Risk Management and Healthcare Policy

Dovepress
Taylor & Francis Group

Open Access Full Text Article

PERSPECTIVES

Vaccine Hesitancy and Immunization Patterns in Central and Eastern Europe: Sociocultural, Economic, Political, and Digital Influences Across Seven Countries

Donata Kurpas[1], Dorota Stefanicka–Wojtas[1], Aneta Soll–Morka[1,2], Katarzyna Lomper[1], Bartosz Uchmanowicz[1], Beata Blahova[3], Aelita Bredelytė[4], Gheorghe Gindrovel Dumitra[5], Vladimíra Hudáčková[6], Katerina Javorska[7], Zoltán Juhász[8], Stanisław Manulik[1], András Mohos[8,9], Egidijus Skarbalius[10], Victoria I Tkachenko[11], Izabella Uchmanowicz[1]

[1]Department of Nursing, Wroclaw Medical University, Wrocław, Poland; [2]Department of Family Medicine and Public Health, University of Opole, Opole, Poland; [3]EURIPA, Slovak Society of General Practitioners, Krompachy, Slovak Republic; [4]Department of Nursing, Klaipeda University, Klaipeda, Lithuania; [5]Family Medicine Department, University of Medicine and Pharmacy of Craiova, Craiova, Romania; [6]The London School of Hygiene and Tropical Medicine, University of London, London, UK; [7]Department of Preventive Medicine, Charles University, Hradec Králové, Czech Republic; [8]Department of Family Medicine, University of Szeged, Albert Szent-Györgyi Medical School, Szeged, Hungary; [9]Department of Family Medicine, Semmelweis University, Budapest, Hungary; [10]Department of Public Health, Klaipeda University, Klaipeda, Lithuania; [11]Department of Internal Medicine and Training Centre of Family Medicine, Bogomolets National Medical University, Kyiv, Ukraine

Correspondence: Dorota Stefanicka–Wojtas, Email dorota.stefanicka-wojtas@umw.edu.pl

Background/Objectives: Vaccination programs are essential for preventing infectious diseases, yet the effectiveness of these programs varies significantly across Central and Eastern European countries due to diverse socio-economic, cultural, and political influences. This study examines vaccination trends in Hungary, Slovakia, Romania, the Czech Republic, Poland, Ukraine, and Lithuania, focusing on misinformation, regional healthcare disparities, and socio-cultural factors on vaccination rates.

Methods: A comprehensive review of national policies, vaccination rates, and factors influencing vaccine hesitancy was conducted across seven Central and Eastern European countries. Input from local health stakeholders and national data sources was analysed to contextualize vaccination patterns and challenges.

Results: Significant cross-country variation was observed. Hungary and the Czech Republic reported consistently high coverage of mandatory childhood vaccinations, while Romania and Ukraine experienced severe declines in uptake, leading to outbreaks of measles and polio. Slovakia demonstrated low COVID-19 vaccination willingness, and Poland recorded a sharp increase in formal vaccine refusals. Conversely, Lithuania implemented successful campaigns that improved uptake, particularly for influenza and pneumococcal vaccines. Differences were influenced by healthcare system structure, public trust, exposure to misinformation, and digital communication strategies.

Conclusion: Addressing vaccine hesitancy requires targeted, context-sensitive communication and digital literacy programs. Additionally, policy reforms to enhance accessibility, particularly in rural areas, and real-time monitoring systems can strengthen vaccination rates. Cross-border collaboration and tailored public health campaigns addressing cultural and socio-economic challenges are necessary to improve immunization coverage in these regions.

Keywords: vaccination trends, vaccine hesitancy, public health, Central and Eastern Europe

Introduction

Global Context of Vaccination Programs

Vaccination remains one of the most cost-effective and impactful public health interventions, crucial in preventing infectious diseases, reducing morbidity and mortality, and contributing to population-level herd immunity. Before the

Received: 2 February 2025
Accepted: 24 May 2025
Published: 12 June 2025

COVID-19 pandemic, immunization programs were estimated in order to avoid between 4 and 5 million deaths annually from diseases such as measles, diphtheria, pertussis, and influenza.[1] These programs have reduced the disease burden and helped achieve the near-elimination of certain illnesses in many countries through widespread coverage and effective surveillance systems.

Although institutions such as the World Health Organization and the European Centre for Disease Prevention and Control provide global guidance, national vaccination policies differ significantly in terms of implementation, legal frameworks, enforcement mechanisms, and public communication strategies. While some countries maintain mandatory immunization schedules with legal consequences for non-compliance, others rely on voluntary participation and public health campaigns to encourage vaccine uptake. These differences reflect not only epidemiological priorities but also cultural values, political ideologies, historical legacies, and levels of public trust in government institutions. In Central and Eastern Europe, such policy divergence is particularly visible, resulting in a patchwork of vaccination approaches that influence public behaviour and shape regional immunization outcomes.

Despite these successes, significant gaps persist in vaccine coverage and equity. The COVID-19 pandemic further exacerbated these disparities by disrupting routine immunization services, particularly in low- and middle-income countries. However, data from 2022 revealed promising signs of recovery, with a 21% reduction in the number of zero-dose children compared to 2021, reflecting the resilience of some national health systems.[2] Nonetheless, the pandemic also contributed to rising scepticism, mistrust, and logistical barriers to vaccine delivery, many of which persist post-crisis.

In the current global landscape, there is growing concern about the downward trend in routine immunization coverage. Vaccine hesitancy driven by multifactorial influences, including perceived safety risks, scepticism about vaccine efficacy, religious or philosophical beliefs, and institutional distrust has emerged as a significant threat to the success of immunization programs.[3] Misinformation, which spreads rapidly through digital and social media, is pivotal in shaping negative attitudes toward vaccination, particularly among parents and caregivers.[4] Although some hesitancy stems from legitimate safety concerns or perceived underrepresentation in clinical trials, much of it is fuelled by unverified claims, conspiracy theories, and distrust in governmental and scientific institutions.[5,6]

Addressing vaccine hesitancy thus requires a multi-pronged strategy that combines evidence-based communication, transparency in public health messaging, and culturally sensitive engagement with communities. Strategies such as motivational interviewing, participatory campaigns, and the use of trusted community figures have shown promise in countering misinformation and rebuilding trust in vaccines and the institutions that promote them.[7,8]

At the policy level, the World Health Organization (WHO) plays a central role in setting normative guidance for immunization programs. It establishes global standards, offers technical support, and coordinates through frameworks such as the Immunization Agenda 2030 (IA2030), endorsed by the World Health Assembly in 2020.[9,10] IA2030 outlines a comprehensive vision to ensure that everyone at every age benefits from vaccines. It emphasizes equity, life-course immunization, and preparedness for future pandemics.

In Europe, the European Centre for Disease Prevention and Control (ECDC) complements WHO's efforts by monitoring vaccine coverage, facilitating data-sharing among EU member states, and offering strategic guidance on immunization schedules and responses to outbreaks.[11] These institutional efforts underline the importance of both national responsibility and international collaboration in strengthening global vaccine confidence and uptake.

Despite these coordinated efforts, the global immunization landscape faces challenges due to socio-political tensions, misinformation, health system fragility, and logistical barriers. This highlights the need for localized analyses of vaccine confidence, uptake trends, and policy interventions - particularly in Central and Eastern Europe, where historical, socio-economic, and cultural factors create unique vaccination landscapes.

In recent years, the role of social media in shaping public attitudes toward vaccination has become increasingly significant. While these platforms offer potential for health promotion and rapid information dissemination, they have also facilitated the uncontrolled spread of vaccine-related misinformation. The emotionally charged content on platforms like Facebook, Instagram, and TikTok contributes to the viral transmission of conspiracy theories, false claims about vaccine safety, and narratives that erode trust in public health institutions.

Unlike traditional media, social media content often lacks editorial oversight or fact-checking, allowing anti-vaccination messages to reach wide audiences, especially among younger and digitally active populations. This dynamic has been particularly pronounced during the COVID-19 pandemic, when fears and uncertainty created fertile ground for misinformation to flourish. Studies across Europe indicate that exposure to false information online correlates with increased vaccine hesitancy and decreased intention to vaccinate, regardless of prior health beliefs.

Moreover, misinformation on social media is not only passively consumed—it is actively shared within trusted peer networks, reinforcing beliefs through echo chambers and confirmation bias. In several countries, including Slovakia, Romania, and Poland, coordinated anti-vaccine movements have exploited these platforms to undermine immunization efforts, leading to measurable declines in vaccine uptake and greater public confusion.

These observations underscore the urgent need for digital health literacy initiatives, real-time misinformation monitoring, and proactive communication strategies that leverage the same platforms to deliver evidence-based, culturally relevant content. Social media must be considered both a challenge and a tool in modern immunization strategies.

Significance of Analysing Regional Vaccination Trends

In the European region, European Centre for Disease Prevention and Control (ECDC), coordinates efforts and shares best practices. ECDC helps to strengthen vaccination programs, increase public awareness of the importance of immunization, and ultimately contribute to the prevention and control of infectious diseases throughout the European region.[11]

In the State of Vaccine Confidence in the European Union document for 2022 confidence in vaccination among the general population and medical personnel was indicated. Vaccine confidence among healthcare professionals was high in 2022: above 90% of healthcare professionals surveyed in all European Union member states agree that vaccines are essential and safe (except for France, Greece, and Austria). The document also states that the overall confidence in the importance, safety, effectiveness, and compatibility with beliefs is lowest in Slovakia (62.2%), Bulgaria (67.5%), and Latvia (65.8%). The document also states that perceptions towards the importance of vaccines have only increased in Poland, which has increased from 75.6% (in 2018) to 80.5% in 2022.[12]

There is a need to highlight the importance of regularly monitoring and analysing regional vaccination trends to detect emerging trends and prompt interventions to build and sustain vaccine confidence. Vaccination programs' effectiveness requires a high acceptance and awareness rate among healthcare workers and the general public.

Healthcare Systems and Vaccination Policies in Central and Eastern Europe

The seven countries analysed in this study - Hungary, Slovakia, Romania, Czech Republic, Poland, Ukraine, and Lithuania - share certain structural similarities in their health systems, such as the decisive role of publicly funded services and centralized vaccine procurement. However, notable differences exist in vaccination strategies, delivery models, and the degree of enforcement of immunization policies.

Hungary, Slovakia, Lithuania, and Poland maintain mandatory vaccination programs for children, enforced through school entry requirements and healthcare regulations. The Czech Republic also mandates a core set of childhood vaccinations. In contrast, Romania and Ukraine have voluntary programs, though Romania has recently introduced strategic policies to increase uptake and accessibility.[13]

Vaccination services in most countries are delivered through primary care systems, typically by general practitioners or nurses in public health clinics. However, coverage gaps often occur in rural or socioeconomically disadvantaged areas, mainly where health worker shortages are acute (eg, rural Romania and Poland).

