Maximizing The Contribution Of Vaccination To The SDGs And The Grand Convergence - Integrating Multi Criteria Decision Analysis With The Broader Benefits Of Vaccination To Align On Sustainable Immunization Strategies

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Abstract
Vaccines play a key role in global health and development, but their broader value is still today highly underestimated. This paper focuses on the broad benefits of vaccination and how pragmatic, evidence-based, multifactorial assessment methods will release the full support of vaccination to achieve the Sustainable Development Goals (SDGs).

Vaccination is the most successful and cost-effective medical intervention ever introduced, saving between 2.5 and 3 million lives every year and preventing countless illnesses heavily impacting individuals, their families and communities, and consequentially hampering development of societies at large. Vaccines have significantly contributed to the dramatic decline in mortality rates witnessed over the past decades, crucially supporting achievement of the Millennium Development Goals. The success vaccines had in the past decades created a certain level of complacency. The value they currently provide is still far behind the significantly greater potential benefits they can offer. Even today the success of vaccination coverage is measured using only the DTP3 indicator while using all of the 11 vaccines recommended by WHO would be much more appropriate. Without more comprehensive future vaccination strategies the SDGs and the Grand Convergence in Health 2035 will not be achieved.

It is of paramount importance to fully exploit the broad benefits vaccination provides to six of the fourteen targets of SDG no. 3, (Ensure healthy lives and promote well-being at all ages), but also to at least six other SDGs and the Grand Convergence in Health over the next 20 years.

In the 20th century, vaccination was used as a public health tool in western countries leading to the near eradication of many infectious diseases (IDs) and consequently facilitating economic development. Over the past decades health economic analysis has become the preferred method to compare cost and benefit of health interventions, and prioritize them. However, neither indirect costs, e.g. time losses for patients, carers and employers due to illness, nor benefits not immediately associated with health outcomes, such as societal benefits, that are consequent to the use of vaccines are currently captured by HEA. Additionally, important multiplier and network effects, e.g. protection of others and at-risk groups, prevention of epidemics and pandemics, and long-term economic benefits for communities plagued by disease and poverty, are not adequately taken into consideration. We argue that HEA should not be used as the only criterion, and consequently should be considered alongside a broader array of criteria to capture more accurately the full benefits of vaccination. Scientific evidence suggests that Multi-Criteria-Decision-Analysis (MCDA) is a method particularly well suited to systematically take into account the many variables needed to capture the broad benefits of vaccination. Additionally, we claim that our research has identified attributes central to vaccine evaluation potentially representing best practice guidelines.

If our goal is to reduce the burden of diseases and facilitate sustainable development, vaccines need to become a top priority on the global health agenda. Without fully capitalizing on the broad benefits of vaccination we will not succeed in achieving several SDGs and the Grand Convergence in Health in 2035.
The Sustainable Development Goals And The Grand Convergence

On 6 July 2015, UN Secretary-General, Mr. Ban Ki-moon, launched The 2015 Millennium Development Goals (MDGs) Report: “2015 is a milestone year. We will complete the MDGs. We are forging a bold vision for sustainable development, including a set of Sustainable Development Goals. And we are aiming for a new, universal climate agreement.” (UN 2015)

The Report shows the highly significant progress made on all goals since their endorsement in 2000 demonstrating how the MDGs have saved millions of lives and improved conditions for countless worldwide. At the same time, it acknowledges the uneven progress made in many areas, which will need to be addressed in the new universal and transformative post-2015 development agenda. (UN 2015)

The success of the MDGs was based on following elements:

- Sharing a visionary agenda for global action with pre-defined measurable goals and targets.
- Collecting and measuring data with scientific methods for objective evaluations and decision-making.

These elements of the global development agenda were key in achieving so many successes for improving human living conditions, probably never achieved before within a 15-year timespan.

We are at the dawn of a second period, which may change the face of our planet and the lives of all of us living on it. The success of the MDGs has to reassure us that the approach taken so far works and that we can continue to succeed, but it does not guarantee our next trip will be any easier: the challenges presented by 17 SDGs and 100 indicators to be adopted in September 2015 are even greater.

