Global Strategy to Leave No One Behind (IA2030) is the World Health Assembly-endorsed global strategy for immunization, bringing countries, civil society and development partners together to optimize the use of vaccines for public health impact. *Research and Innovation* is its seventh strategic priority, or "SP7". In the IA2030 Monitoring and Evaluation (M&E) Plan, Indicator 7.2 will monitor progress relating to a "short list" of global research and development (R&D) targets. According to this plan, "World Health Organization (WHO) headquarters and regional offices together with key partners/stakeholders are to mutually define targets and evaluate progress at the global and regional levels."[a] This call for mutually defined targets is in keeping with the IA2030 core principles of "people-centered, country-owned, partnership-based, and data-guided."

For Indicator 7.2, WHO's Product Development for Vaccines Advisory Committee (PDVAC) has been charged with proposing a short list of pathogen targets for new vaccines (where vaccines do not currently exist, or where a new indication is needed), for endorsement by the WHO Strategic Advisory Group of Experts on Immunization (SAGE). To mutually define these targets, WHO is developing an approach for engaging with regional and country stakeholders on priorities for vaccine R&D. While focusing initially on identifying priorities for new vaccines, this approach can be applied in the future to priorities for operational and implementation research and other important choices.

This collaborative approach is shown in Figure 1. It builds on a landscape analysis of prior initiatives and strategies for immunization; follows advice from experts in priority setting; and has been guided and shaped by consultation with WHO regional offices, Regional Immunization Technical Advisory Group (RITAG) chairs, PDVAC and the IA2030 SP7 Working Group.[b] These experts have also contributed to its implementation.

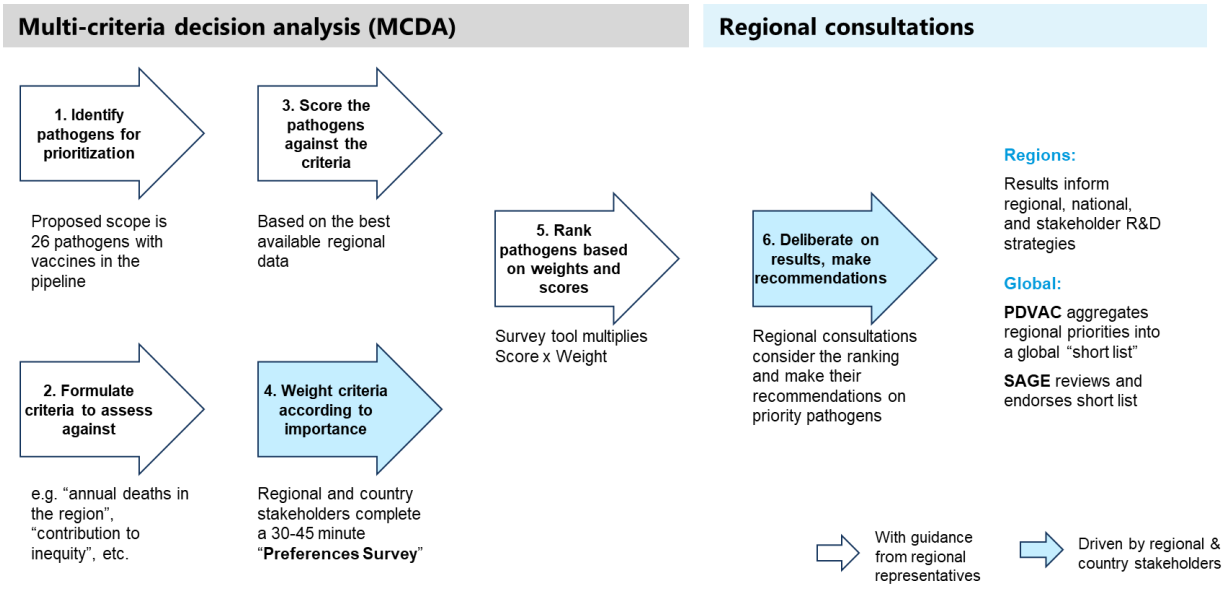
The approach starts with multi-criteria decision analysis (MCDA) using the PAPRIKA survey tool[c] to enable individual stakeholders at the regional and country level to weight 8 discrete criteria for prioritization. Criteria weights are then applied to pathogens in the context of each region to arrive at ranked priority lists. The results from the surveys have been collated by region and will be deliberated upon in regional consultations and inform recommendations for priority pathogens for vaccine R&D.

[a] http://www.immunizationagenda2030.org/images/documents/IA2030_Annex_FrameworkForActionv04.pdf

[b] For more information see the *Landscaping and Methods Brief*, presented to PDVAC in July 2022.

[c] PAPRIKA: "Potentially All Pairwise Rankings of All Possible Alternatives", https://www.1000minds.com/about/paprika

Figure 1 Collaborative approach to identify regional priorities



As described in the *MCDA Survey Preparation and Launch* report, the pathogen scope was identified by filtering potential pathogens based on relevance to human health, the need for new vaccine R&D, and existence of vaccine candidates in clinical development. Eight criteria for prioritization were formulated based on precedents in priority setting for disease research, vaccine R&D, and immunization funding, and in accordance with MCDA good practice guidelines.[a]

Each pathogen was scored for all 8 criteria on a region-by-region basis and the criteria and scores were used to create MCDA "Preferences Surveys" tailored to each region. In parallel, pathogens were scored with a global perspective and these scores were used to prepare a global survey for respondents whose work spans multiple regions. Note: Emerging infectious diseases were not included because their prioritization requires a different set of criteria and data, including predictive models. For these diseases, the WHO R&D Blueprint for Epidemics is conducting a prioritization exercise to define an official WHO list of priority pathogens of epidemic and pandemic potential.[b]

Since November 2022, these surveys have been disseminated by WHO global, regional and country offices and through partners in vaccine R&D and immunization. As of 15 February 2023, 225 respondents in 75 countries have completed the regional surveys. These countries comprise 39% of

[a] Marsh K, IJzerman M, Thokala P, Baltussen R, Boysen M, Kaló Z, Lönngren T, Mussen F, Peacock S, Watkins J, Devlin N; ISPOR Task Force. Multiple Criteria Decision Analysis for Health Care Decision Making--Emerging Good Practices: Report 2 of the ISPOR MCDA Emerging Good Practices Task Force. Value Health. 2016 Mar-Apr;19(2):125-37. doi: 10.1016/j.jval.2015.12.016. Epub 2016 Mar 7. PMID: 27021745.

[b] https://www.who.int/teams/blueprint/who-r-and-d-blueprint-for-epidemics

WHO member states and 81% of the global population. Fourteen countries have 5 or more responses to the regional surveys. The global version of the survey has received 41 responses.

The 8 criteria for prioritization are: 1) Annual deaths in children under 5, 2) Annual deaths in people 5 and older, 3) Annual years lived with disability (all ages), 4) Social and economic burden per case, 5) Disruption due to outbreaks, 6) Contribution to inequity, 7) Contribution to antimicrobial resistance, and 8) Unmet needs for prevention & treatment. When individual criteria weights are averaged with each region, most criteria have similar weights, and no criterion clearly dominates priority setting in any region. Cluster analysis will be conducted on these data to discern patterns based on the respondents' biographical information and their country of work.

Combining regional criteria weights and pathogen scores yields a total weight for each pathogen and generates a ranked list of pathogens for each region. Figure 2 summarizes these ranks and Table 1 gives the ranked lists. ***Mycobacterium tuberculosis*** (TB), **Human immunodeficiency virus 1** (HIV-1), ***Staphylococcus aureus***, and ***Klebsiella pneumoniae*** are among the top 5 pathogens in all regions. ***Plasmodium falciparum***, **Extra-intestinal pathogenic *Escherichia coli*** (ExPEC), ***Streptococcus pyogenes*** (Group A streptococcus, or GAS), and **Leishmania** are among the top 5 pathogens in a subset of regions. While high in priority, vaccines for some of these pathogens present important technical challenges. For example, several HIV-1 and *S. aureus* candidates have failed, and development of vaccines may not be the optimal preventive measure or control intervention. Generally speaking, the lowest-ranked pathogens include Hookworm, Salmonella Paratyphi, and Schistosomes, however the rankings for these differed by region.

These rankings are an ***interim step*** in identifying regional pathogen priorities. Further analysis, including incorporating strategic considerations such as the probability of technical and regulatory success, will be driven by the needs of regional stakeholders and discussed in the regional consultations.

Taking stock of progress to date, the most significant challenge has been **connecting and engaging with regional and country stakeholders. However, once contact is made there is generally interest and support for this initiative, with strong collaboration**. Going forward, it is intended that regional stakeholders will partner to disseminate the surveys and prepare for their consultations. We will continue to explore additional ways to expand and deepen representation and engagement within all regions.

Strengths of the collaborative approach include:

- **Collaborative, systematic, evidence-driven, and transparent**. Guidance from technical experts and regional leaders has been incorporated at every stage to ensure rigor, build collaboration

and create buy-in. Pathogens have been scored systematically, transparently, and based on the best available evidence to reduce the potential for bias and build credibility. The initial scope of 24 pathogens has been expanded to include *Chlamydia trachomatis* and Hepatitis C virus based on the advice of regional experts.

- **Evidence gaps are being identified**. Some pathogens were easily scored on the 8 criteria in all 6 regions. For others, the evidence is less comprehensive. Data gaps identified through this project will inform future research into the burden of these pathogens.
- **MCDA is a powerful tool for minimizing bias and broadening engagement**. The MCDA approach is less subject to bias because it focuses on public health concerns—the criteria—not an individual respondent's experience with specific pathogens. Because of this, their use is not limited to pathogen experts. Thus far, 266 respondents have completed the surveys. Respondents generally agree with their criteria weights and the pathogen rankings. Feedback from respondents indicates that they gained insight by completing the surveys.
- **Existing collaborations are being strengthened, new collaborations are being made.** Active outreach at regional meetings and by well-connected individuals has boosted response rates. Regional stakeholders are eager to partner on consultations. These connections will help to establish a robust approach for engaging with regional and country stakeholders and buy-in to the outcomes.

Regional consultations are now in the planning stages and will be described in future updates to PDVAC and SAGE.

Figure 2 Rank distribution

Pathogens are listed in order of average rank among the 6 WHO regions. The columns of numbers summarize the pathogen ranks. For example, TB was ranked first in 3 regions, second in 2 regions, and fourth in 1 region. Shading shows higher values and boxed cells show the ranks from the Global survey. Ranks are based on survey results as of 15 February 2023. Results are likely to evolve as additional data are collected and because scores for C. trachomatis and Hepatitis C virus are under review.

Pathogen	Number of regions with each rank																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Mycobacterium tuberculosis (TB)	3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Human immunodeficiency virus 1 (HIV-1)	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylococcus aureus	1	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	0	0	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Extra-intestinal pathogenic E. coli (ExPEC)	0	0	0	1	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudomonas aeruginosa	0	0	0	0	0	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Group A streptococcus (Streptococcus pyogenes)	0	0	0	1	1	0	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Respiratory syncytial virus	0	0	0	0	0	1	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shigella	0	0	0	0	0	1	1	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatitis C virus	0	0	0	0	0	0	0	1	0	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Influenza	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0
Group B streptococcus (Streptococcus agalactiae)	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0
Cytomegalovirus	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0
Plasmodium falciparum (malaria)	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0
Norovirus	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	1	0	0	1	0	0	0	0	0	0	0
Leishmania	0	0	0	0	1	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	1	1	0	0	0
Intestinal pathogenic E. coli (InPEC)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	2	0	1	0	0	0	0	0	0	0	0
Neisseria gonorrhoeae	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1	1	0	0	0	0	0	0	0
Mycobacterium leprae (leprosy)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	1	1	0	0	0	0	0
Non-typhoidal Salmonella	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	1	0	0
Chlamydia trachomatis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	2	0	0	0
Chikungunya virus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	2	0	0
Herpes simplex types 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	1	0	0	1
Schistosomes	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	2	1
Salmonella Paratyphi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2
Hookworm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2

Table 1 Pathogen ranks in each region

Ranks are based on survey results as of 15 February 2023. Results are likely to evolve as additional data are collected and because scores for C. trachomatis and Hepatitis C virus are under review.

Rank	African	Americas	E. Med.	European	SE Asian	W. Pacific	Global
1	P. falciparum (malaria)	HIV-1	M. tuberculosis (TB)	Staphylococcus aureus	M. tuberculosis (TB)	M. tuberculosis (TB)	M. tuberculosis (TB)
2	M. tuberculosis (TB)	Staphylococcus aureus	Staphylococcus aureus	M. tuberculosis (TB)	HIV-1	Staphylococcus aureus	HIV-1
3	HIV-1	Klebsiella pneumoniae	Klebsiella pneumoniae	HIV-1	Klebsiella pneumoniae	HIV-1	P. falciparum (malaria)
4	Klebsiella pneumoniae	M. tuberculosis (TB)	HIV-1	Extra-intestinal pathogenic E. coli	Staphylococcus aureus	Group A streptococcus	Staphylococcus aureus
5	Staphylococcus aureus	Extra-intestinal pathogenic E. coli	Leishmania	Klebsiella pneumoniae	Group A streptococcus	Klebsiella pneumoniae	Klebsiella pneumoniae
6	Shigella	Pseudomonas aeruginosa	Extra-intestinal pathogenic E. coli	Pseudomonas aeruginosa	Extra-intestinal pathogenic E. coli	Respiratory syncytial virus	Extra-intestinal pathogenic E. coli
7	Non-typhoidal Salmonella	Group A streptococcus	Shigella	Group A streptococcus	Respiratory syncytial virus	Pseudomonas aeruginosa	Group A streptococcus
8	Pseudomonas aeruginosa	Respiratory syncytial virus	Hepatitis C virus	Respiratory syncytial virus	Pseudomonas aeruginosa	Extra-intestinal pathogenic E. coli	Shigella
9	Extra-intestinal pathogenic E. coli	Shigella	Pseudomonas aeruginosa	Cytomegalovirus	Shigella	Influenza	Pseudomonas aeruginosa
10	Respiratory syncytial virus	Influenza	Group A streptococcus	Hepatitis C virus	Hepatitis C virus	Hepatitis C virus	Respiratory syncytial virus
11	Group B streptococcus	Hepatitis C virus	Norovirus	Shigella	Group B streptococcus	Cytomegalovirus	Non-typhoidal Salmonella
12	Group A streptococcus	Cytomegalovirus	Respiratory syncytial virus	Influenza	P. falciparum (malaria)	Shigella	Hepatitis C virus
13	Leishmania	P. falciparum (malaria)	Intestinal pathogenic E. coli (InPEC)	Norovirus	Influenza	Group B streptococcus	Influenza
14	Schistosomes	Leishmania	Neisseria gonorrhoeae	Neisseria gonorrhoeae	Leishmania	M. leprae (leprosy)	Group B streptococcus
15	Hepatitis C virus	Intestinal pathogenic E. coli (InPEC)	Influenza	Intestinal pathogenic E. coli (InPEC)	Norovirus	Norovirus	Norovirus
16	Norovirus	Group B streptococcus	Group B streptococcus	Group B streptococcus	Intestinal pathogenic E. coli (InPEC)	Intestinal pathogenic E. coli (InPEC)	Leishmania
17	Influenza	Neisseria gonorrhoeae	P. falciparum (malaria)	Chlamydia trachomatis	Cytomegalovirus	Neisseria gonorrhoeae	Intestinal pathogenic E. coli (InPEC)
18	Intestinal pathogenic E. coli (InPEC)	Chikungunya virus	Cytomegalovirus	M. leprae (leprosy)	Neisseria gonorrhoeae	Herpes simplex types 1&2	M. leprae (leprosy)
19	Neisseria gonorrhoeae	Norovirus	M. leprae (leprosy)	Non-typhoidal Salmonella	M. leprae (leprosy)	P. falciparum (malaria)	Cytomegalovirus
20	Cytomegalovirus	M. leprae (leprosy)	Chlamydia trachomatis	Herpes simplex types 1&2	Chikungunya virus	Chlamydia trachomatis	Neisseria gonorrhoeae
21	Herpes simplex types 1&2	Herpes simplex types 1&2	Non-typhoidal Salmonella	Chikungunya virus	Chlamydia trachomatis	Non-typhoidal Salmonella	Chikungunya virus
22	M. leprae (leprosy)	Non-typhoidal Salmonella	Salmonella Paratyphi	Leishmania	Salmonella Paratyphi	Chikungunya virus	Chlamydia trachomatis
23	Chlamydia trachomatis	Chlamydia trachomatis	Schistosomes	Hookworm	Herpes simplex types 1&2	Leishmania	Salmonella Paratyphi
24	Chikungunya virus	Schistosomes	Chikungunya virus	Salmonella Paratyphi	Non-typhoidal Salmonella	Hookworm	Schistosomes
25	Hookworm	Salmonella Paratyphi	Hookworm	P. falciparum (malaria)	Schistosomes	Schistosomes	Herpes simplex types 1&2
26	Salmonella Paratyphi	Hookworm	Herpes simplex types 1 & 2	Schistosomes	Hookworm	Salmonella Paratyphi	Hookworm

