



REVIEW

Infectious diseases and global security: Analysis of global control and vaccination strategies

Enfermedades infecciosas y seguridad mundial: Análisis de las estrategias mundiales de control y vacunación

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ABSTRACT

Introduction: given the recent experience with the COVID-19 vaccine campaign, an optimal global policy to control future pandemics and ensure infectious security globally is highly relevant.

Objective: the study aims to determine the optimal vaccination strategy to reduce COVID-19 morbidity and mortality during a pandemic.

Method: a systematic search of studies on infectious disease control and vaccination strategies for the period 2000-2023 in PubMed, Scopus, Web of Science and Google Scholar databases using keywords was conducted for the review. Relevant publications, data extraction and systematisation were selected.

Results: the findings of the analysis highlight the importance of integrated interventions in global vaccination strategies, including health systems strengthening, innovative technologies for outbreak detection and international collaboration. Vaccination, as an effective preventive measure, significantly reduces the spread of infectious diseases. Vaccination with different types of vaccines has been shown to improve immune response compared to the use of the same type of vaccine. This approach, where the first and second vaccine doses are different, may increase the effectiveness of the immune response.

Conclusions: studies confirm that vaccination reduces the number of cases and deaths, reducing the economic burden. A variety of vaccines, including mRNA, vector, and inactivated vaccines, provide high efficacy in preventing COVID-19 infection and mortality, especially when a heterologous vaccination regimen is used. This review identifies the most effective infectious disease control strategies for the development of global health recommendations.

Keywords: Coronavirus Infection; Epidemiology; International Cooperation; Pandemic; Prevention and Control.

RESUMEN

Introducción: dada la reciente experiencia con la campaña de vacunación contra el COVID-19, es muy pertinente contar con una política mundial óptima para controlar futuras pandemias y garantizar la seguridad infecciosa en todo el mundo.

Objetivo: el estudio pretende determinar la estrategia de vacunación óptima para reducir la morbilidad y mortalidad por COVID-19 durante una pandemia.

Método: para la revisión se realizó una búsqueda sistemática de estudios sobre control de enfermedades infecciosas y estrategias de vacunación en el periodo 2000-2023 en las bases de datos PubMed, Scopus, Web of Science y Google Scholar utilizando palabras clave. Se seleccionaron las publicaciones pertinentes, se extrajeron los datos y se sistematizaron.

Resultados: las conclusiones del análisis ponen de relieve la importancia de las intervenciones integradas en las estrategias mundiales de vacunación, incluido el fortalecimiento de los sistemas sanitarios, las tecnologías innovadoras para la detección de brotes y la colaboración internacional. La vacunación, como medida preventiva eficaz, reduce significativamente la propagación de enfermedades infecciosas. Se ha demostrado que la vacunación con diferentes tipos de vacunas mejora la respuesta inmunitaria en comparación con el uso del mismo tipo de vacuna. Este enfoque, en el que la primera y la segunda dosis de vacuna son diferentes, puede aumentar la eficacia de la respuesta inmunitaria.

Conclusiones: los estudios confirman que la vacunación reduce el número de casos y muertes, reduciendo la carga económica. Diversas vacunas, incluidas las de ARNm, vectoriales e inactivadas, proporcionan una alta eficacia en la prevención de la infección y la mortalidad por COVID-19, especialmente cuando se utiliza un régimen de vacunación heterólogo. Esta revisión identifica las estrategias de control de enfermedades infecciosas más eficaces para el desarrollo de recomendaciones de salud global.

Palabras clave: Infección por Coronavirus; Epidemiología; Cooperación Internacional; Pandemias; Control y Prevención.

INTRODUCTION

The world has experienced several major infectious disease outbreaks in recent decades that have caused significant societal and economic impacts at the global level. From the H1N1 pandemic in 2009 to the recent global crisis caused by COVID-19, infectious diseases have demonstrated their ability to spread rapidly around the world, crossing geographical and political boundaries.

