Master of Public Health

Master de Santé Publique

Factors Contributing to Varying levels of Success in Pneumococcal Conjugate Vaccine Program Implementation in LMICs: A Comparative Analysis on Kenya, Rwanda, and South Africa

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Abstract

Background: Pneumococcal disease, any infection caused by the bacterium *Streptococcus pneumoniae* (S. pneumoniae), is a major public health concern worldwide, especially on the African continent. Kenya, South Africa, and Rwanda have some of the more successful pneumococcal vaccination programs in Africa, but still face challenges that can impact success. It is important to study and examine these countries' PCV programs to understand the similarities and differences of the programs and identify factors that contribute to a successful pneumococcal immunization program that can be implemented in other contexts.

Objective: The main objective is to answer the following research question: "What factors contribute to the varying levels of success in the implementation and sustainability of PCV programs in Kenya, Rwanda, and South Africa?"

Method: This study used a comparative analysis approach in which data was collected from several databases on Kenya, Rwanda, and South Africa's PCV programs. Data was coded according to the WHO IA2030 Framework for Action, and thematic analyzed for main themes of success.

Result: After analysis of the data according to the IA2030 Framework, four main themes of a successful PCV program included implementation strategies, financial sustainability, community engagement, and healthcare infrastructure. Despite using different approaches, all three countries found success in introducing and scaling-up their PCV program with varying degrees of challenges in each of the four categories.

Discussion: This study implies that vaccination coverage is feasible in resource-limited settings despite financial, logistical, and societal barriers. The implementation of and lessons learned from PCV programs in the three countries can provide a model for other LMICs that are aiming to bolster their immunization efforts and reduce mortality due to vaccine-preventable diseases.

Conclusion: This study found that implementation strategies, financial sustainability, community engagement, and healthcare infrastructure are crucial areas to focus on for success of a PCV program. It is important to take lessons learned from these countries' diverse experiences and adapt the factors of success for other countries' immunization programs to continue the trend of eliminating pneumococcal disease burden worldwide.

Keywords: pneumococcal disease, pneumococcal conjugate vaccine (PCV), pneumonia, invasive pneumococcal disease (IPD), and streptococcus pneumoniae

Introduction / Literature Review

Background

Pneumococcal disease epidemiology

Pneumococcal disease, any infection caused by the bacterium *Streptococcus pneumoniae* (S. pneumoniae), is a major public health concern worldwide. Responsible for the deaths of over one million children every year,[1] approximately, 14% of all deaths in children under five,[2] pneumococcal disease significantly contributes to clinical disease and economic burden. Disease and mortality rates are higher in the developing world, with most deaths occurring in Africa and Asia.[3]

There are more than 90 different strains, or serotypes, of S. pneumoniae that can cause infections ranging from mild to severe.[4] Pneumococcal disease is separated into two categories: invasive pneumococcal disease (IPD) and non-invasive pneumococcal disease. Non-invasive infections occur outside the main organs and blood and are typically less serious. These infections include bronchitis (infection of the bronchi—the tubes that run from the windpipe to the lungs), otitis media (ear infection), and sinusitis (sinus infection).[4] Invasive pneumococcal infections are serious and occur within a major organ or the blood. Meningitis (infection of the meninges—the protective membranes surrounding the brain and spinal cord), pneumonia (lung infection), septic arthritis (joint infection), osteomyelitis (bone infection), septicemia (a serious blood infection), and bacteremia (a more mild blood infection) are considered invasive.[4]

The disease occurs mainly in children <2 years and adults ≥65 years, as well as those who are immunocompromised, although anyone can be infected through the spread of airborne droplets frequently colonized in the nasopharynx.[5] Infants are considered the main carrier and transmission group[6], and along with older adults and at-risk groups with certain medical conditions, are also more likely to progress into invasive disease.[7] Carriage rates among children range from 27% to 85%, with higher rates found in children located in low and middle income countries (LMICs).[8]

A focus on Africa

Pneumococcal disease rates are estimated to be the highest on the African continent, causing over 4 million cases annually in children under five years of age.[8] As a leading public health challenge and cause of death among children in Africa, the majority of the 800,000 deaths from pneumococcal disease infections in children under 5 years of age worldwide occur in developing countries.[9] Estimated mortality numbers may be even more substantial, but due to the lack of robust surveillance systems to monitor and address the burden of disease in Africa,

an exact burden count is unknown. A set of 26 countries in Africa, known as the "African Meningitis Belt" (AMB), face high rates of meningococcal disease, but are also heavily burdened by pneumococcal disease (see *Figure 1*).[10] Kenya and Rwanda are considered part of "Meningitis Belt", with South Africa following not far behind in terms of increased risk. Meningococcal disease outbreaks, although possible globally, are most common in the AMB, with large-scale epidemics of the disease every 5-12 years.[10] These areas are also prone to higher levels of pneumococcal disease because *S. Pneumoniae* is a major cause of both bacterial meningitis and pneumonia.[10]