In parallel, the concept of the Grand Convergence in Global Health, an ambitious proposal launched by the Lancet Commission in 2014, will support us in facing the challenges offered by Goal 3: Ensure healthy lives and promote well-being for all at all ages. The report “Global Health 2035: a world converging within a generation” made the case that we have the financial and technical capacities to close the health and longevity gap between low/lower-middle-income and high-income countries, reducing infectious, child, and maternal mortality rates to low levels globally to achieve a “Grand Convergence” (GC) in health by 2035. The Grand Convergence gives us a vision, an objective within our reach and a systematic framework to close the health gap between countries at different levels of development, thereby helping humanity to reach the SDGs as well. (Jamison et al. 2013)

This paper seeks to make the case that we still have to fully capture the benefits vaccinations can offer to humankind. Achievement of the SDGs can be greatly supported by fully leveraging the contribution that vaccines already available today, and of those that will be available in the near future, can offer. Improved decision-making, driven by a more accurate vaccine evaluation method fully capturing the broad benefits of vaccination will be of paramount importance for vaccines to provide their maximum support to the achievement of SDGs and the GC in Health over the next 15-20 years.

The Contribution Of Vaccines To Public Health And Global Development

Vaccines are a public health tool with extraordinary impact: most of the success they have had last century, particularly after WWII, in saving lives in western countries is due to the fact that they were used as public health tools by public health authorities,
deploying vaccines provided both by private and state-owned companies. Vaccination is universally considered the most successful and cost-effective medical intervention ever introduced (WHO 2013), saving yearly between 2.5 and 3 million lives and preventing countless illnesses. (WHO 2015) They have significantly contributed to the dramatic decline in mortality rates witnessed over the past decades. The 2015 MDGs Report states that measles vaccination alone helped prevent nearly 15.6 million deaths between 2000 and 2013, while the number of globally reported measles cases declined by 67 per cent for the same period. (UN 2015)

Vaccines are a crucial component in facing many challenges to reach the SDGs in the future. It was estimated that in 2013 6.3 million children worldwide died before reaching 5 years of age: this represents a decline from 9.9 million in 2000, despite an increase in births, demonstrating great progress in improving child survival. Nevertheless, MDG 4 (reduce child mortality by two-thirds between 1990 and 2015) will probably be achieved by only few countries. (Liu et al. 2015) Of the 6.3 million children who died in their first 5 years of life in 2013 (almost all in low-and middle-income countries - LMICs), 51.8% (3.26 million) died because of infectious diseases (IDs): pneumonia, diarrhoea, and malaria were the leading causes. (Liu et al. 2015)

A well-recognized shift is emerging from the analysis in the timing of child deaths: children are dying closer to the time of birth; deaths caused by infectious diseases (IDs), like pneumonia, diarrhoea and malaria are becoming more concentrated in the first 2 years of life. (Liu et al. 2015) In a recent systematic study Liu concluded that “although reductions in pneumonia, diarrhoea, and measles were responsible for half the decrease in deaths from 2000 to 2013, there is still a major uncompleted agenda for child infections, with a total burden of 3.3 million, just more than half of under-5 mortality.” (Liu et al. 2015)

Already today it is possible to greatly increase the impact vaccines can have on global health, by using the tools we have at hand, even before considering the contribution that new vaccines will offer.

Efforts should be made in two areas:

A. **Immunizing children with the available 11 vaccines against IDs recommended by WHO.**

Despite WHO recommending 11 vaccines, immunization coverage remains tracked via DTP3 coverage (3 doses: combined diphtheria-tetanus-pertussis vaccine). A coverage of 84% in 2013 (WHO 2015) appears high and may indicate the mission is almost accomplished: in reality 22 million children remain unimmunized (WHO 2015).

Coverage rates for other crucial vaccines, e.g. Hib and Rubella, are merely around 50%, while for Pneumococcus and Rotavirus, among the major causes of deaths under 5 years of age (Unicef, WHO 2014), are even lower: 25% and 14% respectively, (Fig. 1).