According to Mamedov⁽¹⁾ and Zharasova et al.⁽²⁾ about 412 million cases of coronavirus infection were registered in the world, of which 5,82 million were fatal cases, which was irreparable damage to the economy and development of society as a whole. In addition, long-term damage to the health of the population was noted, as Zhumabayeva et al.⁽³⁾ cite data that coronavirus infection reduced the functional capacity of working-age people by at least 30 % for at least 6 months, which had a significant impact on the recovery of resources after the pandemic. The pandemic most often affected elderly people with concomitant pathology, which significantly complicated their treatment and subsequent rehabilitation. Thus, according to the data of Abdrakhmanova and Bazarova⁽⁴⁾ from 2022, of all patients with new coronavirus infection, 10 % were persons with obesity and diabetes mellitus type 2. According to Zhurabekova et al.⁽⁵⁾ the group of pregnant female patients was characterised by a systemic inflammatory reaction and renal failure, which created a life-threatening situation for mother and child.

These occurrences have shown the significance of designing and executing effective control and vaccination methods for global security. In recent decades, H1N1 and COVID-19 have revealed inadequacies in global and national health systems and stressed the need for coordinated action and infectious disease dynamics knowledge, including vaccine development, detection and surveillance systems, and public health policy. Zhumabayeva and Molchanov,⁽⁶⁾ noted that the timely use of vaccines such as Hayat-Vac, and CoronaVac has greatly reduced the number of patients with severe disease courses and also reduced mortality from new coronavirus infections. The influence of socioeconomic, cultural, and political factors on the effectiveness of infectious disease control measures cannot be underestimated. Strategies and initiatives successfully implemented in one region may not be effective in another due to differences in social structure, cultural traditions, and political environment.

This literature review examines current, best practices in infectious disease prevention and control, finding successful tactics and knowledge gaps. In this setting, novel technology and methods to control and prevent infectious diseases are prioritised. Studies and analyses of immunisation, antibiotic resistance, early detection and diagnostic technologies, and public health efforts to reduce infection risk are crucial.

METHOD

Research type and Design

Studies published between January 2000 and December 2023 on infectious disease control and vaccination strategies at the global level were selected for this review.

Criteria for inclusion

- Empirical studies, reviews, meta-analyses, and systematic reviews are different types of research

methodologies.

- Concentrate on the implementation of measures to prevent the spread of infectious diseases and the development of strategies for global vaccination.
- Provide empirical evidence on infectious disease control and vaccination strategies and were published between 2021 and the present.
- Articles that have undergone a rigorous evaluation process by experts in the same field.

Criteria for exclusion

- Articles lacking specific information on control or vaccination strategies.
- Unreviewed articles.
- Initial findings.
- Empirical evidence based on personal experiences.

Information sources

- PubMed and Scopus.
- Web of Science.
- Google Scholar.

For each database, the search strategy was tailored to its unique features and capabilities, including the use of specific indices and filters. Once relevant studies were selected, the data were synthesised. Information from the selected sources was extracted and systematised for further analysis. The analysis included an assessment of the methodology of the studies, the effectiveness of the control and vaccination strategies presented, and a comparison and synthesis of the findings.

Search strategy

The search involved using specific keywords and their combinations, such as “infectious diseases”, “global security”, “control strategies”, “vaccination”, “pandemic”, and “epidemiology”. Search strategies were tailored to each database’s unique features, including specific indices and filters.

Data

The criteria were devised to evaluate extracted data completeness and quality. This ensured data collecting uniformity and reliability. If primary source data was inconsistent or incomplete, the authors of the research were contacted to clarify. General trends, strategy efficacy, and research gaps were identified by analysing data. Data type determined qualitative and quantitative analysis methods. All analysed papers were evaluated for scientific ethics, including confidentiality and informed consent. The approval of appropriate ethics committees or institutional ethics boards was also checked, indicating strong ethical standards in the research. This rigorous and methodical approach to research ethics underpins the literature review, ensuring its dependability and confidence in the findings. Research ethics strengthen scientific analysis and sustain public confidence in scientific research and its outcomes.

Ultimately, this approach has identified the most effective and ethically sound strategies for infectious disease control and vaccination, helping to form the basis for the development of global public health recommendations and policies.