Vaccination schedules are generally aligned with WHO and ECDC recommendations and include vaccines against diseases such as measles, mumps, rubella (MMR), diphtheria, tetanus, pertussis (DTP), polio, hepatitis B, and Haemophilus influenzae type b (Hib). Some countries have introduced or expanded HPV, rotavirus, influenza, and pneumococcal vaccinations, with varied levels of implementation and reimbursement.

Differences in the terminology used across policy documents and national debates necessitate clarification in this study. Throughout this manuscript: "Mandatory vaccines" refers to vaccines required by law or regulation, typically for school attendance; "Recommended vaccines" are publicly endorsed but not compulsory; "Routine immunization"

denotes the administration of vaccines according to the national schedule, excluding emergency or outbreak response campaigns; "Vaccine hesitancy" is used per WHO definition, encompassing both delay and refusal despite availability.

By situating vaccination trends within each country's institutional and policy frameworks, this study aims to provide context-sensitive insights into the causes of variation in vaccine uptake and public perception.

Aim of the Article and Its Structure

This paper aims to review and synthesize available literature, epidemiological data, and national policy documents to analyse vaccination trends, public confidence in immunization, and vaccine hesitancy across selected Central and Eastern European countries. The study seeks to identify common challenges and context-specific drivers of vaccine acceptance and inform evidence-based strategies for strengthening immunization programs and public trust in vaccines throughout the region.

Materials and Methods

The present study was designed as a qualitative, comparative analysis of vaccination trends and vaccine hesitancy in seven Central and Eastern European countries: Hungary, Slovakia, Romania, the Czech Republic, Poland, Ukraine, and Lithuania. These countries were selected based on shared historical trajectories, structural similarities in their healthcare systems, and prior engagement in joint public health initiatives at the European level.

National experts carried out data collection, and all co-authors of this article who possess documented experience in healthcare organizations, public health policy, and immunization program implementation in their respective countries. A standardized data collection template was developed and disseminated among the participating experts to ensure methodological consistency and comparability. This template contained predefined thematic domains, including vaccination schedules and calendars, historical and recent immunization coverage, key determinants of vaccine hesitancy, sociocultural and demographic influences, national policy responses, characteristics of information environments, structural features of health systems, and inequalities in access to immunization.

The study focused analytically on selected vaccines of highly epidemiologically and policy-relevant. In particular, national childhood vaccination programs were examined, emphasizing MMR (measles, mumps, rubella), DTP (diphtheria, tetanus, pertussis), and polio vaccines. Additional attention was given to seasonal influenza vaccines and COVID-19 vaccines, given their prominence in recent public health debates. Where applicable, data on HPV, pneumococcal, and meningococcal vaccinations were also included to reflect the diversity of national immunization strategies.

The primary methodological approach was structured desk research conducted independently by each expert. Sources included national legal acts, immunization schedules, epidemiological bulletins, statistical yearbooks, academic literature, strategic policy documents, and official reports from ministries of health and public health institutes: public datasets and surveillance summaries from European institutions such as ECDC and WHO were also consulted whenever possible. The desk research was supplemented by expert insight, which allowed for the inclusion of contextual nuances and identification of country-specific developments not consistently reflected in formal publications.

The temporal scope of the study covered the period from 2010 to 2024, with particular emphasis on the years surrounding the COVID-19 pandemic (2019–2023) due to their profound impact on vaccination systems and public trust.

The collected material was synthesized through thematic analysis and cross-country comparison. Recurring patterns, divergences, and emerging challenges were identified and categorized to support descriptive assessment and comparative interpretation. Although the study relies on secondary data, integrating documentary sources with expert validation enhances the analytical depth and strengthens the contextual robustness of the findings.

This study was approved by the Bioethics Committee of the Medical University of Wroclaw under the number KB230/2024.

Results

Real-Time Fluctuations in Vaccination Rates

In recent years, vaccination rates for routine childhood immunizations have remained relatively stable in several Central and Eastern European countries, with some maintaining high coverage despite broader challenges. For instance, countries

such as Hungary and the Czech Republic succeeded in preserving near-universal uptake of mandatory vaccines in the early stages of the COVID-19 pandemic. However, this stability has not been uniform across the region. In Slovakia, Romania, and Poland, coverage for key childhood vaccines such as measles, mumps, and rubella (MMR) has declined, sometimes falling below the 95% threshold recommended by the WHO for herd immunity.

The COVID-19 pandemic had a differentiated impact on vaccination systems. While it did not immediately reduce coverage of routine immunizations in all countries, its indirect effects - such as limited access to services, disruption of healthcare delivery, and rising vaccine hesitancy - contributed to subsequent declines. Romania and Ukraine experienced particularly steep drops in coverage, with Ukraine reporting critical decreases in vaccination rates against polio, diphtheria, and measles. By 2023, the level of vaccination against diphtheria, tetanus, and pertussis in Ukraine was approximately 37% lower than the EU average, leading to documented outbreaks of both measles and polio.

Flu vaccination coverage followed a distinct pattern. A temporary increase was observed in several countries during the first pandemic year, likely driven by heightened health awareness. However, this trend was not sustained, and subsequent seasons saw declines, sometimes returning to pre-pandemic levels. For example, influenza coverage dropped to below 5% in Slovakia, placing it among the lowest in the EU. At the same time, other countries reported stagnation or only modest uptake (eg, 51% in the Czech Republic).

COVID-19 vaccine uptake itself varied significantly across the region. Some countries initially reported high coverage - Hungary, for instance, achieved one of the highest EU rates by mid-2021. Yet this momentum was not maintained, with later figures indicating a substantial decline (eg, 62.3% in Hungary by December 2022, compared to an EU average of 76.2%). In contrast, countries such as Slovakia and Romania reported persistently low uptake, reflecting more profound structural and societal challenges, including widespread distrust and logistical constraints.

Public resistance to vaccination has also become more visible. In Poland, the number of individuals formally refusing vaccinations more than doubled between 2017 and 2022, with the most pronounced opposition directed at the MMR vaccine. The cumulative effect of these developments has led to suboptimal vaccination levels in several countries, jeopardizing population-level protection and increasing vulnerability to outbreaks of vaccine-preventable diseases.

At the same time, some countries demonstrated adaptive responses. In Lithuania, for example, introducing vaccination certificates in 2021, followed by renewed public health campaigns in 2024, was associated with improved uptake in specific immunization programs, indicating that targeted policy measures can partially mitigate declining trends.

Long-Term Trends in Vaccination

Over the past decade, vaccination coverage in Central and Eastern Europe has followed diverging trajectories shaped by policy developments, shifts in public perception, and the growing influence of digital communication. In several countries, such as Hungary, routine childhood immunization rates have remained exceptionally high. The national program consistently achieves near-complete coverage for key vaccines, including measles. Although anti-vaccination sentiments have become more prominent, mainly through social media, these trends have not resulted in measurable declines in vaccine uptake. Available data confirm the stability of coverage and low incidence of vaccine-preventable diseases, with measles vaccination reaching 100% and 68% of respondents expressing willingness to receive COVID-19 vaccination.

In contrast, other countries demonstrate the vulnerability of vaccination programs in contexts of limited trust and fragmented communication. In Slovakia, the declared willingness to vaccinate against COVID-19 was remarkably low, with actual uptake reaching only 0.4%. At the same time, measles vaccination coverage declined below the 95% threshold required for herd immunity, resulting in an outbreak between 2018 and 2019. In response, the national immunization schedule was revised in 2020, with the second dose of the MMR vaccine now administered at age five instead of eleven.

Romania experienced a comparable scenario. A major measles outbreak occurred between 2016 and 2019, reflecting structural challenges in the public health system. The subsequent onset of the COVID-19 pandemic further disrupted immunization services across Romania, the Czech Republic, and Poland. In Poland, restricted access to health services and concerns about SARS-CoV-2 exposure contributed to the most significant decline in vaccination coverage observed in the past thirty years.

Across the region, increasing exposure to vaccine misinformation has emerged as a significant threat to long-term vaccination trends. Digital platforms have facilitated the widespread circulation of inaccurate and misleading content, targeting parents of young children. In Poland and other countries, this dynamic has contributed to growing vaccine hesitancy and erosion of public trust, leading to a rise in vaccine refusals and delays in administering scheduled immunizations.

Nonetheless, some countries report positive developments. In Lithuania, the COVID-19 pandemic led to a marked change in public attitudes toward immunization. A broader increase in awareness and acceptance of preventive vaccinations accompanied the introduction of COVID-19 vaccination. Interest in seasonal influenza and pneumococcal vaccines also grew during this period, supported by intensified public health communication and access to immunization services. These findings illustrate that shifts in societal perception, coupled with effective policy measures, can contribute to renewed engagement with vaccination programs.

Influencing Factors: Social Media and Socio-Economic Elements

The growing role of social media has significantly reshaped the landscape of public attitudes toward vaccination across Central and Eastern Europe. Digital platforms such as Facebook, Instagram, and Twitter have become key channels for the dissemination of both accurate and false information regarding vaccines. While well-managed online resources can support public understanding and encourage vaccine uptake, misinformation and disinformation has profoundly affected parental attitudes, particularly toward childhood immunization. The difficulty of verifying false claims shared online, combined with the emotive and sensational nature of much of this content, contributes to increasing distrust among caregivers and heightens hesitation regarding vaccine safety and necessity.

Empirical studies confirm that social media carries more disinformation than traditional media sources. For example, research conducted in the Czech Republic identified five distinct types of disinformation narratives related to COVID-19 vaccines, including messages that induce fear or guilt, promote conspiracy, encourage aggression, or express satisfaction at successful vaccine refusal. Nevertheless, interpersonal communication remains a critical moderating factor, especially between healthcare providers and patients. Dialogue with trusted medical professionals continues to influence parental decision-making, often mitigating the effects of online misinformation and reinforcing confidence in vaccines.

In Hungary, national data indicate that reliable government communication through mass media, including television, radio, newspapers, and public health websites, increases trust and readiness to vaccinate. Sociodemographic analysis suggests that men with higher education and income, particularly those living in urban centers, are more likely to vaccinate their children and accept COVID-19 vaccination for themselves. Similar patterns are observed in Lithuania, where vaccination rates are also positively correlated with education level, income, and male gender. In Slovakia, targeted media campaigns implemented during the pandemic, including annual influenza awareness initiatives, demonstrated encouraging outcomes, suggesting that consistent and evidence-based messaging can mitigate vaccine hesitancy. In Lithuania, the public health sector has increasingly relied on digital media to disseminate information and counteract vaccine-related misinformation, while in Romania, the initial lack of governmental engagement created a vacuum partially filled by civil society. Nongovernmental organizations established social media platforms to share evidence-based content and respond to vaccine-related concerns, reflecting the importance of multi-sectoral communication strategies.

