

Article

The formal ability of countries to deliver high-quality vaccination services: Introducing the Country Vaccination Score (CVS)

Heinz-Josef Schmitt^{1,*}, Saidu Y^{2,3}, Hrynkevych K¹, Adam AM⁴, Ankunda C⁵, Barro C⁵, Chacon-Cruz E^{6,7}, Cobanoglu Ö⁵, Costa B⁵, Gutiérrez-Melo N⁵, Kawalazira RC⁵, Khatiwada M⁵, Mahmood S^{1,8}, Mukumbayi PM⁹, Müschenborn-Koglin S¹, Naidu A⁵, Nikdel M⁵, Ribeiro-Moraes J⁵, Saha S⁵, Salloum M⁵, Sanicas MJ¹⁰, Stoma I¹¹, Tan JVG¹², and Sanicas M⁵

¹Global Health Press, Singapore; ²CHAI Cameroon; ³Institute for Global Health, University of Siena, Italy; ⁴Mombasa County Head Research Coordinator; ⁵Vaccinologist; ⁶Department of Pediatric Infectious Diseases, Hospital General de Tijuana, Baja-California, Mexico; ⁷Autonomous University of Baja-California, Mexico; ⁸ShuHaRi Health, Dhaka, Bangladesh; ⁹Department of Pharmacology and Therapeutics, Clinical Pharmacology and Pharmacovigilance Unit, Faculty of Pharmaceutical Sciences, University of Kinshasa, Democratic Republic of Congo; ¹⁰Aix-Marseille Université, Centre de recherche en cancérologie de Marseille, Adhesion and Inflammation Lab, Marseille, France. ¹¹Gomel State Medical University, Gomel, Belarus; ¹²Université Claude Bernard Lyon 1, 69100 Villeurbanne, France. *Corresponding author

All authors participated in this research independent of the institution where they were employed in the past or where they are currently employed. All views expressed are solely the views of each author, and do not represent the opinion of their current or past employers.

Abstract:

Despite the huge benefits of vaccination, vaccine uptake around the globe is surprisingly suboptimal in most places; explanations include vaccine hesitancy and increasingly well-organized anti-vaccine groups. In addition, WHO identified structural gaps in many countries for the delivery of vaccination services, specifically a lack of scientifically sound NITAGs of the highest integrity, as well as a lack of political will and implementation. Here country vaccination systems were evaluated using simple 4x2 managerial criteria (having goals, one plan, implementation, and evaluation), to look into the structural ability of selected countries to deliver appropriate vaccination services, expressed as the Country Vaccination Score (CVS). Based on the availability of expert vaccinologists, each selected country was described (basic demographic, economic, political, health care data) followed by CVS-scoring. All data were centrally reviewed and validated. To date, a total of 42 countries received a CVS, with scores between 1 and 8. Some Low- and Middle-Income Countries (LMICs) scored high, whereas some high income countries scored low. The strengths of the system include the crowdsourcing approach, and scoring based on written documentation followed by a strict central review process. The main weakness may be that “what is on paper may not be what happens in reality”, i.e., overscoring may have happened. The ongoing project may help countries identifying structural gaps in delivering optimal vaccination services and take appropriate actions. Readers are invited to contribute with comments, additional data as well as by evaluating any of the more than 150 countries still missing.

Keywords: Vaccination system; public health; country vaccination score; CVS

Citation:

Schmitt HJ, Saidu Y, Hrynkevych K, et al. The formal ability of countries to deliver high-quality vaccination services: Introducing the Country Vaccination Score (CVS). *Vaccin Review*. 2022;9(1):1-14. doi.10.33442/vr220901.

Academic Editor: Heinz-Josef Schmitt.

Received: August 1, 2022
Accepted: September 2, 2022
Published: September 16, 2022

Publisher's Note: GHP stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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Introduction

Next only to sanitation, vaccines and vaccination are among the most effective public health measures to ensure and maintain the health and wealth of nations (1). Past vaccination successes include smallpox eradication (2), eradication of polioviruses type 2 and 3 globally as well as poliovirus type 1 elimination in most regions of the world ([Poliomyelitis \[polio\] \[who.int\]](#)). Disease elimination, disease eradication, and disease control have been achieved particularly for the “killers of children”, i.e., diphtheria, pertussis, measles, pneumococcal pneumonia, and bacterial meningitis (3, 4). These diseases, however, continue to threaten the life and health of medically underserved children in many regions and may even resurge in high-income countries as a result of vaccination gaps during the COVID-19 pandemic ([UNICEF and WHO warn of perfect storm of conditions for measles outbreaks, affecting children](#); (5)). The manifold benefits of vaccines and vaccination have been summarized (1, 3) and so have the many road blocks preventing universally available vaccination services ((5-7); [History of Anti-Vaccination Movements | History of Vaccines](#)).

The recent and most striking global vaccination successes were to a large part only possible by initiatives and financial support from WHO, UNICEF, GAVI The Vaccine Alliance, and the Bill and Melinda Gates Foundation. The underlying strategies for the future are outlined in the Global Vaccine Action Plan (GVAP) and more specifically in regional Vaccine Action Plans with clear targets and deadlines ([www.who.int/teams/immunization-vaccines-and-biologicals/strategies/global-vaccine-action-plan](#)).

While vaccination successes have been repeatedly mentioned, failures and deficits are less frequently named and analyzed. Among these, wars and armed conflicts, myths seeded by politicians or religious leaders on “deleterious vaccine side effects” (e.g., infertility from polio vaccination; increasing promiscuity due to HPV vaccination), and lack of resources are easily identifiable problems. In addition, vaccine hesitancy has become an ever-increasing global threat for public health (8, 9). It even appears as if increasing vaccination benefits lead to an increase of vaccine hesitancy and resistance.

In high-income countries, the question arises up to which point health care costs may annually rise to pay for easily preventable diseases that are relevant medical cost drivers due to disease, disability, and death (10-12). With increasing proportions of the population ≥ 65 years of age and ever increasing proportions of patients with chronic

underlying diseases (14, 15), frequently served in special institutions with increased exposures to infectious agents, life-course immunization has now been recognized as a prerequisite for an affordable health for all ([CLCI \[cl-ci.org\]](#)(13)). Clearly, for achieving the full benefit of vaccines and vaccination, countries need to have effective vaccination systems in place.