RESULTS

Global strategies and vaccination efficacy

Analyses of current research identified that global strategies for infectious disease control include a range of measures aimed at strengthening health systems, developing, and implementing innovative technologies for early detection and outbreak response, and improving international cooperation in sharing information and resources.^(7,8) Bai et al.⁽⁹⁾ emphasise the importance of developing targeted response strategies to prevent and control potential outbreaks. The study suggests analysing past pandemics and learning from experiences with infectious diseases such as coronavirus, influenza, and Ebola.

In the context of global security, vaccination has demonstrated outstanding results in preventing morbidity and mortality, especially in regions with limited access to health infrastructure.^(10,11) The effectiveness of vaccination is demonstrated not only by the reduction in the number of cases and deaths but also by the reduction in the economic burden associated with the treatment of infectious diseases and their impact on society.^(12,13) Huang and Kuan⁽¹⁴⁾ analysed data from five databases as of 3 September 2021. From the seven identified studies with a total of 1 366 700 participants, 292 significant cases were identified, and the risk in the vaccinated group was 0,12 times lower than in the unvaccinated group. The findings of the study confirmed that all types of vaccines were effective in preventing severe disease. Implementation of epidemiological precautions and vaccination in different countries may improve vaccine protection and reduce COVID-19-

related mortality worldwide. Ghazy et al.⁽¹⁵⁾ in an analysis of 22 articles out of 21 567 selected articles showed that mortality in vaccinated individuals 7 and 14 days after full vaccination was significantly reduced compared to unvaccinated individuals. There was also a significant reduction in the probability of severe disease course and incident infection after the first and second doses. Meta-regression revealed that vaccine type and country were the main predictors of outcome. The results support the effectiveness of mass vaccination in controlling the COVID-19 pandemic. Rahmani et al.⁽¹⁶⁾ found that COVID-19 vaccination including BNT162b2 mRNA, mRNA-1273, ChAdOx1 and their combinations effectively reduced the incidence of COVID-19 infection, hospitalisation, and mortality after the first and second dose in different populations. The vaccines were 71 % and 87 % effective against infection after the first and second doses. Both doses reduced mortality by 68 % and hospitalisation by 73 % and 89 %, respectively. The findings underline the necessity of immunisation to avoid severe disease, especially in preparation for future epidemics.

According to Liu and Ye,⁽¹⁷⁾ based on data from clinical trials and large-scale vaccination, there is a relatively low rate of side effects when inactivated vaccines are used. Such vaccinations are projected to be 60 %, vector-based 65 %, and mRNA-based 90 % effective. In light of the pandemic, RNA-based vaccinations seem particularly promising. However, antibody levels may diminish with time, making a booster vaccine dosage necessary. In addition, heterologous vaccination regimens provide a stronger immunological response than homologous immunisation regimens. Despite achievements, guaranteeing equitable access to vaccines, eliminating “vaccine inequalities” and battling misinformation that undermines vaccination confidence are difficult.^(18,19)

A study by Tatar et al.⁽²⁰⁾ highlights the serious problem of global inequality in COVID-19 vaccine distribution, with wealthy countries hoarding vaccines, leaving fewer resources for less affluent regions. The use of Lorenz curves and Gini coefficients in the analysis confirms the large gap in vaccine availability between countries, which calls for increased international efforts to ensure a more equitable distribution of vaccines in the global pandemic fight.

De Matteis et al.⁽²¹⁾ analysed the different vaccination strategies against COVID-19 applied between December 2020 and April 2021 in France, Germany, Israel, Italy, and the UK. Following the manufacturer’s dose intervals, Israel’s mass population vaccination method reduced COVID-19 mortality the most. Despite its small population, Israel was able to maintain a vaccine supply and vaccinate most of the population with two doses in the necessary timeframe. The UK greatly increased the vaccine delay between the first and second doses to save doses. This allowed a huge section of the population to receive at least one dose quickly but delayed second doses. Germany, with a far larger population than Israel, was able to maintain a vaccination supply and follow manufacturer guidelines for dose intervals. This enabled bulk immunisation at suitable inter-dose intervals (figure 1). Many vaccines supply issues in France and Italy hindered full immunisation schedule adherence. This appears to have weakened immunisation campaigns in these countries.^(22,23)