In addition to informational dynamics, socioeconomic factors play a critical role in shaping vaccination behaviour. Studies from Hungary and Lithuania consistently indicate that older age, male gender, higher educational attainment, and more significant household income are associated with an increased likelihood of vaccination. Political alignment has also emerged as a predictor in some national contexts, with trust in institutions linked to higher vaccine uptake. Conversely, vulnerable and socially excluded populations remain at elevated risk for under immunization. In Slovakia and Romania, the Roma population faces persistent structural barriers, including limited access to health services, low levels of formal education, material deprivation, and distrust in public institutions. Romania has employed community health mediators since 2004 to facilitate communication between health providers and marginalized groups, particularly about childhood immunizations.

Additional at-risk populations include individuals experiencing homelessness, long-term unemployment, or unstable housing. In the Czech Republic, homeless men aged 40 to 60 have historically been the most affected, although increasing numbers of younger and female homeless individuals are now reported. Data from international studies, including the SHARE project conducted in Europe and Israel, confirm that socioeconomic status is the strongest predictor of vaccine acceptance. Higher-income is consistently associated with increased willingness to vaccinate, while paradoxically, better self-reported health is linked with a greater tendency to reject vaccines. Personal experiences with COVID-19 also influence perceptions. Individuals with no direct exposure to severe illness were more inclined to receive the vaccine than those who personally knew someone who had been hospitalized or died, highlighting the complex and sometimes counterintuitive nature of risk perception.

These findings underscore the multidimensional character of vaccine hesitancy, in which digital environments, economic position, and lived experience interact to shape decision-making. Addressing these interrelated factors requires a nuanced approach that combines accessible, trustworthy information with structural interventions to reduce inequality and rebuild public trust.

Cultural and Religious Beliefs

Religious affiliation and belief systems constitute important cultural determinants of attitudes toward vaccination, operating both at the level of individual behaviour and within broader community dynamics. In some contexts, religious or philosophically grounded convictions may conflict with biomedical understandings of immunization, leading to scepticism or outright refusal. These patterns are observed across diverse traditions. Studies have identified religious taboos as a contributing factor to vaccine hesitancy and refusal, including within communities identifying with Hinduism or Sikhism. Although philosophical objections are often framed as moral or theological concerns, they reflect broader identity-based resistance to state-sponsored health interventions.

The relationship between religiosity and vaccine uptake has attracted considerable scholarly attention. A large-scale study spanning 195 regions found that higher levels of spirituality or religiosity were associated with lower COVID-19 vaccination rates. However, this correlation is not universally observed. For example, empirical data from Hungary indicate that neither religiosity nor class-based identity significantly influenced willingness to vaccinate. In Lithuania, no measurable association has been found between religious affiliation and vaccination behaviour, suggesting that the influence of religion may be highly context-specific.

In contrast, other settings reveal more pronounced effects. In Romania, vaccination rates were demonstrably lower in areas with a high concentration of Orthodox monasteries, affecting both adult and paediatric populations. In Ukraine, regions such as Rivne and Transcarpathia reported significant vaccine refusal on religious grounds. Notably, individuals from religious communities were sometimes compelled to seek immunization in secret to avoid social sanctions from family members or spiritual leaders. This phenomenon illustrates the power of intra-community dynamics in shaping individual health decisions and highlights the stigma that may accompany non-conforming behaviour in closely-knit religious settings.

Cultural identity also intersects with regional affiliations and geopolitical self-perception. For instance, research conducted in Brno, Czech Republic, suggests that individuals who identified more strongly with Western European cultural models exhibited higher vaccination willingness. This finding points to a complex interplay between cultural alignment, perceived modernity, and health-related norms.

Addressing religiously motivated vaccine hesitancy must begin with respectful and informed communication strategies. Engaging with religious leaders, clarifying theological misinterpretations, and promoting the compatibility of vaccination with core spiritual values are key components of effective public health outreach. As the noWorld Health Organization noted, religiously rooted vaccine hesitancy constitutes one of the leading public health challenges of the current era. Overcoming it requires factual education and meaningful dialogue acknowledging the moral and symbolic dimensions of health behaviours within religious worldviews.

Policy Impact on Vaccination

Effectiveness of Policies Across Different Regions

Vaccination systems in Central and Eastern Europe display varying degrees of centralization and consistency in implementation. In Hungary, Slovakia, Lithuania, and Poland, immunization policies are highly uniform across regions,

with standardized schedules and centralized coordination ensuring relatively consistent access and uptake. These countries have established nationwide frameworks for administering vaccines, and regional variation in coverage is minimal, owing mainly to unified legal mandates and coherent service delivery structures.

Ukraine is more heterogeneous, with regional discrepancies in policy implementation and vaccination outcomes. Variations in health system capacity, resource allocation, and institutional oversight contribute to uneven coverage across the country, particularly in areas affected by conflict or infrastructural limitations.

Despite centralized frameworks in many countries, localized vaccine refusal and delay patterns have been documented. In Hungary, official records from 2009 to 2017 reported 51 delayed or refused vaccination cases. Notably, 88.1% of these cases reflected deliberate anti-vaccine attitudes rather than logistical or medical constraints. Nonetheless, in 77.8% of instances, the vaccine was ultimately administered, suggesting that initial resistance can often be overcome through follow-up and continued engagement. Primary care nurses were key in identifying non-compliance, with 82.3% of cases reported through routine primary care system surveillance mechanisms.

In Romania, where childhood vaccinations are not mandated by law, regional variation in uptake is not driven by formal policy differences but rather by factors such as health infrastructure, education, cultural attitudes, and local advocacy efforts. The absence of a compulsory vaccination framework creates space for considerable diversity in implementation and outcomes, complicating efforts to achieve uniformly high coverage across the country.

These observations highlight the interplay between national policy architecture and local-level practice. Even within centralized systems, implementation outcomes depend on effective monitoring, community trust, and the responsiveness of primary care actors. In decentralized or voluntary systems, such as in Romania or partially in Ukraine, the success of vaccination programs hinges even more critically on public health communication, social mobilization, and regional investment in service delivery.[14]

Long-Term Policy Changes

In response to evolving public health needs and challenges exposed during the COVID-19 pandemic, several Central and Eastern European countries have substantially modified their vaccination policies. These changes reflect immediate epidemic concerns and broader strategic efforts to improve immunization coverage, equity, and public trust.

Hungary introduced routine immunization against human papillomavirus (HPV) and varicella (chickenpox), significantly expanding its preventive health agenda. These additions are expected to reduce the incidence of vaccine-preventable conditions such as cervical and oropharyngeal cancers, as well as common childhood infections. Similarly, Poland revised its vaccination framework in 2023, expanding access to recommended adult vaccinations and broadening the criteria for mandatory immunization among children. This included the introduction of free pneumococcal and varicella vaccines for children up to 19 years of age from high-risk groups and the extension of mandatory vaccination for all children up to the age of five. Additionally, free HPV vaccinations were made available for 12- and 13-year-olds, reinforcing the national strategy for cancer prevention.

In Romania, the post-pandemic period brought about a comprehensive re-evaluation of national immunization policy. A prescription-based distribution model facilitated a new vaccination strategy, emphasizing equitable access to safe and effective vaccines. The plan outlines ambitious goals, including achieving over 90% coverage for vaccines in the national immunization program, 70% coverage for lifelong vaccinations in high-risk populations, and the eventual elimination of rubella, polio, and measles. These objectives are supported by efforts to increase vaccine demand through public engagement and education.

Ukraine developed a national action plan for immunization and infectious disease prevention covering 2019–2022, which contributed to improved access to vaccination and greater institutional trust. Key interventions included enhanced financial support for the healthcare system, simplified pathways for immunization, and alignment with the European Programme of Work 2020–2025. However, the ongoing war has severely disrupted the implementation of these measures. A nationwide polio vaccination campaign targeting children under six was launched in early 2022 in response to an outbreak but had to be suspended due to conflict-related constraints. Additionally, a newly introduced primary healthcare funding mechanism was halted. The introduction of electronic medical records is anticipated to support improved monitoring of vaccination coverage and quality assurance in immunization services.

Successive strategic frameworks have shaped Lithuania's long-term immunization policy. The National Immunization Plan for 2019–2023 was successfully implemented, expanding free vaccine availability and a measurable increase in vaccination coverage. The upcoming plan for 2024–2028 prioritizes the continued expansion of services, with particular attention to rural populations through the deployment of mobile vaccination units and public education campaigns designed to counteract misinformation and strengthen vaccine confidence.

Across the region, these policy developments illustrate a growing recognition of the need for dynamic, inclusive, and evidence-based immunization programs. Long-term planning, institutional coordination, and responsiveness to structural and psychosocial barriers are increasingly central to vaccination policy in the post-pandemic landscape.

Public Perception and Awareness

Changing Perceptions

Public perception of vaccination in Central and Eastern Europe has undergone considerable change in recent years, shaped by historical patterns of vaccine rollout, structural limitations in healthcare systems, and the profound effects of the COVID-19 pandemic. One recurring issue across the region is the delayed integration of newly available vaccines into national immunization programs. In Poland, for example, introducing the rotavirus vaccine required over a decade of deliberation, while the HPV vaccine was only implemented after 15 years. Financial barriers further complicate the adoption of new immunizations. Vaccines recommended in national schedules but not officially mandated are often financed out-of-pocket, limiting their accessibility and reducing their impact on herd immunity. Notably, in the past ten years, no newly approved vaccines have been incorporated into Poland's mandatory calendar, and broader reforms in this area are progressing markedly slowly.

Beyond structural inertia, the pandemic has had a substantial psychological and sociocultural impact on vaccine trust across the region. The crisis significantly eroded confidence in protective vaccinations in Slovakia, particularly among previously vaccine-compliant groups. In Romania, survey data revealed a pronounced decline in trust toward childhood immunizations following the pandemic, with a ten-percentage-point drop in overall confidence. Young adults under 35 were significantly affected, with trust falling by 13.4%. Gender-specific patterns were also evident: trust declined by nearly 15% among men and approximately 6% among women. However, these shifts were not uniform; trust levels remained high among healthcare workers and medical students, highlighting the role of professional knowledge in shaping vaccine attitudes.

Lithuania presents a distinct case in which public attitudes are characterized by high perceived risk and notable ambivalence. While most Lithuanians believe in the importance of vaccination, concerns regarding vaccine safety and efficacy remain widespread. Public opinion exhibits high temporal variability, suggesting that a substantial segment of the population is undecided and may be susceptible to persuasion depending on the prevailing informational environment. This fragility in perception underscores the importance of stable, evidence-based public communication strategies.