Moreover, in the words of GAVI’s CEO, Seth Berkley:

“When you include all of the 11 [vaccines] that the WHO says every child should have, a very different picture emerges. Less than 5 per cent of the world’s children are fully immunized when you add [when taking the other recommended vaccines into consideration] BCG (for tuberculosis), measles, rubella, polio, hepatitis B, *Haemophilus influenzae type B* (Hib), pneumococcal and rotavirus vaccines.” (Berkley 2014)
Figure 1: Global coverage (2013) for the 11 vaccines recommended by WHO

Besides targeting prevention programs more towards early age and reducing young children’s mortality through better planning and implementation of the primary series immunizations, newborns could benefit more from vaccines even before they establish their own immunity. During this period (usually until 4 to 6 months of age), infants are exposed to several pathogens. Vaccinating pregnant women during the third trimester against these pathogens induces immunity in the mother and, through the transplacental transfer of antibodies, in the newborn baby. (Rappuoli et al. 2014)

B. Including in decision-making methods capturing the full benefits of vaccination reaching well into a child’s life through adulthood, positively affecting the wider community and ultimately national economies. (Berkley 2014, Barnighausen et al. 2014a)

The level of contribution vaccines can offer to the reduction of poverty and economic/personal development is largely underestimated. (Bloom 2015) Research findings suggest that improvements in life expectancy translate into higher annual growth added to income per head. Once protected from IDs and resulting sequelae (disabilities), vaccinated children will grow up to be healthier children with improved cognitive development and longer periods of school attendance. Parents will be able to work instead of caring for a sick child, generate more income, save money, increase their spending power and improve their personal and economic development. (Berkley 2014) Findings from studies in the Philippines demonstrate that vaccination-related improvements in cognitive capacity and resulting test scores in children had a return on investment as high as 21%. (Bloom 2015) At the same time, the burden of IDs for humankind is not only reflected in the number of cases and deaths they cause, but also in resulting sequelae. For example, diarrhoeal and enteric diseases, besides being the second most frequent cause of deaths after pneumonia, result in life-long disabilities for children and their families. High incidence of enteric infections in countries lacking safe
water and adequate sanitation disrupts intestinal functions resulting in up to 43% stunted growth, affecting one-fifth of children worldwide and one-third of children in LMICs. Besides the health-related implications, the resulting life-long and chronic sequelae have a very serious impact on the capacity of children to become economically independent, greatly impacting on their personal development and on the wealth of the communities they belong to. (Guerrant et al. 2013)

**Fig 2: The impoverished gut - a triple burden of diarrhoea, stunting and chronic disease**

Vaccines are not the only solution to economic development and the reduction of poverty, but it is a fact that their impact is largely underestimated: more accurate analysis is needed to correlate increased coverage with the 11 recommended vaccines and the contribution they can offer to SDGs and the GC achievement.

**Vaccines In The SDGs And The GC**

Public and private sectors need to work together on a sustainable plan to align priorities on vaccination: priority setting based on simple microeconomic or isolated cost-effectiveness analysis will not capture the full benefits of vaccination: doing so, vaccines will remain significantly undervalued, underused and therefore we will not be able to fully leverage their contribution to the achievement of the GC and the SDGs. We argue that vaccines play a key role in directly supporting the achievement of at least 6 of the 14 SDG3 targets. We hold that better comprehension and assessment of the full benefits offered by vaccines and their optimal deployment, will facilitate development of comprehensive strategies to reduce burden of IDs paralyzing countless communities in LMICs, and consequently directly and significantly contribute to achievement of SDG3. Coincidentally, reducing morbidity and mortality due to IDs will contribute indirectly to the achievement of five other SDGs, as illustrated in Box 1.
Box 1. Impact of vaccination against infectious diseases on SDGs

**Goal 1. End poverty in all its forms everywhere**

Today, poverty has two major causes: conflicts and infectious diseases, blocking economic and social development. Preventing the infectious disease component of this vicious cycle will improve life and increase each individual’s contribution to their communities. Reducing sequelae, such as stunted growth and cognitive impairment, repeated infection and food malabsorption caused, for example, by diarrhoeal diseases, will ultimately reduce poverty. (Guerrant et al. 2013)

**Goal 4. Ensure inclusive and equitable quality education and promote life-long earning opportunities for all**

As reported above, vaccination-related improvements in test scores in children, had a return on investment as high as 21%. (Barnighausen et al. 2014a) Children free from IDs and life-long sequelae will become young workers with more personal achievements and longer, more satisfying personal working lives, reaching economic independence earlier in life.