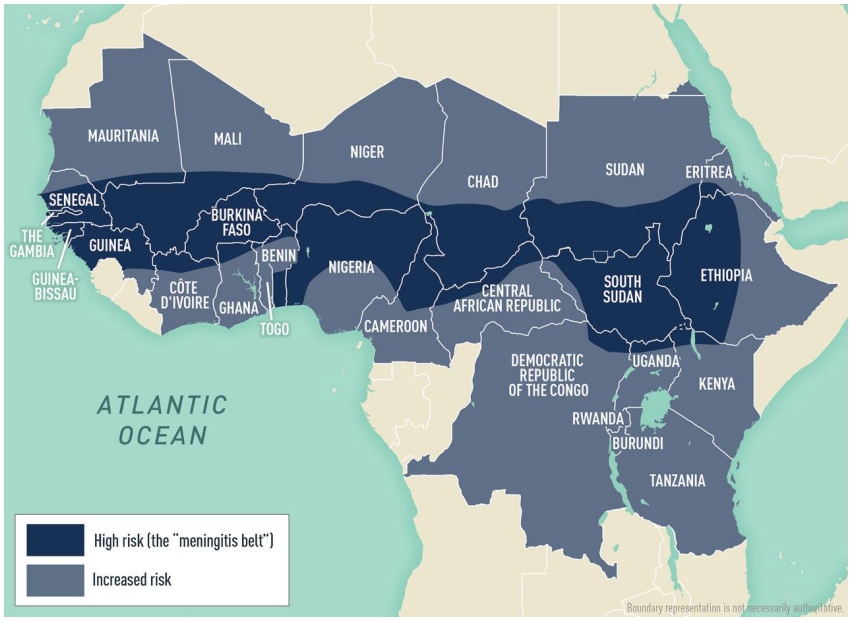


Figure 1. African Meningitis Belt[10]

Africa has the world's second-largest population of approximately 1.3 billion people,[11] and faces critical health challenges that highlight the need for robust immunization strategies. The continent is home to many diverse LMICs, in terms of geography, culture, healthcare systems, and socioeconomic factors. Therefore, one approach to immunization programs will not be successful if applied to all countries in Africa. Kenya, South Africa, and Rwanda have some of the more successful pneumococcal vaccination programs in Africa, but still face challenges that can impact success, and are also at varying points with other vaccine introductions.[12] It is important to study and examine these countries' pneumococcal vaccine programs to understand the similarities and differences of the programs and outcomes and identify factors that contribute to a successful pneumococcal immunization program. The results

can be developed and adapted for implementation in diverse contexts throughout the continent—allowing immunization programs to be more sustainable and equitable, as well as ensure better health outcomes overall.

Kenya

The Kenyan Ministry of Health leads vaccination efforts but spends below the recommended amount of the country's GDP on healthcare, so support from Gavi, The Vaccine Alliance, WHO, and UNICEF is necessary.[13] The healthcare system is a mix of public and private sectors, with disparities noticeable in access and quality.[14] In 2008, before PCVs were introduced, the country had an estimated 111,000 deaths of children under five years.[2] In 2011, Kenya introduced the PCV10 vaccine into its national immunization program. It was one of the first African countries to roll out this vaccine. Since the introduction of the vaccine, there has been a substantial reduction in pneumococcal disease, but challenges still exist, particularly with uniform vaccination coverage across different regions.[2] The pneumococcal vaccine is a key component of the country's immunization program for its large and diverse population of approximately 55 million people,[15] but remains the single leading cause of death in children under five.[2]

Rwanda

Rwanda, a small landlocked country in east Africa, densely populated with 13 million people[16], was the first low-income country to introduce PCV to its routine schedule for children in 2009.[17] Rwanda has a decentralized health system with a focus on community based primary healthcare.[18] The Rwandan Ministry of Health oversees immunization programs with substantial aid from Gavi, WHO, and UNICEF. CITE. NGOs and community health workers are critical in the healthcare system. Approximately 7-8% of the GDP is spend on health.[19] Before PCV introduction, in 2007, 154,000 children under five died each year in Rwanda.[20] Despite barriers, including physical geography and extreme poverty,[21] PCV coverage rates are currently around 98%—some of the highest in Africa.[22]

South Africa

South Africa, home to around 60 million people,[23] introduced PCV into its public immunization program in 2009.[24] The implementation was State funded, because as a middle-income country South Africa is ineligible for financial support from GAVI, and qualifies for less external funding from international partners like UNICEF than many other African countries.[25] The country has a relatively advanced two-tiered health system with a large public sector,

spends 8-9% if its GDP spent on healthcare, more than the WHO recommended amount, yet remains under resourced relative to need.[26]In 2009, after the introduction of PCV, the estimated vaccine coverage was 10%, and in 2012 it was 99%.[24] According to current data, in 2019 the coverage rate was around 90.7%.[27] South Africa has one of the highest vaccine coverage rates in Africa, but disparities are prevalent across socioeconomic classes, and there is still considerable PCV-13 serotype disease in both children and adults, as well as stability in IPD incidence.[28,29]

Pneumococcal Immunization

Immunization is an important prevention strategy to control the spread of and prevent deaths from pneumococcal disease. The high levels of disease in Africa require attention and prioritization within their vaccination programs to reduce pneumococcal-related deaths. The pneumococcal conjugate vaccine (PCV) protects against infections caused by *S. pneumoniae*, particularly among children under five years of age.[12] The first PCV vaccine was PCV7, to protect against seven of the most common and invasive serotypes of *S. pneumoniae*. As the disease epidemiology progressed over the years, and the need for new vaccines to cover emerging serotypes grew, PCV10, PCV13, PCV15, and PCV20 have developed over the years to offer broader protection of serotypes.[30] Following the WHO recommendation for all countries to include PCV in their national immunization schedules, 48 of the 54 countries in Africa have added PCV into their national or subnational immunization schedules from the introduction of the vaccine in Africa in 2009 to 2016.[12,31] Kenya, Rwanda, and South Africa include PCV in their immunization schedules, with a recent overall reduction in hospitalizations and deaths association with pneumonia, sepsis, and meningitis.[12,32] However, despite these successes, challenges such as vaccine coverage disparities and health system limitation continue to impact the full potential of PCV vaccines in Africa. For example, with overall high coverage within the immediate introduction period, two years post introduction of PCV in Africa, nearly one-third of countries did not achieve 80% infant coverage, and 58% of countries experienced a decline in coverage 2-4 years post PCV introduction.[33]

Substantial mortality rates in Africa continue to be driven predominantly by mortality from pneumococcal pneumonia (see *Figure 2*).[34] Vaccines have the ability to effectively reduce pneumococcal disease and could have a major impact on Africa's morbidity and mortality overall.[11,35] A focus on the successes and challenges of pneumococcal vaccination programs in

Kenya, Rwanda, and South Africa will not only provide insight into their PCV immunization programs and improve health outcomes in these countries, but will also contribute to reducing the global burden of pneumococcal disease[36]—particularly those in the six remaining countries in Africa who have yet to add the vaccine to their routine schedules and those with low coverage.

