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COVID-19 in modern history: Epidemics, Pandemics, Culture, and the Learning curve of Health systems

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Abstract

This study examines epidemics and pandemics in modern history, focusing on the interactions between public health, scientific and technological progress, and cultural factors. Through a historical review of crises such as the Spanish Influenza (1918–1919), poliomyelitis epidemics, the HIV/AIDS pandemic, and more recent infectious diseases (SARS, H1N1, Ebola), it highlights how each health crisis acts as a catalyst for the advancement of medical science and technology.

The COVID-19 pandemic confirmed the importance of the "learning curve" concept for health systems, emphasizing that experience, training, research, and quality assurance are foundational for the resilience of healthcare structures. At the same time, the pandemic highlighted the cultural dimensions of infectious diseases, influencing social behavior, values, perceptions of individual and collective responsibility, and the development of new forms of cultural entrepreneurship.

The study concludes that pandemics are not merely biological phenomena but multifaceted challenges linking scientific and technological progress with social and cultural evolution. COVID-19 serves as a contemporary example underscoring the need to strengthen public health systems, develop innovative technologies, and create institutions that combine human-centered care with scientific excellence.

Keywords: COVID-19; Epidemic; Pandemic; Public health; Learning curve; Culture; Scientific and technological progress

1. Introduction

The distinction between an epidemic and a pandemic constitutes a fundamental conceptual axis in epidemiology and public health. An epidemic is defined as the sudden increase in cases of a disease within a specific geographic area and time period, exceeding expected epidemiological levels. In contrast, a pandemic is characterized by the spread of an infectious disease across multiple countries or continents, with extensive transmission in the general population and significant social and economic impacts.

This conceptual distinction is not purely quantitative but also qualitative, as a pandemic represents a multi-level crisis that exceeds the boundaries of biomedical management and affects institutions, cultural practices, economic structures, and social cohesion. The experience of the COVID-19 pandemic has emphatically demonstrated that managing a

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pandemic requires a cross-sectoral approach, where medical science intersects with technology, communication, politics, and culture (Maniou et al., 2025g; Maniou, Manola & Maniou, 2025).

2. Historical Experience of Epidemics and Pandemics in the Modern Era

The modern history of public health is closely linked to successive epidemic and pandemic crises, which have served as catalysts for institutional transformation, scientific innovation, and social restructuring. From the early 20th century to today, infectious diseases have been more than biological phenomena; they have been historical events with profound political, economic, and cultural consequences.

The Spanish Influenza pandemic (1918–1919) represents a landmark in modern epidemiological history. It caused tens of millions of deaths worldwide, primarily affecting young age groups and highlighting the inadequacy of health systems at the time. The absence of antibiotics (penicillin had not yet been discovered), limited understanding of viruses, and the lack of organized epidemiological surveillance mechanisms made response extremely difficult. Nevertheless, this experience accelerated the establishment of national public health systems and the development of mechanisms for international collaboration.

During the first half of the 20th century, recurring poliomyelitis epidemics caused social panic, particularly in industrialized countries. The development of vaccines by Jonas Salk (injectable vaccine) and Albert Sabin (oral vaccine) marked a turning point in preventive medicine. The success of vaccination campaigns demonstrated the importance of organized public health and Primary Health Care (PHC) as a pillar of prevention and community-based intervention (Pierarakos, 2008; Kyriopoulos et al., 2007).

The emergence of HIV/AIDS in the early 1980s radically transformed infectious disease management. The disease highlighted the interaction of biological, social, and cultural factors, as it was associated with stigma, discrimination, and inequalities in access to treatment. The development of antiretroviral therapies transformed AIDS from a fatal disease to a manageable chronic condition while strengthening the link between public health, human rights, and social policy.

The SARS epidemic of 2003 was the first major test of the globalized era, emphasizing the importance of timely epidemiological surveillance and transparency. Likewise, the H1N1 pandemic in 2009 tested countries' operational readiness, leading to revisions in pandemic preparedness plans. The Ebola outbreaks in West Africa (2014–2016) exposed the vulnerability of countries with weak health systems and highlighted the importance of community engagement.