The urgency and visibility of the COVID-19 crisis catalysed shifting public discourse in several countries. In Lithuania, the pandemic stimulated the development of vaccination infrastructure and enhanced public awareness, leading to a modest rise in uptake for other vaccines, such as influenza. However, sustaining these gains in trust and behavioural engagement remains a challenge, particularly in the face of disinformation, systemic delays, and uneven policy commitment.

Overall, the observed fluctuations in vaccine confidence reflect the dynamic interplay between institutional responsiveness, societal attitudes, and the legacy of past public health decisions. Strengthening and stabilizing vaccine perception will require long-term investment in communication, access, and the credibility of national immunization strategies.

Role of Modern Information Sources

Digital media platforms have become central to shaping public perceptions of vaccination, particularly among younger populations less engaged with traditional mass media or formal governmental communication channels. Social media environments serve simultaneously as arenas for the dissemination of scientifically grounded, pro-vaccine content and as

conduits for misinformation and anti-vaccination rhetoric. These platforms' dual nature presents opportunities and challenges for public health communication across Central and Eastern Europe.

In countries like Hungary and Lithuania, authorities and health organizations have increasingly turned to social media to disseminate reliable information and promote protective behaviors. These platforms have been recognized for their potential to reach previously disengaged demographic groups, especially adolescents and young adults. During the COVID-19 pandemic, Lithuanian public health campaigns effectively utilized digital channels to disseminate timely information, increasing awareness and engagement with immunization programs.

Conversely, the unregulated nature of social media also facilitates the spread of misleading or false narratives. In Slovakia and Romania, the proliferation of anti-vaccine content online has been linked to observable declines in vaccination coverage, particularly during the early 2010s. Anti-vaccination groups often exploit emotional rhetoric, anecdotal evidence, and conspiracy frameworks to undermine scientific consensus, contributing to heightened public uncertainty.

Nonetheless, innovative strategies have also emerged to counteract misinformation. In the Czech Republic, a government-funded campaign engaged popular internet influencers to produce short videos debunking myths about COVID-19 vaccination. Shared widely on social media, this campaign exemplified a strategic approach to reaching sceptical or undecided audiences through familiar and credible voices in the digital space.

Despite these promising examples, the use of digital platforms for health promotion remains ethically and operationally complex. Challenges include concerns about user privacy, the rapid circulation of unverified content, and the difficulty of regulating platform algorithms that prioritize sensational or polarizing information. To fully leverage social media's potential to support vaccination goals, governments, and health institutions must not only produce accurate and accessible content but also actively engage in digital literacy initiatives and collaborate with technology providers to moderate harmful content.

The experience of Central and Eastern European countries underscores the critical importance of digital ecosystems in the contemporary vaccination landscape. As traditional sources of health authority are increasingly supplemented—or in some cases supplanted—by online networks, the effectiveness of vaccination campaigns may depend as much on digital communication strategies as clinical infrastructure or policy design.

Effectiveness of Counter – Misinformation Campaigns

In contemporary society, social media has become a primary platform for communication, information exchange, and public discourse. However, the widespread dissemination of unverified or scientifically unfounded content related to vaccines contributes to fear, uncertainty, and declining trust in immunization. Counteracting vaccine misinformation has emerged as a critical public health challenge across Europe, with limited effectiveness of existing strategies. Addressing this issue requires coordinated, multisectoral action involving national and European institutions. The European Union has called on digital platforms to prioritize the visibility of credible sources, restrict the spread of false or misleading content, and remove illegal materials that undermine public health objectives.

Among the studied countries, several have implemented targeted campaigns to mitigate misinformation's impact. In the Czech Republic, a state-funded communication initiative to debunk vaccine myths provoked public debate, reflecting tensions around the role of government in shaping information ecosystems. In Hungary, communication strategies emphasizing clarity and authenticity, tailored to specific population groups, have been promoted as a promising approach, although their long-term impact remains limited. In Romania, multiple awareness campaigns have been launched, yet their outcomes are difficult to quantify, and restoring public trust remains a long-term process. Lithuania, in turn, implemented nationwide educational initiatives to improve public discourse around vaccination. Following the assessment of these efforts, the National Public Health Center published formal recommendations on effective vaccine communication strategies.

Despite these efforts, several countries in the region have experienced a marked decline in COVID-19 vaccine uptake over the past two years, suggesting that misinformation continues to influence public attitudes. This highlights the need for sustained and adaptive communication policies grounded in behavioural science and supported by public health authorities and civil society actors.

Health Outcomes and Epidemiological Data

Incidence and Prevalence Analysis

Epidemiological data from Central and Eastern Europe demonstrate a strong correlation between vaccination coverage and the incidence of vaccine-preventable diseases. In countries maintaining high immunization levels, such as Hungary, regional disparities in disease occurrence are negligible. The structure and effectiveness of the national vaccination system contribute to sustained control of infectious diseases in the paediatric population, with no significant regional variation reported.

Although the overall incidence of tetanus and pertussis has declined in Slovakia, intermittent resurgences have been observed. For example, in 2014, increased rates of pertussis were recorded across all regions, with a peak of 35 cases per 100,000 inhabitants in the Trenčín region. A subsequent resurgence occurred between 2018 and 2020, primarily affecting central and eastern areas, including some western regions. Measles outbreaks east of Slovakia between 2018 and 2019 reflected declining MMR vaccine coverage, with the highest incidence reaching 70 cases per 100,000 inhabitants in the Košice region. Although the number of cases decreased in 2019 and remained sporadic in the following years, the recurrence highlights the consequences of incomplete immunization. Other diseases, including mumps and hepatitis B, have shown fluctuating trends. No rubella cases have been reported over the past decade, while influenza incidence has increased significantly in 2022 and 2023 following the pandemic-related suppression of respiratory infections in 2021.

Romania has experienced two significant measles epidemics within the last decade, occurring between 2016 and 2019 and again in 2023 and 2024. These outbreaks were directly linked to a decline in vaccination coverage below the critical 95% threshold. A World Health Organization risk assessment conducted before the 2016 outbreak identified 27 of Romania's 42 districts as high or very high risk for measles resurgence. These districts were primarily located in the western part of the country and around the capital city, Bucharest. The primary contributing factors included suboptimal population immunity and inadequate epidemiological surveillance. Follow-up data from 2017 confirmed that the highest incidence rates aligned with the districts identified as high risk.

The epidemiology of other diseases, such as pertussis and chickenpox, exhibits cyclical patterns across the region, with increases observed every two to five years. In many countries, the lowest incidence of pertussis was reported in 2013 and 2014, with a peak in 2016, followed by a gradual decline until 2021. A slight increase occurred in 2022, although the overall trend remains downward. The incidence of measles also declined after the 2018–2019 peak, stabilizing during the COVID-19 pandemic, when transmission of several infectious diseases was temporarily reduced due to public health restrictions.

In Lithuania, vaccination coverage reached 94 to 99% by 2009, contributing to low incidence rates for vaccine-preventable diseases. However, from 2010 to 2022, a significant decline in coverage was observed, raising concerns about the potential for future outbreaks. These patterns underline the need for continued investment in immunization infrastructure, surveillance systems, and public trust in vaccination programs.

Herd Immunity and Outbreak Containment

Maintaining high vaccination coverage is essential for achieving herd immunity, which is critical in interrupting transmission chains and preventing the resurgence of vaccine-preventable diseases. When a sufficiently large proportion of the population is immunized, the spread of infectious agents is significantly curtailed, thereby protecting individuals who cannot be vaccinated due to medical contraindications or limited access. Conversely, vaccine refusal or delayed immunization weakens collective immunity and increases the likelihood of outbreaks, as observed across various Central and Eastern European countries.

The long-term effects of declining vaccination rates are particularly evident in diseases such as measles, pertussis, and poliomyelitis. In Slovakia, post-pandemic assessments revealed a decrease in MMR coverage to 94.43%, falling below the threshold required to sustain herd immunity. Several regions failed to meet the national target of 95% for childhood vaccinations, prompting enhanced monitoring by public health authorities. The risk of renewed measles transmission remains significant given the increased mobility within Europe and persistent immunity gaps.

Romania faces continued vulnerability to outbreaks of poliomyelitis and diphtheria due in part to its geographical proximity to Ukraine, where cases of these diseases have been reported in recent years. Regional instability, interrupted

healthcare services, and low vaccination coverage in conflict-affected areas contribute to cross-border epidemiological risks.

The experience of the Czech Republic illustrates the long-term benefits of sustained immunization. Before the introduction of vaccines, tens of thousands of measles cases were reported annually, with more than 89,000 cases documented in 1966 alone. Following the establishment of systematic vaccination, the incidence declined sharply. However, recent administrative checks suggest that only 93.46% of children are vaccinated, indicating a gradual erosion of coverage that may compromise the country's historically strong protection. In the context of a deteriorating epidemiological situation in neighbouring countries, the risk of cross-border transmission is increasing.

Lithuania experienced its highest number of measles cases in 2019, reporting 834 infections, followed by a steep decline to just two cases in 2020 and none in the subsequent years. Pandemic-related behavioural changes and public health measures likely influenced this reduction. Nevertheless, despite ongoing vaccination efforts, the country has observed a growing incidence of pneumococcal infections. Since introducing the pneumococcal vaccine into the national schedule, annual coverage among one-year-old children has remained at approximately 80%, with a peak of 83.4% recorded in 2020. While infections such as diphtheria and HBV have shown downward trends, continued vigilance is warranted, especially given the resurgence of other European diseases.

Hungary's public health strategy has prioritized the maintenance of high immunization rates in children as a foundation for population-level immunity. The government has also recognized the need to extend protection to adult and elderly populations through a life-course immunization approach. Efforts to improve the uptake of non-mandatory vaccines and integrate adult immunization into national policy are essential for strengthening overall resilience.

The COVID-19 pandemic underscored the critical role of vaccines in outbreak control. High uptake reduced severe illness and mortality, limited transmission, and demonstrated the population-level benefits of immunization. As vaccination coverage fluctuates, the capacity to control both endemic and emerging diseases depends increasingly on consistent coverage, real-time surveillance, and targeted public health responses to restore and preserve herd immunity.

Barriers and Challenges

Emerging Barriers to Vaccination

Multiple social and institutional factors impede efforts to achieve and sustain high vaccination coverage across Central and Eastern Europe. In several countries, declining trust in public institutions, the proliferation of vaccine misinformation, and changes in public perception of health risks have created an environment increasingly resistant to immunization messaging.

In Hungary, generational differences in media consumption and health-related behaviours have emerged as key factors influencing vaccination attitudes. Younger individuals, although increasingly valuing health and preventive care, are particularly vulnerable to misinformation disseminated through digital platforms. The erosion of trust in state institutions further compounds the problem. Public debates at national and international levels, particularly regarding vaccine procurement and regulatory processes, can bolster or undermine public confidence. When such discussions are perceived as opaque or politically motivated, they diminish the credibility of health authorities and healthcare workers who act as front-line communicators of vaccine-related information.