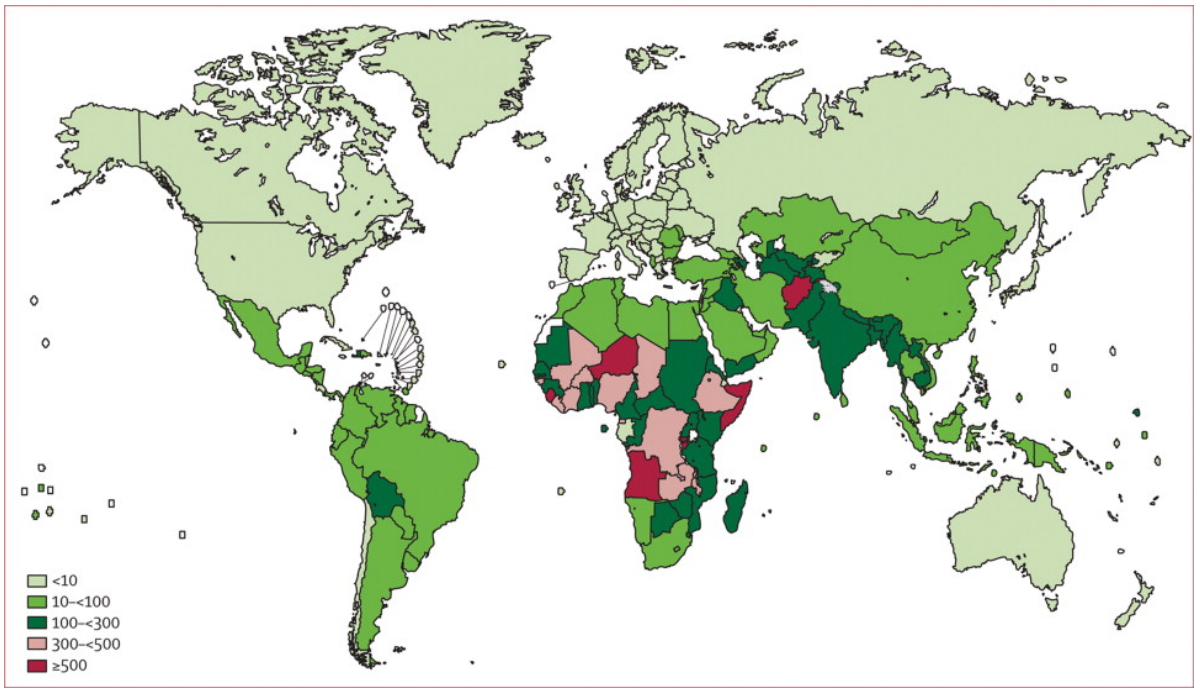


Figure 2. Pneumococcal mortality rate.[34]

The impact of vaccination relies heavily on each country's implementation strategies. While vaccines have made strides in controlling the spread and severity of pneumococcal vaccinations in industrialized countries, there is growing concern, particularly in some countries within the WHO African region, of stagnated infant immunization coverage and the continued growth of pneumococcal infections despite the introduction of new vaccines.[33] Therefore, it is important to understand what drives a successful pneumococcal vaccine campaign— and what failures can derail progress and sustainability of the vaccine's impact. With the accelerating uptake of pneumococcal vaccination in Africa and across the world, there is a need to document low-and-middle income countries' experiences for future planning and implementation of new vaccines.

Aims and Objectives

The main objective is to answer the following research question: "What factors contribute to the varying levels of success in the implementation and sustainability of PCV programs in Kenya, Rwanda, and South Africa?"

Sub-objectives include:

- Conduct an analysis of the PCV program implementation strategies in Kenya, Rwanda, and South Africa
- Analyze challenges to a successful and sustainable immunization program
- Highlight best practices and successful strategies that can be replicated in other regions

This study aims to provide a broad picture of successful PCV programs in LMICs, specifically in Africa. It also aims to highlight challenges and define best practices that can be implemented in other regions through the analysis of three case studies of selected countries.