Access to vaccines and vaccination has been well regulated around the globe. To date, almost all countries have written legal modalities for vaccine licensure and the pathways for marketing authorization are clear-cut. Moreover, based on a WHO initiative, also the formal aspects of vaccination recommendations have become standardized as more than 140/195 countries on earth have a WHO-type National Immunization Technical Advisory Group (NITAG) (16-18). On a country level, NITAGs give vaccination and sometimes also vaccine recommendations, which may then be implemented in comprehensive national vaccination programs. These recommendations consider and take advantage of local historical, cultural, political, and financial aspects needed for the success of a vaccination program. While vaccine licenses are granted in an often-global development process to document vaccine safety and efficacy, vaccination recommendations only become available after a review of current scientific medical data (e.g., burden of disease), financial aspects (healthcare budget), cooperation between the many local stakeholders (politics, vaccine manufacturers, logistics, vaccinators, etc.) and expected public acceptance. With this in mind, clearly, vaccination successes and failures are mostly successes and failures in each single country.

A recent international evaluation indicates shortcomings in this process, specifically as there is limited ownership by countries and other stakeholders resulting in incomplete implementation and poor accountability (19, 20). Here a simple, universal management tool is used to evaluate whether countries are formally positioned to provide effective, high-quality vaccination services. The evaluation is based on 4 widely used management criteria to review and manage projects, i.e., availability of goals, a plan, implementation, and evaluation. Summing up the points granted, a “Country Vaccination Score” (CVS) indicates strengths and weaknesses of each national vaccination system.

Materials and Methods

In an ongoing effort, the currently 42 countries presented here were selected based on the availability of

an experienced (>10 years work in the field of vaccinology) and/or trained vaccinologist (masters in vaccinology) with appropriate language and local knowledge. Data presented in this manuscript were re-validated by at least one additional expert. To put the CVS into perspective, demographic, political, geographical, educational, economic and health care data were also collected. The www and specifically the websites of local Ministries of Health (MoH) as well as their respective public health institutes were searched to find out (1) if there are vaccination goals and future vaccination targets; (2) if there is a single and comprehensive vaccination plan and if “pipeline vaccines” are evaluated early on before licensure (horizon scanning); (3) if there are clear responsibilities

and accountabilities to achieve goals and targets and if this is supported by government funded information campaigns; (4) if there is a valid and timely evaluation of pre- and post-vaccination disease burdens as well as of vaccine uptake. These 4 items were evaluated by asking 4 x 2 questions (**Table 1**). For each available item one point was granted, resulting in a CVS between 0 and 8. All sources of information were captured in the CVS-table for each country which can be found at [www.id-ea.org/VaccINATION](http://www.id-<u>ea.org/VaccINATION</u>), including unvalidated information on countries currently under evaluation. Searches were accomplished between January and March 2022. COVID-19 vaccination was excluded from the analysis here, as it represents an emergency situation that is different from vaccination against “regular” disease threats.

1) Are there any vaccination goals and targets?

- a. There are goals for future vaccine needs (e.g., over the next 3, 5 or 10 years).
- b. There is ≥ 1 specific, officially published and well-known national vaccination target to be reached by a specific date (e.g., measles elimination by end 2025).

2) Is there a national vaccination plan?

- a. There is one (and only one) plan published by a WHO-type NITAG.
- b. Pipeline vaccines are continuously reviewed pre-licensure by NITAG.

3) Is there appropriate implementation of the NITAG plan?

- a. There are clearly defined responsibilities and accountabilities for implementation of the NITAG plan with action in case of failure.
- b. The NITAG plan is regularly supported by government-funded national information campaigns.

4) Is there a scientifically valid evaluation of implementation success?

- a. There are up to date (\leq every 2 years) validated studies on vaccine-uptake, completion and compliance at age 2 years, before school entry, for adolescents and for those ≥ 65 years (some countries: ≥ 60 years).
- b. There is scientifically sound and timely (≤ 2 years) burden-of-disease data by age group on all vaccine-preventable diseases including relevant pipeline vaccines.

Table 1. Criteria for assessing the country-vaccination score (CVS)

Results

(see also Table 2; References see [VaccINATION – Global Health Press \[id-ea.org\]](#))

AUSTRALIA: CVS 6/8

Australia, with a population of about 25.7 million, a GNP of € 55,772 (2021) per inhabitant and health care expenses around € 5,333 per capita (2019), has universal health insurance. Medical care is provided by more than 104,000 physicians in patient care, 31,000 of whom are family doctors. There is a WHO-type scientific NITAG (Australian Technical Advisory Group on Immunization [ATAGI]) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are free of charge; vaccines not included in the National Immunisation Program may be available as part of the Pharmaceutical Benefits Scheme (PBS), which covers medicines and vaccines used on an outpatient basis (i.e., outside hospitals) and supplied through community pharmacies. Adverse event (AE) reporting is managed by the Department of Health Therapeutic Goods Administration.

AUSTRIA: CVS 4/8

Austria, with a population of about 8.9 million, a GNP of € 51,300 (2021) per inhabitant and health care expenses around € 5,150 (2019) per capita, has universal health insurance. Medical care is provided by more than 47,000 physicians in patient care, 13,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Nationales Impfgremium) with bi-annual meetings providing annually updated recommendations. Reimbursement of the vaccine cost is different for each vaccine. For example, measles vaccines provided in the national immunization program are covered by the federal government (two-thirds) and by provinces and social health insurance funds (one-sixth each). AE reporting can be done by postal services, fax or directly via the website of the BASG (Austrian Federal Office for Safety in Health Care).

BANGLADESH: CVS 8/8

Bangladesh, with a population of about 166.5 million, a GNP of € 2,574 (2021) per inhabitant and health care expenses around € 45 (2019) per capita, has no universal health insurance. Medical care is provided by more than 101,538 registered physicians in patient care according to Bangladesh Medical and Dental Council. There is a WHO-type NITAG. Recommended vaccines that are enlisted in the national Expanded Program on Immunization (EPI) are provided free to all eligible

children and women of reproductive age. Vaccines not listed under EPI can be obtained from the private market provided they are approved by the Directorate General of Drug Administration (DGDA). Potential vaccine damage is not compensated. Health facility- and community-based Adverse Event Following Immunization (AEFI) surveillance is carried out by the Expanded program on Immunization (EPI). The “Disease surveillance Focal Person” reports AEFI to the EPI Headquarter as per national guideline for AEFI surveillance. Additionally, for COVID-19 vaccines, AEFI is reported directly to the Directorate General Drug Administration’s (DGDA) online portal.

BELARUS: CVS 5/8

Belarus has a population of about 9.4 million, with a GNP of € 6,829 (2021) per inhabitant and healthcare expenses around € 392 (2019) per capita. A nationally controlled system of state employees is the basis of health system, with a few privately-owned insurance service providers. Access to health services for citizens is universal and free of charge. Medical care is provided by more than 55,000 physicians (2018) in patient care, 2,789 (2018) of whom are GPs in out-patient practices and hospitals. There is a WHO-type scientific NITAG (Expert Council on Immunization of The Ministry of Health) with meetings at least once per annum, providing updated recommendations. Recommended vaccines are reimbursed by The Ministry of Health. AE reporting is managed by physicians (in hospitals and out-patient settings) electronically filing a «Report of AE» to the Republican Unitary Enterprise «Center for Examinations and Tests in Health Service» of the Ministry of Health.