In the Czech Republic, barriers to vaccination include persistent scepticism among parents, particularly in response to new or recently recommended vaccines. The COVID-19 pandemic has intensified these attitudes by fueling broader anti-vaccine movements and amplifying concerns regarding vaccine safety and necessity. Misinformation continues circulating widely and remains a central obstacle to increasing immunization rates.

Slovakia presents a distinctive challenge rooted in the paradoxical effects of public health success. The low current incidence of many infectious diseases has led to a false sense of security, contributing to complacency among the general population and the healthcare sector. This complacency can undermine proactive immunization efforts. In addition, particular attention is required for vulnerable communities, especially the Roma population, where systemic barriers, limited access to health services, and historical marginalization contribute to suboptimal adherence to vaccination schedules.

Romania has experienced similar dynamics. Public discourse surrounding vaccine procurement during the COVID-19 pandemic significantly influenced trust in national authorities and healthcare professionals. The public often conflated bureaucratic delays and administrative decisions with doubts about vaccine safety and efficacy. This conflation made it difficult for health officials to communicate scientific evidence effectively, especially in contexts marked by pre-existing scepticism.

In Lithuania, the rapid spread of misinformation online has created substantial obstacles to building and maintaining public trust in vaccination. Anti-vaccine narratives have gained traction, mainly through social media, which increasingly serve as the primary source of health information for large segments of the population. The decline in trust in governmental and healthcare institutions has been cited in multiple studies as a key determinant of hesitancy.

Together, these barriers illustrate the region's multifaceted nature of vaccine resistance. Beyond individual concerns about vaccine efficacy or side effects, broader sociocultural, political, and informational dynamics shape willingness to participate in immunization programs. Addressing these challenges requires technical and logistical interventions, culturally sensitive communication strategies, and long-term investment in restoring public trust.

Challenges for Healthcare Providers

Healthcare providers across Central and Eastern Europe face growing challenges in maintaining public trust in vaccination and effectively communicating with patients in an increasingly complex informational landscape. A central difficulty identified in multiple national contexts is the sheer volume of information to which the public is exposed, encompassing both scientifically validated content and widespread misinformation propagated by anti-vaccine movements. This informational overload complicates many individuals' decision-making processes and undermines medical professionals' authority.

In Hungary, the need to engage younger populations has become a priority. Health authorities emphasize the importance of adapting communication strategies to the media preferences and values of distinct demographic groups, especially those who rely on social media rather than traditional information channels. This demographic shift requires healthcare providers to employ more flexible, audience-specific outreach methods.

Slovakia highlights the educational dimension of the challenge, particularly the need to improve the population's ability to assess information sources critically. The ability to distinguish between reliable and misleading content is increasingly essential for informed vaccine-related decisions, yet remains underdeveloped in many population segments. Healthcare workers are expected to provide clinical care and act as mediators between scientific knowledge and lay understanding.

In Romania, structured communication interventions have been introduced to support this role. The National Society of Family Medicine, in collaboration with the Vaccinology Society working group, has implemented motivational interviewing techniques. These approaches aim to guide conversations with hesitant or undecided individuals, especially parents, fostering trust and informed decision-making through empathetic and individualized dialogue.

The Czech Republic underscores the importance of equipping physicians with clear and practical communication skills. The COVID-19 pandemic placed new demands on providers to explain unfamiliar vaccine technologies and address rapidly evolving concerns. While much attention was directed toward the coronavirus vaccine, healthcare professionals are now encouraged to re-engage patients in discussions about foundational immunizations included in routine childhood and adult schedules.

Poland reports a continuous rise in parental refusals of childhood vaccines, prompting the development of targeted education campaigns and digital tools to support providers. These initiatives aim to build confidence in the safety and necessity of immunization, emphasizing tailored communication that addresses the concerns of specific audience groups.

In Lithuania, healthcare providers contend with systemic and informational barriers. These include widespread public distrust in institutions, a lack of digital communication infrastructure in primary care, and limited training in online engagement. Additionally, healthcare workers often face overwhelming workloads and insufficient institutional support to counter misinformation effectively. Addressing these constraints requires improved communication skills among providers and structural investment in time, resources, and supportive policy frameworks.

These challenges underscore the expanded role of healthcare professionals in the contemporary vaccination landscape. Beyond their clinical responsibilities, providers are increasingly tasked with navigating complex social dynamics, countering misinformation, and re-establishing trust in scientific institutions- all within health systems that may be under-resourced or organizationally fragmented.

Interventions and Strategies

Innovative Digital Campaigns

Digital communication strategies have emerged as a vital component in public health efforts to increase vaccination uptake, particularly among younger age groups less responsive to traditional outreach methods. Campaigns conducted through social media platforms, websites, and mobile applications offer several advantages, including rapid dissemination of content, broad population reach, and the capacity for demographic targeting and customization. These features make digital interventions especially effective among individuals aged 18 to 30, a cohort often characterized by lower vaccination rates than older populations.

Interactive formats such as gamified content, quizzes, and participatory tools have further enhanced the appeal of digital campaigns, increasing user engagement and message retention. In Poland, the #SzczepimySię initiative successfully applies these principles. The campaign combined multiple digital channels to promote awareness of COVID-19 vaccination and foster public dialogue. Its flexibility allowed for timely updates and adjustments in response to changing circumstances and audience feedback.

Similar approaches were implemented in Lithuania, where the most effective digital campaigns during and after the COVID-19 pandemic were those adapted to the specific behavioural patterns and cultural norms of the intended recipients. These tailored messages demonstrated a higher potential to influence decision-making and address hesitancy than generic health promotion content.

While digital tools are powerful, they are not universally effective across all population segments. In Hungary and other contexts, older adults rely on traditional information channels such as television, print media, and in-person consultations. Conventional communication methods remain essential for maintaining or increasing vaccine confidence for these groups.

The integration of digital and traditional approaches is therefore considered best practice. Individuals progressing from vaccine hesitancy to acceptance encounter different informational needs and psychological barriers, requiring varied forms of support. Romania's experience highlights the value of combining modern media with interpersonal communication strategies, particularly in engaging hesitant individuals at early and intermediate stages of the decision-making process.

In sum, deploying innovative digital campaigns represents a key element in contemporary vaccination strategies. Their success, however, depends on thoughtful design, audience segmentation, and coordinated integration with established communication methods.

Real-Time Evaluation of Initiatives

The assessment of vaccination initiatives increasingly relies on real-time data collection and analysis, enabling public health authorities to monitor program effectiveness, identify emerging challenges, and refine strategies accordingly. Several complementary methods are employed across Central and Eastern Europe to evaluate immunization outcomes and public engagement.

Core approaches include systematically collecting data on the number of vaccinated individuals, disaggregating by age, region, or risk group, and comparing against historical benchmarks. These datasets enable trend analysis and early identification of declines in coverage. In parallel, serological studies assessing antibody levels among vaccinated individuals provide insight into the immunogenicity and durability of vaccine-induced protection. Epidemiological surveillance, mainly through comparing disease incidence in vaccinated versus unvaccinated populations, further informs assessments of vaccine effectiveness.

Qualitative feedback mechanisms also play an essential role. Gathering information from program participants regarding their experiences, perceived barriers, and motivations offers valuable context for interpreting quantitative indicators and helps tailor future interventions to community needs.

Hungary has developed a digital infrastructure that facilitates centralized recording and analysis of vaccination data. Through the national online healthcare platform, healthcare providers input vaccination records directly into a secure cloud system. This enables continuous national-level monitoring of vaccination rates and supports the timely identification of coverage gaps.

In Slovakia, digital technologies are similarly used to enhance data flow between local and national systems. Real-time information exchange allows for rapid evaluation of vaccination progress and facilitates the deployment of targeted responses in regions or populations with suboptimal coverage.

Integrating digital tools into evaluation systems improves the accuracy and timeliness of monitoring and strengthens the responsiveness of public health programs. As immunization strategies become more complex and adaptive, particularly in emerging infectious threats, real-time evaluation will remain a cornerstone of effective vaccine governance.

Future Outlook

Predictions for Vaccination Trends

A complex interplay of biomedical, socio-political, and institutional factors will shape the trajectory of future vaccination trends in Central and Eastern Europe. Key determinants include the type and origin of vaccines, perceived safety, and the profile and frequency of reported side effects. These factors influence both individual decision-making and broader societal attitudes toward immunization programs.

Political engagement and trust in public institutions are also expected to play a pivotal role. In contexts where institutional credibility is high, vaccine acceptance tends to be more stable For instance, trust in government health policy in Hungary remains a critical variable in shaping public compliance with immunization schedules. Conversely, in countries where political discourse around vaccination has been marked by controversy or fragmentation, hesitancy may persist or intensify.

Romania anticipates that future efforts must move beyond vaccine availability to address structural challenges in health service delivery. A particular emphasis is placed on mitigating disparities in rural healthcare provision and establishing centralized crisis intervention units to support vaccination communication during emergencies.

While Slovakia has not issued formal projections regarding future trends, other countries have begun exploring broader immunization applications beyond infectious disease control. In the Czech Republic, attention is turning toward the potential of therapeutic vaccines for chronic conditions such as cancer or autoimmune diseases. The development of vaccines tailored to individual patient profiles, including those based on mRNA or other novel platforms, is expected to become increasingly prominent in the coming years.

Lithuania has experienced a gradual decline in vaccination rates over the past decade, raising concerns about long-term public health resilience. Although the country does not publish formal forecasts of coverage levels, it responds to negative trends by implementing targeted communication campaigns designed to realign national uptake with thresholds recommended by the World Health Organization.

In sum, the future of vaccination in the region is likely to be defined by the dual pressures of innovation and trust. Advances in vaccine technology will offer new possibilities for disease prevention and treatment, but their successful adoption will depend on public confidence, equitable access, and adaptive health communication strategies.

Preparedness for Future Outbreaks

The COVID-19 pandemic served as a critical stress test for healthcare systems across Central and Eastern Europe, revealing systemic vulnerabilities and prompting a revaluation of preparedness for future infectious disease outbreaks. While national responses varied, common challenges included insufficient funding, workforce shortages, and fragmented coordination between institutional actors. In the post-pandemic context, countries have undertaken various reforms to strengthen resilience and ensure more effective responses to future public health emergencies.

In Hungary, experts have highlighted the urgent need to bolster the healthcare system, particularly in light of persistent underfunding and significant deficits in medical personnel. These structural limitations, coupled with the population's generally poor health status, represent significant risk factors in the event of a future pandemic or large-scale

outbreak. Strategic investment in healthcare capacity, infrastructure, and workforce development has been identified as a national priority.