**Goal 5. Achieve gender equality and empower all women and girls**

In the words of Seth Berkley, GAVI Alliance CEO: “Vaccination is one of the most gender equitable public health interventions ever. GAVI supports the immunization of about 60% of the girls born in the world”. (Berkley 2013) Moreover, reduction in the incidence rates of diseases affecting primarily children will allow mothers and female carers to reduce the time they have to devote to sick children, especially in countries where women bear the main burden of childcare. (Berkley 2014)

**Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all**

Reducing the negative impact of IDs will have a very positive economic impact on families, allowing their members to work, be economically independent, save money not spent on medicines or medical care, enabling their communities to benefit from healthier workforces. Lower child mortality will reduce birth rates, resulting in a general improvement of women’s health, giving higher financial stability to the entire family, as both parents will be able to regularly pursue a profession.

**Goal 10. Reduce inequality within and among countries**

The first step to realize the demographic dividend is improving health, especially women’s and children’s health, resulting in decrease in the number of births in each family, as children’s survival rates will be significantly higher. With more people contributing to the economy and fewer people needing support, countries will have better prospects of rapid economic growth. (General Assembly of the UN 2015)

The Lancet Commission Report on Global Health 2035 identified the ongoing high rates of infectious diseases and mortality from reproductive, maternal, newborn and child health diseases in LMICS as the first of the three challenges that governments will have to address in the coming 20 years. (Jamison et al. 2013) Examples of rapid decline in death rates recorded by China, Chile, Costa Rica and Cuba have been reported by the Commission on Investing in Health. (The Lancet Commission on Investing in Health 2014)
An even more compelling case for the role that the prevention of IDs through vaccination can play for fostering the development of nations and helping achieve the GC in Health in 2035 has been made by Rappuoli et al, comparing the relationship between ID incidence, life expectancy and national income in high-income countries in the last century with the current situation in LMICs. (Rappuoli et al. 2014) The analysis shows, on the one hand, how life expectancy at birth and per-capita income are strongly positively correlated, and on the other how both are strongly negatively correlated with the incidence rate of IDs: the relationship becomes clear when looking at specific indicators for the US in the last century. Life expectancy at birth has risen from 47.3 years in 1900 to 78.7 in 2014 (Arias 2014, National Center for Health Statistics 2015), while coincidently deaths caused by IDs fell from over 50% to less than 5%, a marginal percentage mainly due to two diseases, today already vaccine-preventable: influenza and pneumonia (Figs. 3 and 4).

Figures 3 and 4: Causes of death and life expectancy in the US in the 20th century

Van Panhuis et al. studied the reduction in IDs incidence rates vs. the introduction of vaccines targeting them. The analysis started with the smallpox vaccine introduced in the US around 1800, and compared life expectancy at birth, before and after vaccine licensure. Assuming that the difference between incidence rates before and after vaccine licensure for these diseases was attributable solely to vaccination, the authors estimated that a total of 103.1 million cases of these IDs have been prevented since 1924. Of those hypothetical cases, approximately 26 million were prevented in the past decade. (van Panhuis et al. 2013) A similar trend can be observed today for life expectancy and incidence rates for communicable diseases in countries worldwide, when considering their income level (Figs. 5 and 6).

Figures 5 and 6: Causes of death, life expectancy and per-capita income 2013
The graphs clearly show in 2013 a reduction of causes of total deaths in LMICs strikingly similar to the one in the US in 1800. Communicable diseases in LMICs are still causing >50% of deaths and life expectancy at birth is around 40 years. In the same year in other countries, as IDs’ contribution to total deaths decreased, life expectancy at birth increased and country income increased. Comparison of Figs. 3 and 4 with 5 and 6 clearly gives us a vision of how to attain the GC and, as a consequence, boost chances to reach the SDGs.

From the arguments presented here we can draw two important conclusions:
1. Fighting IDs carries a value reaching far beyond the prevention of death and sequelae; it is also dramatically correlated with country income and welfare levels.
2. The value of fighting IDs with the most effective public health tool available, i.e. vaccination, needs to be assessed with vaccine evaluation methods better suited to capture the full benefits of vaccination reaching well beyond the information simple cost-effectiveness can offer.