BELGIUM: CVS 2/8

Belgium, with a population of about 11.5 million, a GNP of € 49,631 (2021) per inhabitant and health care expenses around € 4,874 (2019) per capita, has a social security system, which includes the compulsory health insurance managed by the Belgian National Institute for Health and Disability Insurance. Medical care is provided by more than 36,000 physicians in total, 13,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (The Superior Health Council) with bi-annual meetings providing annually updated recommendations. Reimbursement for vaccine costs is provided by compulsory health insurance but differs according to the reimbursement category of the vaccine. For example, influenza vaccine has general reimbursement rate of 40%. AE reporting can be done online to the Federal Agency for Medicines and Health Products (FAMHP).

BRAZIL: CVS 5/8

Brazil, with a population of about 212 million, a GNP of € 7,585 (2021) per inhabitant and health care expenses around € 838 (2019) per capita, has universal health insurance. Medical care is provided by more than 450,000 physicians in patient care, 170,000 of whom are family doctors. There is a WHO-type scientific NITAG (Consultation on interactions between National Regulatory Authorities and National Immunization Technical Advisory Groups) providing annually updated recommendations that has members of more than 5 expertise areas. Recommended vaccines that are part of the National Immunization Program (NIP) are provided by the Unified Health System (Sistema Único de Saúde, or SUS) free of charge. Vaccines not included in the NIP might be reimbursed by health insurances. AE reporting can be done by any citizen through a specific electronic system to Brazilian Health Regulatory Agency (Anvisa).

CAMEROON: CVS 7/8

Cameroon, with a population of about 27 million, a GNP of € 1,562 (2021) per inhabitant and health care expenses around € 53 (2019) per capita, has partially universal health insurance. Medical care is provided by more than 2,400 physicians in patient care, 1,541 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (National Immunization Technical Advisory Group Cameroun) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are fully subsidized by the government and its global partners and in case recommendations are adopted by the Ministry of Public Health's Expanded Program on Immunization (EPI), potential vaccine damage is compensated. AE reporting is managed by the EPI, regularly updating data via the web-based platform, the District Health Information System version 2 (DHIS-2).

CANADA: CVS 5/8

Canada, with a population of about 38 million, a GNP (2020) of € 42,000 per inhabitant and health care expenses around € 300 billion (2021; i.e., € 8,000 per inhabitant), has decentralized, universal, publicly funded health system called Canadian Medicare. Medical care is provided by more than 90,000 physicians in patient care, 46,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (National Advisory Committee on Immunization - NACI) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are publicly funded for children; however, funding is much more limited for the adult immunization. Potential vaccine damage is not

compensated. AE reporting is managed by the Public Health Agency of Canada (PHAC), in collaboration with the health authorities of determined regions.

COLOMBIA: CVS 5/8

Colombia, with a population of about 50 million, a GNP (2021) of € 5,000 per inhabitant and health care expenses around € 20 billion (2019; i.e., € 490 per inhabitant), has a public health insurance plan, provided by regional entities, called "Entidades Promotoras de Salud" (EPS). Apart from it, Colombia has private insurance and social assistance ("SISBEN"), providing free government-subsidized health care. Medical care is provided by more than 123,000 physicians in patient care, 87,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Comité Nacional de Prácticas en Inmunización (CNPI)) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by PAHO Revolving Fund covering most of the vaccines. AE reporting is managed by the National institute for Drug and Food surveillance.

DEMOCRATIC REPUBLIC OF CONGO: CVS 4/8

Democratic Republic of Congo with a population of about 108 million, a GNP (2020) of € 570 per capita and health care expenses around € 48 (2019) per capita, has no general health insurance. The country faces a healthcare professional shortage, with only 0.07 physicians per 1,000 population (2016). Medical care is provided by 544 physicians in total (2018). There is a WHO-type scientific NITAG (Groupe Technique Consultatif pour la Vaccination, GTC) providing annually updated recommendations. The frequency of GTC meetings is not documented. Recommended vaccines are fully subsidized by the government and its global partners. There is not any documented plan for potential vaccine damage compensation. AE reporting is managed by the Expanded Program on Immunization in collaboration with the National Pharmacovigilance System, under the Ministry of Health.

DENMARK: CVS 6/8

Denmark, with a population of about 5.8 million, a GNP (2020) of € 60,000 per inhabitant and health care expenses around € 6,000 per inhabitant (2019), has universal health insurance. Medical care is provided by more than 18,000 physicians in patient care, 3,300 of whom are family doctors. There is a WHO-type scientific NITAG (Sundhedsstyrelsens vaccinationsudvalg (Vaccination Committee for Health)) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by

National Health Service. Potential vaccine damage is compensated for citizens. AE reporting is managed electronically.

FINLAND: CVS 7/8

Finland, with a population of about 5.5 million, a GNP of € 52,726 (2021) per inhabitant and health care expenses around € 4,372 (2018) per capita as part of social protection expenditure, has an universal health care system. Medical care is provided by more than 30,000 physicians, almost 4,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG at the National Institute for Health and Welfare (THL) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are reimbursed by the Finnish Social Insurance Institution, Kansaneläkelaitos (Kela). AE reports are stored in Fimea's adverse reaction register and sent regularly to THL. Finland was the first country to eliminate indigenous measles, mumps, and rubella as early as 1994.

FRANCE: CVS 5/8

France, with a population of about 67 million, a GNP of € 43,116 (2021) per inhabitant and health care expenses around € 4,413 (2019) per capita, has universal health insurance. Medical care is provided by more than 220,000 physicians in patient care, 58,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (The Technical Committee on Vaccinations (CTV)) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by statutory health insurance. AE reporting is managed by the single on-line platform for reporting adverse health events. The SAE notification process is built on 2 regional and national levels.

GERMANY: CVS 1/8

Germany, with a population of about 83 million, a GNP of € 50,151 (2021) per inhabitant and health care expenses around € 5,345 (2019) per capita, has universal health insurance. Medical care is provided by more than 400,000 physicians in patient care, 160,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Ständige Impfkommision am Robert-Koch-Institut, STIKO) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by insurances and in case recommendations are adopted by the local state, potential vaccine damage is compensated. AE reporting is managed by the licensing agency, (Paul-Ehrlich-Institut, PEI), regularly providing AE data on their website.

HUNGARY: CVS 3/8

Hungary, with a population of about 9 million, a GNP of € 17,431 (2021) per inhabitant and health care expenses around € 1,043 (2019) per capita, has universal health insurance. Medical care is provided by more than 30,000 physicians in general, 5,800 of whom are GPs in outpatient practices. There is no WHO-type scientific NITAG or other institution that provides annually updated recommendations. Vaccination is mandatory and covered from the central government budget under the Ministry of Human Capacities. AE reporting is managed through the EU Individual Case Safety Report.