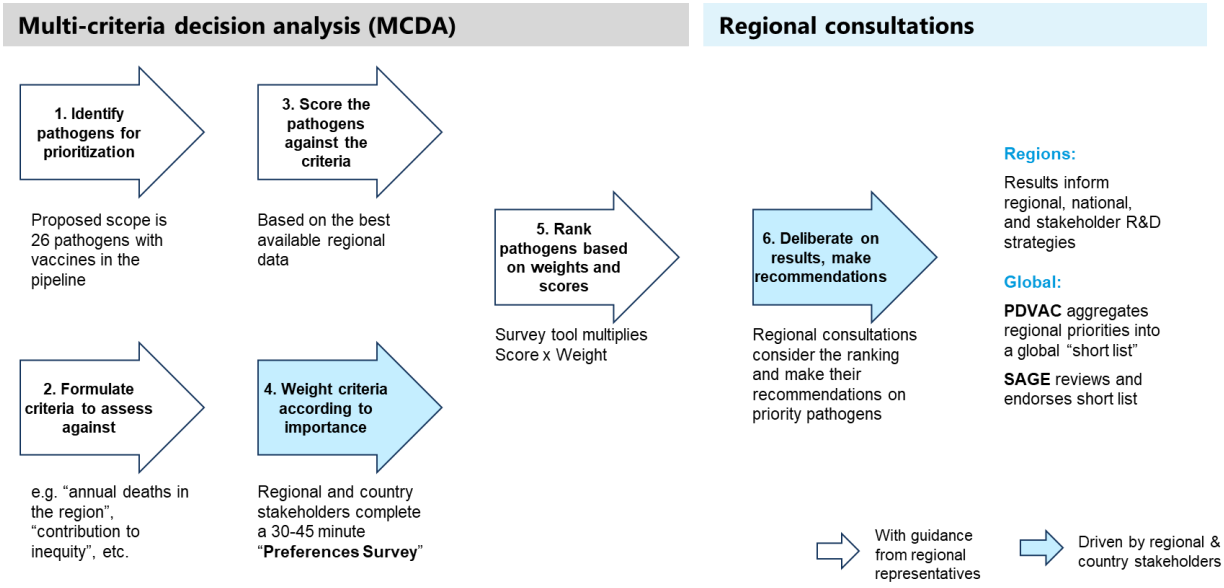
II. Report

A. Introduction

WHO's Product Development for Vaccines Advisory Committee (PDVAC) has been charged with proposing a short list of pathogen targets for new vaccines (where vaccines do not currently exist, or where a new indication is needed), for endorsement by the WHO Strategic Advisory Group of Experts on Immunization (SAGE). These targets will be used to monitor progress under Immunization Agenda 2030: A Global Strategy to Leave No One Behind (IA2030), specifically in Strategic Priority 7 (SP7), Research and Innovation.

To define these targets, WHO is developing an approach for engaging with regional and country stakeholders on priorities for vaccine research and development (R&D), shown in Figure 3. This approach builds on a landscape analysis of prior initiatives and strategies for immunization; follows advice from experts in priority setting; and has been guided and shaped by consultation with WHO regional offices, Regional Immunization Technical Advisory Group (RITAG) chairs, PDVAC and the IA2030 SP7 Working Group.[a] These experts have also contributed to its implementation. While focusing initially on identifying priorities for new vaccines, this approach can be applied in the future to priorities for operational and implementation research and other important choices.

Figure 3 Collaborative approach to identify regional priorities



[a] For more information see the *Landscaping and Methods Brief*, prepared for PDVAC in July 2022.

The *MCDA Survey Preparation and Launch* report described Steps 1 - 3 in detail. Briefly,

1. **Step 1. Identified pathogens for prioritization.** The initial list of pathogens was compiled from a landscape of existing vaccine-related priorities identified in the published and gray literature. A series of filters was applied to the pathogen list to reduce it to a more manageable number. The pathogens retained are those that affect humans; are not emerging infectious diseases (which require different criteria); lack licensed vaccines, or existing vaccines do not meet needs of certain populations; have vaccine candidates in clinical development; and are prioritized for vaccine R&D by global stakeholders. The initial scope of 24 pathogens has been expanded to include *Chlamydia trachomatis* and Hepatitis C virus based on the advice of regional experts and more pathogens can be added if requested.
2. **Step 2. Formulated criteria to assess against**. A literature review was conducted to identify priority-setting criteria used in vaccine R&D, vaccine implementation, and health technologies assessments. These criteria were consolidated into a minimal number, taking good practices in MCDA[a] and data availability into account, and finalized based on guidance from MCDA experts and PDVAC. The 8 criteria for prioritization are: 1) Annual deaths in children under 5, 2) Annual deaths in people 5 and older, 3) Annual years lived with disability (YLDs, all ages), 4) Social and economic burden per case, 5) Disruption due to outbreaks, 6) Contribution to inequity, 7) Contribution to antimicrobial resistance, and 8) Unmet needs for prevention & treatment.
3. **Step 3. Scored the pathogens against the criteria**. Pathogens were scored on a region-by-region basis and from a global perspective. The 3 quantitative criteria were scored using data from Global Burden of Diseases Project (GBD)[b] for each pathogen identified in Step 1.[c] Estimates for 2019 were used throughout. The 5 qualitative criteria were scored by a team of analysts based on literature searches. All scores were reviewed by at least 2 experts per region and 1 expert per pathogen to ensure that they reflect current data and regional realities.

This report describes Steps 4 and 5, and emerging results from the surveys.

---

[a] Marsh K, IJzerman M, Thokala P, Baltussen R, Boysen M, Kaló Z, Lönngren T, Mussen F, Peacock S, Watkins J, Devlin N; ISPOR Task Force. Multiple Criteria Decision Analysis for Health Care Decision Making--Emerging Good Practices: Report 2 of the ISPOR MCDA Emerging Good Practices Task Force. Value Health. 2016 Mar-Apr;19(2):125-37. doi: 10.1016/j.jval.2015.12.016. PeHUB 2016 Mar 7. PMID: 27021745.

[b] https://vizhub.healthdata.org/gbd-results/ and https://ghdx.healthdata.org/record/ihme-data/global-bacterial-antimicrobial-resistance-burden-estimates-2019

[c] *Mycobacterium tuberculosis* was scored using data for 2019 from the WHO Global Tuberculosis Report 2022. (https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022/tb-disease-burden/2-2-tb-mortality

B. Survey versions

The criteria, pathogens, and scores, and the PAPRIKA survey tool[a] were used to create Preferences Surveys tailored to each region. Surveys were created in English and in the major languages for each region. A Global survey was prepared in English for respondents whose work spans multiple regions. In total, 20 versions of the survey were finalized between 8 November 2022 and 21 December 2022 as shown in Table 2.

Table 2 Survey versions

Region	Languages	Date finalized
African	English, French, Portuguese	11 November 2022
Americas	English, Portuguese, Spanish	11 November 2022
E. Mediterranean	English Arabic French	11 November 2022 18 November 2022 23 November 2022
European	English, French, Portuguese, Spanish, Russian	15 November 2022
South-East Asian	English, Portuguese	11 November 2022
Western Pacific	English, French Chinese	11 November 2022 21 December 2022
Global	English	8 November 2022

[a] PAPRIKA: "Potentially All Pairwise Rankings of All Possible Alternatives", https://www.1000minds.com/about/paprika

C. Survey dissemination

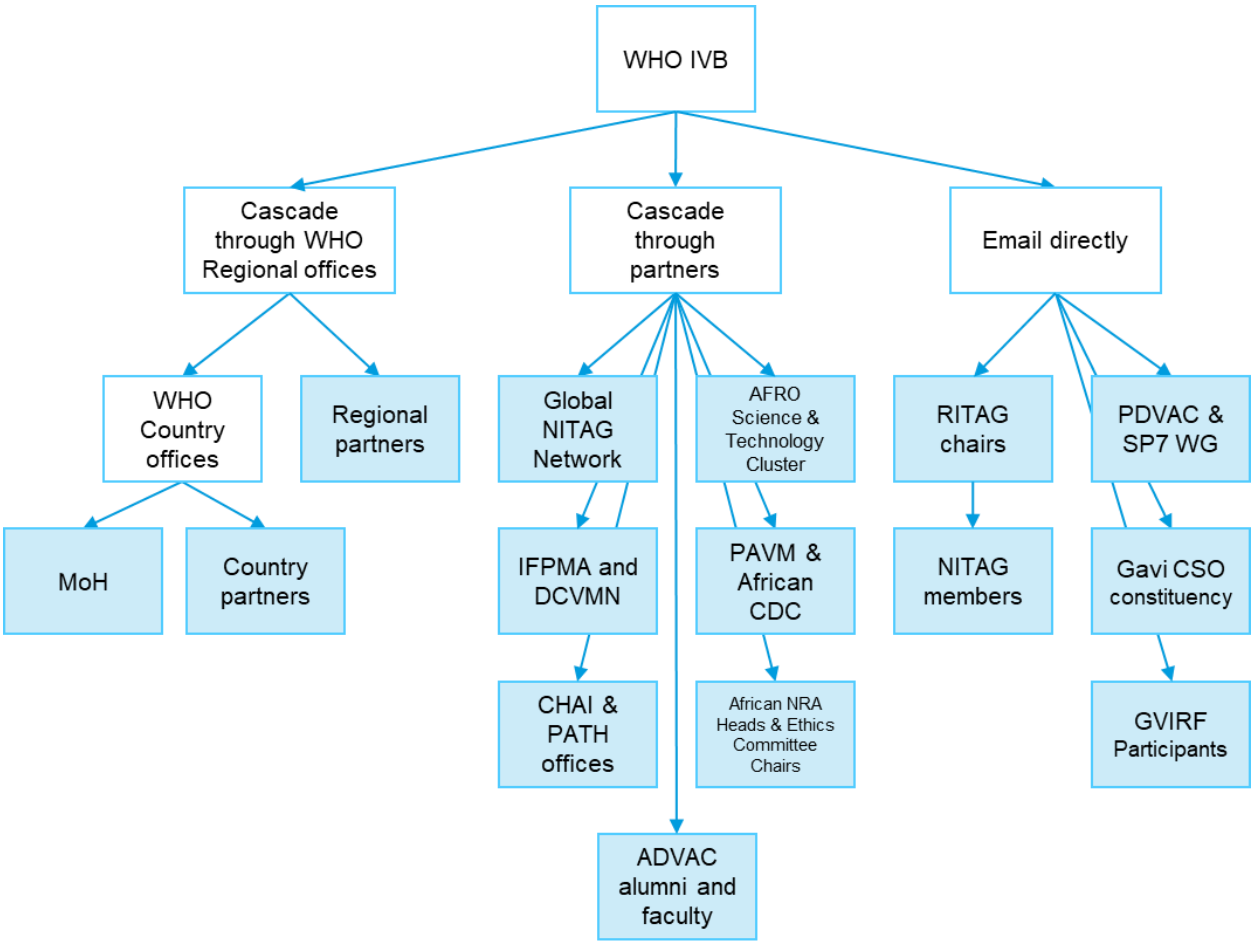
Survey invitations included the following components:

- **Cover emails.** Emails were tailored to the audience and encouraged the recipients to share the survey with colleagues.
- **Invitation memo** in English signed by Dr Katherine O'Brien, Director of WHO's Immunization, Vaccines and Biologicals Department. (See example in Annex A: Survey invitation).
- **Survey lookup table.** This table allowed respondents to find the link for an appropriate survey based on their country and preferred language. Links were created using the Bitly link shortener to enable monitoring of dissemination on a country-by-country basis.

As shown in Figure 4, survey invitations were disseminated through partners, including WHO regional and country offices, global partners such as the Global National Immunization Technical Advisory Group (NITAG) Network, regional partners such as the African Centers for Disease Control, and directly from IA2030-SP7@who.int. Invitations targeted Ministry of Health officials, policy makers, technical advisory groups, health care professionals, regulators, experts in public health and infectious diseases, pharmaceutical companies, and funders. The survey was not disseminated through more public channels such as the TechNet-21, LinkedIn, or Twitter because targeted dissemination through partner networks was seen as a more selective way of reaching experienced immunization stakeholders, especially policymakers. Surveys remain open and data collection is ongoing. Responses as of February 15 are included in this analysis.

Figure 4 Survey dissemination as of February 2023

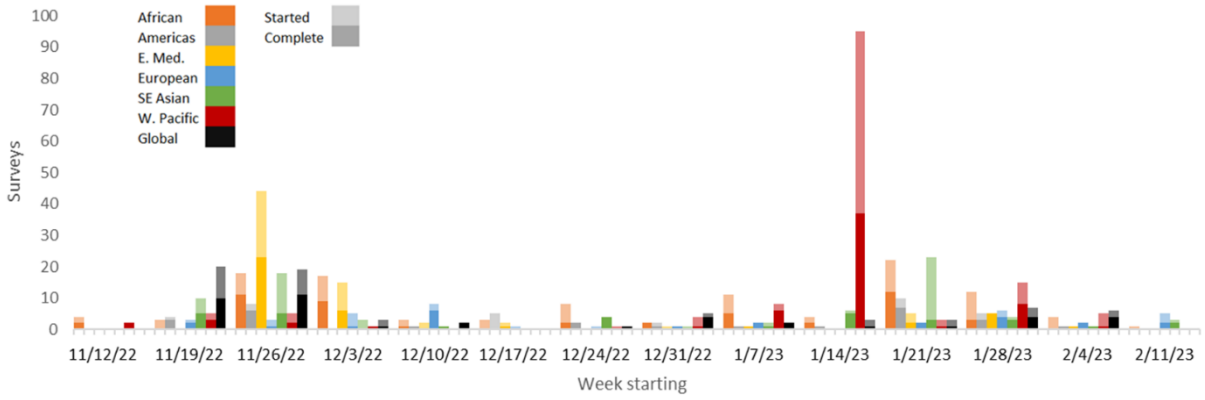
Survey invitations were cascaded through many partners and disseminated directly. See page 1 for abbreviations.