Vaccination Evaluation And Decision-Making

“‘Good’ (global)’ governance for health should exhibit at least the following key traits: effectiveness, equity, and efficiency in achieving outcomes, as well as credibility and legitimacy in decision-making processes.” (Frenk and Moon 2013)

The following deliberations outline general challenges of contemporary vaccine evaluation and decision-making and review new evidence and methods better suited to evaluate and consequently maximize vaccine-related health gains at the individual and aggregate level. We argue:
1. For manifold reasons, current methods of health economic evaluation - health economic analyses (HEA) – do not accurately predict the full impact of vaccines, especially as they fail to predict network effects at aggregate levels.
2. Highly significant effects not historically attributed to vaccination (broad benefits) remain greatly under-represented in current vaccine evaluation.
3. Multi-criteria-decision-analysis (MCDA) tools offer sophisticated and effective methods to incorporate and compound, for example, the diverse (direct and indirect) broad benefits of vaccination.
4. To leverage the maximum potential contribution vaccines can offer for attainment of sustainable development, vaccine evaluation methods should:
   a) capture and compound the broad benefits of vaccination,
   b) offer insights into how to systematically amplify the magnitude of broad benefits associated with vaccination and, for facilitating this,
   c) be standardized, streamlined and well-coordinated.
Contemporary Methods Of Economic Evaluation Of Health Interventions (Including Vaccines)

Today, economic feasibility is one of the most frequently used criteria for evaluating new vaccines. Generally, new candidate interventions are assessed by comparing one unit (increment) of value gained in return for one increment of cost, and comparing these ratios to existing interventions or other prospective alternative candidate interventions. (Phillips 2009, Barnighausen et al. 2014b) Different types of analysis, such as cost-effectiveness analysis (CEA) or cost-benefit analysis (CBA) exist to evaluate these ratios, but some appear more suited to evaluating vaccines than others. (Barnighausen et al. 2014b)

They all have in common computational models and sub-models simulating the behavior and interactions of variables, i.e. elements of cost (e.g. vaccine prices, administration costs), value (e.g. health gains, savings) and value decrease (e.g. discounting of health gains) (Beutels et al. 2002) over time. Many types of models with specific structures and many possibilities to calibrate, i.e. customize, exist. The choice of model and its calibration is a major challenge as its hypotheses/assumptions are often extrapolated from small datasets generated in clinical trials. (Black 2015) These assumptions have paramount influence on the results by determining how a model processes data, and consequently predicts, for example, the interactions between subjects, disease transmission rates, vaccine impact, and many other factors. (Bambha and Kim 2004, Kim and Goldie 2008) In particular, significant network and multiplier effects at the community and population level, such as herd immunity, and other indirect effects are difficult to predict. For example, measles ‘re-programs’ existing immune memory cells, resulting in a loss of previously established diversified immunity towards other infectious disease pathogens. By conducting time-series analysis for three countries, each spanning a period of 20 years (range: 1945-2010), and comparing the trends of Measles cases with those of mortality rates resulting from other infectious diseases, Mina et al. traced, at the population level, the significant benefit the measles vaccine represents for protecting against long-term (2-3 years) “measles-associated immune memory loss.” (Mina et al. 2015)

However, despite the importance of these highly beneficial effects, the design and conduct of clinical trials at this scale is neither practical nor ethically feasible. Moreover, many studies have demonstrated that models can be highly sensitive to relatively small modifications of, in some cases, only one assumption. For example, Bilcke et al. concerning different levels of vaccine efficacy among different age groups concluded that: “under assumptions least in favor of vaccination, vaccination is unlikely to be judged cost-effective at the expected vaccine price of €90 per dose […]. At the same price, but under assumptions most in favor of vaccination, vaccination is likely to be considered cost-effective for all age cohorts…”. (Bilcke et al. 2012)

It is therefore imperative to conduct sensitivity analysis to identify which parameters impact significantly on the results of a modeling study, especially with cost-effectiveness analysis, as the results are later related to pre-defined cost-effectiveness thresholds. This holds especially true for assumptions concerning economic parameters such as discount rates and vaccine prices as exemplified by the debate surrounding Nice’s generally rigid cost-effectiveness threshold (£20.000 to £30.000 per QALY gained) and the appropriateness of assumptions driving HEA in light of the recommendation of a Meningitis B vaccine to be introduced into the national healthcare system in the UK in 2013 and 2014. (Moxon and Snape 2013, Christensen et al. 2013, Christensen et al. 2014, Joint Committee on Vaccination and Immunisation 2013, 2014)