INDIA: CVS 7/8

India, with a population of over 1.3 billion, is a € 1.3 trillion economy spending around 3.54% of its GDP on healthcare which is around € 95 billion (2018). There is no mandatory healthcare insurance scheme in the country yet around 35% percent of the population have health coverage from different private and public channels. To review and recommend vaccines, a NITAG has been established which fulfils all the six WHO criteria. Immunization occurs mainly through public channels under the Universal Immunization Program (UIP). A follow-up mechanism to report vaccine-associated Adverse Events (AE) is well established; manufacturers and the state are accountable to pay for compensatory and putative damages associated with immunization.

INDONESIA: CVS 4/8

Indonesia, with a population of about 279 million, a GNP of € 4,067 (2021) per inhabitant and health care expenses around € 118 (2019) per capita, has universal health insurance. Medical care is provided by more than 140,000 physicians, most of whom are family doctors. There is a WHO-type scientific NITAG ("The Indonesian Technical Advisory Group on Immunization") with bi-annual meetings providing annually updated recommendations. Recommended vaccines are reimbursed for all residents by JKN insurance at both private and public health facilities, while at private facilities only JKN members eligible for JKN reimbursements. Causality Assessment between vaccine and injury is done by National AEFI Committee. The AEFI Committee thoroughly investigates each reported case.

IRAN: CVS 4/8

Iran, with a population of about 85 million, a GNP of € 3,311 (2020) per inhabitant and health care expenses around € 462 (2019) per capita, has no general health

insurance. However, there is a combination of “Social Health Insurance” which is mandatory for employees with the government, with formal private sectors, self-employed persons, the military and their families, as well as for voluntary contributors. In addition, health care funds are provided through Institutional Health Insurance Funds or Commercial Health Insurances. Medical care is provided by more than 160,000 physicians in patient care, 93,000 of whom are GPs in outpatient practices and hospitals. There is a WHO-type scientific NITAG (National Immunization Committee) with quarterly meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by the Ministry of Health and Medical Education. There is no documented plan for potential vaccine damage compensation. AE reporting is managed by Center for Disease Control and Prevention, a division of the Ministry of Health and Medical Education.

ITALY: CVS 3/8

Italy, with a population of about 60 million, a GNP of € 35,088 (2021) per inhabitant and health care expenses around € 2,854 (2019) per capita, has universal health insurance (not all services are completely free). Medical care is provided by more than 230,000 physicians in patient care, 50,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually covered by the National Health Fund, which is a statutory financing system (via taxation). AE reports can be sent from doctors, healthcare professionals and patients to the National Pharmacovigilance Network (Rete nazionale di farmacovigilanza - RNF) database.

KAZAKHSTAN: CVS 4/8

Kazakhstan, with a population of about 19 million, a GNP (2021) of € 9,000 per inhabitant, and health care expenses around € 260 per inhabitant (2019), has universal health insurance based on a single public insurer operated by the Ministry of Health. Medical care is provided by more than 76,000 physicians in patient care, more than 10,300 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Advisory Committee on Immunization (ACI) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by health insurance. Potential vaccine damage is not compensated. While any AE can be reported to family physicians, no follow up the information is given and there is no summarized public AE information.

KENYA: CVS 7/8

Kenya, with a population of about 54 million, a GDP per capita of € 1,975, and current health expenditure per capita of € 81, has a non-universal health insurance system but is on the pathway to universal health care. Medical care is provided by more than 5,602 general practitioners working in hospitals mainly, 601 of whom are pediatricians in specialized clinics. There is a WHO-type scientific NITAG (keNITAG) with annual meetings providing annually updated recommendations. Immunization targets are set by the national immunization program. The review of pipeline vaccines is done annually, and clear responsibilities and accountabilities for implementation have been set. Recommended vaccines are usually free of charge. There are government funded campaigns in collaboration with philanthropists like the Gates Foundation in Polio and HPV or research-led campaigns. District Health Information System (DHIS2) an integrated web-based platform is used to report data from all other programs. AE reporting is managed by a collaborative initiative between the National Regulatory Authority (NRA), which is the Pharmacy and Poisons Board (PPB), and the National Vaccines and Immunization Program (NVIP).

LITHUANIA: CVS 5/8

Lithuania, with a population of about 2.7 million, a GNP of € 21,233 (2021) per inhabitant and health care expenses around € 1,346 (2019) per capita, has universal health insurance. Medical care is provided by more than 12,000 physicians working in hospitals, while 2,700 are GPs in outpatient practices. There is a WHO-type scientific NITAG with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually free of charge, and so are seasonal influenza and pneumococcal vaccines for groups at risk, vaccines for post-exposure prophylaxis. Booster doses are also free of charge once per decade (diphtheria and tetanus vaccines) for adults over 25 years. AE reporting is managed by the State Agency for the Control of Medicinal Products.

MALAWI: CVS 7/8

Malawi, with a population of about 19 million, a GNP (2021) of € 619 per inhabitant and health care expenses around € 29 per capita, has no universal health insurance. Medical care is provided by more than 650 medical doctors in patient care. There is a WHO-type scientific NITAG (Malawi Immunization Technical Advisory Group- MITAG) with meetings at least once per year providing annually updated recommendations. Malawi buys vaccines through GAVI, and they are free of

charge. AE reporting is managed the Ministry of Health, Expanded Program of Immunization department through a passive surveillance system.

MEXICO: CVS 4/8

Mexico, with a population of about 129 million, a GNP of € \$9,216 (2021) per inhabitant and health care expenses around € 530 (2019), has mandatory universal state-based health insurance, with some additional private insurance in parallel. Medical care is provided by more than 286,000 physicians. There is a WHO-type scientific NITAG (Grupo Técnico Asesor de Vacunas) with four annual meetings providing annually updated recommendations. Recommended vaccines are not usually reimbursed by insurances. Currently (2022), vaccines bought through PAHO are free of charge. There is no program for potential vaccine damage from a recommended vaccine. AE reporting is managed by the Ministry of Health through a passive sentinel-based surveillance system.

NEPAL: CVS 6/8.

Nepal, with a population of about 29 million, a GNP of € 1,208 (2021) per inhabitant and health care expenses around € 52 (2019) per capita, has no universal health insurance. Medical care is provided by more than 24,814 physicians in patient care. There is a WHO-type scientific NITAG (Nepal National Committee on Immunization Practices) with at least bi-annual meetings providing updated recommendations. Recommended vaccines that are enlisted in the National Immunization Program (NIP) are provided free of cost to all the eligible children, and those not listed in the NIP have to be paid by the individuals out of their own pocket. Potential vaccine damage is not compensated, and no documents or guidelines are yet available on this topic. Adverse Events Following immunization (AEFI) are reported from the local clinics to the District Health centers and then are reported and entered in the national database. The AEFI committee assist in streamlining the reporting mechanism, investigate the reported serious AEFI and are involved in the causality assessment.