Slovakia has adopted a formal pandemic preparedness plan, outlining a phased framework for addressing future crises related to acute respiratory infections. This national plan details the responsibilities of governmental bodies, local authorities, and healthcare institutions across five stages of pandemic evolution. In addition to public health measures, the plan recognizes the role of the private sector, encouraging companies of all sizes to establish internal pandemic protocols that define specific actions and lines of responsibility. The experience of COVID-19 has redefined employer obligations, emphasizing workplace health protection as a core component of societal resilience.

Romania responded to the pandemic by approving a National Vaccination Strategy against COVID-19 and establishing the National Committee for Coordination of Vaccination Activities (CNCAV). This centralized body played a key role in organizing logistics, communication, and the rollout of mass immunization infrastructure, including dedicated vaccination centers. These institutional frameworks are now being adapted to support long-term emergency response capabilities.

In the Czech Republic, preparedness is embedded within the broader "Strategic Frameworks for Health Care Development until 2030", prioritizing strengthening primary care as a foundational pillar of the pandemic response. The need to enhance coordination, accessibility, and continuity of services has become more urgent in light of the pandemic's systemic impacts.

In Poland, the crisis exposed multiple structural deficits, prompting targeted reforms. Key focus areas include elevating health protection in national policy agendas, expanding the medical workforce, improving access to modern therapies, reforming healthcare financing models, promoting e-health solutions, and transitioning more services from inpatient to outpatient care. These shifts aim to improve adaptability, reduce system strain, and enhance long-term capacity.

Lithuania conducted a comprehensive post-pandemic audit to assess the robustness of its healthcare system under emergency conditions. The audit led to several recommendations, including revising legal frameworks, improving collaboration with non-governmental actors, and developing systems for real-time tracking of healthcare resources. New procedures for identifying medical personnel and mapping their competencies were also proposed to ensure the optimal allocation of human resources during future crises.

Together, these initiatives reflect an emerging consensus on the importance of proactive, system-wide preparedness. While varying in scope and maturity, national strategies across the region increasingly recognize that pandemic readiness depends not only on rapid response mechanisms but also on long-term investments in healthcare infrastructure, institutional coordination, and public trust.

Demographic and Regional Variations

Urban vs Rural Vaccination Rates

Geographic disparities in vaccination coverage between urban and rural areas remain a persistent challenge in several Central and Eastern European countries. These differences are shaped by a combination of structural, logistical, and sociocultural factors and directly impact the equity and effectiveness of immunization programs.

Higher vaccination rates are consistently reported in urban centres, particularly capital cities and large county towns. In Hungary, this pattern is associated with higher levels of education, income, and access to healthcare services. Local media and healthcare personnel have been recognized as key actors in mitigating these disparities by facilitating access to information and promoting vaccine uptake in underserved communities.

The contrast between urban and rural vaccination rates is especially pronounced in Slovakia and Poland. Urban areas benefit from denser healthcare infrastructure, including greater availability of physicians, nurses, and public health professionals. Rural regions, by contrast, face several interrelated obstacles, such as geographic isolation, limited transport options, shortages of healthcare personnel, and lower levels of health literacy. Cultural traditions and entrenched beliefs may inhibit vaccine acceptance in some rural communities.

A range of interventions have been implemented to address these gaps. These include deploying mobile vaccination units, expanding telemedicine services for remote consultations, and training local healthcare workers to serve as trusted

points of contact within their communities. Public awareness campaigns, collaboration with local leaders, and improving transportation services have also been used to strengthen outreach and accessibility.

In Romania and the Czech Republic, workforce imbalances further exacerbate rural vulnerabilities. In Romania, only 36.5% of family doctors serve rural areas, despite nearly half of the population residing there. Similar shortages are reported in the Czech Republic, where the absence of family doctors in some regions has directly impacted local vaccination rates.

Poland faces a growing deficit of medical personnel in rural areas, particularly nurses responsible for administering vaccines. This deficit is compounded by limited access to reliable information and comparatively low trust in public health institutions, which undermines the effectiveness of national immunization strategies.

Lithuania is an exception to this trend, where national statistics do not indicate significant differences in vaccination rates between urban and rural populations. This relative uniformity may reflect more evenly distributed healthcare services or effective national-level coordination in immunization delivery.

Addressing urban-rural disparities in vaccination requires sustained policy attention, resource allocation, and community-level engagement. Ensuring equitable access to immunization is a matter of public health efficiency and social justice, particularly in regions where structural disadvantages are historically entrenched.

Impact of Demographics (Age, Gender, Ethnicity)

Demographic characteristics such as age, gender, socioeconomic status, and ethnic background considerably influence vaccination behaviours in Central and Eastern Europe. Understanding these factors is essential for designing inclusive and responsive immunization policies.

Age remains a key determinant of vaccine uptake. In Hungary, lower vaccination rates are observed among individuals under the age of 59, particularly men with low education and income who are not classified as belonging to clinical risk groups. Conversely, elderly individuals, especially those over 65, tend to exhibit higher vaccination rates, likely due to increased perceived vulnerability to infectious diseases and targeted public health messaging. In Slovakia, the aging population has led to greater demand for vaccines against influenza, pneumococcal disease, and COVID-19, while rising birth rates have increased the importance of maintaining high coverage of childhood immunizations such as those for pertussis, measles, mumps, and rubella.

Gender dynamics also play a role. For example, women of childbearing age represent a population group with specific immunization needs, particularly in maternal and neonatal health. In contrast, some studies suggest that men are more likely to delay or decline vaccinations, particularly when compounded by other demographic risk factors such as lower education levels or social isolation.

Family status influences vaccine decisions in nuanced ways. In Hungary, research indicates that single and childless individuals are more likely to accept vaccinations. In contrast, individuals in couples may reinforce each other's hesitancy, mainly when influenced by concerns related to fertility or reproductive health.

Ethnicity and migration status introduce additional layers of complexity. The influx of migrants and refugees, mainly from Ukraine, necessitates adaptive vaccination strategies to address incomplete or undocumented immunization histories. These populations may require catch-up immunizations and culturally appropriate information to align with national vaccine schedules.

One group requiring sustained attention is the Romani population, which is present across several regional countries. These communities are often characterized by socioeconomic disadvantage, limited access to healthcare services, and lower levels of formal education. Their historically marginalized status contributes to mistrust toward public institutions, including health authorities. Effective vaccination outreach in these contexts requires culturally tailored communication strategies and partnerships with Romani community leaders to build trust and facilitate participation in immunization programs.

In contrast, Lithuania's demographic profile remains relatively stable, with limited ethnic diversity. The homogeneity of the population makes it more challenging to isolate the influence of ethnicity on vaccination behaviours; however, ongoing migration patterns may gradually alter this landscape in the future.

As demographic structures evolve, vaccination strategies must remain flexible and data-informed. Tailored interventions that address the specific needs of diverse population groups are essential for achieving equitable and comprehensive immunization coverage across the region.

Policy Impact - Post-Pandemic Policy Adaptations

The COVID-19 pandemic has profoundly influenced vaccination policies and broader approaches to public health protection across Central and Eastern Europe. The crisis revealed systemic vulnerabilities, prompted policy innovations, and redefined national priorities in preventive health and emergency preparedness.

The government introduced mandatory COVID-19 vaccination requirements in Slovakia, restricting access to workplaces, public events, and retail spaces for unvaccinated individuals. While these measures aimed to increase uptake, they also generated public controversy. They contributed to a sense of coercion, diminishing trust in vaccination efforts among specific population groups. The Slovak experience highlights the delicate balance between public health mandates and the need to preserve autonomy and trust in health institutions.

In Romania, vaccination coverage during the pandemic remained below 50% of the eligible population, exposing significant deficits in public knowledge about infectious disease prevention. This underscored the necessity of adopting a comprehensive educational approach beyond childhood immunization. Future strategies increasingly emphasize integrating health education into schools, community outreach, and workplace-based counselling, to foster a culture of lifelong immunization literacy.

The Czech Republic has identified improved accessibility as a central post-pandemic policy objective. Expanding the number and types of vaccination sites- including pharmacies has been proposed to reduce logistical barriers. There is also recognition of the need for more excellent continuity and coordination in vaccination delivery, mainly through digital registries and centralized appointment systems.

In Hungary, post-pandemic recommendations include the systematic planning of immunization programs and investment in logistical infrastructure. Priorities include ensuring stable vaccine supply chains, improving geographic access to vaccination services, and enhancing public awareness. Additional strategies under consideration involve proactive communication measures, such as sending personalized reminders, utilizing schools for HPV vaccination delivery, and eliminating the requirement for prior registration to encourage spontaneous participation. Understanding the psychological and social determinants of vaccine hesitancy is considered integral to developing more responsive policy frameworks.

Poland's pandemic response catalysed advancements in biomedical innovation and immunization infrastructure. The crisis accelerated the development and approval of novel technologies, including mRNA vaccines, while stimulating public investment in research and vaccine production. Implementing a National Vaccination Program facilitated improved public access to vaccines and demonstrated the potential for centralized coordination of large-scale immunization campaigns.

In Lithuania, the pandemic prompted the development of evidence-based policies through targeted research initiatives. The Lithuanian Science Council launched dedicated funding calls to examine the effectiveness of pandemic-related health interventions. The outcomes informed national decision-making and led to the adoption of strategic resolutions, including the critical review of existing vaccination strategies, assessment of both successful and ineffective measures, and the application of international best practices. Emphasis was placed on aligning future vaccination policies with scientific evidence and expert recommendations.

Collectively, these adaptations illustrate a regional shift toward more data-driven, inclusive, and resilient vaccination policies. While country-specific approaches differ, the overarching trend reflects a growing commitment to integrating scientific knowledge, public engagement, and system-level coordination in the design of immunization strategies for the post-pandemic era.

A comparison of vaccination trends and challenges across Central and Eastern Europe is presented in Table S1.

Discussion

This article provides an in-depth examination of vaccination trends across seven Central and Eastern European countries, focusing on the multifaceted influences shaping public vaccine confidence and policy effectiveness. By analysing socio-

cultural, economic, digital, and policy-related factors, this study offers a nuanced understanding of vaccine hesitancy and the interventions required to sustain and improve immunization rates in these regions.

Socio-Cultural Influences and Vaccine Confidence

This study reinforces prior research demonstrating that vaccine confidence is highly context-dependent and shaped by cultural norms, historical legacies, and levels of institutional trust. Countries in Central and Eastern Europe, particularly Slovakia, Romania, and Bulgaria, have been characterized by fluctuating trust in vaccines, often linked to broader scepticism toward public institutions.[15,16] Vaccine hesitancy in these contexts is not solely the result of misinformation but frequently intersects with perceptions of medical paternalism, especially in regions with a legacy of top-down healthcare governance.[5,13] In this context, risk perception remains a decisive factor in vaccine acceptance, particularly among parents. A recent systematic review and meta-analysis by Liu and He (2025)[17] comparing paediatric outcomes of SARS-CoV-2 and seasonal influenza found that COVID-19 may be associated with more distinct and sometimes more severe clinical presentations. Such findings reinforce the importance of accurate, evidence-based communication strategies tailored to parental concerns and paediatric risk profiles.