Through this dissemination, 225 included survey responses have been received as of 15 February 2023.

Figure 5 shows responses over time. See Section II.E for a discussion of survey respondents.

Figure 5 Survey responses over time



Lessons learned from the survey dissemination include:

- Email invitations are often overlooked or ignored. Periodic reminders can elicit additional responses.
- Invitations shared by trusted sources can garner many responses. For example, the survey invitation was discussed and shared with participants at an immunization meeting in the Eastern Mediterranean region. As a result, responses have been received from 71% of the countries in the region, including high, middle and low-income countries. A PDVAC member shared the link to the Chinese-language survey within his network. Since then, 37 responses have been received from China, the most for any single country.
- While making the surveys available in multiple languages helped to promote diverse responses, disseminating links for each of the 20 surveys created many opportunities for error. Incorrect links were shared occasionally by dissemination partners and by the project team, leading to some confusion. In the future, a web page that allows the respondent to enter their country of work and select from among the available languages, and then redirects them to the correct survey would be a more robust, user-friendly approach.
- The Bitly links were useful when the surveys were initially launched since they provided confirmation that the surveys were disseminated in every region. However, Bitly links are blocked in China and may also be blocked by some institutions. In addition, Bitly data become progressively more uninterpretable over time due to clicks from search engines. For these reasons, using Bitly links is not recommended for future surveys.

D. Survey responses

Results were exported from the survey tool and compiled and analyzed in Excel. These datasets included 3 types of responses.

- **Started responses**. The respondent started but did not finish the survey. Many of these respondents returned later and completed the survey.
- **Complete, excluded responses**. Four surveys were complete but excluded by the survey tool because the respondent clicked a single option repeatedly. In addition, 3 responses were manually excluded because the respondents later completed the survey a second time.
- **Complete, included responses**. These responses were used for the data analysis described in this report.

As shown in Table 3, 57% of respondents completed the survey. Non-completion could be due to the time required to complete the survey (30 to 45 minutes), the cognitive burden of the survey, the degree of commitment of the survey takers, or a combination of those factors.

Table 3 Survey respondents

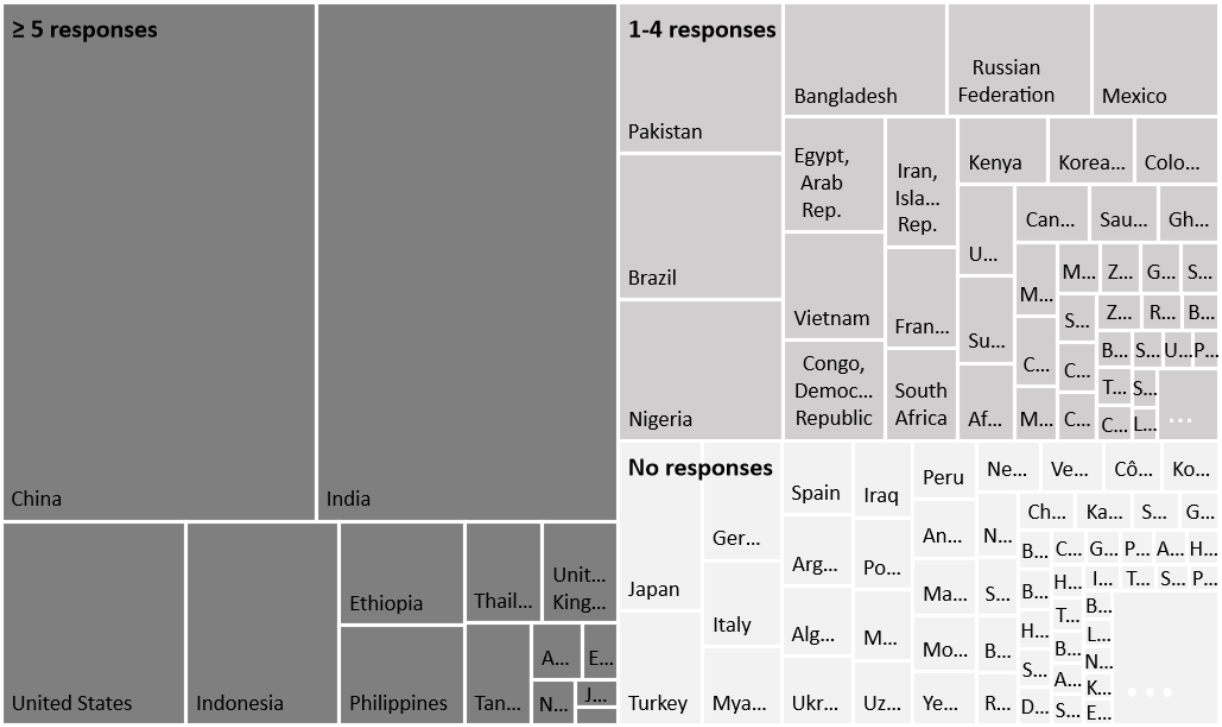
Surveys	Total respondents	Complete, included	% included
African	99	50	51%
Americas	33	25	76%
E. Mediterranean	64	38	59%
European	35	22	63%
South-East Asian	56	30	54%
Western Pacific	119	60	50%
Global	57	41	72%
Total	**463**	**266**	**57%**

E. Respondents

As of 15 February 2023, 225 respondents in 75 countries have completed the regional surveys. These countries comprise 39% of WHO member states and 81% of the global population. As shown in Figure 6, 14 countries have 5 or more responses. For more detailed data, see Annex B: Responses per region and country.

Figure 6 Responses per country, scaled by population

Of the world's population, 51% lives in countries with 5 or more responses and 30% lives in countries with 1 to 4 responses.



Each survey asks respondents for self-reported biographical information. Answers to these questions are summarized in Table 4. While there was variation among regions, overall there was strong representation by individuals in academic institutions and working in government. Many respondents had expertise in disease epidemiology or vaccine research and development. These data will inform further survey dissemination and analysis of results.

Table 4 Biographical information for respondents

Variation among regions, with many responses from academics, government staff, disease epidemiologists and vaccine R&D experts. Respondents could pick multiple organization types and areas of expertise.

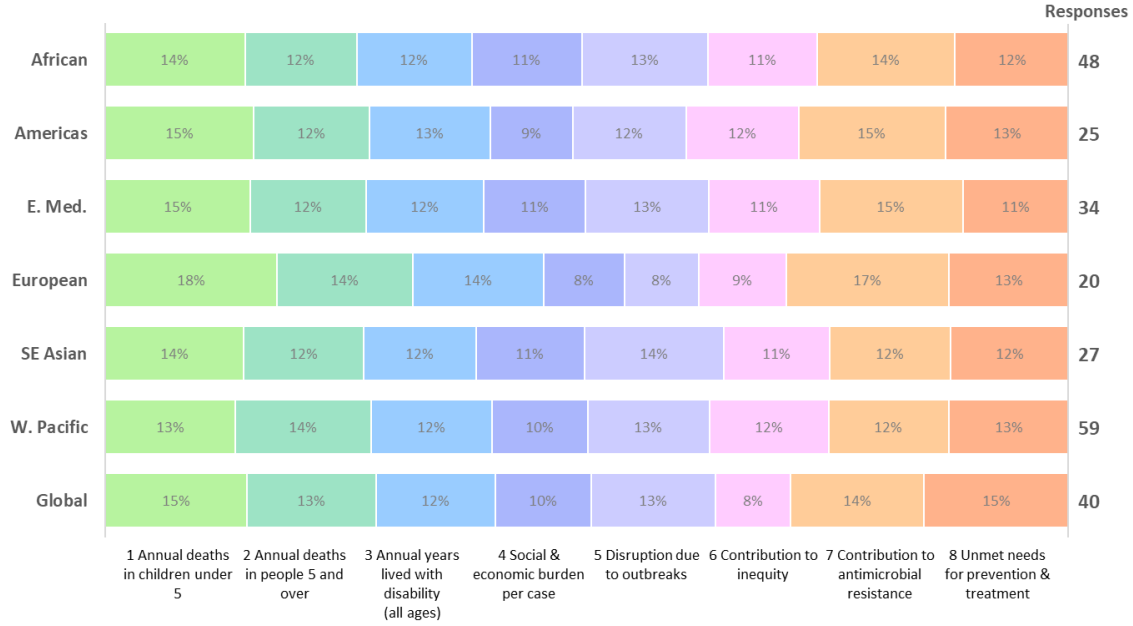
Organization type	**African**	**Americas**	**E. Med.**	**European**	**SE Asian**	**W. Pacific**	**Global**	**Total**
Academic institution	14	13	9	7	12	27	6	**88**
Funding agency	1	0	1	2	0	4	3	**11**
Government	18	6	14	11	15	10	4	**78**
Healthcare provider	7	8	7	4	2	10	1	**39**
Non-governmental organisation	6	1	7	0	3	7	12	**36**
Pharmaceutical industry	0	4	2	3	0	13	12	**34**
Regulatory agency	5	1	2	0	1	2	1	**12**
United Nations agency	12	1	7	2	2	3	5	**32**
Other organisation	3	1	1	0	3	2	2	**12**
Expertise								
Disease epidemiology	29	17	23	11	15	28	13	**136**
Economics and health financing	4	3	4	0	3	2	4	**20**
Healthcare	19	15	20	7	9	14	6	**90**
Health policy	18	8	14	10	9	12	10	**81**
Regulatory affairs	4	1	2	1	2	6	3	**19**
Vaccine R&D	17	14	11	17	15	31	29	**134**
Other expertise	10	3	4	3	1	7	6	**34**
Experience								
Up to 10 years	5	3	3	2	4	6	9	**32**
11 - 20 years	27	8	14	5	10	17	11	**92**
21 - 30 years	9	7	12	7	7	18	8	**68**
More than 30 years	9	7	9	8	9	19	13	**74**

F. Criteria weights

Each survey response includes the "weight" of each of the 8 criteria for prioritization. These weights reflect the relative importance of each criterion to each individual respondent and are computed from the choices made by the respondent throughout the survey. Individual criteria weights were averaged to give regional criteria weights. As shown in Figure 7, most criteria have similar average weights, and no criterion clearly dominates priority setting in any region.

Figure 7 Regional criteria weights

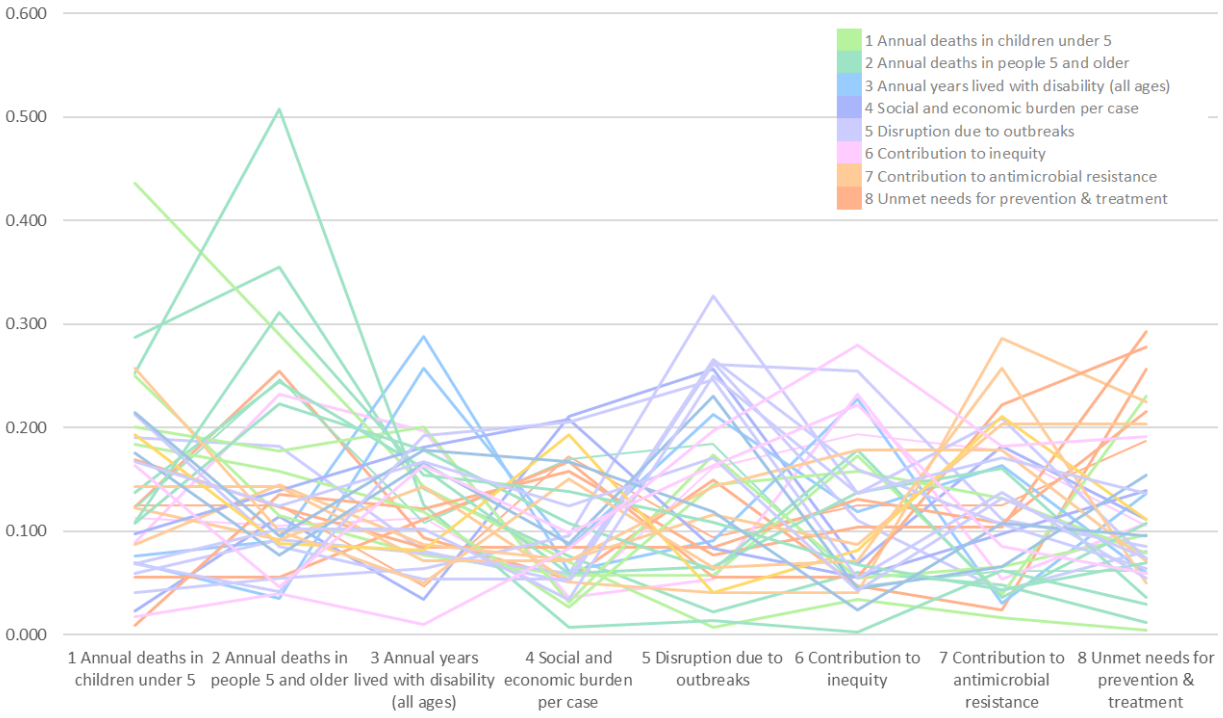
Most criteria have similar weights, no criterion clearly dominates priority setting in any region.



Individual responses are highly diverse within countries and regions, as shown in Figure 8 and in Annex C: Individual criteria weights. Cluster analysis will be conducted on these data to discern patterns based on the respondents' biographical information and their country of work.

Figure 8 Individual criteria weights from a single country

Criteria weights shown for 37 individual responses from a single country. Lines are color-coded according to the most heavily weighted criterion for each person.



G. Pathogen ranks

Combining regional criteria weights and pathogen scores gives a total weight for each pathogen in each region, which are used to generate a ranked list of pathogens for each region. Figure 9 summarizes these ranks. Complete lists are given in Annex E: Pathogen ranks and calculation method.

Mycobacterium tuberculosis (TB), Human immunodeficiency virus 1 (HIV-1), *Staphylococcus aureus*, and *Klebsiella pneumoniae* are among the top 5 pathogens in all regions. *Plasmodium falciparum*, Extra-intestinal pathogenic *Escherichia coli* (ExPEC), *Streptococcus pyogenes* (Group A streptococcus, or GAS), and Leishmania are among the top 5 pathogens in a subset of regions. While high in priority, vaccines for some of these pathogens present important technical challenges. For example, several HIV-1 and *S. aureus* candidates have failed, and development of vaccines may not be the optimal preventive measure or control intervention.

The middle ranks show diversity across regions, driven by differences in pathogen scores and average criteria weights. Generally speaking, the lowest-ranked pathogens include Hookworm, *Salmonella* Paratyphi, and Schistosomes, however the rankings for these also differed by region.

These rankings are an interim step in identifying regional priorities. Regional consultations on the rankings are now in the planning stages and will be described in future updates to PDVAC and SAGE. Further analysis, including incorporating strategic considerations such as the probability of technical and regulatory success, will be driven by the decision-making needs of regional stakeholders.

Figure 9 Rank distribution

Pathogens are listed in order of average rank among the 6 WHO regions. The columns of numbers summarize the pathogen ranks. For example, TB was ranked first in 3 regions, second in 2 regions, and fourth in 1 region. Shading shows higher values and boxed cells show the ranks from the Global survey. Ranks are based on survey results as of 15 February 2023. Results are likely to evolve as additional data are collected and because scores for C. trachomatis and Hepatitis C virus are under review.