The international shift toward strengthening Primary Health Care, as outlined in the Alma-Ata Declaration and re-evaluated thirty years later (Lawn et al., 2008), confirmed that resilient health systems rely on strong local structures, universal access, and social participation. In the European context, the restructuring of primary care is linked to health system reforms and fiscal challenges (Boerma et al., 2015), while in Greece, health planning and socio-economic dimensions have been analyzed since the 1980s (Yfantopoulos, 1988).

Thus, epidemics and pandemics are not isolated health events but historical junctures that redefine the relationship between the state, society, and health, continuously highlighting the centrality of Primary Health Care as a fundamental mechanism for prevention, equity, and social cohesion (Pierarakos, 2008; Kyriopoulos et al., 2007).

3. Modern History of Public Health and the Learning Curve of Health Systems

The modern history of public health is inextricably linked to successive epidemic and pandemic crises, which have acted as catalysts for institutional transformation, scientific innovation, and social restructuring. From the early 20th century to the present, infectious diseases have not been merely biological phenomena, but historical events with profound political, economic, and cultural consequences.

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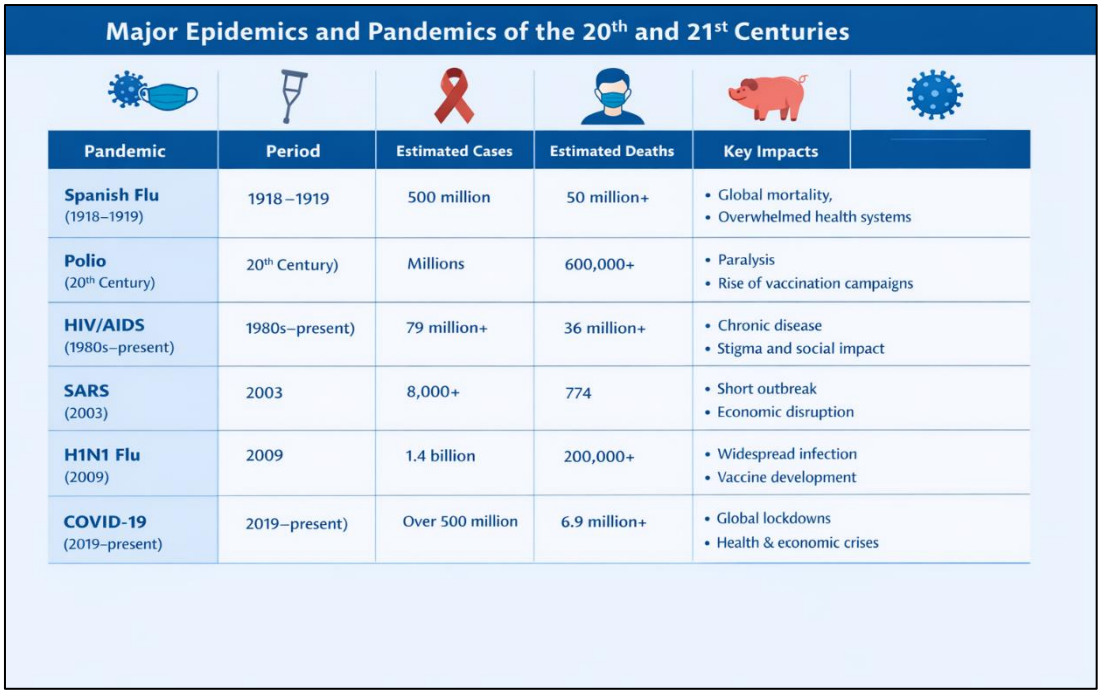

Pandemic	Period	Estimated Cases	Estimated Deaths	Key Impacts
Spanish Flu (1918–1919)	1918–1919	500 million	50 million+	• Global mortality, • Overwhelmed health systems
Polio (20th Century)	20th Century)	Millions	600,000+	• Paralysis • Rise of vaccination campaigns
HIV/AIDS (1980s–present)	1980s–present)	79 million+	36 million+	• Chronic disease • Stigma and social impact
SARS (2003)	2003	8,000+	774	• Short outbreak • Economic disruption
H1N1 Flu (2009)	2009	1.4 billion	200,000+	• Widespread infection • Vaccine development
COVID-19 (2019–present)	2019–present)	Over 500 million	6.9 million+	• Global lockdowns • Health & economic crises