Community-based approaches, such as involving religious leaders, educators, and local mediators, have effectively bridged trust deficits.[13,18] Tailored communication, including culturally resonant storytelling and visual materials, has been particularly successful among marginalized groups, such as the Roma population, by reframing vaccination as collective care.[19]

National variations are also notable In Poland, vaccine confidence among healthcare professionals remains high, supporting public trust and adherence. In contrast, Slovakia and Bulgaria exhibit lower trust levels. In societies with strong natural healing traditions, vaccines may be perceived as conflicting with cultural practices.[16] Political instability further erodes trust when public health measures are seen as coercive rather than collaborative. These observations support recommendations for culturally sensitive campaigns incorporating trusted figures and local narratives to increase acceptance.[13,20]

Consistent with our findings, recent reports highlight that vaccine hesitancy is significantly influenced by socio-cultural and economic contexts, underlining the importance of tailoring public health interventions to address these diverse factors. For instance, the Expert Panel on Effective Ways of Investing in Health emphasizes that vaccine hesitancy often results from a complex interplay of misinformation, socioeconomic barriers, institutional trust deficits, and logistical challenges, which resonate strongly with observations from this study (EXPH, 2018).[21] Building trust in healthcare institutions and promoting dialogue through community-based outreach involving trusted figures such as religious leaders or local health professionals has effectively addressed vaccine hesitancy in European contexts (EXPH, 2018). Additionally, the report underscores the critical role of primary care providers, advocating for better training in empathetic communication strategies to manage hesitancy effectively (EXPH, 2018).

Furthermore, our findings align with the Expert Panel's recommendation that improving vaccine uptake requires addressing misinformation directly and enhancing healthcare accessibility through initiatives like mobile vaccination units, conditional cash transfer schemes, and improved healthcare infrastructure - particularly in underserved regions (EXPH, 2018). Effective monitoring systems and agile, data-driven health policy responses are also critical to rapidly adapting to evolving public sentiments and misinformation threats, emphasizing the importance of real-time analytics and intersectoral coordination in vaccination programs (EXPH, 2018).

Integrating these multi-dimensional insights into future vaccination strategies could significantly improve vaccine acceptance and coverage, particularly in regions facing persistent vaccine hesitancy and socioeconomic challenges.

Socio-Economic Barriers to Vaccine Access

Socio-economic disparities are critical to vaccine uptake. Rural communities and socioeconomically disadvantaged populations across the region face significant barriers, including limited access to healthcare professionals, logistical constraints, and out-of-pocket vaccine expenses.[18,22]

Mobile vaccination units, conditional cash transfer schemes, and local health infrastructure investments have reduced these barriers.[19,23] The role of community health workers and Roma health mediators in Romania and local health initiatives in Poland and Slovakia, underscore the importance of community-based outreach.[13,22]

Access is not only a function of logistics but also of perceived value and trust in health services. Sustained engagement, co-location of services with primary care, and multilingual materials are critical for improving reach and equity in immunization.[18,23,24]

The Role of Digital Misinformation

Digital misinformation remains a substantial threat to Central and Eastern European vaccination efforts. The COVID-19 pandemic highlighted how online platforms amplify fears related to vaccine safety, particularly in populations with low digital literacy and fragile institutional trust.[6,23,25]

Effective countermeasures include real-time social media monitoring, strategic partnerships with fact-checking organizations, and dissemination of locally adapted and verified health content.[7,8] Campaigns featuring peer influencers and respected local health professionals, such as those in the Czech Republic, have proven particularly effective in reaching younger demographics.[26,27]

Digital health literacy must be systematically addressed through integration into school curricula, training for healthcare providers, and collaboration with social media platforms to flag and remove misleading content.[28–30]

Healthcare Providers as Trusted Sources

Healthcare professionals are key agents of vaccine promotion. Their endorsement significantly shapes public perceptions and vaccination behaviour.[8,31] Countries such as Poland, where trust in medical personnel remains high, can serve as models for peer-led communication and education strategies.

However, even informed providers may encounter challenges in contexts of low vaccine confidence. Communication training emphasizing empathy, narrative competence, and motivational interviewing is essential.[26,27] Patient-centered approaches that validate concerns while presenting scientific evidence can enhance acceptance, especially when institutional support for vaccine counselling is sustained.[27]

Recent findings from a mixed-methods study by Petrazzuoli et al,[32] encompassing 16 European countries, highlighted that the resilience of primary care systems - including their ability to maintain patient communication and service continuity during the pandemic - was a key determinant of vaccination system stability. Countries with strong primary care infrastructure and coordinated provider responses demonstrated greater public trust and adaptability in the face of uncertainty.

Government Policy and Health System Responsiveness

Adaptive and data-driven policies have proven effective in maintaining immunization coverage. Countries such as Hungary and Lithuania, with established health informatics systems and flexible service models, were better equipped to mitigate disruptions during the COVID-19 pandemic.[28,33]

In contrast, countries with fragmented governance or limited surveillance capacity struggled to maintain vaccination rates. Real-time analytics, intersectoral coordination, and proactive communication strategies are essential to ensure responsiveness during public health crises.[34,35]

Public health governance must prioritize flexibility, inclusivity, and transparent communication to maintain public trust and rapidly respond to emerging threats.[28,36]

Addressing Emerging and Evolving Barriers

Vaccine hesitancy continues to evolve in response to technological shifts, socio-political dynamics, and changing risk perceptions. The pandemic has exposed both structural gaps and attitudinal barriers, demanding innovative and interdisciplinary approaches.[34,36]

Sentiment analysis tools, digital surveillance of misinformation, and rapid feedback loops can support the timely adaptation of health messaging. These tools should be integrated with behavioural insights to tailor responses to local contexts and shifting public narratives.[34,37]

Integrated communication strategies involving behavioural scientists, public health experts, and local stakeholders are essential to address both cognitive and emotional drivers of hesitancy.[35]

Implications for Future Vaccination Programs

Future immunization efforts must be context-sensitive, participatory, and rooted in cross-sector collaboration. Engaging local stakeholders while aligning with international best practices offers a sustainable path to addressing vaccine hesitancy.[25,37]

Cross-border partnerships in disease surveillance, public health communication, and technological innovation can bolster regional preparedness. Investment in trust-building, digital infrastructure, and education will be essential to closing vaccination gaps.

Flexible, inclusive, and resilient programs will be better positioned to confront future public health challenges, from pandemics to misinformation crises.

Demographic Patterns and Regional Inequities

Findings from this study highlight significant demographic and geographic disparities in vaccine coverage. Urban residents, individuals with higher education and income, and older adults are more likely to be vaccinated. At the same time, rural populations, ethnic minorities (particularly the Roma), and low-income groups exhibit lower vaccination rates.

Efforts to bridge these gaps must include mobile vaccination teams, targeted education campaigns, transportation assistance, and collaboration with community leaders. Health workforce shortages in rural regions, such as the lack of family doctors in Romania and nurses in Poland, further compound access issues. Lithuania is an exception, where no significant urban-rural disparities were observed.

Culturally tailored interventions are needed to address historically marginalized communities and migrants with incomplete immunization histories. Demographic transitions, including aging populations and migration flows, demand adaptable vaccination strategies for changing population structures.

Post-Pandemic Policy Evolution

The COVID-19 pandemic served as a stress test for national immunization systems. Countries have responded with varying degrees of legislative and strategic reform. Romania and Poland revised vaccination policies to expand coverage and integrate new vaccines, such as HPV and pneumococcal immunization.

Some countries, including Slovakia and Hungary, introduced pandemic response plans emphasizing digital registration systems, mobile infrastructure, and flexible vaccine delivery. However, the pandemic also exacerbated public mistrust in some settings, particularly where mandates were perceived as coercive.

Strengthening vaccination programs post-pandemic requires legal reforms, public communication investment, and stakeholder feedback mechanisms. Evaluating pandemic response strategies and incorporating lessons learned into future planning is critical.

Strategic Recommendations

This study suggests several strategic priorities for enhancing vaccination uptake in Central and Eastern Europe. First, expanding digital and mobile infrastructure is essential to improve access among underserved populations, particularly in rural or socioeconomically disadvantaged areas. Simultaneously, targeted investment in digital health literacy is crucial, especially for youth and marginalized groups, who are often more exposed to online misinformation and less equipped to assess health-related content critically. Equally important is promoting context-specific, value-based communication strategies that reflect local cultural, religious, and social norms, fostering trust and relevance in public health messaging.

Healthcare professionals should be trained in empathetic vaccine counselling and motivational interviewing, enabling them to address concerns more effectively and strengthen patient-provider trust. The integration of real-time monitoring systems, including digital surveillance and sentiment analysis, would allow for the early detection of emerging hesitancy trends and enable timely policy adjustments. In addition, fostering cross-border collaboration in epidemiological surveillance, data sharing, and capacity building can enhance regional resilience and harmonize public health responses.

Finally, ensuring inclusive governance that actively incorporates local voices, including community leaders, educators, and patient groups, into policy development is imperative. Such participatory frameworks promote shared responsibility and can significantly improve the acceptance and sustainability of immunization programs. Implementing these recommendations requires long-term commitment, multisectoral coordination, and alignment with broader regional public health goals.

Limitations of the Study

This study presents several limitations that should be considered when interpreting its findings. Firstly, the analysis relied primarily on secondary data sources, including national reports, policy documents, published literature, and stakeholder expertise. Although this approach enabled a broad comparative perspective across the selected countries, it also introduced potential inconsistencies due to differences in the availability, quality, and timeliness of national data and reporting practices.

Secondly, the use of expert stakeholder input, while offering valuable context-specific insights, may have introduced subjective interpretations or national biases. The absence of primary data collection through structured surveys or interviews limits the ability to fully assess public perceptions, behavioural drivers, and vaccination intentions at the individual level.

Additionally, the dynamic nature of vaccine policy and public discourse, especially in the aftermath of the COVID-19 pandemic, presents a challenge to capturing real-time developments. Some national strategies and public attitudes may have evolved since the data were collected, affecting specific findings' temporal relevance.

Another limitation is the heterogeneity in the granularity of available data. Not all countries provided disaggregated data by age group, gender, ethnicity, or socio-economic status, which restricts the capacity to perform a more nuanced intersectional analysis.