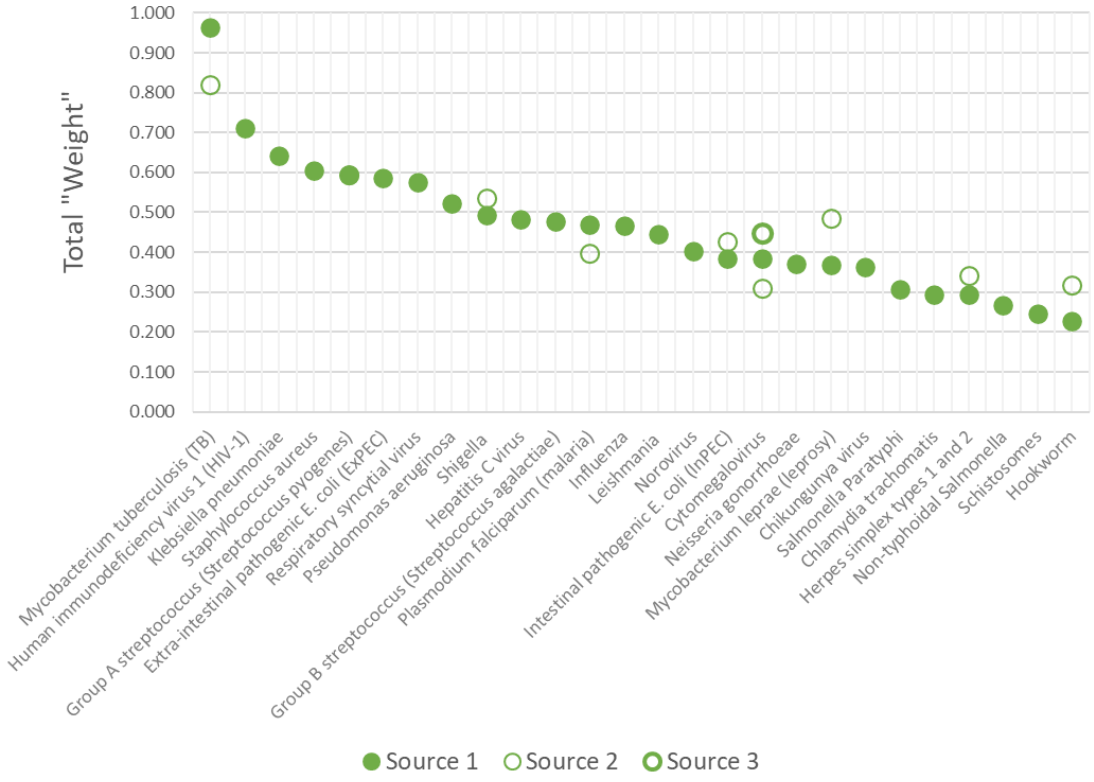
Pathogen	Number of regions with each rank																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Mycobacterium tuberculosis (TB)	3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Human immunodeficiency virus 1 (HIV-1)	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylococcus aureus	1	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	0	0	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Extra-intestinal pathogenic E. coli (ExPEC)	0	0	0	1	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudomonas aeruginosa	0	0	0	0	0	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Group A streptococcus (Streptococcus pyogenes)	0	0	0	1	1	0	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Respiratory syncytial virus	0	0	0	0	0	1	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shigella	0	0	0	0	0	1	1	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hepatitis C virus	0	0	0	0	0	0	0	1	0	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Influenza	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0
Group B streptococcus (Streptococcus agalactiae)	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0
Cytomegalovirus	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0
Plasmodium falciparum (malaria)	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0
Norovirus	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	1	0	0	1	0	0	0	0	0	0	0
Leishmania	0	0	0	0	1	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	1	1	0	0	0
Intestinal pathogenic E. coli (InPEC)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	2	0	1	0	0	0	0	0	0	0	0
Neisseria gonorrhoeae	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1	1	0	0	0	0	0	0	0
Mycobacterium leprae (leprosy)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	1	1	0	0	0	0	0
Non-typhoidal Salmonella	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	1	0	0
Chlamydia trachomatis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	2	0	0	0
Chikungunya virus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	2	0	0
Herpes simplex types 1 and 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	1	0	0	1
Schistosomes	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	2	1
Salmonella Paratyphi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2
Hookworm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2

H. Priority weights and sensitivity testing

Example results are given in Figure 10, which shows the total weights for each pathogen in the South-East Asian region. (All regions are shown in Annex E: Pathogen ranks and calculation method.)

Figure 10 Pathogen ranks: South-East Asian Region (N=27)

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-ranked pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.



In these figures, "Source 1" results reflect the pathogen scores used in the Preferences Surveys. These scores were proposed based on data from GBD 2019 and literature searches as described in the *MCDA Survey Preparation and Launch* report.

"Source 2" and "Source 3" refer to results from additional datasets used for sensitivity testing. These datasets are described in Annex D: Sensitivity testing datasets. Briefly,

- For 4 pathogens, Cytomegalovirus, Herpes simplex virus Types 1 and 2, Hookworm, and *Mycobacterium leprae* (leprosy), GBD 2019 did not include all of the data needed for scoring. These pathogens were scored based on expert opinion and a range of scores was used in sensitivity testing to understand the potential range of outcomes. For these pathogens, "Source 2" and "Source 3" show the range of results.

- For 4 pathogens, Group A streptococcus, Intestinal pathogenic *E. coli* (InPEC), *M. tuberculosis*, and *Shigella*, additional datasets suggested by pathogen experts were used for sensitivity testing. These results are shown as "Source 2" in the figures.
- For *P. falciparum*, global and region-specific data for deaths and YLDs attributable specifically to *P. falciparum* were not found. As discussed in Annex D: Sensitivity testing datasets, for each region, the maximum and minimum potential burden were estimated based on data for malaria and the % of *Plasmodium vivax* found in each region. Results from minimum potential score is shown as "Source 2" for the South-East Asian region. In other regions, both estimates gave the same result.

All pathogen scores and sensitivity datasets were reviewed by multiple disease and regional experts.

As shown in Figure 10 and Annex E: Pathogen ranks and calculation method, many pathogens are similar in total weight. The datasets used for sensitivity testing shifted priority weights but did not change outcomes for the top-ranked pathogens.

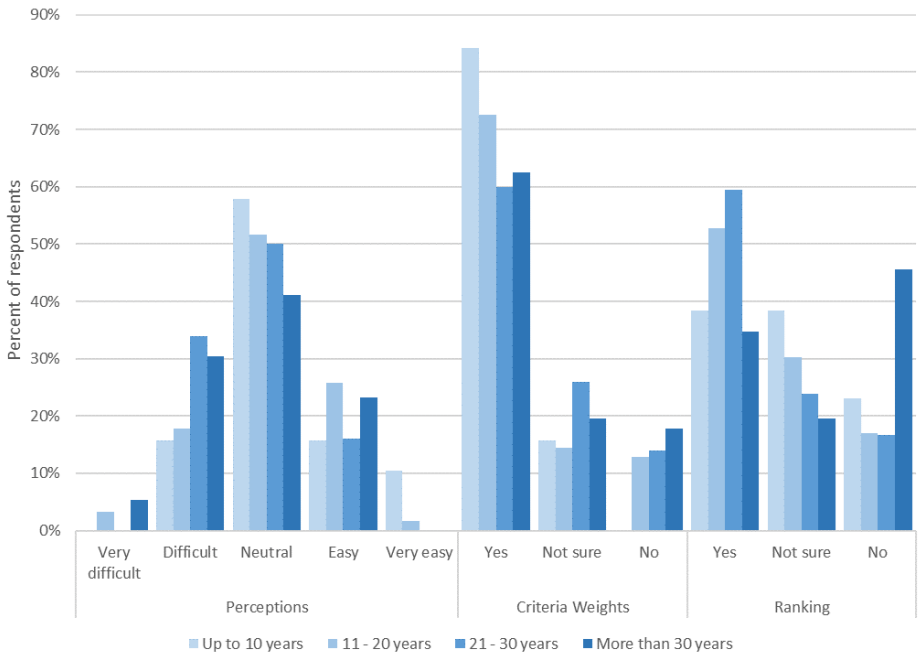
I. Respondent feedback

After seeing their survey results, respondents answered additional questions that assessed face validity:

1. **Perceptions**: Was the survey easy or difficult to understand?
2. **Criteria Weights**: Does the order of criteria in the bar chart seem correct to you?
3. **Ranking**: Does the order of pathogens listed seem reasonable to you? (Ranks were not included in the Global survey)
4. **Open-ended (optional):**
    1. In your results, what was surprising? What was as expected?
    2. Do you have any suggestions you would like to share?

Figure 11 shows the multiple-choice responses. Of respondents, 45% thought that the survey was neither difficult or easy, 71% agreed with the order of the criteria, and 55% agreed with their pathogen ranks. Respondents with the longest experience disagreed most with their pathogen ranks.

Figure 11 Feedback by years of experience (N=266)

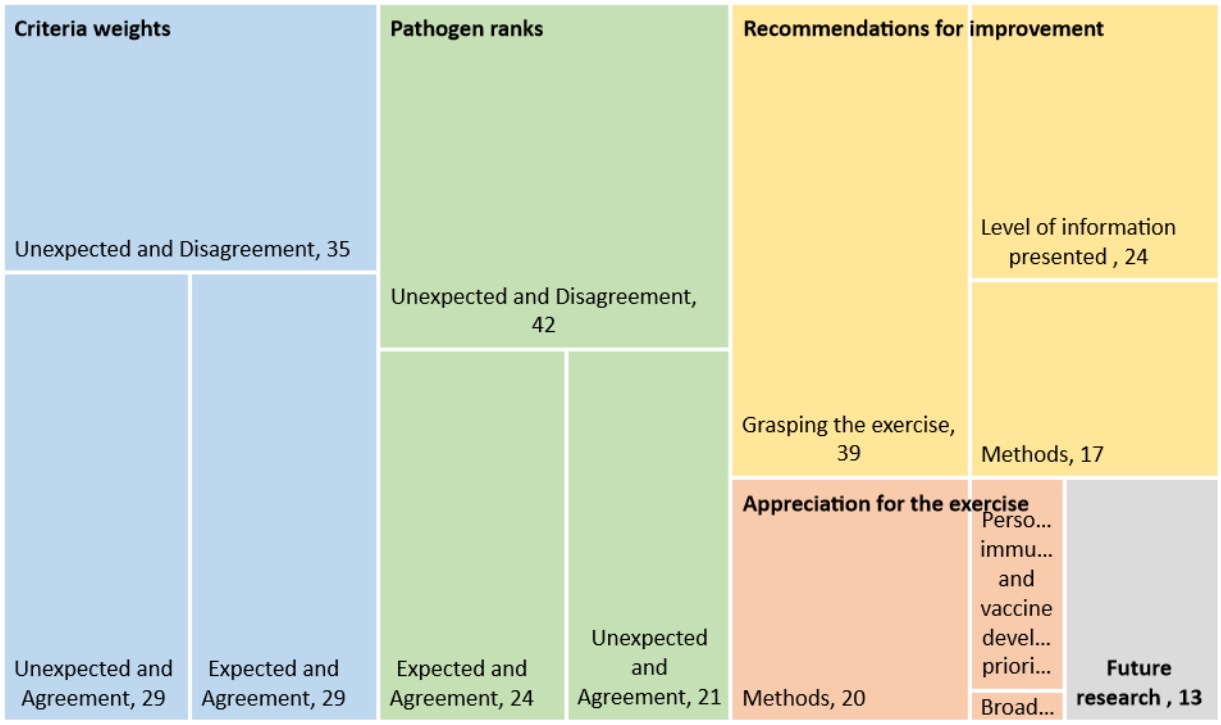


Out of 158 regional respondents who agreed with their criteria weights, 28 (18%) disagreed with the pathogen rankings derived from those weights. This could be due to differences between their perspectives on specific pathogens and the results of the systematic scoring process.

In total, 180 (68%) of respondents made free text comments. A thematic analysis was conducted to understand these comments and to synthesize feedback on the survey method. As shown in Figure 12, the comments fell into 5 major themes: *Criteria weights*, *Pathogen ranks*, *Recommendations for improvement*, *Appreciation for the exercise*, and *Future research*. (Annex F: Thematic analysis gives a more detailed discussion of these themes.)

Figure 12 Thematic analysis of free text responses (N=180)

Large rectangles correspond to themes, smaller rectangles within show sub-themes. The size of rectangles corresponds to the number of comments from survey respondents.



Two themes, *Criteria weights* and *Pathogen ranks*, had sub-themes of "*Unexpected and agreement*". In these, respondents expressed surprise at their results but agreed with them, suggesting that they gained insight by completing the surveys. For example, respondents commented,

> *In the abstract I thought I would think the AMR (anti-microbial resistance) contribution would be important, but when I had to weigh it up against everything else, I became aware, it was always my lowest priority.* (ID: 206720, Singapore, Academic institution)
>
> *Prior to completing the survey, I had ranked the eight criteria. Comparing my ranking pre-survey with the results of the survey, I noticed the following: 1) my number one priority remained the same: annual deaths in children under 5 and 2) disruption due to outbreaks remained the penultimate criterion. The ranking of the other criteria did not match at all. Looking at the results of the survey, I think, despite not matching my pre-survey ranking, the weight presented*

above might represent better my true beliefs regarding immunization and vaccine development. (ID: 206543, Switzerland, UN Agency)

Some comments on the survey method were strongly positive. For example,

> *I was somewhat surprised that the survey questions captured so accurately our current portfolio prioritization. Although we use similar criteria in prioritizing pathogens for vaccine development, we had not looked at trade-offs in the way in which they were asked in the survey.* (ID: 212705, US, Pharmaceutical company)

Other respondents commented that the choices were difficult to make, did not reflect real-world complexities, or were sensitive to how the criteria and levels are defined and interpreted. For example,

> *Excellent attempt to quantify trade-offs. But there are always more than 2 variables in play and the interaction with the third and fourth dimensions often are significant in decision making. But you seem to have concluded quite accurately that my personal prioritization is mortality in children trumps the others. However between the next three on the list, socioeconomic burden, equity, unmet need for prevention, the way questions were phrased could have altered their ranking a bit.* (ID: 212688, India, Academic institution)

Finally, 42 comments (23%) noted differences between the respondent's personal vaccine development priorities and their survey results.

> *I would expect Tuberculosis at the top and Salmonella paratyphi to be higher - above M leprae.* (ID:211609, South Africa, Healthcare organization)
>
> *Tuberculosis was as expected. I would have liked to see group A strep, HIV, RSV and influenza given more priority.* (ID: 207164, Lebanon, Academic institution)
>
> *I think Group A Streptococcus would come above staphylococcus and Malaria would come above hookworm.* (ID: 206706, Papua New Guinea, Academic institution)

J. Discussion

Taking stock of progress to date, the most significant challenge has been **connecting and engaging with regional and country stakeholders. However, once contact is made there is generally interest and support for this initiative, with strong collaboration**. Going forward, it is intended that regional stakeholders will partner to disseminate the surveys and prepare for their consultations. We will continue to explore additional ways to expand and deepen representation and engagement within all regions.

Strengths of the collaborative approach include:

- **Collaborative, systematic, evidence-driven, and transparent**. Guidance from technical experts and regional leaders has been incorporated at every stage to ensure rigor, build collaboration, and create buy-in. Pathogens have been scored systematically, transparently, and based on the best available evidence to reduce the potential for bias and build credibility. The initial scope of

24 pathogens has been expanded to include *Chlamydia trachomatis* and Hepatitis C virus based on the advice of regional experts.