Here, a comparison of different national cost-effectiveness threshold models based on willingness-to-pay, such as the highly flexible threshold in The Netherlands, can be
instructive. (Baltussen 2015) Additionally, it should be noted that there is generally “no theoretical basis” (Raftery 2014) for the value of cost-effectiveness thresholds, and empirical evidence is only “very weak”. (Rawlins, Barnett and Stevens 2010) Furthermore, indirect costs, such as time losses for patients, carers and employers due to illness, are not traditionally captured in HEA. (Jit, Newall and Beutels 2013) Finally, the impact of disease outbreaks on short- and long-term business, such as tourism and foreign direct investments (FDI), can be significant and need to be incorporated into the analysis. (Bloom 2015) For all these reasons, and as “policies that block access to vaccines or prioritize vaccine-development efforts purely on the basis of economic considerations are both ethically and strategically flawed”, (Mekalanos 2013) HEA should not be employed as a gating criterion (Black 2013) for vaccine evaluation and decision-making, but rather assessed and contrasted alongside a comprehensive set of benefit-oriented criteria.

The Broad Benefits Of Vaccination

Over the past few years a growing body of research has been tracing and identifying benefits not previously associated with vaccination and consequently significantly expanding the scope of vaccine assessment from a narrow to a broad perspective (Barnighausen et al. 2014b, Bloom 2015). Conservative estimates indicate that the return on investment (ROI) of vaccination today in part matches and, in the near future will match, the ROI of education (18-21%) (Bloom 2015, Bloom and Madhavan 2015). Many benefits of vaccination at the family, community and national population levels are still not fully captured but the body of evidence is growing rapidly and methods to capture these benefits are becoming increasingly sophisticated. For example, a re-evaluation of the Haemophilus influenzae type b vaccine showed “that incorporating broad benefits of Hib vaccination would drive its benefit-cost ratios [BCR] well above 1 in a range of studies, indicating that the vaccination should be included in national immunization programs because it is net beneficial to society to do so.” (Barnighausen et al. 2014b)

As reported above, recent studies and study reviews have demonstrated that vaccination is key to reaching public health endpoints and, additionally, is a strong driver of economic development. The significant reduction of mortality rates and long-term sequelae due to vaccination result in demonstrably higher cognitive capacity in children, longer duration of education and consequently higher national productivity rates: “translating those gains [cognitive capacity of vaccinated children] into adult earnings yielded […] a 21% rate of return on the vaccine spending.” (Bloom 2015) Vaccination should therefore be appreciated as central to growth-oriented investment strategies, and not, as it sometimes is, viewed as a budgetary burden. Additionally, the cognitive and education-related benefits resulting from vaccination produce spill-over effects facilitating consecutive benefits such as higher individual and aggregate financial stability, savings and welfare, increased political stability, FDI and tourism and others. (Bloom 2015) Further benefits include herd-effects (vaccinated individuals do not host those pathogens against which they are protected and therefore cannot transmit them to unvaccinated individuals effectively protecting them too), decreased need for antibiotics and consequently deceleration of bacteria establishing antibiotic-resistance, significant reduction of outbreak control costs through outbreak prevention measures.

Moreover, assessment of different delivery methods and intervals of vaccine administration (i.e. accessibility) as well as other factors, such as the potential expansion of vaccine valence (the number of strains/diseases covered) and ‘ideal’ dosage are key in identifying the strategy leveraging the highest possible benefits of
introducing a vaccination program into a national health care system. (Bloom 2015)

Once compounded the broad benefits resulting from vaccination (and consequent health gains) constitute a considerable and comprehensive package of value frequently outweighing the associated costs. (Barnighausen et al. 2011) Consequently, vaccination represents long-term value for national, regional and global investment strategies reaching far beyond current individual health gains. (Bloom 2015)