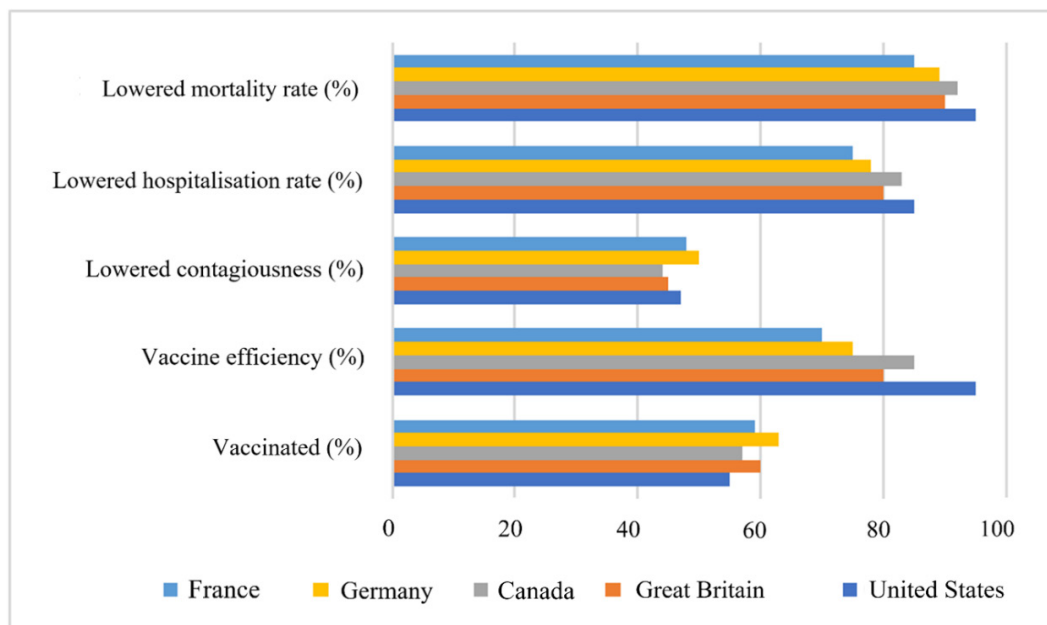


Figure 1. Effectiveness of vaccine strategies

Source: Compiled by the authors based on De Matteis et al.⁽²¹⁾

Vaccines for HIV/AIDS, malaria, and tuberculosis, for which none exist or are under development, should be prioritised. Accelerating research in this field could improve global health and help accomplish the Sustainable

Development Goals. However, contemporary technologies and digital solutions are needed to improve infectious hazard monitoring and response systems. Data gathering and analysis using mobile apps, web platforms, and AI technologies can increase epidemiological surveillance and action speed. The global plan also combats misinformation and promotes vaccination.⁽²⁴⁾

International cooperation and social aspects

International cooperation is a fundamental element in the global strategy to combat infectious threats. In an era of globalisation, where diseases can spread with incredible speed across borders, collaborative efforts between countries and international organisations become critical to prevent and control disease outbreaks.⁽²⁵⁾ Sharing knowledge and expertise, coordinating research and development, and sharing resources and vaccines among countries can greatly accelerate the process of creating and implementing effective medical solutions and public health strategies.^(26,27,28,29,30)

International collaboration also involves developing WHO health standards, which ensures infectious disease control uniformity. International partnerships must overcome political, economic, and health system development issues to succeed. A study by Kim and Cho⁽³¹⁾ highlights the critical importance of international scientific collaboration in response to the COVID-19 pandemic, demonstrating that pooling efforts and knowledge from different countries and fields of science contributes to better understanding and effectively addressing global challenges. Effective international collaborations and global solidarity can help post-pandemic countries achieve sustainable development, improved health systems, and equitable resource access.^(32,33,34,35)

A study by Van Lange and Rand,⁽³⁶⁾ emphasises the importance of understanding the mechanisms of human cooperation to address key social dilemmas, such as climate change, the COVID-19 pandemic, and the crisis of misinformation. It examines the evolution of cooperation, reputation's role in inspiring collaboration, and social preferences' involvement in cooperative psychology. Mansouri, and Sefidgarbaei⁽³⁷⁾ also noted that the COVID-19 pandemic identified existing global challenges related to the risks of modern society, emphasising the need to rethink and strengthen international cooperation. It demonstrated the need to overcome individualism and work together to confront global threats.