Methods and Framework

The research design is a comparative analysis of PCV programs within LMICs in Africa, using secondary data. Kenya, Rwanda, and South Africa were chosen as three countries of focus. These countries were chosen to examine further because they were early adopters of PCV in Africa and represent diverse healthcare landscapes and varying levels of success in implementation. Kenya was the first African country to roll out PCV10 in 2011.[37] Rwanda, with significant support from Gavi, introduced PCV into its national immunization program around the same time and was the first developing country to do so.[38] South Africa followed soon after and has one of the oldest PCV programs in sub-Saharan Africa.[39]

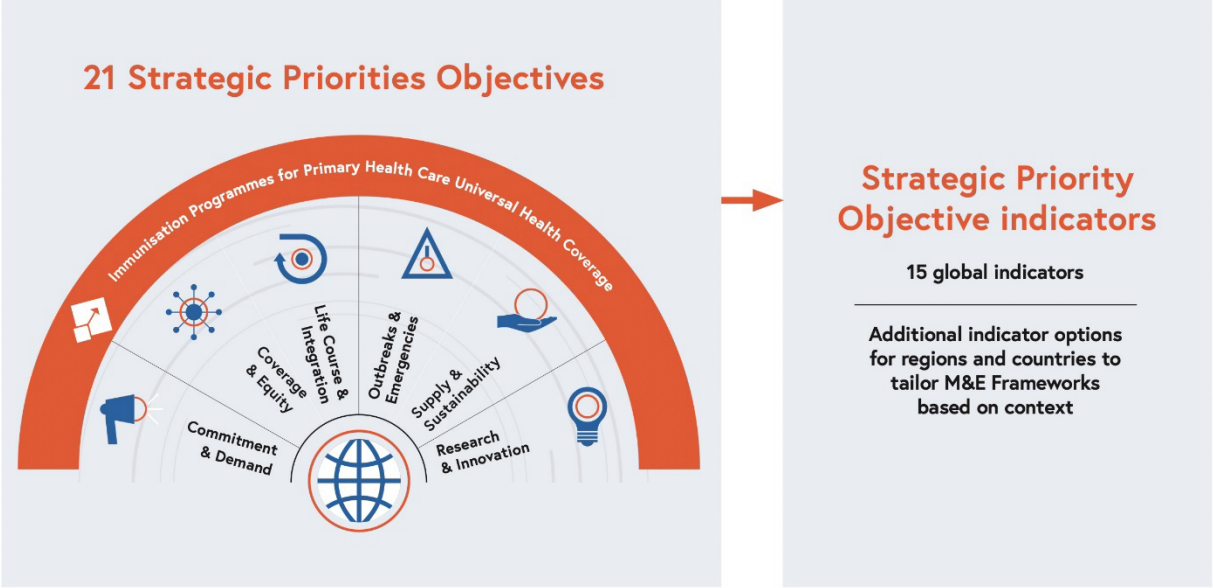
Data was collected between mid-March 2024 to June 2024 using two methods. First, the primary data collection method was a specific literature search using reports from WHO, Gavi, and UNICEF to review the context of pneumococcal disease in each country and any available evaluation reports on their PCV programs. For any missing pieces of data, a second method was conducted, which included an online literature search on the following databases: PubMed, Science Direct, JSTOR, and Medline. The following keywords were used to complete this search: *pneumococcal disease, PCV (pneumococcal conjugate vaccine), PCV7/10/13/15/20, (childhood) pneumonia, invasive pneumococcal disease (IPD),* and *streptococcus pneumoniae.* A general search strategy also included key phrases *"pneumococcal disease in Kenya"* and *"PCV immunization program in Kenya."* Similar searches were conducted for both Rwanda and South Africa. Data inclusion criteria included literature in English, and focused on literature

published from 2009 to 2024, as PCV implementation in selected countries didn't begin until 2009. Sources published before 2009 were not ruled out, if relevant to understand the pre-vaccine pneumococcal disease context. Other study quality criteria included peer reviewed journals and authors' affiliation to a reputable organization or university. A total of 51 scientific articles or reports were reviewed. The types of studies were collected were quantitative, qualitative, systematic reviews, and mixed methods in the African scope. Using Zotero software, the data collected was then thematically analyzed for each country using the WHO Immunization Agenda 2030 Framework for Action (see *Figure 3*) as a benchmark to discover common factors of success against the seven strategic imperatives. These seven indicators include Commitment and Demand, Coverage and Equity, Life course and Integration, Outbreaks and Emergencies, Supply and Sustainability, Research and Innovation, and Immunization Programs for Primary Health Care and Universal Health Coverage.[40]

WHO Immunization Agenda 2030 (IA2030) Framework

The IA2030 is a global strategy developed by the WHO to maximize the lifesaving impact of vaccines over the next decade by aligning all stakeholders around a shared vision, priorities, and goals.[41] It was developed using lessons learned from the implementation of the Global Vaccine Action Plan (2011-2020).[41] The Framework for Action was originally created to focus on the COVID-19 vaccine response, is intended to be an adaptive and flexible strategy tailored by countries to meet their needs.[40] A framework specific to PCV in each of the selected countries has not yet been established. Only a general regional IA2030 report for Africa has been published.[40] Therefore, there is a need to evaluate the current PCV programs in these countries in parallel with the IA2030 Framework to ensure successful and sustainable strategies related to pneumococcal disease and vaccination. The IA2030 includes seven strategic priorities along with strategic priority goals as the basis for evaluation (Appendix 1). The purpose of the Framework for Action is to describe how critical operational elements from immunization programs enable a successful strategy into its implementation phase.[40]

Figure 3. IA2030 Strategic Framework for Action.



Results

After analysis of the secondary data according to the IA2030 Framework strategic priorities and goals, four main themes emerged of what contributes to the foundation of a successful PCV program in a LMIC. These four themes included implementation strategies, financial sustainability, community engagement, and healthcare infrastructure. In line with the IA2030 Framework, financial sustainability and healthcare infrastructure fall under the Supply and Sustainability strategic priorities. The implementation theme was categorized under Research and Innovation strategic priorities, as well as Coverage and Equity. Community engagement was categorized under the priorities of Commitment and Demand. Despite using different approaches, all three countries found success in introducing and scaling-up their PCV program with varying degrees of effectiveness in each of the four categories.