Methods To Support Multi-Criteria Decision-Making

Capturing and assessing the broad and diverse set of benefits associated with vaccination necessitates the use of rational and user-friendly evaluation and decision support tools facilitating rapid ad-hoc evaluation of the real potential value of a vaccine under consideration and in particular its broader (e.g. societal) implications. Multi-criteria-decision-analysis (MCDA) is a method for “summarizing” the relevant information and structuring decisions and deliberative processes that involve multiple criteria” (Devlin and Sussex 2011) by providing “a systematic process for clarifying what is being taken into account (the ‘criteria’), how each of those criteria is to be measured, and how much importance (‘weight’) to put on each.” (Devlin and Sussex 2011) It should be noted here, that “criteria can be defined as attributes of benefit or aspects of social value that we value alongside health gain” (Claxton 2015), and thus attributes for MCDA are obligatorily not attributes of cost. Additionally, the weights assigned to the different attributes ideally should be consensually determined by a deliberative process involving the stakeholder groups affected by the outcomes produced by MCDA supported decision-making (Claxton 2015).

MCDA tools all follow a similar logic:
1. All attributes relevant to a vaccine or alternative interventions under consideration are quantified and entered into a performance matrix (table).
2. The different attributes are then weighted according to their relative importance.
3. Finally, based on the performance matrix, the different interventions/programs evaluated and scored in rank-order. (Baltussen and Niessen 2006, Devlin and Sussex 2011, Bærøe and Baltussen 2014)

MCDA not only facilitates integration and comparison of diverse attributes and multiple interventions but, additionally, offers the possibility to modify attributes within a reasonable range to assess different vaccine impact strategies/scenarios in order to identify those offering the most overall benefit.

Improving Vaccine Evaluation Through MCDA

Despite the considerable value MCDA tools represent for integrating and capturing the full benefits of vaccination, vaccine decision-making faces one particular challenge: there exists no consensus on which general attributes should be considered to capture the full benefits of a vaccine under consideration. In February 2015 we conducted an original exploratory study aimed at demonstrating that by surveying global vaccine experts, collectively representing a wide range of vaccine-specific professional expertise, it is possible to identify criteria, i.e. attributes, central to vaccine evaluation. Using rigorous statistical methods we identified 5 attributes chosen significantly more frequently than others (core criteria). The results of our exploratory survey provided a proof-of-concept. In July 2015, the survey was repeated with a different yet similarly composed group of vaccine experts and decision-makers prior to their attending a meeting on how to standardize, improve and streamline future vaccine evaluation procedures.

The results of the first and second survey were nearly identical (100% agreement on 4
out of the top five attributes chosen). The results of both surveys were then presented at the meeting, “Global Health 2035: Mission Grand Convergence. Multi-Criteria Systems Analysis to enhance and align vaccine decisions”, on the 18th of July 2015, in Siena, Italy. After presentation of the results, six focus groups consisting of representatives of academia, industry, public health policy, regulatory and donor agencies, discussed priority criteria for vaccine evaluation, and strategies to facilitate efficient, equitable and sustainable vaccine delivery, in light of the of the GC in Health 2035 framework. They not only confirmed the meaningfulness of core attributes (a shortlist of attributes) for vaccine evaluation but, in addition, echoed the specific results of the 2 surveys. Agreement was found on 2 key attributes, both of which had been identified as top attributes in the surveys, and on a third new attribute which, together, have become the potential list of 3 core attributes for vaccine evaluation. The results of the surveys and the meeting will be published in the near future.

Conclusions

Vaccination is a key public health tool and its benefits go well beyond the mere intervention on a target population to enhancing health and development of a country. If our goal is to reduce the burden of diseases and facilitate sustainable development, vaccines need to become a top priority on the global health agenda. We argue that utilizing vaccine evaluation methods capturing the full benefits of vaccination like MCDA alongside core attributes will create flexible, yet standardized, assessment processes leading to a more complete comprehension of the role and value of vaccines in facilitating and leveraging long-term sustainable development, across many sectors, creating synergies on a national, regional and global scale.

Once the broader benefits of vaccination will be more accurately estimated in evaluation method capturing its full benefits, considerable efforts should be invested in tailoring vaccination programs to amplify their leverage on all or a specific subset of broad benefits. Evaluation results for one setting will be readily adapted for evaluation of a vaccine in another setting: complex interconnectedness effects can be better understood anticipated and, in a next step, integrated in future evaluations. Without fully exploiting the broad benefits of vaccination we will not succeed in achieving several SDGs and the Grand Convergence in Health in 2035.

Conflict of interest statement
RR is a full-time employee of GSK Vaccines
JKT was also an intern at GSK Vaccines
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