Figure 1 Major epidemics and pandemics of the 20th and 21th centuries

During the first half of the 20th century, recurring poliomyelitis epidemics caused social panic, particularly in industrialized countries. The development of vaccines by Jonas Salk (injectable vaccine) and Albert Sabin (oral vaccine) represented a turning point in the history of preventive medicine. The success of vaccination campaigns highlighted the importance of organized public health and primary health care as a pillar of prevention and community-based intervention (Pierarakos, 2008; Kyriopoulos et al., 2007).

The emergence of HIV/AIDS in the early 1980s radically transformed the landscape of infectious diseases. The disease highlighted the interplay of biological, social, and cultural factors, as it was associated with stigma, discrimination, and inequalities in access to treatment. The development of antiretroviral therapies transformed AIDS from a fatal disease to a chronic manageable condition, while simultaneously reinforcing the link between public health, human rights, and social policy.

The SARS epidemic in 2003 constituted the first major test of the globalized era, emphasizing the importance of timely epidemiological surveillance and transparency. Similarly, the H1N1 pandemic in 2009 tested countries' operational preparedness, leading to revisions of pandemic preparedness plans. The Ebola epidemics in West Africa (2014–2016) exposed the vulnerability of countries with weak health systems and underscored the importance of community engagement.

The international turn toward strengthening Primary Health Care (PHC), as articulated in the Alma-Ata Declaration and re-evaluated thirty years later (Lawn et al., 2008), confirmed that resilient health systems rely on strong local structures, universal access, and social participation. In the European context, the restructuring of primary care is linked to health system reforms and fiscal challenges (Boerma et al., 2015), while in Greece, the planning and socio-economic dimensions of health have been analyzed since the 1980s (Yfantopoulos, 1988).

Consequently, epidemics and pandemics are not isolated health events but historical junctures that redefine the relationship between the state, society, and health, continuously highlighting the centrality of Primary Health Care as a fundamental mechanism for prevention, equity, and social cohesion (Pierarakos, 2008; Kyriopoulos et al., 2007).

4. Scientific and Technological Progress: The "Learning Curve" of Health Systems

The historical experience of epidemics and pandemics demonstrates that health crises are not only threats to public health but also powerful accelerators of scientific and technological progress. Each crisis exposes weaknesses, activates innovation mechanisms, and drives transformations at both the clinical practice and institutional organization levels.

The development of vaccines, advances in molecular biology, the evolution of diagnostic techniques, and the integration of advanced technologies into medical practice are expressions of this dynamic adaptation.

The acceleration of biomedical research during epidemics is a recurring historical pattern. Crises create an urgent need to understand the pathophysiology of infectious agents, develop therapeutic protocols, and optimize diagnostic algorithms. Scientific mobilization is accompanied by increased funding, international collaboration, and data sharing.

At the same time, technological advances in medical imaging, bioinformatics, and robotic medicine form part of a long historical trajectory of convergence between medicine and technology (Maniou et al., 2025; Maniou et al., 2025g). This progress is not linear but characterized by leaps often triggered by critical health contingencies.

The concept of the "learning curve" originates from educational theory and the improvement of performance through repeated practice. In medicine, the learning curve has been systematically studied in interventional techniques, where complication rates and procedure times decrease as the clinician's experience grows (Michalopoulos, Maniou & Zografos, 2012; Maniou et al., 2019). Similarly, in diagnostic imaging, experience improves accuracy and reduces interpretive errors (Bruyère et al., 2020).

Applying this concept to health systems allows for the understanding of institutional learning. Just as a trainee physician gradually improves their skills, health systems acquire experience through successive crises. They develop preparedness protocols, invest in epidemiological surveillance, and integrate quality assessment mechanisms (Maniou, 2024).

