

COVID-19 AS A BIOLOGICAL AND ECOLOGICAL CRISIS: IMPLICATIONS FOR ENVIRONMENTAL SECURITY AND PUBLIC HEALTH IN GEORGIA

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Abstract: The COVID-19 pandemic demonstrated that infectious disease emergencies cannot be examined solely through a biomedical lens. In states with limited structural capacity and complex geopolitical positioning, such as Georgia, the crisis exposed structural interdependencies between biological risk governance and environmental regulatory systems. Beyond its immediate public health consequences, the pandemic generated ecological pressures that reshaped the relationship between environmental security and national health governance. **The aim of the paper is:** To analyze the interrelationship between biological risk management and environmental governance in Georgia during the COVID-19 pandemic and to evaluate systemic vulnerabilities revealed by the crisis. **Research methods:** A case study methodology was applied, incorporating systematic review of national strategic documents, legislative acts, and emergency response protocols alongside secondary epidemiological and environmental data from 2020–2022. An interdisciplinary bio-ecological security framework guided the assessment of institutional coordination, biomedical waste regulation, environmental monitoring practices, and intersectoral crisis governance mechanisms. **Research results:** The analysis indicates that the pandemic amplified pre-existing governance fragmentation. The rapid increase in biomedical waste, temporary regulatory adaptations, and limited integration between environmental oversight and health emergency planning generated cumulative ecological stress. Although epidemiological surveillance capacity expanded, environmental risk assessment remained insufficiently integrated into preparedness strategies. **In conclusion:** COVID-19 should be conceptualized as a dual biological–ecological crisis requiring integrated governance approaches. Strengthening environmental monitoring within biosecurity planning and enhancing cross-sector coordination are essential for long-term resilience in Georgia.

Keywords: Biological security, COVID-19, Environmental security, Ecological crisis, Biosecurity policy, Georgia.

Introduction. The COVID-19 pandemic fundamentally challenged conventional understandings of health security by demonstrating that infectious disease crises extend beyond biomedical containment and clinical response. Rather than constituting a purely epidemiological event, the pandemic exposed systemic interdependencies between biological risk governance, environmental regulation, and institutional resilience. In countries characterized by transitional governance structures and complex geopolitical environments, these interdependencies became particularly visible. Georgia represents a pertinent case in which pandemic response mechanisms intersected with environmental management systems, revealing structural asymmetries and regulatory fragmentation.

During the peak years of the crisis, emergency measures were primarily oriented toward infection control, surveillance expansion, and healthcare system stabilization. However, parallel ecological pressures emerged, including increased biomedical waste generation, intensified chemical disinfection practices, and shifts in urban environmental dynamics. These developments underscored the conceptual limitations of approaching biological security without integrating environmental security considerations. The pandemic thus functioned as a stress test for governance architectures, illuminating gaps in cross-sector coordination and strategic planning.

The evolving discourse on global health security increasingly recognizes the need for integrated frameworks that bridge public health preparedness and environmental sustainability. Within this context, examining Georgia's experience provides insight into how small states navigate biological emergencies amid institutional constraints and regional geopolitical sensitivities. By situating COVID-19 within a broader bio-ecological security paradigm, this study contributes to interdisciplinary debates on resilience, governance integration, and sustainable crisis management in the post-pandemic era.

This study aims to examine the interrelationship between biological risk management and environmental governance in Georgia during the COVID-19 pandemic. It seeks to identify systemic vulnerabilities revealed by the crisis and to evaluate the need for integrated bio-ecological security frameworks within public health and environmental policy structures.

Materials and Methods - This study employed a qualitative case study approach to examine the interrelationship between biological risk management and environmental governance in Georgia during the COVID-19 pandemic. Case studies are particularly suited for analyzing complex social-ecological phenomena, allowing for in-depth investigation of institutional structures, policy frameworks, and cross-sectoral interactions (Wouters, et al. 2021). The research integrated systematic review of national strategic documents, legislative instruments, and emergency response protocols implemented between 2020 and 2022. These sources provided insight into pandemic preparedness measures, biomedical waste management regulations, and environmental monitoring practices.

Secondary epidemiological and environmental data were obtained from official governmental and international repositories, including the Ministry of Health of Georgia, World Health Organization (WHO), and United Nations Environment Programme (UNEP) reports (World Health Organization (WHO). 2021). Data extraction focused on identifying governance gaps, environmental pressures, and coordination mechanisms between health and environmental authorities. An interdisciplinary bio-ecological security framework guided the analysis, integrating concepts from public health security, environmental risk management, and governance theory (Hotez, et al. 2021). This framework facilitated assessment of institutional coordination, regulatory alignment, and intersectoral crisis management. Data were analyzed thematically to identify patterns of systemic vulnerability and resilience, emphasizing the interaction between epidemiological control measures and environmental impacts.

Ethical considerations were observed by relying exclusively on publicly available secondary data and official policy documents, ensuring no personal or sensitive information was utilized. The methodology allows for generalizable insights into the structural challenges faced by small, geopolitically sensitive states in managing dual biological and ecological crises, providing a basis for evidence-informed recommendations for integrated governance strategies.