Implementation strategies

All three countries included PCV in their National Immunization Policy Guidelines, but each with an approach to their implementation strategy that reflected their unique healthcare landscape. One of Kenya's key program components was their focus on "catch-up" vaccination. After the introduction of the vaccine for a three-dose schedule of PCV10 for infants and an initial catch-up vaccination for those less than one year old,[42] Kenya expanded their catch-up strategy to vaccinate children up to five years of age who were older than the typical infant vaccination age but remained vulnerable to pneumococcal diseases.[43] Another strength of the Kenyan implementation strategy was their adaptability by continuously monitoring and surveilling

pneumococcal disease to assess vaccine impact and adjust strategy accordingly. For example, in Kilifi, Kenya, a robust surveillance system detected the decrease of IPD by 68% in children under five years of old post vaccine implementation from 2012-2016.[44,45] Despite overall high coverage rates, a challenge faced by Kenya's implementation strategy was their "fixed post" administration to deliver vaccinations at designated health facilities. This strategy created barriers for those living in rural communities who have limited access to health facilities to complete all doses of PCV.[46] It can be shown in their slight decline of final dose vaccine coverage from 87% to 84% in 2023, according to official WHO reports.[47]

Rwanda's implementation strategy took advantage of their smaller size to create a streamlined rollout that placed a strong emphasis on equitable access to vaccines, even in the most remote communities.[48] This has allowed them to currently have the highest final dose vaccination coverages rates out of the three countries at 94% in 2023, and had a coverage of 88-98% in 2021 for those who received at least one dose.[47] Rwanda was able to integrate their PCV program into their existing primary healthcare system, which allowed for routine access to vaccination during visits.[48,49] The country has an inter-agency coordinating committee (ICC) that manages all national immunizations and completed the PCV implementation sequentially by province to ensure central oversight and quality.[48] Rwanda's centralized and coordinated implementation strategies were very efficient for a rapid nationwide rollout and sustained PCV coverage. Their Ministry of Health began intensive cross-sectoral planning at least one year before introducing each vaccine, carefully reviewing pneumococcal burden data.[48] However, knowledge gaps exist, as official data reports for 2022 vaccination coverage are unknown.[47]

As a LMIC with a higher income than Kenya or Rwanda, South Africa's relatively advanced healthcare system has supported an efficient implementation strategy with a high overall PCV final dose coverage rate of 84% in 2023,[47] but large disparities are prevalent between urban and rural communities.[50] South Africa showed a coordinated effort to streamline its implementation as the first African country to incorporate PCV into its national routine infant immunization program.[51,52] South Africa also switched their strategy from using PCV13 to PCV10 due to their supplier the Serum Institute of India (SII), which allowed for broader vaccine coverage in a cost effective manner.[53] This vaccine strategy transition did not compromise the overall effectiveness of the program, since despite the fact that PCV13 protects from more serotypes, PCV10 covers the most common serotypes in South Africa.[27]

Healthcare infrastructure

Despite Kenya's success in its pneumococcal program, the country initially faced numerous logistical issues with its cold chain systems, such as lack of reliable electricity. They also had

difficulty reaching remote areas due to inadequate road infrastructure to less populated areas, however, according to Gavi, the estimated 83% coverage is considered reasonably equitable with respect to income and urban versus rural settings.[54] Although infrastructure and logistics was a weak point of the Kenyan PCV program, governmental and international support from Gavi were crucial to overcoming logistical challenges by investing in cold chain improvements to correct temperature errors during transportation and storage.[54] The use of information and communication technology (ICT) for supply chain management improved over time to reduce pneumococcal disease burden, but small delays and inefficiencies remain with vaccine distribution.[54,55] To mitigate weaknesses with Kenya's supply chain, the Kenya Ministry of Health developed the "Immunization Manual for Health Workers" to provide healthcare workers with strong training, which them to maintain high quality clinical services and effectively delivery the vaccine.[56,57] This was part of their initiative to build resilient and responsive health systems and progress toward universal health coverage.[56,58] In both Kenya and Rwanda, introduction of PCV was found to strengthen health workers' skills through training and increase the perceived credibility of the overall immunization program of the country.[59]

Rwanda had a very well-organized healthcare infrastructure and logistics plan which led to more effective vaccine distribution and administration. PCV was available throughout the nation within five months of the start date.[60] Specifically, they developed specialized training and micro-planning workshops in all districts for workers involved in vaccine handling, delivery, and immunization education beginning years prior to PCV introduction.[48] These trainings involved topics such as immunization technology, vaccine and equipment management, injection safety, waste disposal, adverse events education, and communication techniques.[48] Logistically, Rwanda focused on vaccine availability, cold chain capacity, and disease burden. In 2007, two years before the introduction of the vaccine, there was a countrywide evaluation of cold chain and storage capacity that led the Ministry of Health to lease new storage space, as well as build an extra cold room and new incinerators.[61] In 2011, Rwanda's switch from PCV7 to PCV13 created flexibility in their infrastructure because PCV13 requires a lower incineration temperature than PCV7 and requires less cold storage space.[48] To deliver vaccines to remote areas and eliminate any geographic disparities, motorcycles and cold box transport were used.[48] Rwanda has a very robust Health Management Information System (HMIS) that was used to monitor pneumococcal data for public and private health facilities in order to support broad vaccine rollout decisions.[48]