The learning curve of health systems includes three main stages:

- **Initial phase of shock**, dominated by uncertainty and lack of information.
- **Adaptation phase**, during which guidelines are established and organizational structures are improved.
- **Maturation phase**, where experience is transformed into institutional knowledge and incorporated into permanent health policies.

Quality assurance and patient protection constitute central pillars of institutional learning. Experience from interventional techniques, such as stereotactic breast biopsy, has highlighted the importance of systematic training and monitoring performance indicators in order to reduce complications and improve patients' quality of life (Maniou et al., 2011; Maniou, 2024).

Similarly, in pandemic crises, investment in healthcare workforce training, crisis scenario simulation, and continuous evaluation of procedures contributes to reducing mortality and improving the effectiveness of interventions. Quality is not a static concept but a dynamic process of continuous improvement.

The experience of the COVID-19 pandemic demonstrated that, despite scientific progress, health systems remain vulnerable when investment in infrastructure and education is insufficient. The rapid development of vaccines and diagnostic tests proved the dynamic potential of modern biotechnology; however, unequal resource distribution and healthcare workforce fatigue revealed structural weaknesses.

Accumulated knowledge from previous epidemics does not automatically translate into preparedness. Institutional integration of experience, adequate funding, international cooperation, and the cultivation of a scientific culture that encourages transparency and evidence-based decision-making are required (Maniou, 2024).

Technological progress cannot be separated from its social dimension. The resilience of health systems depends not only on the availability of advanced technologies but also on social trust, leadership, and the cultural acceptance of public health measures. The integration of technological innovation with human-centered care constitutes a prerequisite for sustainable health policy (Maniou et al., 2025g).

5. The COVID-19 Pandemic as a Multilevel Public Health Challenge

The COVID-19 pandemic emerged as the greatest health crisis of the 21st century, with multiple and interconnected consequences for public health, society, the economy, education, and culture. The rapid spread of the SARS-CoV-2 virus exceeded the limits of national health systems, placing enormous pressure on hospital care structures, intensive care units, and primary health care (WHO, 2020; Maniou, 2024).

The crisis strongly highlighted inequalities in access to healthcare services, both between countries and within societies. Population groups with lower socioeconomic status, limited access to healthcare structures, or chronic diseases faced an increased risk of severe illness and mortality (Maniou, 2024; Maniou et al., 2025g). The need to strengthen primary health care and prevention became evident, as early diagnosis and patient monitoring ensure both reduced hospital burden and improved intervention effectiveness.

The crisis brought back to the forefront the importance of evidence-based decision-making and the utilization of data to achieve balanced public health policies. Health systems that had invested in electronic data recording and analysis demonstrated greater resilience and adaptability (Maniou et al., 2025f; Maniou, 2024).

The initial management of the pandemic relied on non-pharmaceutical interventions such as lockdowns, social distancing, mask use, and mobility restrictions. The implementation of these measures highlighted both the need for public awareness and the difficulties of managing social and economic consequences (Ferguson et al., 2020).

The next phase focused on the development and global distribution of vaccines. The speed of production, extensive clinical evaluation, and vaccination campaigns reflected the capacity of modern biomedical science to respond to urgent crises (Polack et al., 2020). At the same time, vaccine distribution revealed inequalities between countries and population groups, raising issues of justice and access.

Digital technology proved crucial at multiple levels: epidemiological surveillance through contact-tracing applications, remote healthcare service provision (telemedicine), staff training, and public information. Digitalization introduced new tools for adaptation and crisis management, reducing response time and improving service accessibility (Maniou et al., 2025g; Maniou et al., 2025h).

The COVID-19 pandemic highlighted the close relationship between medicine, technology, and the cultural framework. As historically noted (Maniou et al., 2025g; Maniou, Manola & Maniou, 2025), progress in biomedical research, the integration of robotic systems, and the application of advanced diagnostic and therapeutic techniques are embedded within a broader cultural and social dynamic. The effectiveness of public health measures depends not only on technological capacity but also on societal acceptance, collective behavior, and communication strategies.