Finally, while the study provides descriptive and comparative insights, it does not aim to establish causal relationships between specific determinants and vaccination uptake. The findings should be considered exploratory and hypothesis-generating to inform future empirical research and policy refinement.

Conclusions

This study underscores the importance of targeted and adaptable vaccination strategies for Central and Eastern Europe, highlighting that factors such as socio-economic challenges, regional healthcare infrastructure, and vaccine confidence disparities significantly affect vaccination rates. By addressing these issues, public health programs can improve vaccine accessibility and acceptance across diverse populations. This requires coordinated efforts across national and local levels to enhance the quality and use of immunization and surveillance data, as the SAGE Working Group on Immunization and Surveillance Data Quality and Use recommends. Utilizing high-quality data to inform strategies allows for the timely identification of gaps in vaccination coverage, ensuring interventions are responsive to real-time public health needs.[35]

In addition to robust data-driven approaches, fostering trust through transparent, culturally sensitive communication can help counteract misinformation and build vaccine confidence. This includes leveraging trusted community figures and local healthcare providers and deploying digital literacy campaigns to address misinformation spread via social media. With these multifaceted efforts, health authorities can create a resilient, community-centric foundation for addressing the region's current and future vaccine-preventable health challenges.

Ethics Approval and Consent to Participate

This study was approved by the Bioethics Committee of the Medical University of Wroclaw under the number KB230/2024.

Acknowledgments

The views expressed are those of the authors and do not necessarily reflect the European Union or HaDEA. Neither the European Union nor the granting authority can be held responsible for them.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

The EUVABECO project was co-funded by the European Union's EU4Health Programme under Grant Agreement No. 101132545 and by the Polish Ministry of Science and Higher Education in the framework of the International Co-financed Projects program. The funders had no role in the study's design; in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

Disclosure

The authors have no relevant financial or non-financial interests to disclose for this work.

References

1. Rodrigues CMC, Plotkin SA. Impact of vaccines: health, economic and social perspectives. *Front Microbiol*. 2020;10:142–149.
2. Kaur G, Danovaro-Holliday MC, Mwinnyaa G, et al. Routine vaccination coverage — worldwide, 2022. *MMWR Morb Mortal Wkly Rep*. 2023;72:1155–1161. doi:10.15585/mmwr.mm7243a1
3. Andigema SA, Ngnotouom NTC. Addressing vaccine hesitancy: a review of factors contributing to vaccine refusal and effective communication strategies for promoting vaccine acceptance. *Preprints*. 2024. doi:10.20944/preprints202407.1224.v1
4. Smith SE, Sivertsen N, Lines L, De Bellis A. Exploring social media influences on vaccine decision-making in parents: a netnography. *Ther Adv Vaccines Immunother*. 2024;12:25151355241249607. PMID:38726045;PMCID:PMC11080448. doi:10.1177/25151355241249607
5. Kelsall J, Sorell T. Two kinds of vaccine hesitancy. *Soc Epistemol*. 2024;39:215–228. doi:10.1080/02691728.2024.2330466
6. Ecker UKH, Lewandowsky S, Cook J, et al. The psychological drivers of misinformation belief and its resistance to correction. *Nat Rev Psychol*. 2022;1:13–29. doi:10.1038/s44159-021-00006-y
7. Steffens MS, Dunn AG, Wiley KE, et al. How organisations promoting vaccination respond to misinformation on social media: a qualitative investigation. *BMC Public Health*. 2019;19:1348. doi:10.1186/s12889-019-7659-3
8. Holford D, Anderson EC, Biswas A, et al. Healthcare professionals' perceptions of challenges in vaccine communication and training needs: a qualitative study. *BMC Prim Care*. 2024;25:264. doi:10.1186/s12875-024-02509-y
9. World Health Organization. Vaccine standardization. Available from: https://www.who.int/teams/health-product-policy-and-standards/standards-and-specifications/norms-and-standards/vaccine-standardization. Accessed December 7, 2024.
10. World Health Organization. Immunization Agenda 2030: a global strategy to leave no one behind. Available from: https://cdn.who.int/media/docs/default-source/immunization/strategy/ia2030/ia2030-draft-4-wha.pdf. Accessed December, 5, 2024.
11. European Centre for Disease Prevention and Control. ECDC Vaccine Scheduler. Available from: https://vaccine-schedule.ecdc.europa.eu/. Accessed November 24, 2024.
12. Figueiredo A, Eagan RL, Hendrickx G, Karafillakis E, Van Damme P, Larson HJ. State of vaccine confidence in the European Union. 2022.
13. Sinuraya RK, Nuwarda RF, Postma MJ, Suwantika AA. Vaccine hesitancy and equity: lessons learned from the past and how they affect the COVID-19 countermeasure in Indonesia. *Glob Health*. 2024;20(1):11. doi:10.1186/s12992-023-00987-w
14. Vojtek I, Larson H, Plotkin S, Van Damme P. Evolving measles status and immunization policy development in six European countries. *Hum Vaccin Immunother*. 2022;18(1). doi:10.1080/21645515.2022.2031776
15. Kaur M, Coppeta L, Olesen OF. Vaccine hesitancy among healthcare workers in Europe: a systematic review. *Vaccines*. 2023;11(11):1657. PMID:38005989;PMCID:PMC10675787. doi:10.3390/vaccines11111657
16. Ali GG, Rahman MM, Hossain MA, et al. Public perceptions of COVID-19 vaccines: policy implications from US spatiotemporal sentiment analytics. *Healthcare*. 2021;9(9):1110. PMID:34574884; PMCID:PMC8465389. doi:10.3390/healthcare9091110
17. Liu C, He F. Systematic review and meta-analysis of randomized controlled trials comparing the clinical outcomes of SARS-CoV-2 and influenza in pediatric patients. *Adv Clin Exp Med*. 2025. doi:10.17219/acem/192224
18. Ekezie W, Awwad S, Krauchenberg A, et al. Access to vaccination among disadvantaged, isolated and difficult-to-reach communities in the WHO European Region: a systematic review. *Vaccines*. 2022;10(7):1038. PMID:35891201;PMCID:PMC9324407. doi:10.3390/vaccines10071038
19. Patel J, More S, Sohani P, et al. Sustaining the mobile medical units to bring equity in healthcare: a PLS-SEM approach. *Int J Equity Health*. 2024;23:175. doi:10.1186/s12939-024-02260-x
20. Dickson K, Aboltins C, Pelly J, Jessup RL. Effective communication of COVID-19 vaccine information to recently-arrived culturally and linguistically diverse communities: a qualitative study. *BMC Health Serv Res*. 2023;23(1):877. PMID:37605184; PMCID:PMC10440864. doi:10.1186/s12913-023-09836-3

21. Expert Panel on Effective Ways of Investing in Health (EXPH). *Vaccination Programmes and Health Systems in the European Union*. Luxembourg: Publications Office of the European Union; 2018. doi:10.2875/18503
22. Piccoliori G, Barbieri V, Wiedermann CJ, Engl A. Special roles of rural primary care and family medicine in improving vaccine hesitancy. *Adv Clin Exp Med*. 2023;32(4):401–406. doi:10.17219/acem/162349
23. Ngai CSB, Singh RG, Yao L. Impact of COVID-19 vaccine misinformation on social media virality: content analysis of message themes and writing strategies. *J Med Internet Res*. 2022;24(7):e37806. PMID:35731969;PMCID:PMC9301555. doi:10.2196/37806
24. Obregon R, Mosquera M, Tomsa S, Chitnis K. Vaccine hesitancy and demand for immunization in Eastern Europe and Central Asia: implications for the region and beyond. *J Health Commun*. 2020;25(10):808–815. doi:10.1080/10810730.2021.1879366
25. Lee SK, Sun J, Jang S, Connelly S. Misinformation of COVID-19 vaccines and vaccine hesitancy. *Sci Rep*. 2022;12(1):13681. PMID:35953500; PMCID:PMC9366757. doi:10.1038/s41598-022-17430-6
26. Lip A, Pateman M, Fullerton MM, et al. Vaccine hesitancy educational tools for healthcare providers and trainees: a scoping review. *Vaccine*. 2023;41(1):23–35. doi:10.1016/j.vaccine.2022.09.093
27. Patel P, Nguyen M, Wilson D, et al. New initiatives in vaccination programs. *Health Promot Int*. 2019;36(2):182–194. doi:10.1093/heapro/daz012
28. Gravagna K, Becker A, Valeris-Chacin R, et al. Global assessment of national mandatory vaccination policies and consequences of non-compliance. *Vaccine*. 2020;38(49):7865–7873. doi:10.1016/j.vaccine.2020.09.063
29. Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger JA. Vaccine hesitancy: an overview. *Hum Vaccin Immunother*. 2013;9(8):1763–1773. doi:10.4161/hv.24657
30. Smith A, Yarwood J, Salisbury DM. Tracking mothers' attitudes to MMR immunisation 1996–2006. *Vaccine*. 2007;25:3996–4002. PMID:17395344. doi:10.1016/j.vaccine.2007.02.071
31. Furman FM, Zgliczyński WS, Jankowski M, et al. The state of vaccine confidence in Poland: a 2019 nationwide cross-sectional survey. *Int J Environ Res Public Health*. 2020;17(12):4565. PMID:32599943; PMCID:PMC7345001. doi:10.3390/ijerph17124565
32. Petrazzuoli F, Gokdemir O, Antonopoulou M, et al. Resilience of primary healthcare facilities: experiences from 16 European countries during the COVID-19 pandemic. *Adv Clin Exp Med*. 2025:487–505. doi:10.17219/acem/194212.
33. Tuckerman J, Kaufman J, Danchin M. Effective approaches to combat vaccine hesitancy. *Pediatr Infect Dis J*. 2022;41(5):e243–e245. doi:10.1097/INF.0000000000003499
34. Struelens MJ, Ludden C, Werner G, Sintchenko V, Jokelainen P, Ip M. Real-time genomic surveillance for enhanced control of infectious diseases and antimicrobial resistance. *Front Sci*. 2024;2:1298248. doi:10.3389/fsci.2024.1298248
35. Scobie HM, Edelstein M, Nicol E, et al. Improving the quality and use of immunization and surveillance data: summary report of the working group of the strategic advisory group of experts on immunization. *Vaccine*. 2020;38(46):7183–7197. doi:10.1016/j.vaccine.2020.09.017
36. Karafillakis E, Van Damme P, Hendrickx G, Larson HJ. COVID-19 in Europe: new challenges for addressing vaccine hesitancy. *Lancet*. 2022;399 (10326):699–701. doi:10.1016/S0140-6736(22)00150-7
37. Chirico F, Teixeira da Silva JA. Evidence-based policies in public health to address COVID-19 vaccine hesitancy. *Future Virol*. 2023;18 (4):261–273. doi:10.2217/fvl-2022-0028