South Africa's relatively well-developed vaccination infrastructure facilitated the PCV rollout and helped in reaching wide coverage, but not without challenges from pressures of the country's geographic and socioeconomic diversity. Post-apartheid, the South African government has invested in projects to build up infrastructure and reduce the disparities the country has been fraught with for years. These projects include improving access to healthcare facilities, developing a National Health Insurance plan, improving access to sanitation, as well as free primary education.[62] A crucial part of the country's PCV implementation success relied on the fact that the government provides free health care to all children which ensured access to the vaccine.[24] Additionally they are able to have a country wide laboratory based surveillance system, because 80% of the population and almost 100% of hospitalizations are serviced by a single laboratory, to track IPD and pneumococcal trends.[63] South Africa's well-equipped health facilities and reliable electricity access were essential for maintenance of the vaccine cold chain. Broad improvements in the healthcare system, such as HIV testing and treatment programs, were found to support the reduction of IPD and pneumonia mortality through limiting co-infections and decreasing vulnerabilities that impact health outcomes.[59] Overall PCV coverage rates in South Africa were high, but there were some disparities between individuals in urban vs. rural settings.[64] It was found that rural areas had lower vaccination rates due to logistical challenges and resource limitations, limiting timely vaccine administration and completion of follow-up doses.[65] Despite the contradiction of South Africa suffering from numerous socioeconomic inequalities, it was found that effective and targeted logistics were able to help them achieve a successful overall PCV program. For example, mobile clinics utilizing their railway network were used to reach rural and remote areas for vaccination.[62,66]

Community engagement

One of the challenges of sustaining high PCV coverage in Kenya was maintaining accurate immunization histories. Without accurate data, it is hard to assess vaccine and program impact. To overcome this, Kenya deployed community health workers (CHWs) to retrieve vaccine cards that included medical record and receipt of vaccines in the national immunization program from community members. It was found to increase history card retrieval by 27% from 2012 to 2013, and aided in filling in knowledge gaps from the ongoing demographic surveillance system.[55,67] Additionally, community health volunteers were selected to serve approximately 100-500 individuals each month in their county to share vaccination promotion messages, refer community members to vaccination locations, and dispel any myths and misinformation about PCV.[68]

This study showed that one of the keys to Rwanda's PCV program success was their emphasis on utilizing community health workers to engage the public. Prior to this program, the country faced an issue of decentralization of communication, technology, and medical capacity.[48] It was found that community health workers helped to bridge this gap, along with awareness days and campaign media strategies. To change public perception of the vaccine and encourage public acceptance, awareness days included numerous members of the community, such as, local authorities, teachers, traditional healers, religious leaders, and non-governmental local community organizations. Media campaigns distributed by radio, newspapers, television, and at community meetings were effective forms of outreach by community members, focusing on the risks and benefits of vaccinations.[48] Before PCV implementation, around 80% of the population lived in rural areas in 2007. To broaden vaccine coverage, it was essential to decentralize messaging, as well as medical and technical capacity to ensure vaccines were equitably distributed nationwide.[48]

In South Africa, vaccine hesitancy was found to be an issue influenced by misinformation, cultural beliefs, and trust issues within the healthcare system. Widespread community engagement in general was found to be difficult to achieve, as the country is diverse both in geography and socio-economically.[69,70] Community health workers had a voice in this instance, and despite challenges made progress in maintaining public trust to achieve high levels of PCV coverage.[71] They were found to have a helpful role in remote areas, where they built trust within the community, where many individuals had past negative experiences with the healthcare system or cultural beliefs that made them question the vaccine.[72] Compared to Kenya and Rwanda, South Africa had the least amount of data on community engagement and its effectiveness specific to PCV.

Financial sustainability

All three countries analyzed rely on Gavi for financial support, to varying degrees. Rwanda received the most support, Kenya in a similar manner, and South Africa with the least financial support from Gavi as they are considered a middle-income country. Due to the help of the Vaccine Alliance, countries supported by Gavi were able to access PCVs at the same time as high-income countries.[73] In the past, new vaccines have taken up to 15 years to reach lower-income countries. This is known as the Pneumococcal Advance Market Commitment (AMC), which is largely funded by the World Bank, Italy, the UK, Canada, Russia, Norway, and the Bill & Melinda Gates Foundation who have contributed more than $1.5 billion to the Pneumococcal

AMC.[73] In 2023, the AMC's eleventh year of implementation, has facilitated 161 million pneumococcal vaccine doses for lower income countries, which is 8% higher than in 2018.[73] With procurement, distribution, and technical assistance from the WHO and UNICEF, Gavi also contributed $3.3 billion from 2009 to 2020 to support the cost of PCVs.[74]

When Kenya introduced PCV, Gavi paid a majority of the costs of implementation.[73] In 2022, Kenya entered the accelerated transition phase out of Gavi support, which raised major concerns over the sustainability of the program.[45] Kenya was highly reliant on Gavi funding and not prepared to successfully transition from their financial support. Cost effectiveness studies demonstrated a strong rationale for continued investment,[75] and Gavi has extended support for Kenya's PCV program until 2029.[67] Despite successes of the PCV program, a future transition to self-financing poses challenges.

Rwanda government overcame challenges related to difficulty reaching the rural population by relying on targeted funding to increase the number of community health workers, communication techniques, and new cellular-data collection strategies.[76] Rwanda has met or exceeded expected results using Gavi funding, which helped the country continue to secure necessary external funding in years after.[76] For example, in 2011, an assessment found that many primary health centers in Rwanda needed additional cold chain capacity. The government applied for Gavi support and received the funding 3 months later.[77] Overall, Rwanda was found to have a PCV program was financially prepared and sustainable.