- **Evidence gaps are being identified**. Some pathogens were easily scored on the 8 criteria in all 6 regions. For others, the evidence is less comprehensive. Data gaps identified through this project will inform future research into the burden of these pathogens.
- **MCDA is a powerful tool for minimizing bias and broadening engagement**. The MCDA approach is less subject to bias because it focuses on public health concerns—the criteria—not an individual respondent's experience with specific pathogens. Because of this, their use is not limited to pathogen experts. Thus far, 266 respondents have completed the surveys. Respondents generally agree with their criteria weights and the pathogen rankings. Feedback from respondents indicates that they gained insight by completing the surveys.
- **Existing collaborations are being strengthened, new collaborations are being made.** Active outreach at regional meetings and by well-connected individuals has boosted response rates. Regional stakeholders are eager to partner on consultations. These connections will help to establish a robust approach for engaging with regional and country stakeholders and buy-in to the outcomes.

Regional consultations are now in the planning stages and will be described in future updates to PDVAC and SAGE.

K. Acknowledgments

This project has benefitted from timely and helpful contributions by many stakeholders, including:

- SP7 Working Group Chairs, KP Asante and David Kaslow, for sponsorship and advice.
- PDVAC, for recommendations for the pathogen prioritization approach and effective ways to engage with regions.
- Many stakeholders who have helped to disseminate the survey among their networks, including Sunil Bahl, Paula Barbosa, Moredreck Chibi, Siddhartha Datta, Peter Figueroa, Adam Finn, Jessica Gu, Qamrul Hasan, Louise Henaff, Benido Impouma, Gagandeep Kang, Shaowei Li, Ziad Memish, Chris Morgan, Nicaise Ndembi, Marc Perut, Helen Rees, Daniel Salas, Kamel Senouci, Rajinder Suri, Yoshihiro Takashima, Ole Wichmann, and many others at regional and country levels

The project team consists of:

- WHO Immunization, Vaccines and Biologicals
    - Team lead: Birgitte Giersing
    - Contributors: Mateusz Hasso-Agopsowicz and Erin Sparrow
- Bridges to Development
    - Team lead: Angela Hwang
    - Contributors: Ísis Umbelino, Anastasia Pantelias, Maria Dreher
    - Managing partner: Alan Brooks

III. Annexes

A. *Annex A: Survey invitation* *29*
B. *Annex B: Responses per region and country* *32*
C. *Annex C: Individual criteria weights* *33*
D. *Annex D: Sensitivity testing datasets* *35*
E. *Annex E: Pathogen ranks* *38*
F. *Annex F: Thematic analysis* *47*

A. Annex A: Survey invitation

World Health Organization

20, AVENUE APPIA – CH-1211 GENEVA 27 – SWITZERLAND – TEL CENTRAL +41 22 791 2111 – FAX CENTRAL +41 22 791 3111 – WWW.WHO.INT

Tel. direct:

Fax direct:

E-mail : IA2030-SP7@who.int

In reply please refer to:

Your reference:

22 November 2022

Regional priorities for vaccine development

Dear Colleagues,

This letter serves as a request for assistance in defining regional priorities for vaccine research and development. Under Immunization Agenda 2030, the World Health Organization (WHO) is responsible for assembling a "short list" of pathogens that should be prioritized for new vaccine development.

To aid in identifying these priorities, WHO is conducting a survey to understand what is most important from a regional and country perspective. The survey is meant to capture diverse perspectives and will take 30 - 45 minutes to complete.

As an expert in public health, your perspectives are important to this work. **Please see the table on the next page to access the survey for your region.** If you would like to complete the survey from a global perspective, please go to https://bit.ly/GLOBAL_EN instead.

Additional information about this project may be found at www.technet-21.org/en/topics/regional-and-country-priorities.

Should you have any questions or suggestions, please contact us by email at **IA2030-SP7@who.int**.

Yours sincerely,

Dr Kate O'Brien
Director, Immunization, Vaccines and Biologicals,
Universal Health Coverage and Life Course

Africa Afrique África	English: https://bit.ly/AFRO_EN Français: https://bit.ly/AFRO_FR Português: https://bit.ly/AFRO_PT	Algeria Angola Benin Botswana Burkina Faso Burundi Cabo Verde Cameroon Central African Republic Chad Comoros Congo, Dem. Rep. Congo, Rep. Côte d'Ivoire Equatorial Guinea	Eritrea Eswatini Ethiopia Gabon Gambia, The Ghana Guinea Guinea-Bissau Kenya Lesotho Liberia Madagascar Malawi Mali Mauritania Mauritius Mozambique	Namibia Niger Nigeria Rwanda São Tomé and Principe Senegal Seychelles Sierra Leone South Africa South Sudan Tanzania Togo Uganda Zambia Zimbabwe
Americas Américas Américas	English: https://bit.ly/AMRO_EN Español: https://bit.ly/AMRO_ES Português: https://bit.ly/AMRO_PT	Antigua and Barbuda Argentina Bahamas, The Barbados Belize Bolivia Brazil Canada Chile Colombia Costa Rica Cuba	Dominica Dominican Republic Ecuador El Salvador Grenada Guatemala Guyana Haiti Honduras Jamaica Mexico Nicaragua	Panama Paraguay Peru St. Kitts and Nevis St. Lucia St. Vincent and the Grenadines Suriname Trinidad and Tobago United States Uruguay Venezuela
شرق المتوسط Eastern Mediterranean Méditerranée orientale	العربية ا https://bit.ly/EMRO_AR English: https://bit.ly/EMRO_EN Français: https://bit.ly/EMRO_FR	Afghanistan Bahrain Djibouti Egypt, Arab Rep. Iran, Islamic Rep. Iraq Jordan	Kuwait Lebanon Libya Morocco Oman Pakistan Qatar Saudi Arabia Somalia	Sudan Syrian Arab Republic Tunisia United Arab Emirates Yemen, Rep.
Europe L'Europe Europa Europa Европа	English: https://bit.ly/EURO_EN Français: https://bit.ly/EURO_FR Español: https://bit.ly/EURO_ES Português: https://bit.ly/EURO_PT Русский: https://bit.ly/EURO_RU	Albania Andorra Armenia Austria Azerbaijan Belarus Belgium Bosnia and Herzegovina Bulgaria Croatia Cyprus Czech Republic Denmark Estonia Finland France Georgia Germany	Hungary Iceland Ireland Greece Israel Italy Kazakhstan Kyrgyz Republic Latvia Lithuania Luxembourg Malta Moldova Monaco Montenegro Netherlands North Macedonia Norway	Poland Portugal Romania Russian Federation San Marino Serbia Slovak Republic Slovenia Spain Sweden Switzerland Tajikistan Turkey Turkmenistan Ukraine United Kingdom Uzbekistan

South-East Asia Sudeste Asiático	English: https://bit.ly/SEARO_EN Português: https://bit.ly/SEARO_PT	Bangladesh Bhutan India Indonesia	Korea, Dem. People's Rep. Maldives Myanmar	Nepal Sri Lanka Thailand Timor-Leste
Western Pacific Pacifique occidental 西太平洋地区	English: https://bit.ly/WPRO_EN Français: https://bit.ly/WPRO_FR 中文: https://survey.1000minds.com/16166/WHO_VAC_WPRO_ZH	Australia Brunei Darussalam Cambodia China Cook Islands Fiji Japan Kiribati Korea, Rep.	Lao PDR Malaysia Marshall Islands Micronesia, Fed. Sts. Mongolia Nauru New Zealand Niue Palau	Papua New Guinea Philippines Samoa Singapore Solomon Islands Tonga Tuvalu Vanuatu Vietnam

B. Annex B: Responses per region and country

Table 5 Responses per region and country

Complete, included responses as of 15 February 2023. Surveys remain open and responses will continue to accrue.

African	**50**	**Americas**	**25**	**E. Med.**	**38**	**European**	**22**	**SE Asian**	**30**	**W. Pacific**	**60**	**Global survey**	**41**
Benin	1	Brazil	1	Afghanistan	1	France	1	Bangladesh	2	Australia	11	Argentina	1
Burundi	1	Canada	3	Bahrain	2	Israel	1	India	10	Cambodia	1	Australia	1
Cameroon	1	Colombia	1	Djibouti	1	Netherlands	6	Indonesia	10	China	37	Belgium	1
Chad	2	Cuba	1	Egypt, Arab		Norway	1	Maldives	1	Korea, Rep.	1	China	4
Comoros	1	Ecuador	6	Republic	4	Russian Fed.	2	Thailand	6	Lao PDR	1	France	1
Congo, Dem.		Guatemala	1	Iran, Islamic		Sweden	2	Timor-Leste	1	New Zealand	1	India	1
Rep.	2	Guyana	1	Republic	1	Switzerland	3			Papua New		Indonesia	1
Congo, Rep.	2	Jamaica	1	Jordan	8	United				Guinea	1	Ghana	1
Eritrea	1	Mexico	1	Kuwait	1	Kingdom	6			Philippines	6	Lao PDR	1
Eswatini	1	Suriname	1	Lebanon	7					Vietnam	1	Rwanda	1
Ethiopia	7	United States	8	Oman	2							Sierra Leone	2
Gabon	1			Pakistan	4							Singapore	2
Ghana	2			Saudi Arabia	1							Switzerland	7
Kenya	2			Sudan	1							Tanzania	1
Madagascar	2			Syrian Arab								United	
Malawi	2			Republic	1							Kingdom	6
Mali	1			Tunisia	1							United States	10
Nigeria	2			United Arab									
Rwanda	1			Emirates	3								
Senegal	2												
Seychelles	1												
Sierra Leone	1												
South Africa	3												
Tanzania	7												
Uganda	2												
Zambia	1												
Zimbabwe	1												

C. Annex C: Individual criteria weights

Individual criteria weights are shown in Figure 13 and Figure 14. In these plots, the boxes show the inter-quartile range (IQR) of individual weights for each criterion. The line within each box shows the median value and the "X" shows the average. Whiskers extend to the most extreme data points within 1.5 IQR, and remaining data points are plotted individually.

Within each region, there is substantial overlap between the IQR of the different criteria, suggesting that differences are not likely to be statistically significant. Similar results are found when grouping responses by World Bank income classification, Gavi eligibility, self-reported organization type (Figure 14) or self-reported areas of expertise.

Figure 13 Criteria weights by region

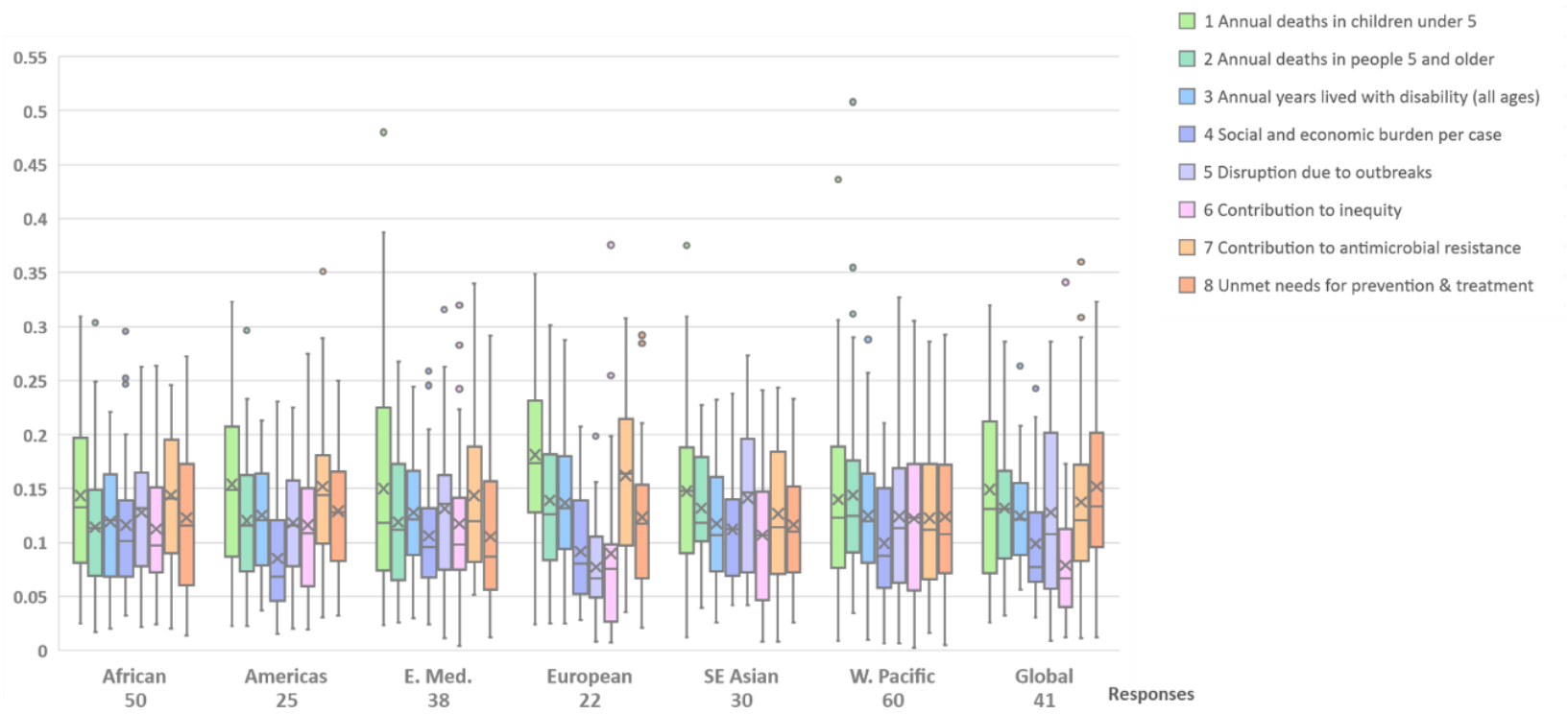
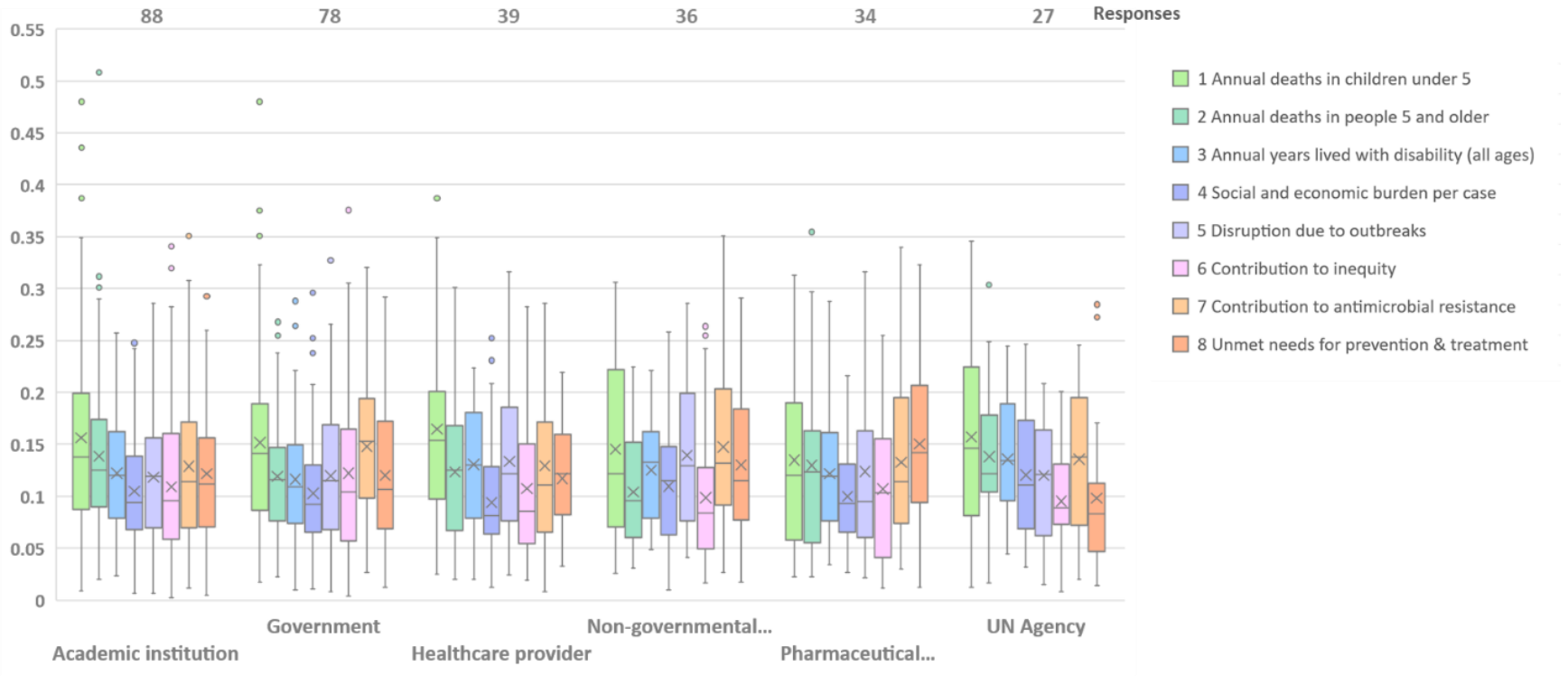


Figure 14 Criteria weights by type of organization

Results are shown for organization types with 20 or more responses. Both regional and global respondents are included.