The NETHERLANDS: CVS 6/8

The Netherlands, with a population of 17.5 million, a GNP of € 55,389 (2021) per inhabitant and health care expenses around € 5,242 (2019) per capita, has universal health insurance. Medical care is provided by 66,870 physicians, 31,037 of whom are GPs in outpatient practices. The Health Council of the Netherlands is a WHO-type scientific NITAG that is an independent scientific advisory body whose legal task it is to advise the Dutch ministers and Parliament in the field of public

health and healthcare research. Recommended vaccines are usually reimbursed, normally by a municipality based on article 60 of the Dutch Public Health Act (Wet publieke gezondheid). AE reporting, such as any side effects of medications or vaccines, are managed by the Netherlands Pharmacovigilance Centre Lareb, which will notify the Medicines Evaluation Board (College ter Beoordeling van Geneesmiddelen or CBG) within 15 days about any severe side effects reported.

NORWAY: CVS 3/8

Norway, with a population of about 5.5 million, a GNP of € 82,626 (2021) per inhabitant and health care expenses around € 7,868 (2019) per capita, has universal health coverage, funded primarily by general taxes and by payroll contributions shared by employers and employees. Medical care is provided by more than 30,000 physicians, 16,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Norwegian Institute of Public Health) with bi-annual meetings providing annually updated recommendations. Reimbursement of recommended vaccines (either full or partial) is accomplished by National Insurance. AE reporting is managed by using reports collected the in Norwegian Adverse Drug Reaction (ADR) registry.

The PHILIPPINES: CVS 6/8

The Philippines, with a population of about 111 million (2021), a GNP of € \$ 3,576 (2021) per inhabitant, has a health care expenditure of € 20.4 billion (2020; € 139 per capita [2019]). The Philippine healthcare system is mixed with 40% of the hospitals publicly funded by the Department of Health and the rest as private institutions. There are 2 types of health insurance programs, the government run National Health Insurance Program (NHIP) and voluntary private health insurance (PHI). The local NITAG has biannual meetings. A National EPI is in place with recommended vaccines covered by the Department of Health. Adverse events (AE) are reported to and accounted for by the National Adverse Event Following Immunization Committee (NAEFIC) which is a collaboration between the National Epidemiology Center (NEC) the National Center for Disease Prevention and Control (NCDPC) and the Philippine Food and Drug Administration (FDA).

POLAND: CVS 4/8

Poland, with a population of about 37 million, a GNP of € 16,379 (2021) per inhabitant and health care expenses around € 996 (2019) per capita, has universal health insurance. Medical care is provided by more than 90,000 specialized physicians, 15,000 of whom are GPs in outpatient practices. There is a WHO-type scientific

NITAG (The National Institute of Public Health–National Institute of Hygiene [Narodowy Instytut Zdrowia Publicznego–Państwowy Zakład Higieny, NIZP-PZH]) with bi-annual meetings providing annually updated recommendations. Reimbursement of a vaccine as a rule depends on its classification into one of three law-based categories: (i) obligatory; (ii) recommended; and (iii) recommended for certain professions. AE reporting is managed by a national authority (Państwowej Inspekcji Sanitarnej and Kontrola systemu szczepień).

PORTUGAL: CVS 3/8

Portugal, with a population of about 10 million, a GNP of € 23,317 (2021) per inhabitant and health care expenses around € 2,182 (2019) per capita, has universal health insurance. Medical care is provided by more than 30,000 physicians in patient care, 5,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG, (National Vaccination Committee). Recommended vaccines are usually reimbursed by compulsory insurance: Potential vaccine damage is usually not compensated. AE reporting is managed by GPs who can file a “report of AE / lack of effectiveness” electronically to the Ministry of Health.

ROMANIA: CVS 5/8

Romania, with a population of about 19 million, a GNP of € 13,923 (2021) per inhabitant and health care expenses around € 725 (2019) per capita, has universal health insurance. Medical care is provided by more than 64,000 physicians in patient care, 15,000 of whom are GPs. There is a WHO-type scientific NITAG (National Committee of Vaccinology) providing updated vaccination recommendations. Recommended vaccines are usually reimbursed by the Ministry of Health through a centralized procedure and distributed to the District Public Health Authorities. AE reporting is managed online through reporting to the National Drug and Medical devices agency.

SLOVENIA: CVS 6/8

Slovenia, with a population of about 2 million, a GNP (2021) of € 24,000 per inhabitant and health care expenses around € 2,200 (2019) per capita, has universal health insurance based on a single public insurer, the Health Insurance Institute of Slovenia. Medical care is provided by more than 31,000 physicians in patient care according to the National Institute of Public Health (NIJZ). There is a WHO-type scientific NITAG (Advisory Committee on Immunization - Posvetovalna skupina za cepljenje [PSC]) - with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by the Health Insurance

Institute of Slovenia. Potential vaccine damage is compensated. AE reporting is managed online but can be also done using paper form and sending reports to the National Center for Pharmacovigilance of Slovenia.

REPUBLIC OF SOUTH KOREA: CVS 5/8

South Korea, with a population of about 51 million, a GNP of € 34,371 (2021) per inhabitant and health care expenses around € 2,578 (2019) per capita, has universal health insurance obtained through the National Health Insurance Corporation which is housed under the Ministry of Health and Wellness. Medical care is provided by more than 118,000 physicians in patient care, and more than 23,000 oriental medicine practitioners. There is a WHO-type scientific NITAG (Korean Advisory Committee on Immunization Practice [KACIP]) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are usually reimbursed by Long-Term Care Insurance that is mandatory for all citizens to own. AE reporting is done through an adverse reaction reporting system created by medical and government agencies.

SPAIN: CVS 4/8

Spain, with a population of about 47.4 million, a GNP of € 29,222 (2021) per inhabitant and health care expenses around € 2,664 (2019) per capita, has universal health insurance. Medical care is available through more than 267,000 physicians (2019), 35,000 of whom are GPs in outpatient practices (2018). There is a WHO-type scientific NITAG (Working Group on Vaccines [Ponencia del Programa y Registro de Vacunaciones]). Vaccines included in the national vaccination program are reimbursed by the national government while regions can opt for broader protection and pay for additional vaccines (e.g., meningococcal B vaccines). AE reporting is managed by the La Agencia Española de Medicamentos y Productos Sanitarios (AEMPS).