South Africa's middle-income classification meant that the government had to co-finance a much larger portion of its PCV program compared to Rwanda and Kenya.[73,78] While this brought on challenges, the approach allowed for long-term sustainability and for South Africa to gradually take over financial responsibility for the immunization program without backsliding its reduction in pneumococcal disease burden.[79] Results showed that despite receiving less financial support than other low-income countries, South Africa still benefitted from negotiated vaccine prices and technical assistance from Gavi.[79]

Discussion

IA2030 has three main impact goals (see Appendix 2) that overarch the seven impact goal indicators. These include reducing mortality and morbidity from vaccine preventable disease throughout the life course, leaving no one behind by increasing equitable access and use of new and existing vaccines, and ensuring good health and wellbeing for everyone by strengthening immunization within primary health care and contributing to universal health coverage and sustainable development.[40] The analysis of PCV programs in LMICs alongside

the IA2030 framework is crucial to ensure that countries are aligned with and set up to progress and meet WHO's immunization goals. This study found that Kenya, Rwanda, and South Africa focused on at least 4 showed that if countries focus on at least a few of these priorities in their immunization strategies—which led them to implement successful PCV programs.

These results highlight the fact that successful PCV implementation is possible in LMICs with strategies tailored to handle a country's unique challenges and strengths. Overall, Rwanda, a small and low-income country, had one of the most coordinated PCV programs. South Africa, with the highest income out of the three countries studied, had high coverage and reduction in pneumococcal disease, but faced challenges with geographic and socioeconomic disparities. Kenya had a strong phased rollout approach integrated into their existing vaccination programs alongside community health volunteers but struggled with securing financial sustainability.

While these case studies provided an opportunity to understand what makes a PCV program successful in a diverse set of countries, there were a few limitations to the study. First, for a more in-depth analysis, a greater number of articles and reports could have been collected. As data surveillance from LMICs is difficult to collect and manage due to limited resources, some data on country programs may not fully reflect the current situation or was missing. Most data collected was from 2007-2011, around the time of the first PCV implementation. Once more recent data is made available, it could be compared against the less recent data. Future research should focus on collecting more primary data, such as interviews from government leaders, community members, and other stakeholders to analyze what components are crucial for a LMIC to have a successful and sustainable immunization program. Additional research can use the IA2030 Framework to not only study PCV, but other vaccines as well.

Implications of this study are that high vaccination coverage is feasible in resource-limited settings despite financial, logistical, and societal barriers. While progress has been made in terms of reducing global pneumococcal disease burden,[80] efforts must continue in LMICs to ensure the success and sustainability of immunization programs in order to continue to reduce pneumococcal-related morbidity and mortality. The implementation of and lessons learned from PCV programs in Rwanda, Kenya, and South Africa can provide a model for other LMICs that are aiming to bolster their immunization efforts and reduce mortality due to vaccine-preventable diseases.

Conclusion

The introduction of PCV vaccines in Africa has made a major impact on pneumococcal disease and mortality, but it remains a global health problem--particularly for LMICs.[81] Pneumococcal vaccination programs in Africa are largely focused on immunizing children as the target population. However, data on the epidemiology of pneumococcal disease and carriage before and several years after PCV introduction in the AMB suggest the current infant only PCV program may not be appropriate to control transmission in the near term.[82] The success studied in Kenya, Rwanda, and South Africa's programs could be applied to improving and controlling pneumococcal disease in other African countries, as well as other for diseases, in the adult population.[82] This highlights the importance of continuing to study what contributes to successful immunization programs in the LMIC context.

Kenya, South Africa, and Rwanda are examples of successful and effective pneumococcal vaccination programs but were not immune to challenges. This study found that implementation strategies, financial sustainability, community engagement, and healthcare infrastructure are crucial areas to focus on for success of a PCV program. As the pace of vaccine uptake accelerates across Africa and around the world with the support of Gavi and other organizations,[83] it is important to take lessons learned from these countries' diverse experiences and adapt the factors of success for other countries' immunization programs to continue the trend of eliminating pneumococcal disease burden worldwide.

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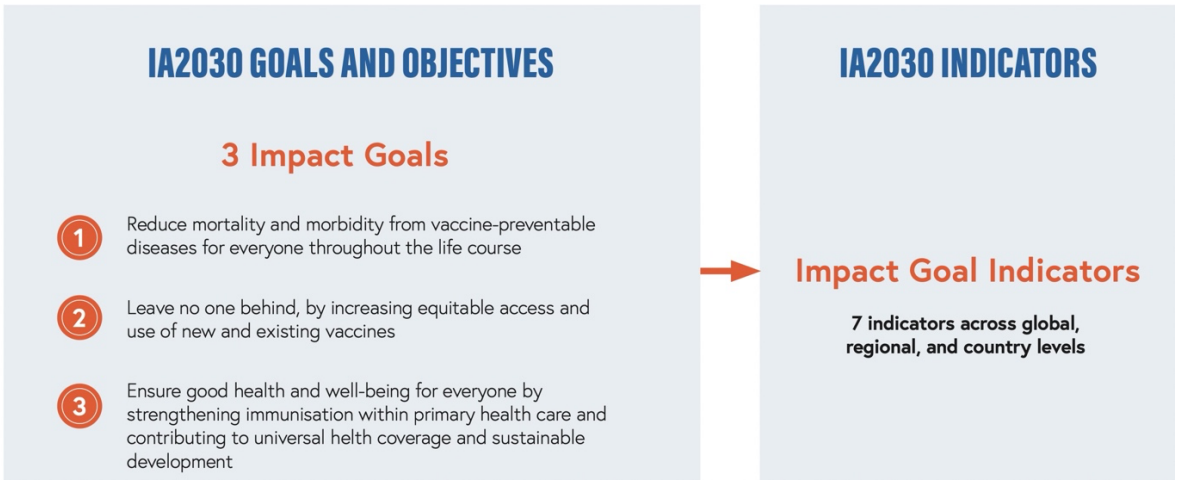
Appendix