D. Annex D: Sensitivity testing datasets

Most pathogens were scored for criteria 1 – 3 using data from GBD 2019.[a] For 4 pathogens, GBD 2019 did not include all of the data needed for scoring. These pathogens were scored based on expert opinion and a range of scores was used in sensitivity testing to understand the potential range of outcomes. Table 6 summarizes these cases.

In some cases, additional datasets suggested by pathogen experts were used for sensitivity testing. These datasets are shown in Table 7 and the *MCDA Survey Preparation and Launch* report discusses these datasets in detail.

Table 6 Scores based on expert opinion

Pathogen	Criteria	Source 1	Source 2	Source 3
Cytomegalovirus	2 Annual deaths in people 5 and older	Low	Very low	Medium
	3 Annual years lived with disability (all ages)	Medium	Low	High
Herpes simplex virus Types 1 and 2	2 Annual deaths in people 5 and older	Very low	Low	—
Hookworm	1 Annual deaths in children under 5	Very low	Low	—
	2 Annual deaths in people 5 and older	Very low	Low	—
Mycobacterium leprae (leprosy)	1 Annual deaths in children under 5	Very low	Low	—
	2 Annual deaths in people 5 and older	Very low	Low	—
	3 Annual years lived with disability	Very low	Low	—

[a] https://vizhub.healthdata.org/gbd-results/ and https://ghdx.healthdata.org/record/ihme-data/global-bacterial-antimicrobial-resistance-burden-estimates-2019

Table 7 Alternative datasets suggested by pathogen experts

Pathogen	Criteria	Datasets	Data Sources
Group A Streptococcus	1 Annual deaths in children under 5 2 Annual deaths in people 5 and older 3 Annual years lived with disability	Source 1	Burden calculated as sum of (a) burden for antibiotic resistant and susceptible forms of GAS from GBD 2019 and (b) burden of rheumatic heart disease from GBD 2019.
		Source 2	Burden calculated as sum of (a) burden of invasive GAS (iGAS) estimated using incidence and case fatality rates from a systematic review conducted by the Strep A Vaccine Global Consortium (SAVAC) and population estimates from the GBD project and (b) burden of rheumatic heart disease from GBD 2019.
Intestinal pathogenic *E. coli* (InPEC)	1 Annual deaths in children under 5	Source 1	Global Bacterial Antimicrobial Resistance Burden Estimates 2019.
		Source 2	Anderson JD, et al. Burden of enterotoxigenic Escherichia coli and shigella non-fatal diarrhoeal infections in 79 low-income and lower middle-income countries: a modelling analysis. The Lancet Global Health [Internet]. 2019 Mar 1 [cited 2022 Nov 1];7(3):e321–30. Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(18)30483-2/fulltext.
Mycobacterium tuberculosis	1 Annual deaths in children under 5 2 Annual deaths in people 5 and older	Source 1	WHO Global Tuberculosis Report 2022, Regional distribution of estimated TB mortality in HIV-negative people by age group. (https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022/tb-disease-burden/2-2-tb-mortality, deaths by age group and region obtained from the WHO TB team.)
		Source 2	GBD Results [Internet]. Institute for Health Metrics and Evaluation. [cited 2022 Oct 5]. Available from: https://vizhub.healthdata.org/gbd-results

Pathogen	Criteria	Datasets	Data Sources
Plasmodium falciparum (malaria) Global and region-specific data for deaths and YLDs attributable to *P. falciparum* not found.	1 Annual deaths in children under 5 2 Annual deaths in people 5 and older 3 Annual years lived with disability	Source 1	**Maximum potential score:** Assumes that all malaria deaths or YLDs are caused by *P. falciparum*. Since other malaria species, such as *P. vivax*, contribute to malaria burden, these scores would over-estimate the burden of malaria.
		Source 2	**Minimum potential score:** Scales back the total burden of malaria by the percent of cases that are caused by *P. vivax* in each region (according to World Malaria Report 2021, https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021).
Shigella	1 Annual deaths in children under 5	Source 1	GBD Results [Internet]. Institute for Health Metrics and Evaluation. [cited 2022 Oct 5]. Available from: https://vizhub.healthdata.org/gbd-results
		Source 2	Anderson JD, Bagamian KH, Muhib F, Amaya MP, Laytner LA, Wierzba T, et al. Burden of enterotoxigenic Escherichia coli and shigella non-fatal diarrhoeal infections in 79 low-income and lower middle-income countries: a modelling analysis. The Lancet Global Health [Internet]. 2019 Mar 1 [cited 2022 Nov 1];7(3):e321–30. Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(18)30483-2/fulltext.

E. Annex E: Pathogen ranks and calculation method

Table 8 Pathogen ranks in each region

Ranks are based on survey results as of 15 February 2023. Results are likely to evolve as additional data are collected and because scores for C. trachomatis and Hepatitis C virus are under review. Graphs on following pages show sensitivity testing results.

Rank	African	Americas	E. Med.	European	SE Asian	W. Pacific	Global
1	P. falciparum (malaria)	HIV-1	M. tuberculosis (TB)	Staphylococcus aureus	M. tuberculosis (TB)	M. tuberculosis (TB)	M. tuberculosis (TB)
2	M. tuberculosis (TB)	Staphylococcus aureus	Staphylococcus aureus	M. tuberculosis (TB)	HIV-1	Staphylococcus aureus	HIV-1
3	HIV-1	Klebsiella pneumoniae	Klebsiella pneumoniae	HIV-1	Klebsiella pneumoniae	HIV-1	P. falciparum (malaria)
4	Klebsiella pneumoniae	M. tuberculosis (TB)	HIV-1	Extra-intestinal pathogenic E. coli	Staphylococcus aureus	Group A streptococcus	Staphylococcus aureus
5	Staphylococcus aureus	Extra-intestinal pathogenic E. coli	Leishmania	Klebsiella pneumoniae	Group A streptococcus	Klebsiella pneumoniae	Klebsiella pneumoniae
6	Shigella	Pseudomonas aeruginosa	Extra-intestinal pathogenic E. coli	Pseudomonas aeruginosa	Extra-intestinal pathogenic E. coli	Respiratory syncytial virus	Extra-intestinal pathogenic E. coli
7	Non-typhoidal Salmonella	Group A streptococcus	Shigella	Group A streptococcus	Respiratory syncytial virus	Pseudomonas aeruginosa	Group A streptococcus
8	Pseudomonas aeruginosa	Respiratory syncytial virus	Hepatitis C virus	Respiratory syncytial virus	Pseudomonas aeruginosa	Extra-intestinal pathogenic E. coli	Shigella
9	Extra-intestinal pathogenic E. coli	Shigella	Pseudomonas aeruginosa	Cytomegalovirus	Shigella	Influenza	Pseudomonas aeruginosa
10	Respiratory syncytial virus	Influenza	Group A streptococcus	Hepatitis C virus	Hepatitis C virus	Hepatitis C virus	Respiratory syncytial virus
11	Group B streptococcus	Hepatitis C virus	Norovirus	Shigella	Group B streptococcus	Cytomegalovirus	Non-typhoidal Salmonella
12	Group A streptococcus	Cytomegalovirus	Respiratory syncytial virus	Influenza	P. falciparum (malaria)	Shigella	Hepatitis C virus
13	Leishmania	P. falciparum (malaria)	Intestinal pathogenic E. coli (InPEC)	Norovirus	Influenza	Group B streptococcus	Influenza
14	Schistosomes	Leishmania	Neisseria gonorrhoeae	Neisseria gonorrhoeae	Leishmania	M. leprae (leprosy)	Group B streptococcus
15	Hepatitis C virus	Intestinal pathogenic E. coli (InPEC)	Influenza	Intestinal pathogenic E. coli (InPEC)	Norovirus	Norovirus	Norovirus
16	Norovirus	Group B streptococcus	Group B streptococcus	Group B streptococcus	Intestinal pathogenic E. coli (InPEC)	Intestinal pathogenic E. coli (InPEC)	Leishmania
17	Influenza	Neisseria gonorrhoeae	P. falciparum (malaria)	Chlamydia trachomatis	Cytomegalovirus	Neisseria gonorrhoeae	Intestinal pathogenic E. coli (InPEC)
18	Intestinal pathogenic E. coli (InPEC)	Chikungunya virus	Cytomegalovirus	M. leprae (leprosy)	Neisseria gonorrhoeae	Herpes simplex types 1&2	M. leprae (leprosy)
19	Neisseria gonorrhoeae	Norovirus	M. leprae (leprosy)	Non-typhoidal Salmonella	M. leprae (leprosy)	P. falciparum (malaria)	Cytomegalovirus
20	Cytomegalovirus	M. leprae (leprosy)	Chlamydia trachomatis	Herpes simplex types 1&2	Chikungunya virus	Chlamydia trachomatis	Neisseria gonorrhoeae
21	Herpes simplex types 1&2	Herpes simplex types 1&2	Non-typhoidal Salmonella	Chikungunya virus	Chlamydia trachomatis	Non-typhoidal Salmonella	Chikungunya virus
22	M. leprae (leprosy)	Non-typhoidal Salmonella	Salmonella Paratyphi	Leishmania	Salmonella Paratyphi	Chikungunya virus	Chlamydia trachomatis
23	Chlamydia trachomatis	Chlamydia trachomatis	Schistosomes	Hookworm	Herpes simplex types 1&2	Leishmania	Salmonella Paratyphi
24	Chikungunya virus	Schistosomes	Chikungunya virus	Salmonella Paratyphi	Non-typhoidal Salmonella	Hookworm	Schistosomes
25	Hookworm	Salmonella Paratyphi	Hookworm	P. falciparum (malaria)	Schistosomes	Schistosomes	Herpes simplex types 1&2
26	Salmonella Paratyphi	Hookworm	Herpes simplex types 1 and 2	Schistosomes	Hookworm	Salmonella Paratyphi	Hookworm

In the following figures, “Source 1” results reflect the pathogen scores used in the Preferences Surveys. “Source 2” and “Source 3” results reflect additional datasets used for sensitivity testing. These datasets are described in Annex D: Sensitivity testing datasets. All pathogen scores were reviewed by multiple disease and regional experts.

Figure 15 Pathogen ranks: African region

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-tier pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

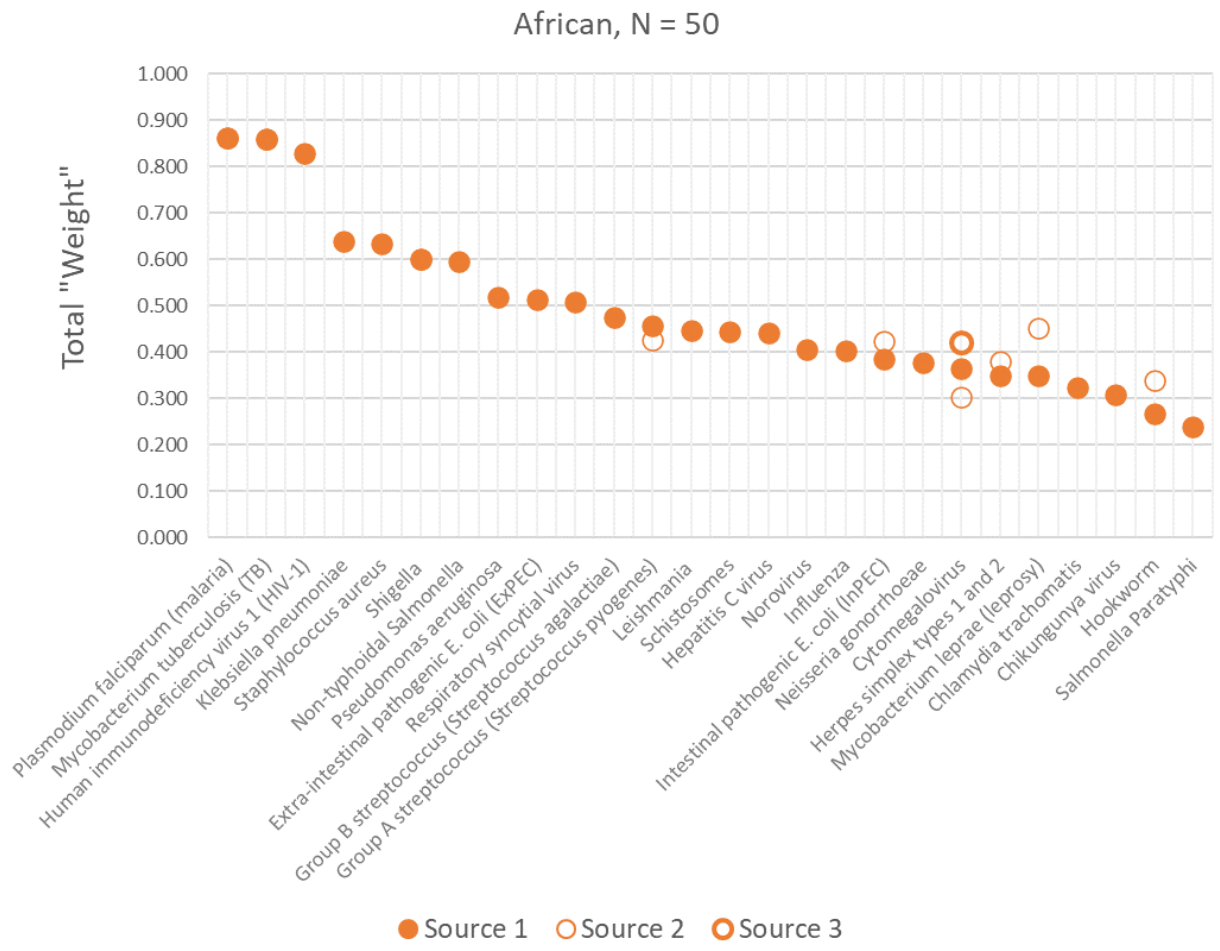


Figure 16 Pathogen ranks: Region of the Americas

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-tier pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