SWEDEN: CVS 3/8

Sweden, with a population of about 10 million, a GNP of € 57,865 (2021) per inhabitant and health care expenses around € 5,572 (2019) per capita, has universal and automatic health coverage. Emergency coverage is provided to all patients from the European Union, European Economic Area countries, and nine other countries with which Sweden has bilateral agreements. Medical care is provided by more than 46,000 physicians, 6,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (National Board of Health and Welfare) with bi-annual meetings providing annually updated recommendations. Vaccine reimbursement is fully or partially funded by the NHI (public funding).

Some vaccines were excluded but can be paid by third party payers (e.g., private insurers or out-of-pocket expenses). AE reporting is managed by the Swedish Medical Products Agency (Swedish MPA).

SWITZERLAND: CVS 6/8

Switzerland, with a population of about 8,7 million, a GNP of € 88,787 (2021) per inhabitant and health care expenses around € 9,498 (2019) per capita, has universal health coverage that is mandatory but not socialized. The Swiss health care system relies heavily on the private sector. It is mandatory for all residents to obtain at least basic health insurance “LAMal” (Loi sur l’Assurance Maladie obligatoire) or KVG (Krankenversicherungsgesetz). Medical care is provided by more than 38,000 physicians in patient care, 7,000 of whom are GPs and 985 primary care pediatricians. There is a WHO-type scientific NITAG (The Federal Vaccination Commission in Switzerland) with bi-annual meetings providing annually updated recommendations. Recommended vaccines are reimbursed by insurances that all residents are obliged to have. AE reporting is managed by Swissmedic. Healthcare professionals should report adverse drug reactions directly to Swissmedic.

SYRIA: CVS 4/8

Syria, a country at war with a population of about 17 million, a GNP of € 913 (2018) per inhabitant and health care expenses around € 68 (2012) per capita, does not have universal healthcare coverage. Health care expenses are covered by multiple sources such as government tax money for public hospitals and clinics. Health insurances cover most employed individuals through different health expenditure management companies while there is just out-of-pocket coverage for health expenses of the remaining residents when in need of physician visits or private hospitals. Medical care is provided by more than 19,000 physicians in patient care. There is only a very small number of GPs, as most patients directly see specialists. There is a WHO-type scientific NITAG, but as a website of the Ministry of Health is not accessible, details and recommendations are not publicly available. WHO prequalified vaccines are procured and distributed through UNICEF and GAVI, The Vaccine Alliance. Syria additionally receives vaccine doses free of charge from Russia, China, and Qatar. Vaccines that are included in the Expanded Program of Immunization (EPI) are free of charge. No documents or guidelines are yet available regarding reimbursement in case of potential vaccine induced damage. Adverse events (AEs) are reported by local clinics to the District Health Centers going into a national database.

TURKEY: CVS 3/8

Turkey, with a population of about 83 million, a GNP (2021) of € 9,730 per inhabitant and health care expenses around € 396 (2019) per capita, has universal health insurance. Medical care is provided by more than 1.8 physicians per 1,000 population (2018), more than 41,000 are GPs in outpatient practices. There is a WHO-type scientific NITAG (Türkiye Ulusal Bağışıklama Teknik Danışma Grubu). Recommended vaccines included in the national immunization program are given free of charge to children and adults. Adverse event (AE) reporting is managed by the responsible healthcare provider (Aşı Sonrası İstenmeyen Etki İzlem Sorumlusu) and the report is sent it to the provincial health directorate.

UGANDA: CVS 4/8

Uganda, with a population of about 45.74 million (2020), a GNP of € 825 (2021) per inhabitant and health care expenses around € 31 (2019) per capita, does not have universal health insurance. Medical care is provided by more than 4,811 physicians in patient care, 3,993 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Uganda’s NITAG [UNITAG]) with at least annual meetings providing annually updated recommendations. The Uganda National Expanded Program on Immunization (UNEPI) is a national program that mainly targets infants and women of childbearing age and are usually free of charge provided by the ministry of health and its partners. Potential vaccine damage is not usually compensated. AE reporting is managed by the licensing agency, the National drug authority (NDA), regularly providing data on their website.

UNITED KINGDOM (UK): CVS 8/8

The UK, with a population of about 67 million, a GNP (2020) of € 42,000 per inhabitant, and health care expenses around € 320 billion (2021), has universal health insurance. Medical care is provided by more than 350,000 physicians (2022). There is a WHO-type scientific NITAG (Joint Committee on Vaccination and Immunisation, JCVI) providing recommendations to the country’s government health officials. There are usually three annual meetings. If accepted, recommended vaccines are paid for. A one-time, tax-free, compensation of € 138,000 is paid by the government for any severe vaccine damage. AE reporting is managed by the Medicines and Healthcare products Regulatory Agency (MHRA).

UKRAINE: CVS 4/8

Ukraine, with a population of about 44 million (2021), a GNP of about € 4,000 (2021) per inhabitant and health care expenses around € 243 (2019) per capita, has

universal health insurance. Medical care is provided by more than 147,000 physicians in patient care, 24,000 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG, detailed information regarding its activities were not found. Recommended vaccines are usually reimbursed by compulsory insurance, potential vaccine damage is usually not compensated. AE reporting is managed by GPs filing a “report of AE / lack of effectiveness” electronically to the Ministry of Health.

USA: CVS 7/8

The United States of America, with a population of about 331 million has a GNP of € 69,204 (2021) per inhabitant and health care expenses around € 10,730 (2019) per capita. The US healthcare system does not provide universal coverage and can be defined as a mixed system, where publicly financed government Medicare and Medicaid health coverage coexists with privately financed market coverage. Medical care is provided by more than 1,018,000 physicians in patient care, 228,900 of whom are GPs in outpatient practices. There is a WHO-type scientific NITAG (Advisory Committee on Immunization Practices, ACIP) with tri-annual meetings. A National nominal electronic immunization registry is in place. Recommended vaccines are usually covered by insurances or the government, potential vaccine damage is compensated by the National Vaccine Injury Compensation Program (VICP). AE reporting is accomplished by the governmental Vaccine Adverse Event Reporting system (VAERS) along with legal obligations by manufactures with reporting to the U.S. Food and Drug Administration (FDA).

Discussion

With this ongoing work, we inaugurate the formal evaluation of country vaccination systems in order to address the question, if a country is structurally able to deliver high-quality vaccination services on a population level as well as for the individual. The methodology based is widely used in management as “*goal, plan, implementation, evaluation*” and are standard criteria to assess performance and to manage projects and progress.

Without a goal, no action has any justification for public health. Without a plan, resources cannot be allocated efficiently, and action would be erratic at best. Without implementation actions are arbitrary and may result in a waste of resources, while a lack of evaluation reduces any project to an optional practicing exercise. The details of individual local vaccination plans – vaccine products

used, vaccination schedules, resources put into the system etc. – are irrelevant here, as such details can only be addressed locally based on the individual historical, cultural, political, medical, and financial situation. “Harmonization of vaccination” is a bad idea that has repeatedly failed, e.g., in the European Union, as vaccination successes are local success. In contrast, the overall ability of a country to deliver high-class vaccination services as evaluated here is solely based on the presence or absence of simple structural elements and public health services.