A study by Roozenbeek et al.⁽³⁸⁾ highlights a significant association between susceptibility to misinformation about COVID-19 and attitudes towards vaccination and healthcare adherence. Despite a relatively low prevalence of belief in misinformation, a significant proportion of the population across countries believe it to be true, which negatively affects willingness to vaccinate and adherence to public health recommendations.⁽³⁹⁾ Gabarron et al.⁽⁴⁰⁾ found that the proportion of misinformation about COVID-19 in social media ranged from 0,2 % to 28,8 % among posts. This study included 22 papers and showed that misinformation can lead to undesirable consequences such as fear and panic. Such findings highlight the importance of developing strategies to combat misinformation and prepare for future infodemics based on the analysis and experience of the current pandemic. A study by Barua et al.⁽⁴¹⁾ show that the spread of misinformation on social media hurts individual perception and response to COVID-19. Religion and conspiracy theories negatively affect human reactions when assessing misinformation credibility. Based on 483 responses from an online poll during the epidemic, the study emphasises the importance of public awareness of disinformation and the need for authorities to protect public health from misinformation. The development and transmission of science-based information and public and opinion leader participation in the process of informing the public are necessary to solve this challenge.

DISCUSSION

The identification of gaps in existing research points to the need for further work in several key areas. First, new vaccines need to be further developed and tested, especially for diseases for which vaccines do not yet exist or for which existing vaccines are ineffective against new strains of viruses. Second, improving disease monitoring and outbreak response systems is critical to prevent future global health crises.^(42,43) Chen et al.⁽⁴⁵⁾ in 2021 noted that an analysis of 1 312 COVID-19 vaccine studies revealed a leading role for the US, China, India and the UK, with key contributions from Harvard University in scientific collaboration. Seven major research areas emphasise a focus on vaccine safety, efficacy, and immunology. Thus Bok et al.⁽⁴⁶⁾ emphasise that the successful acceleration of COVID-19 vaccine development through public-private collaboration in the US demonstrates the importance of cross-sector partnerships in responding to pandemic threats. The rapid advancement of several vaccine candidates with proven efficacy and already in use globally confirms the potential of collaborative efforts to address future public health emergencies. Advances in vaccinomics and the promising field of quantum vaccinomics are greatly enhancing the ability to create more effective and safer vaccines. These approaches provide a deep understanding of the molecular basis of the immune response and enable precise targeting of protective antigen epitopes, which is particularly important to combat global threats such as the COVID-19 pandemic. The employment of these innovative methods can accelerate vaccine development and improve their efficacy in preventing and controlling emergent infectious diseases worldwide.^(47,48)

The social and economic consequences of pandemics, which can have long-term impacts on societies and

economies, are also important.^(49,50) Research in health economics, social psychology and political science can provide valuable data for developing strategies to minimise the negative impact of future epidemics. According to Callegari and Feder,⁽⁵¹⁾ pandemics significantly impact social and economic aspects of society, including overburdening health systems with subsequent shortages of health workers and resources, which increases mortality not only from the pandemic itself but also from other diseases due to lack of timely treatment. School closures and the shift to distance learning have a negative impact on the quality of education and the social adaptation of students. Isolation, fear of infection, loss of loved ones and economic hardship lead to a deterioration in the mental health of the population. In addition, the pandemic increases social and economic inequalities as vulnerable populations, including low-wage workers, poor families, migrants and ethnic minorities, are most severely affected. In addition, COVID-19 has had a significant impact on business, causing a shift to remote working, reduced demand in many sectors, disrupted supply chains, accelerated digital transformation, changing consumer preferences, financial difficulties for small and medium enterprises, and the need to adapt business models and strengthen health and safety measures. These changes have fuelled innovation and forced companies to rethink strategies to survive in the new environment.⁽⁵²⁾ Research by Mastrogianni et al.⁽⁵³⁾ shows that pandemics cause profound social disruption, including mental illness, isolation, discrimination, human rights violations, as well as economic disruption: reduced labour force, reduced production activity, reduced demand for goods, increased inflation and unemployment, and increased health care costs. These findings confirm the importance of understanding the impact of pandemics and developing effective measures to minimise their socio-economic impact.