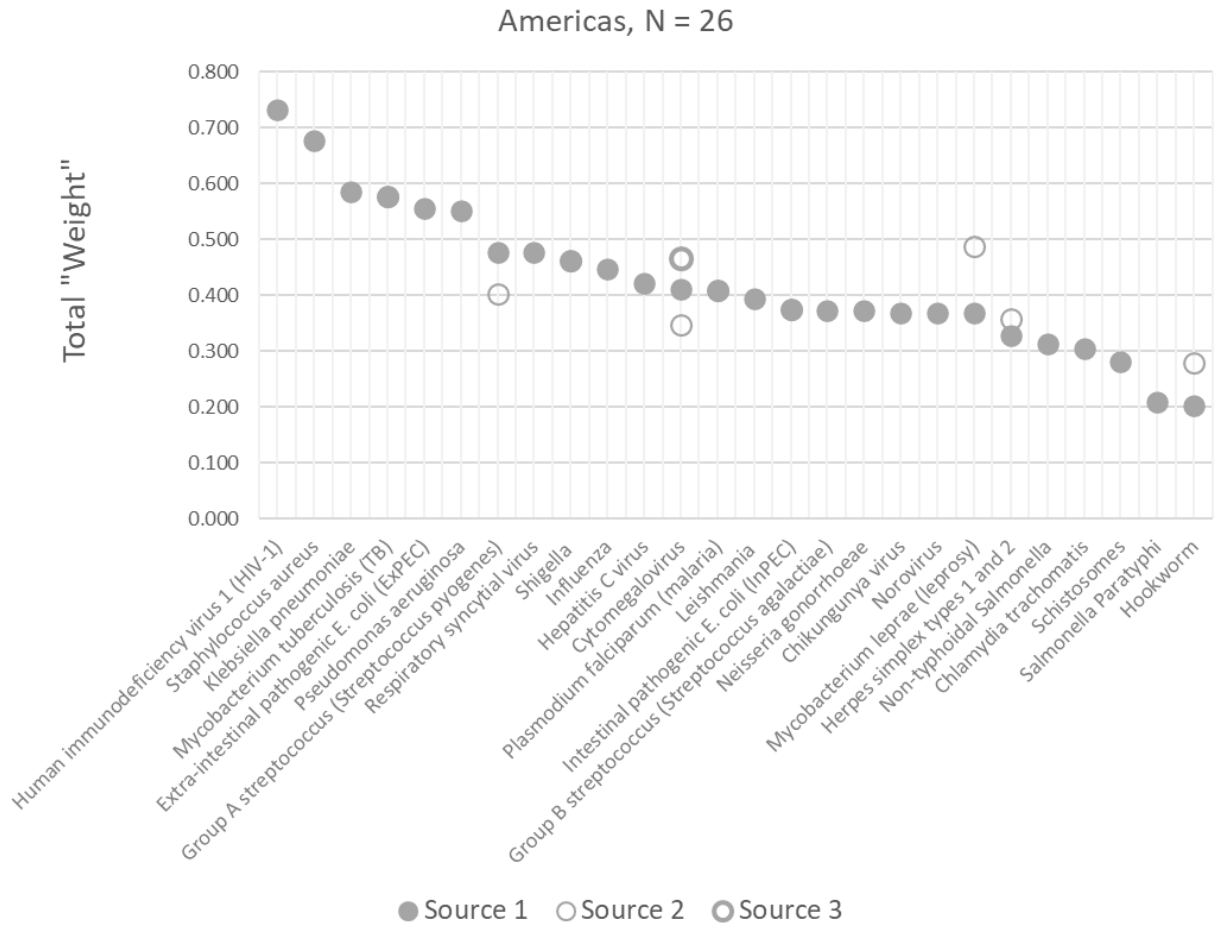


Figure 17 Pathogen ranks: European region

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-tier pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

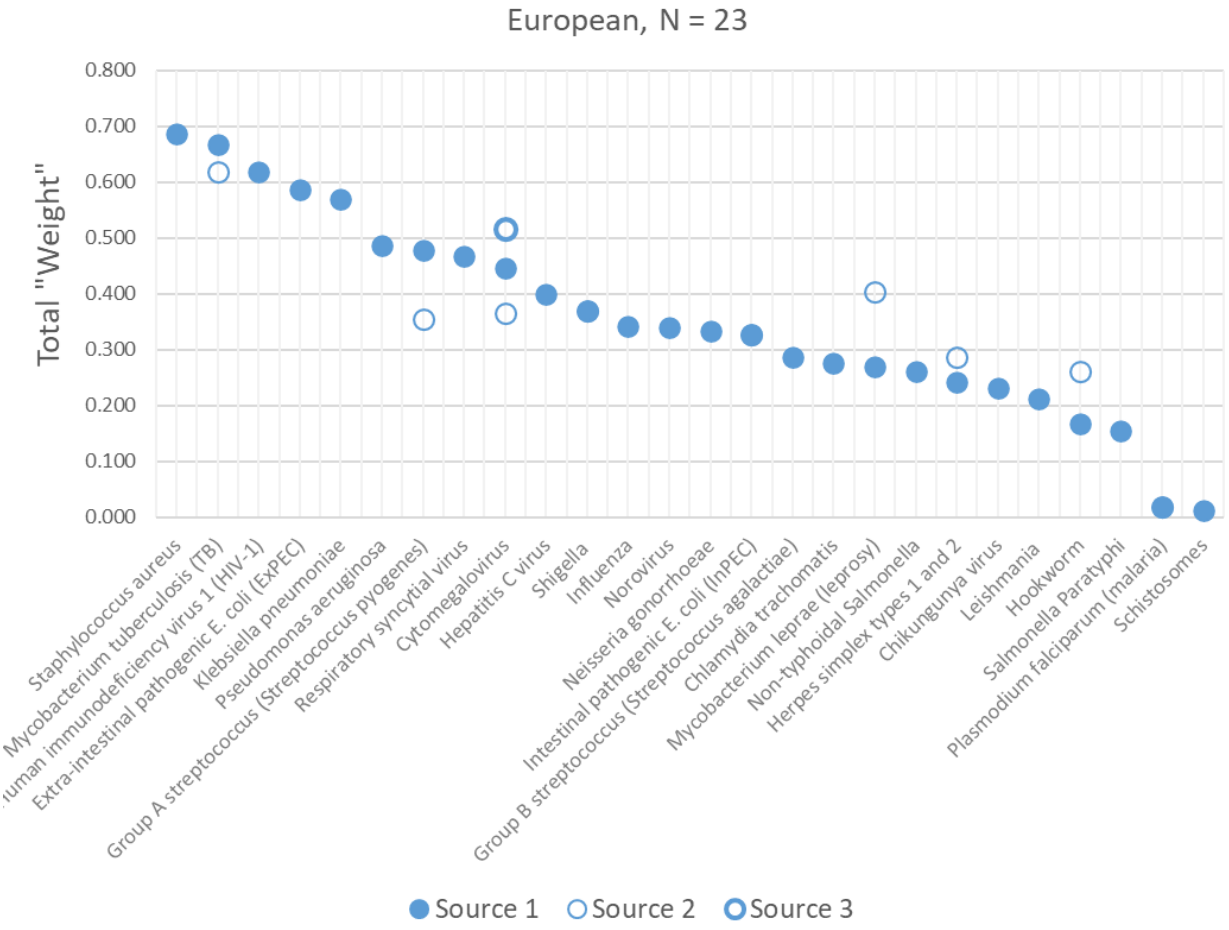


Figure 18 Pathogen ranks: Eastern Mediterranean region

Based on survey responses as of 15 February 2023. Alternative dataset for Shigella would result in a tie with Leishmania for 5th place. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

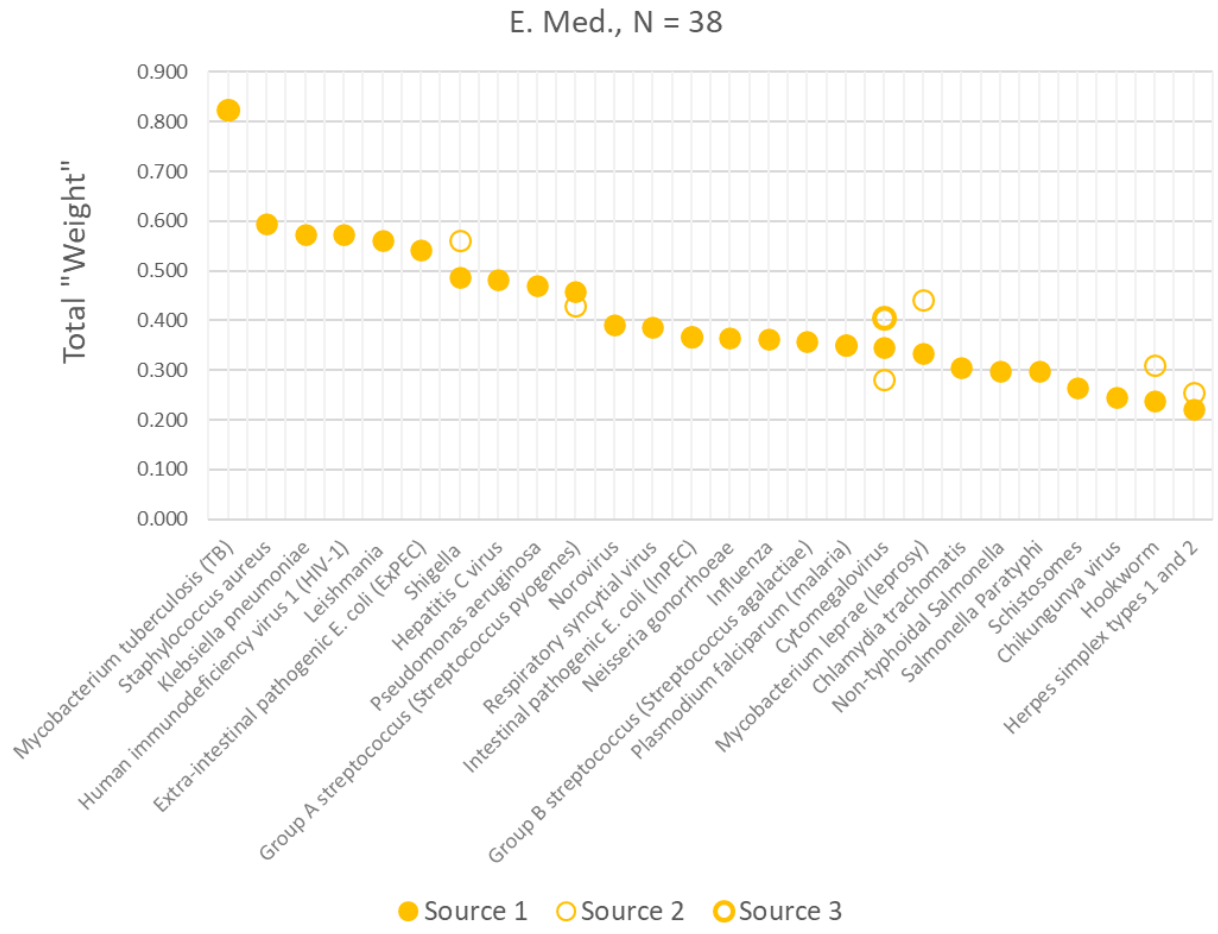


Figure 19 Pathogen ranks: South-East Asian region

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-tier pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

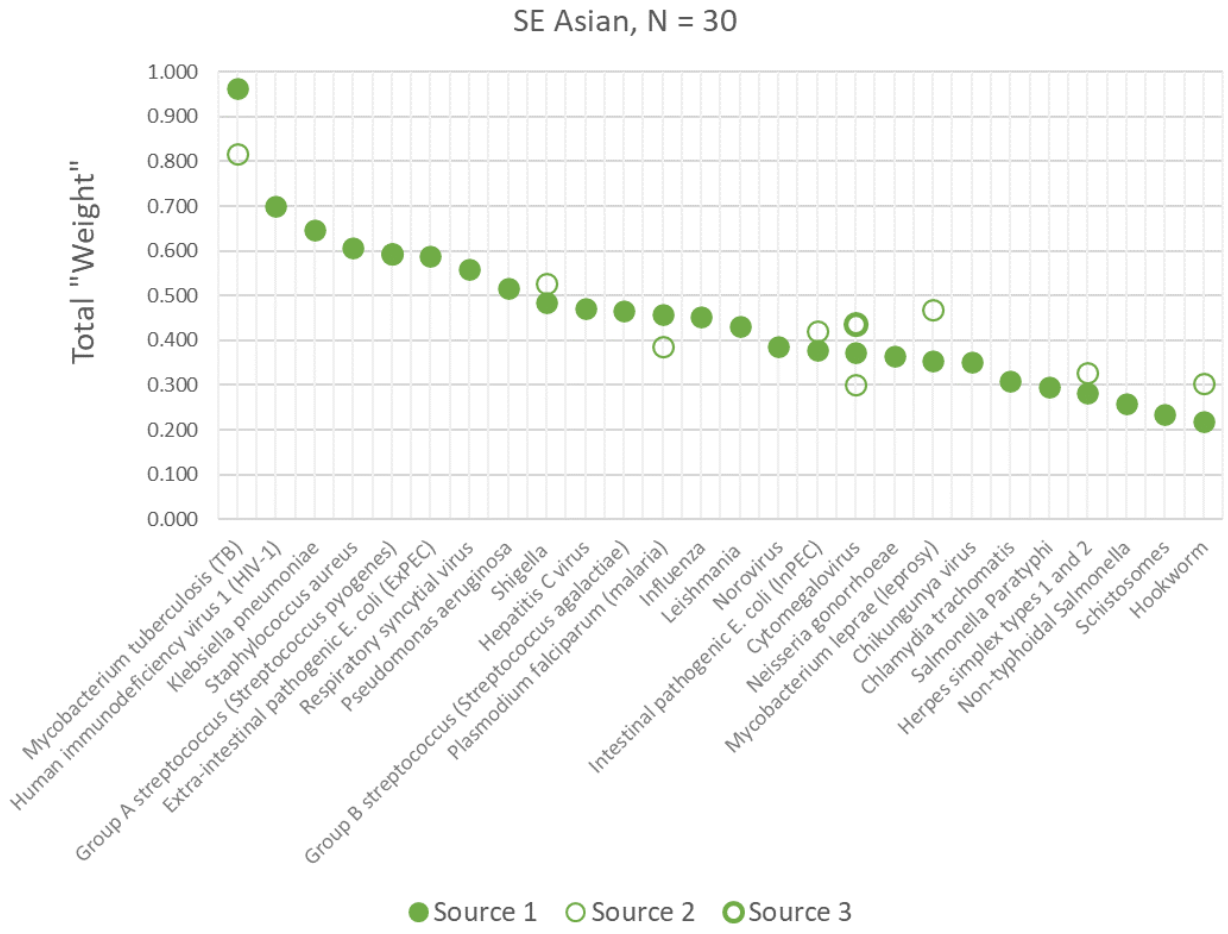


Figure 20 Pathogen ranks: Western Pacific region

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-tier pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