We refrained from adding additional items to the score in order to ensure it remains a simple and purely managerial tool. Other relevant items contributing to the success of vaccination may include for example vaccine damage compensation, timely, adequate and publicly available (online) safety surveillance, the resources (e.g., fraction of the GNP) that go into vaccine prevention, the legislative framework for vaccination, equal accessibility of vaccines to all members of society, the source(s) of funding and transparency of the technicalities of the vaccination system, to mention some. While these items are important, from a management point of view they can be subsumed under “implementation”. In the end, each country has to decide on its own how to implement in the best possible way – and that may differ and cannot be part of a CVS.

We also refrained from commenting on the performance of single countries. With currently only 42 countries selected and assessed in an unrepresentative manner, it is not possible to aggregate the data from a global perspective. Some methodological issues, however, have already become evident:

Giving a yes/no answer may be difficult and subjective in some instances. Canada, for example, has not just one but several vaccination plans resulting in a “0” score for “having one plan”. Several plans may cause confusion in the public, may prevent optimal individual vaccination for moving families or travelers and may even erode vaccination confidence, particularly in the scientific validity of the different NITAG recommendations. Moreover, purchasing of vaccines and logistics may become more cumbersome and expensive. Germany on the other side has 16 vaccination plans, one in each federal state, and in contrast to Canada, 1 point was granted. This was based on the fact that in the perception of physicians and the public in Germany only the national (STIKO-) NITAG plan appears to be relevant (which is legally not the case though). In the future, such individual decisions will be explained in a comments section.

	Score	Future needs	Defined targets	One NITAG plan	Timely update	Clear responsibilities & accountabilities	Information campaigns	Vaccine uptake data	Burden of disease data
BANGLADESH	8	1	1	1	1	1	1	1	1
UNITED KINGDOM	8	1	1	1	1	1	1	1	1
CAMEROON	7	1	1	1	1	1	1	1	0
FINLAND	7	0	1	1	1	1	1	1	1
INDIA	7	1	1	1	1	1	1	1	0
KENYA	7	1	1	1	0	1	1	1	1
MALAWI	7	1	1	1	1	1	1	1	0
USA	7	1	1	1	1	0	1	1	1
AUSTRALIA	6	1	1	1	0	1	1	1	0
DENMARK	6	0	1	1	1	1	1	1	0
NEPAL	6	1	1	1	0	1	1	1	0
NETHERLANDS	6	0	1	1	1	1	1	1	0
PHILIPPINES	6	1	1	1	1	1	1	0	0
SLOVENIA	6	0	1	1	0	1	1	1	0
SWITZERLAND	6	0	1	1	1	1	1	1	0
BELARUS	5	0	0	1	1	1	1	1	0
BRAZIL	5	0	1	1	1	1	0	1	0
CANADA	5	1	1	0	0	1	1	1	0
COLOMBIA	5	0	1	1	0	0	1	1	1
FRANCE	5	0	1	1	0	1	1	1	0
LITHUANIA	5	1	1	0	1	1	1	0	0
ROMANIA	5	1	1	1	0	1	1	0	0
SOUTH KOREA	5	0	1	1	1	1	1	0	0
AUSTRIA	4	0	1	1	1	0	1	0	0
DR of CONGO	4	0	1	1	1	0	1	0	0
INDONESIA	4	1	1	1	0	0	1	0	0
IRAN	4	0	1	1	0	1	1	0	0
KAZAKHSTAN	4	0	1	1	0	1	1	0	0
MEXICO	4	1	0	1	0	0	1	0	1
POLAND	4	1	1	1	0	0	1	0	0
SPAIN	4	0	1	1	0	0	1	1	0
SYRIA	4	0	1	1	0	0	1	1	0
UGANDA	4	1	0	1	0	0	1	1	0
UKRAINE	4	0	1	1	0	1	1	0	0
ITALY	3	0	0	1	0	1	0	1	0
NORWAY	3	0	1	1	0	1	0	0	0
PORTUGAL	3	0	1	1	0	0	1	0	0
SWEDEN	3	1	0	1	1	0	0	0	0
TURKEY	3	0	0	1	0	0	1	1	0
HUNGARY	3	0	0	1	0	1	0	1	0
BELGIUM	2	0	0	0	0	1	1	0	0
GERMANY	1	0	0	1	0	0	0	0	0

Table 2. Country Vaccination Score (CVS)

Another methodological issue identified here is the fact that documents from public health institutions and governments do not necessarily reflect the situation in real life, or, as one co-author put it, “what is on paper is not necessarily what happens in reality.” With input from readers, in the future, we aim to add such information in the comments section and perhaps, if useful, we may even introduce a second “corrected CVS” which may be closer to reality. It appears unlikely, that any useful positive information on the structure of a country’s vaccination system would not be published. If it exists, “hidden information” would result in a lack of transparency, and thus a “0” score would be justified anyway in such instances. What cannot be excluded, though, is that available information was missed in our searches. While this cannot be excluded, it appears to be unlikely, given the fact that mostly local experts / native speakers performed the searches, and that the data was validated by a second round of review.

The main strength of this evaluation is that it allows to formally distinguish between countries with a “vaccination program” and those with just a “vaccination plan”. Our impression is that most countries in Europe have “vaccination plans” but particularly lack implementation and valid evaluation of disease burdens and vaccine uptake. In contrast, as a tendency, LMICs often achieved a high CVS as they have true “vaccination programs”. High CVS-scores for LMICs may frequently result from external support by GAVI, WHO or other institutions.

Countries with a “plan only” vaccination system but little, if any, implementation and evaluation are expected to have a low vaccine uptake and a low impact of vaccination on the burden of vaccine preventable diseases. It is expected that they will observe regular disease outbreaks, e.g., of measles. This will be evaluated in future research. One may even go as far as to suspect that a lack of transparency with regard to having valid burden of disease and vaccine uptake data are based on the political wish not to reveal the poor performance of public health services.

“Data protection” as an argument not to evaluate disease burden or vaccine uptake is not acceptable, as the respective data is available anyway and as anonymized statistical information does in no way jeopardize any individual rights. Actually, one co-author would even consider a lack of a digital vaccine registry as a lack of transparency and hiding relevant information from the public.

Compulsory vaccination was not used as an evaluation item here as it has not been convincingly shown that vaccination goals can be achieved by legal enforcement. It is at the discretion of each country to decide how best to achieve their goals.