The COVID-19 pandemic demonstrated that health crises are multidimensional, combining medical, social, technological, and cultural dimensions. Their management requires the integration of experience, continuous education, institutional reforms, investment in technological infrastructure, and social trust. COVID-19 showed that public health cannot be examined in isolation: scientific knowledge, technological progress, and the cultural dimension form an integrated ecosystem for protecting society, capable of responding to future challenges (Maniou et al., 2025g; Maniou, 2024).

In the above mentioned multidimensional challenging framework, the importance of all digital technologies in the field of health education is emphasized. These technologies are highly effective and productive, facilitate and improve assessment, intervention, and educational procedures through mobile devices that bring educational activities anywhere [20], various ICTs applications that are the main supporters of education [21-25], and AI, STEM, and ROBOTICS [26-29] that raise educational procedures to new performance levs. In addition, the development and integration of ICTs with theories and models of metacognition, mindfulness, meditation, and the development of emotional intelligence [30-34], accelerates and improves educational practices and results more than those, particularly in the health education domain and its practices like assessment and intervention.

6. Cultural Dimensions of the Pandemic

Pandemics extend beyond the strictly biological sphere and function as catalysts for social and cultural transformations. The COVID-19 pandemic constitutes a characteristic example, as it affected not only the health reality but also reshaped collective behaviours, social values, and perceptions of individual responsibility and social solidarity (Maniou et al., 2025h).

The interaction between medicine and culture proves to be crucial: the acceptance and implementation of scientific innovations are not self-evident but depend on the cultural context and on social representations of science. Societies with higher levels of trust in institutions and scientific knowledge demonstrate greater compliance with public health measures and faster integration of preventive practices (Maniou et al., 2025h).

Cultural activity, both in terms of creation and participation, suffered significant disruption due to restrictive measures. Museums, festivals, theatres and cultural events suspended their operations, leading to the search for new forms of cultural entrepreneurship, such as digital exhibitions, virtual tours and online cultural initiatives (Pagkalos et al., 2025e; Maniou et al., 2025f). The crisis highlighted that cultural innovation can function as a tool of social resilience and psychological support, maintaining community bonds even under conditions of isolation.

COVID-19 also brought forward high-intensity ethical and social dilemmas: allocation of scarce resources, vaccination prioritisation, and the balance between individual rights and collective protection. Cultural values and social norms influenced the management of these dilemmas, as reflected in differences in the acceptance of restrictive measures and vaccination strategies across countries and social groups.

The concept of the "learning curve" acquires particular significance in times of crisis. Healthcare professionals were required to rapidly acquire new skills, implement innovative technologies, adapt to constantly evolving protocols, and manage large patient flows under pressure of time and limited resources (Maniou, 2024; Bruyère et al., 2020). This experience reinforces the necessity of institutionalising mechanisms for continuous education, professional evaluation and quality improvement, in order to render health systems more resilient and adaptable.

Overall, COVID-19 demonstrates that public health, social cohesion and cultural development are interdependent. Pandemic response requires a multidimensional approach that integrates medical, technological and cultural dimensions, strengthening both the effectiveness of interventions and social trust and solidarity.

7. Conclusions

Epidemics and pandemics in modern history constitute ongoing tests for health systems and societies, highlighting the necessity of effective preparedness, management and adaptation. While the conceptual distinction between epidemic and pandemic provides a theoretical framework, the primary challenge lies in addressing the multidimensional social, economic and cultural consequences accompanying each health crisis.

The notion of the "learning curve" of health systems offers an analytical tool for understanding the relationship between experience and progress: each crisis generates collective learning, protocol adaptation and reinforcement of epidemiological surveillance mechanisms. Epidemics and pandemics are not deviations from historical normality but structural events that reshape the boundaries of science, policy and social solidarity. The future challenge lies in transforming accumulated experience into institutional memory capable of ensuring quality, equity and resilience in the face of future health threats.

The COVID-19 pandemic demonstrated that public health cannot be examined in isolation; it is intrinsically linked to culture, technology, education and social organisation. Contemporary historical experience indicates that societal resilience depends on the ability to combine scientific knowledge, technological innovation and cultural understanding. Investment in knowledge, education and cross-sectoral collaboration constitutes the core of an effective, human-centred public health strategy capable of addressing the complex challenges of the 21st century.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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