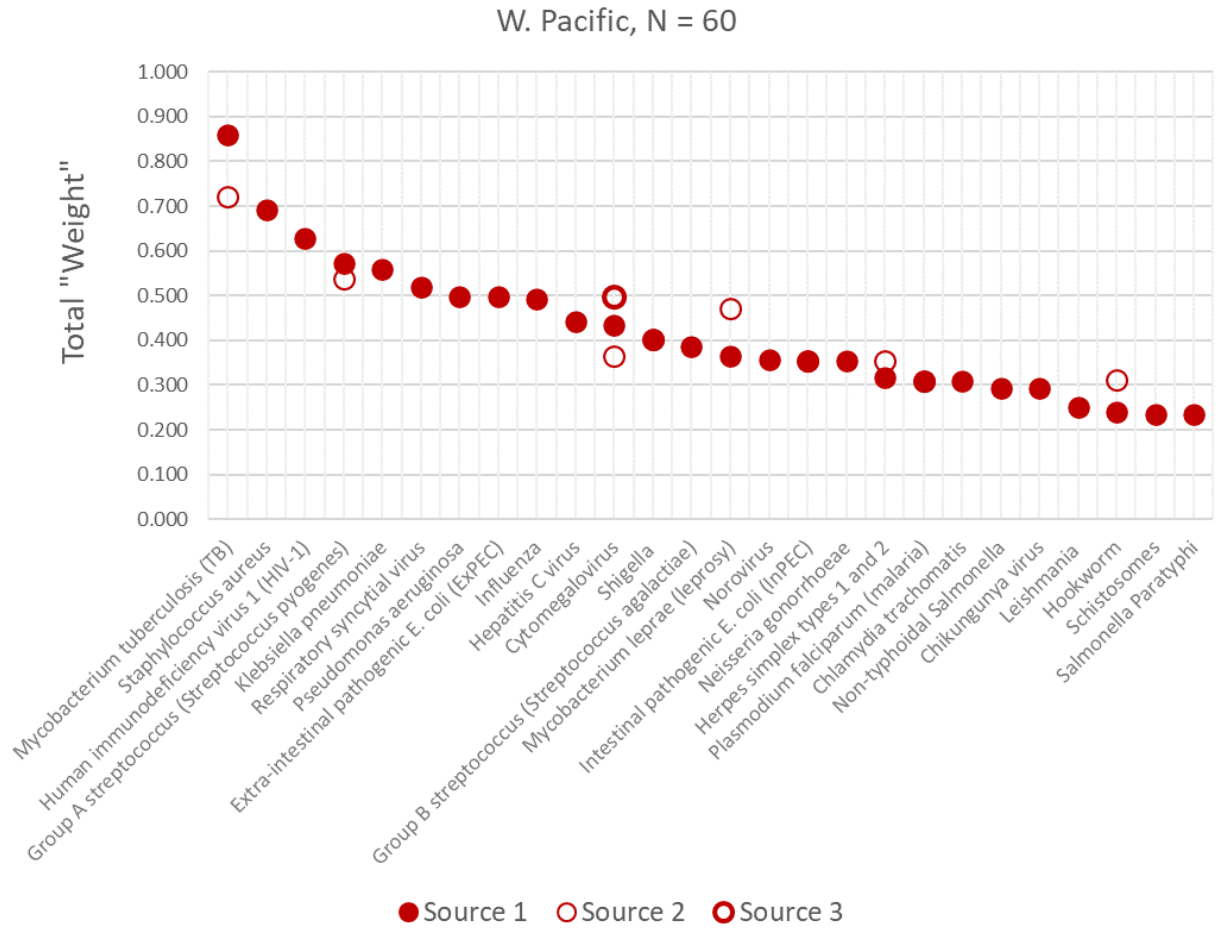


Figure 21 Pathogen ranks: Global survey

Based on survey responses as of 15 February 2023. Sensitivity testing datasets do not change results for top-tier pathogens. Chlamydia trachomatis and Hepatitis C virus scores currently under review.

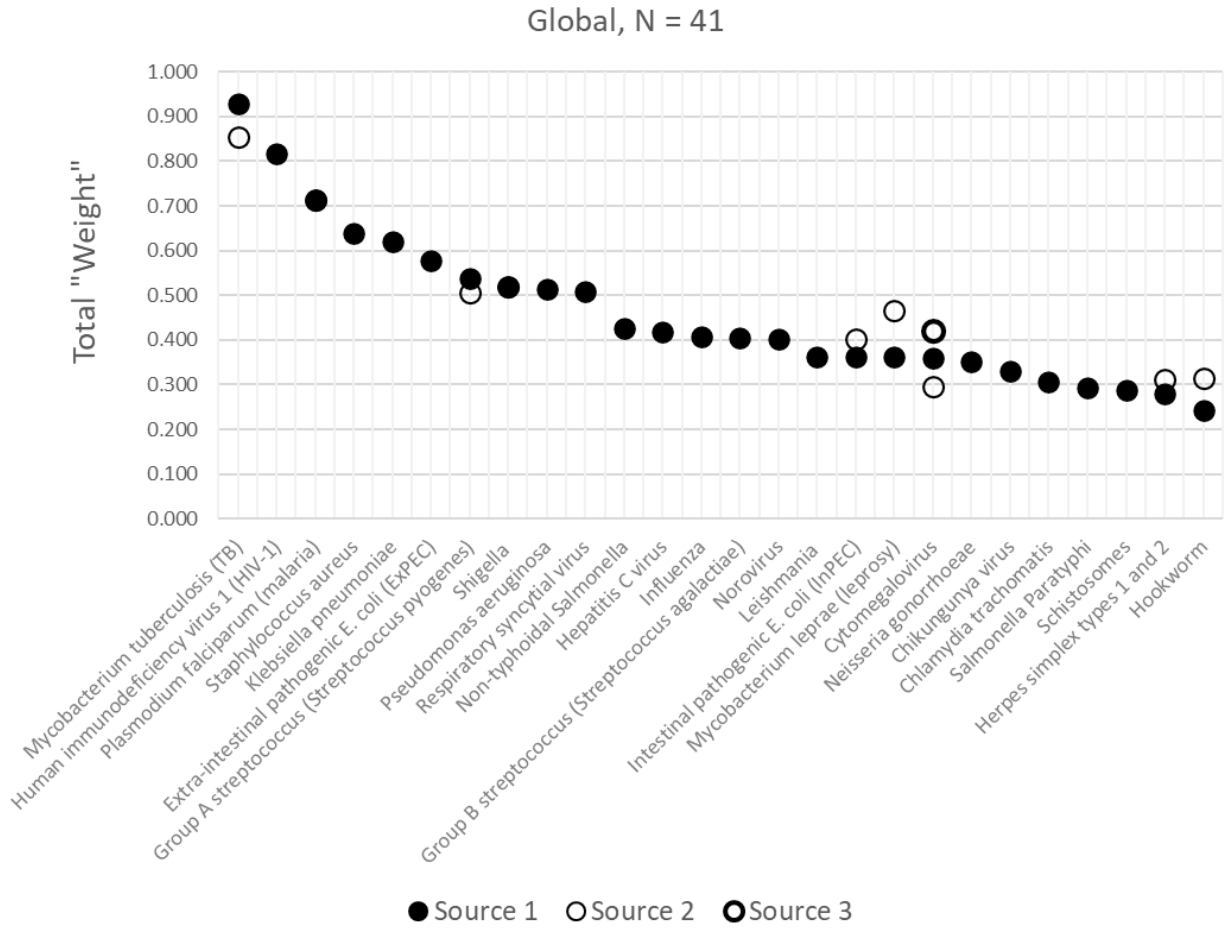


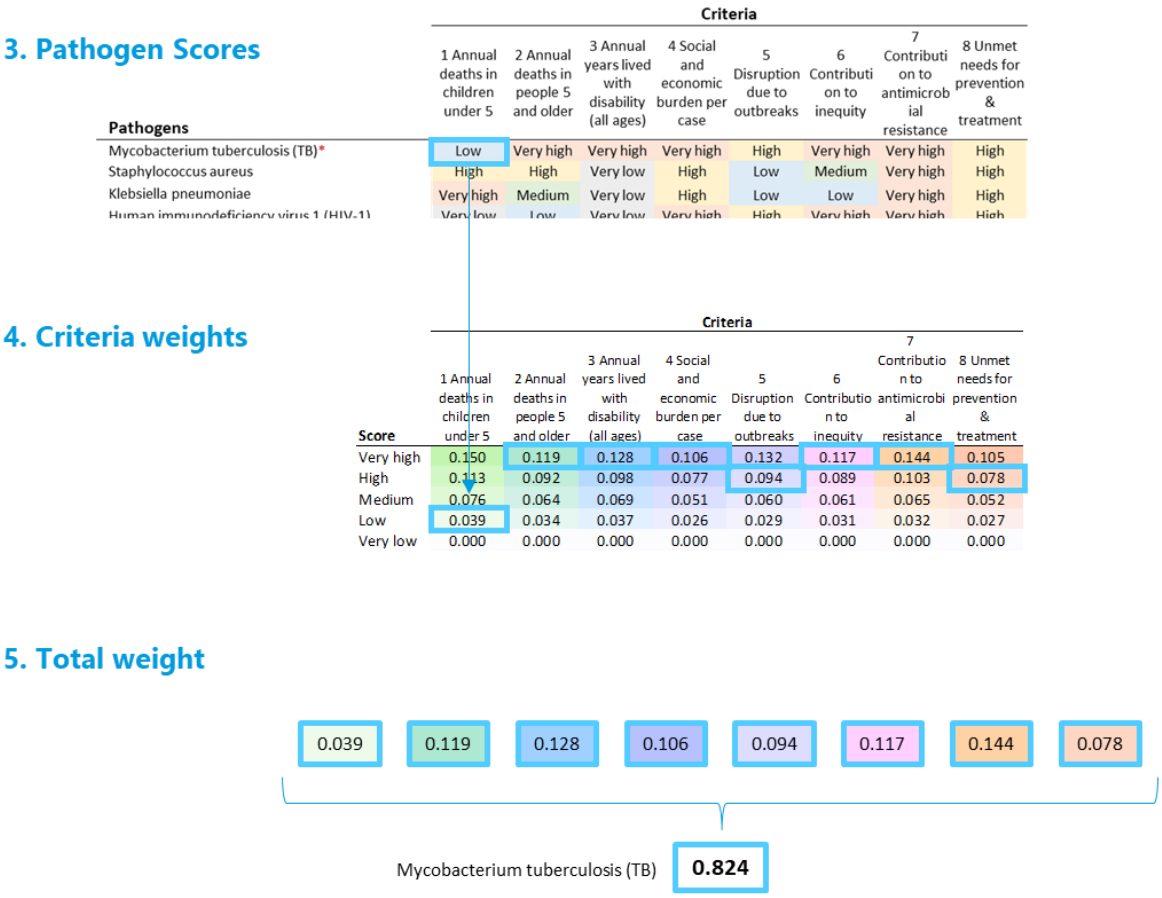
Figure 22 Calculation method

Step numbers refer to Figure 3.

Step 3: *Each pathogen has been scored on each criterion in the regional context.*

Step 4: *In the Preferences Surveys, individual choices reveal the relative weights of all criteria/score combinations. Individual weights are averaged to give criteria weights for all criteria/score combinations for the region.*

Step 5*: Pathogen scores and criteria weights together give the total weight for each pathogen. Total weights are then used to rank the pathogens within the region.*



F. Annex F: Thematic analysis

Ísis Umbelino (Bridges to Development) conducted the thematic analysis. Free-text responses were compiled and as necessary translated to English using Google Translate. Themes were identified through a close reading of the responses, first in a pilot analysis with 35 responses, then through analysis of all 180 responses in the data set as of February 15. Thematic analysis included three steps: reading and exploration, selective coding, and identifying thematic patterns.[a] Results from this analysis are described in Table 9 and summarized in Figure 12. Themes and sub-themes are not mutually exclusive, and some comments addressed multiple themes.

Table 9 Code book: Themes, sub-themes and illustrative quotes

Theme	Sub-theme and definition	Illustrative quotations
A Criteria weights	**Expected and Agreement.** Respondent reports no surprises and agrees with the order of criteria presented as their survey result.	*"The priority of amr and unmet medical needs is in line."* (ID: 206510, Singapore, Pharma)
	Unexpected and Agreement. Respondent reports surprise but agrees with the order of criteria presented as their survey result.	*"In the abstract I thought I would think the AMR contribution would be important, but when I had to weigh it up against everything else, I became aware, it was always my lowest priority. I am a bit surprised that my deaths in children was lower than adults. The contribution to inequity being the highest is consistent with my beliefs."* (ID: 206720, Singapore, Academic Institution)
	Unexpected and Disagreement. Respondent does not agree or agrees partially, and reports doubts related to the order of the criteria presented as their survey result.	*"Equity was expected to be the topmost in vaccine development policy."* (ID: 205625, Tanzania; Government)

[a] Williams M, Moser T. The art of coding and thematic exploration in qualitative research. International Management Review. 2019 Jan 1;15(1):45-55. Available at http://www.imrjournal.org/uploads/1/4/2/8/14286482/imr-v15n1art4.pdf

Theme	Sub-theme and definition	Illustrative quotations
B Pathogen ranks	**Expected and Agreement.** Respondent reports no surprises and agrees with the ranking of pathogens presented as their survey result.	*"The order in which the Vaccine developments should take place is correct."* (ID: 207369, Seychelles, Government and Healthcare)
	Unexpected and Agreement. Respondent reports surprise but agrees with the ranking of pathogens presented as their survey result.	*"In Europe, I would not expect TB to still have a large impact, this must be very concentrated in Eastern Europe."* (ID: 213572, Switzerland, Academic and Healthcare)
	Unexpected and Disagreement. Respondent partially agrees or does not agree, and reports doubts related to the ranking of pathogens presented as their survey result	*"Some seem too high - Expec, Norovirus. I am not sure how to classify organisms that are mostly hospital acquired such as Klebsiella, Pseudomonas. RSV is too low. Hookworm, schisto, leishmania and malaria are important in certain areas, but may not be important in most of the region. I am not sure about leprosy."* (ID: 205471, Australia, Academic Institution)
C Recommendations for improvement	**Methods.** Respondent reports dissatisfaction with the methodology employed.[a]	*"The answers really depend on interpretation of terms like moderate or very high"* (ID: 205471, Australia, Academic Institution)
	Level of information presented. Respondent reports that more information or different types of information is needed to complete the exercise.	*"Some choices are hard as more criteria is needed to decide. Some options seemed repeated."* (ID: 206978, Lebanon, NGO)
	Grasping the exercise. Respondent reports difficulty understanding the exercise.	*"Some of the questions didn't make sense and the death toll was not significantly different (e.g. 1.4 versus 1.8 million. There was no denominator"* (ID: 206273, United Kingdom, NGO)

[a] Multiple respondents commented that some survey questions were repeated. This is the "consistency checking" feature of the PAPRIKA software, which repeats 2 questions at the end of the survey.

Theme	Sub-theme and definition	Illustrative quotations
D Appreciation for the exercise	**Personal immunization and vaccine development priorities.** Respondent comments that the exercise is useful for identifying individual immunization and vaccine development priorities.	*"The exercise is useful for looking at personal priorities."* (ID: 205471, Australia, Academic Institution)
	Broader immunization and vaccine development priorities. Respondent comments that the exercise is useful for identifying broader or global immunization and vaccine development priorities.	*"Overall results represent the current status of potential priorities globally."* (ID: 206510, Singapore, Pharma)
	Methods. Respondent reports satisfaction with the methodology employed.	*"While answering the survey, I kept asking myself, how the comparison pairs were created as it feels like those personality tests where the same question is asked multiple times but phrased slightly differently to measure how strongly one feel about a particular topic. If this survey was developed using this type of methodology, kudos!"* (ID: 206543, Switzerland; UN Agency)
E Future Research	Respondent suggests applying the same methodology to other research topics.	*"It would be interesting to see how current VPDs fall under the different criteria used in this survey."* (ID: 206533, Switzerland, UN Agency)

Respondents suggested including the following pathogens in the survey: Dengue virus, *Acinetobacter baumannii*, *Clostridia difficile*, Hand, foot and mouth disease, coronaviruses, *Streptococcus pneumoniae*, and *Haemophilus influenzae*.