Finally, public health and global infectious disease control must have sustainable finance. This encompasses vaccine development, distribution, infrastructure, health professional training, and public awareness. Health systems have faced unprecedented financial challenges due to the COVID-19 pandemic, including increased costs for intensive patient care, protective equipment, infrastructure rebuilding for new safety measures, and staff costs due to high risk and overtime. reduced income from unrelated COVID-19 health services, along with the economic slump and reduced government revenues, have increased financial strains. Countries have found strategies to raise funding, adjust payment systems, and make health care cheap to address these issues.⁽⁵⁴⁾ A study by Chinnery et al.⁽⁵⁵⁾ identified that the COVID-19 pandemic period saw changes in clinical research such as accelerated regulatory approvals, use of adaptive study designs, use of real patient data, international collaboration in research, integration of telemedicine and mobile technologies for patient monitoring, repositioning of existing medicines, increased research funding and enhanced patient-centred approach through digital platforms. These changes have led to more flexible and technologically advanced methods in clinical research. A study by Shueb et al.⁽⁵⁶⁾ presents a comprehensive analysis of the financial landscape of COVID-19 research. The funding ratio is 32 %, which confirms the high interest in research in this field. The geographical distribution shows that China leads with a share of 43,182 %, followed by the USA (27,386 %) and the UK (10,17 %), reflecting the global mobilisation against the pandemic. China's National Natural Science Foundation, the US Department of Health and Human Services and others are providing significant support, focusing on scientific research. The U.S. stands out as a central node in the international cooperation network, having established primacy in cooperation with China. Open access is provided to 95,11 % of funded research, contributing to the wider dissemination of knowledge about the virus. Overall, the study highlights the significance of funding for research on COVID-19 and the importance of international cooperation in this area.

The analysis shows that global infectious disease control is complicated and requires an integrated approach incorporating scientific research, public policy, international cooperation, and active public participation. Governments, scientists, the commercial sector, and civil society must work together to address global infectious disease risks. Current and future public health issues require continued research and development. New infectious disease treatments and prevention methods require global collaboration between laboratories, research institutes, and the pharmaceutical sector. Innovative technologies like genetic engineering and nanotechnology can help build safer and more effective vaccines.

CONCLUSIONS

Scientific research has verified that vaccination effectively decreases the incidence of cases and fatalities, thereby reducing the economic strain. Different types of vaccines, such as mRNA, vector, and inactivated vaccines, have shown high effectiveness in preventing COVID-19 infection and death, particularly when a mixed vaccination schedule is used. This review aims to identify the most efficient strategies for controlling infectious diseases to create global health recommendations.

The evidence review highlights the importance of broad interventions in global vaccination programmes, such as improving health systems, using sophisticated epidemic detection technologies, and promoting international cooperation. Contagious diseases are greatly reduced by vaccination. Using multiple immunisations improves immune response. However, global vaccine inequities, misinformation, and the need for long-term funding for global health efforts remain. Next studies should focus on developing vaccines for diseases without effective

immunisation, improving disease surveillance, and studying pandemics' long-term socioeconomic effects.

Although there has been progress in understanding and implementing effective infectious disease management strategies, such as COVID-19 vaccines, many challenges remain. Future efforts should prioritise fair and equal vaccine availability worldwide, countering false information, improving international collaboration, and developing comprehensive pandemic strategies that address both health and social impacts. Research, surveillance, and public health infrastructure must be funded to prepare for and mitigate future infectious disease risks.

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