A strength of the CVS is the crowdsourcing method for information gathering of public and global health data from all over the world and the iterative review by other experts within the working group. Crowdsourcing has been successfully used in a range of tasks, from translating texts to collecting information and hiring skilled workers to build complex algorithms or software. Crowdsourcing utilizes the creativity and collaborative spirit of people all over the world, enabling them to solve global problems and bypassing traditional knowledge-hoarders. ([Leveraging crowdsourcing to accelerate global health solutions | Nature Biotechnology](#)). Future studies may show that formally “strong vaccination programs” with a high CVS are valid indicators for vaccination successes and guarantee the best use of public health resources as well as success. These programs do not “appear overnight” but take years of hard work and efforts to be established before people trust “their” public health system.

NOTE: This is an ongoing project with the aim to review the CVS of $\geq 80\%$ (156/195) of countries by the end of the year and to repeat the exercise annually. Vaccinologists and public health experts are cordially invited to comment on the available findings and to add information for current as well as additional countries as appropriate to make the CVS an editorially guided user-generated content (see end of the paper). Vaccinologists willing to support this project for a specific country, please write to us (joe.schmitt@globalhealthpress.org) and we will consider you as a country author based on academic achievements, and nationality / languages spoken (fluency in English is a must). All contributions will be double checked and verified by additional experts and the review board.

Acknowledgments:

The authors acknowledge the excellent technical support provided by Brian Ong, Muhammad Shaqeez, and Augustine Hong as well as superb language editing by John Hatley.

Conflict of Interest statement:

All authors state that they have no conflicts of interest regarding the topic covered in this manuscript.

References

1. Andre FE, Booy R, Bock HL, et al. Vaccination greatly reduces disease, disability, death and inequity worldwide. *Bull World Health Organ.* 2008;86(2):140-146. doi:10.2471/blt.07.040089
2. Fenner F, Henderson DA, Arita I, Ježek Z, Ladnyi ID. *Smallpox and its eradication.* Geneva: WHO; 1988.
3. Whitney CG, Zhou F, Singleton J, Schuchat A; Centers for Disease Control and Prevention (CDC). Benefits from Immunization During the Vaccines for Children Program Era — United States, 1994–2013. *MMWR.* 2014;63(16):352-355.
4. WHO, UNICEF. *Pneumonia - the forgotten killer of children.* Geneva, 2006.
5. Gambrell A, Sundaram M, Bednarczyk RA. Estimating the number of US children susceptible to measles resulting from COVID-19-related vaccination coverage declines. *Vaccine.* 2022;40(32):4574-4579. doi:10.1016/j.vaccine.2022.06.033
6. Sobkowicz P, Sobkowicz A. Agent Based Model of Anti-Vaccination Movements: Simulations and Comparison with Empirical Data. *Vaccines (Basel).* 2021;9(8):809. doi:10.3390/vaccines9080809
7. Dubé E, Vivion M, MacDonald NE. Vaccine hesitancy, vaccine refusal and the anti-vaccine movement: influence, impact and implications. *Expert Rev Vaccines.* 2015;14(1):99-117. doi:10.1586/14760584.2015.964212
8. Larson HJ, de Figueiredo A, Xiahong Z, et al. The State of Vaccine Confidence 2016: Global Insights Through a 67-Country Survey. *EBioMedicine.* 2016;12:295-301. doi:10.1016/j.ebiom.2016.08.042
9. Larson HJ, Gakidou E, Murray CJL. The Vaccine-Hesitant Moment. *N Engl J Med.* 2022;387(1):58-65. doi:10.1056/NEJMra2106441
10. Carrico J, Talbird SE, La EM, et al. Cost-benefit analysis of vaccination against four preventable diseases in older adults: Impact of an aging population. *Vaccine.* 2021;39(36):5187-5197. doi:10.1016/j.vaccine.2021.07.029
11. Ozawa S, Portnoy A, Getaneh H, et al. Modeling The Economic Burden Of Adult Vaccine-Preventable Diseases In The United States. *Health Aff (Millwood).* 2016;35(11):2124-2132. doi:10.1377/hlthaff.2016.0462
12. Gil de Miguel Á, Eiros Bouza JM, Martínez Alcorta LI, et al. Direct Medical Costs of Four Vaccine-Preventable Infectious Diseases in Older Adults in Spain. *Pharmacoecoon Open.* 2022;6(4):509-518. doi:10.1007/s41669-022-00329-3
13. United Nations, Department of Economic and Social Affairs, Population Division. *World Population Ageing 2019: Highlights.* Geneva: ISBN: 978-92-1-148325-3; 2019.
14. Clark A, Jit M, Warren-Gash C, et al. Global, regional, and national estimates of the population at increased risk of severe COVID-19 due to underlying health conditions in 2020: a modelling study. *Lancet Glob Health.* 2020;8(8):e1003-e1017. doi:10.1016/S2214-109X(20)30264-3
15. Walker JL, Grint DJ, Strongman H, et al. UK prevalence of underlying conditions which increase the risk of severe COVID-19 disease: a point prevalence study using electronic health records. *BMC Public Health.* 2021;21(1):484. doi:10.1186/s12889-021-10427-2
16. Adjagba A, MacDonald NE, Ortega-Pérez I, Duclos P; 2016 Global NITAG Network Meeting Participants. Strengthening and sustainability of national immunization technical advisory groups (NITAGs) globally: Lessons and recommendations from the founding meeting of the global NITAG network. *Vaccine.* 2017;35(23):3007-3011. doi:10.1016/j.vaccine.2017.04.039
17. Duclos P, Dumolard L, Abeysinghe N, et al. Progress in the establishment and strengthening of national immunization technical advisory groups: Analysis from the 2013 WHO/UNICEF joint reporting form, data for 2012. *Vaccine.* 2013;31(46):5314-5320. doi:10.1016/j.vaccine.2013.08.084
18. Perronne C, Adjagba A, Duclos P, et al. Implementing efficient and sustainable collaboration between National Immunization Technical Advisory Groups: Report on the 3rd International Technical Meeting, Paris, France, 8-9 December 2014. *Vaccine.* 2016;34(11):1325-1330. doi:10.1016/j.vaccine.2016.01.063
19. MacDonald N, Mohsni E, Al-Mazrou Y, et al. Global vaccine action plan lessons learned I: Recommendations for the next decade. *Vaccine.* 2020;38(33):5364-5371. doi:10.1016/j.vaccine.2020.05.003
20. Hwang A, Veira C, Malvolti S, et al. Global Vaccine Action Plan Lessons Learned II: Stakeholder Perspectives. *Vaccine.* 2020;38(33):5372-5378. doi:10.1016/j.vaccine.2020.05.048

Addendum, November 2022:

Tan JVG is registered in the EMJMD LIVE (Erasmus+ Mundus Joint Master Degree in Leading International Vaccinology Education), co-funded by the EACEA (Education, Audiovisual and Culture Executive Agency, award 2018–1484) of the European Commission, and received a scholarship from the EACEA .