Appendix 1: IA2030 Strategic Imperatives & Goals

Immunisation Programmes for primary health care/universal health coverage	• Ensure adequate health workforce availability • Build and strengthen comprehensive vaccine-preventable disease surveillance supported by strong and reliable laboratory-based systems • Secure high-quality supply chains and effective vaccine management to facilitate equitable coverage in immunisation and establish synergies with other primary health care supply chains where possible • Generate fit-for-purpose immunisation data for evidence-based decision-making • Ensure functional vaccine safety systems in close collaboration with national regulatory agencies
Commitment & Demand	• Build and sustain strong social, financial and political commitment for immunisation • Strengthen leadership, management and coordination for immunisation at all levels • Ensure people and communities value, actively support and seek out immunisation services
Coverage & Equity	• Reach high equitable immunisation coverage at national level and in all districts • Increase coverage of vaccines among the most disadvantaged populations • Reduce the number of children not reached through the immunisation programme ("zero-dose" children)
Life course & Integration	• Strengthen policies and service delivery to provide new and underused vaccines and appropriate catch-up vaccination across the life-course • Establish integrated delivery touchpoints for immunisation and other public health interventions across the life course
Outbreaks & Emergencies	• Decrease the number and magnitude of outbreaks of epidemic-prone vaccine-preventable diseases • Ensure timely, well-organized responses to outbreaks of epidemic-prone vaccine-preventable diseases • Establish timely and appropriate vaccination services in acute emergencies and humanitarian crises
Supply & Sustainability	• Build and sustain healthy markets across all antigens at the global level • Safeguard access quality assured vaccines in a timely fashion in all countries • Ensure sufficient financial support for immunisation programmes across all countries to achieve universal coverage • Increase immunisation expenditure from domestic resources for aid dependent countries, and when transitioning away from aid, secure government domestic funding to sustain coverage of all vaccines after transition
Research & Innovation	• Establish and strengthen country capacity to identify, create and manage innovation • Develop new vaccines and technologies and improve existing products and services for immunisation programmes • Introduce and scale up new and underused vaccines and improved technologies, services and practices

Appendix 2: IA2030 Impact Goals


IA2030 GOALS AND OBJECTIVES
3 Impact Goals
1
Reduce mortality and morbidity from vaccine-preventable diseases for everyone throughout the life course
2
Leave no one behind, by increasing equitable access and use of new and existing vaccines
3
Ensure good health and well-being for everyone by strengthening immunisation within primary health care and contributing to universal helth coverage and sustainable development
IA2030 INDICATORS
Impact Goal Indicators
7 indicators across global, regional, and country levels

Résumé

Contexte : Les maladies pneumococciques, toutes les infections causées par la bactérie Streptococcus pneumoniae (S. pneumoniae), constituent un problème majeur de santé publique dans le monde entier, en particulier sur le continent africain. Le Kenya, l'Afrique du Sud et le Rwanda disposent de programmes de vaccination antipneumococcique parmi les plus performants d'Afrique, mais ils sont toujours confrontés à des difficultés qui peuvent avoir un impact sur leur réussite. Il est important d'étudier et d'examiner les programmes de vaccination antipneumococcique de ces pays afin d'en comprendre les similitudes et les différences et d'identifier les facteurs qui contribuent à la réussite d'un programme de vaccination antipneumococcique pouvant être mis en œuvre dans d'autres contextes.
Objectif : L'objectif principal est de répondre à la question de recherche suivante : « Quels sont les facteurs qui contribuent aux différents niveaux de réussite dans la mise en œuvre et la durabilité des programmes PCV au Kenya, au Rwanda et en Afrique du Sud ?
Méthode : Cette étude a utilisé une approche d'analyse comparative dans laquelle les données ont été collectées à partir de plusieurs bases de données sur les programmes PCV du Kenya, du Rwanda et de l'Afrique du Sud. Les données ont été codées selon le cadre d'action IA2030 Framework for Action et ont fait l'objet d'une analyse thématique afin de dégager les principaux thèmes de réussite.
Résultat : Après analyse des données selon le cadre IA2030, quatre thèmes principaux d'un programme PCV réussi sont les stratégies de mise en œuvre, la viabilité financière, l'engagement communautaire et l'infrastructure des soins de santé. Malgré l'utilisation d'approches différentes, les trois pays ont réussi à introduire et à étendre leur programme PCV avec des degrés variables de défis dans chacune des quatre catégories.
Discussion : Cette étude montre que la couverture vaccinale est possible dans des contextes où les ressources sont limitées, malgré les obstacles financiers, logistiques et sociétaux. La mise en œuvre des programmes (PCV) dans les trois pays et les enseignements qui en ont été tirés peuvent servir de modèle à d'autres PRFM qui cherchent à renforcer leurs efforts de vaccination et à réduire la mortalité due aux maladies évitables par la vaccination.
Conclusion : Cette étude a montré que les stratégies de mise en œuvre, la viabilité financière, l'engagement communautaire et l'infrastructure des soins de santé sont des domaines cruciaux sur lesquels il faut se concentrer pour assurer le succès d'un programme de vaccination antipneumococcique. Il est important de tirer les leçons des diverses expériences de ces pays et d'adapter les facteurs de réussite aux programmes de vaccination d'autres pays afin de poursuivre la tendance à l'élimination du fardeau des maladies pneumococciques dans le monde.
Mots clés : maladie pneumococcique, vaccin conjugué antipneumococcique (PCV), pneumonie, maladie pneumococcique invasive et streptococcus pneumoniae.