Biomedical Waste Accumulation and Environmental Pressures

During the initial and peak phases of the pandemic (2020–2021), Georgia experienced a substantial increase in biomedical waste, including personal protective equipment (PPE), testing materials, and disinfectants. According to UNEP (2021), countries in the Caucasus region, including Georgia, faced a 30–40% increase in hospital and laboratory waste volumes compared to pre-pandemic levels. The government introduced temporary regulatory frameworks to manage this surge, however, the lack of comprehensive coordination between environmental authorities and health institutions led to inconsistent disposal practices. Field reports indicated that waste segregation and recycling procedures were insufficiently enforced, resulting in potential contamination of water bodies and urban ecosystems. These findings align with global observations indicating that biomedical waste management was a widespread ecological challenge during COVID-19 (Klemeš, et al. 2021).

As for institutional coordination and fragmented governance. Analysis of policy documents revealed fragmented governance structures between the Ministry of Health, National Center for Disease Control and Public Health, and environmental agencies. While epidemiological surveillance was strengthened through rapid laboratory network expansion and contact tracing mechanisms ((World Health Organization (WHO), 2021), environmental oversight remained peripheral in crisis planning. Coordination gaps were observed in decision-making hierarchies, with environmental considerations often integrated reactively rather than proactively. This fragmentation mirrors findings in other small, geopolitically sensitive states where public health imperatives overshadow environmental monitoring during acute crises (Ostroff, et al. 2021). The absence of a formalized intersectoral task force contributed to delays in implementing environmentally sustainable biomedical waste management protocols and urban sanitation measures.

Epidemiological systems were expanded during the pandemic, including the digitization of case reporting and integration of laboratory test data. While these measures improved detection and response efficiency, environmental data streams, such as waste generation metrics, air quality, and chemical contamination, were not systematically incorporated into decision-making frameworks (World Health Organization (WHO), 2021). Consequently, the feedback loops necessary for anticipatory environmental risk assessment were underdeveloped. The lack of integration limited the capacity of policymakers to understand the broader ecological consequences of public health interventions, consistent with observations from similar regional contexts (Hotez, et al. 2021).

Lockdown measures induced temporary reductions in vehicular traffic and industrial activity, resulting in short-term improvements in air quality and urban noise levels. However, these ecological gains were offset by the environmental burden of increased single-use plastics and disinfectants. Waste management systems struggled to adapt to these rapid shifts, highlighting the need for dynamic governance mechanisms capable of integrating fluctuating public health and environmental pressures (Klemeš, et al. 2021). Observational data from Tbilisi indicate that non-compliance with waste segregation protocols increased the risk of contamination in municipal landfills and surface water bodies.

Regarding systemic vulnerabilities and lessons learned, it should be noted that the study identified many systemic vulnerabilities revealed as a result of the COVID-19 pandemic. Second, the limited integration of

environmental monitoring within health governance structures impeded proactive risk mitigation. Third, intersectoral coordination mechanisms were insufficiently institutionalized, creating reactive rather than preventive management patterns. These findings suggest that small states with constrained administrative capacities are particularly susceptible to compounded biological and ecological crises (Hassan, et. al. 2021).

It is important to also focus on sustainability mechanisms and positive outcomes. Despite these challenges, Georgia demonstrated adaptive resilience in several areas. Strengthened laboratory networks, rapid deployment of testing infrastructure, and centralized data management facilitated efficient public health responses (World Health Organization (WHO). 2021). Additionally, emergency environmental guidelines, though reactive, provided a temporary framework for managing biomedical waste, reflecting an emergent capacity for cross-sector problem-solving. These adaptive measures underscore the potential for integrating biosecurity and environmental monitoring into cohesive governance strategies in the future.

Synthesis of Findings - Overall, the findings illustrate the dual nature of COVID-19 as a biological and ecological crisis. While public health interventions were largely successful in mitigating disease spread, environmental risks remained insufficiently addressed. The interdependence of health governance and ecological sustainability suggests that integrated frameworks, combining epidemiological surveillance with environmental monitoring and cross-sector coordination, are essential for enhancing resilience in Georgia and similar geopolitical contexts. These insights contribute to the broader literature on pandemic governance, environmental security, and sustainable crisis management, emphasizing the importance of proactive, rather than reactive, integration of ecological considerations into public health policy (Gotsadze, & Kipiani, 2020).

Discussion. The findings of this study highlight the complex interplay between biological risk management and environmental governance during the COVID-19 pandemic in Georgia, underscoring the systemic vulnerabilities exposed by the crisis. While the country demonstrated rapid mobilization of public health infrastructure, including enhanced laboratory networks and centralized surveillance systems, the ecological dimension of the crisis was insufficiently integrated into planning and decision-making processes. This duality emphasizes that pandemic management cannot be narrowly conceived as a biomedical problem, but must be approached through a bio-ecological lens that considers both public health outcomes and environmental sustainability (Hotez, et al. 2021).

Intersectoral Coordination and Governance Challenges

One of the primary challenges identified was the fragmentation of governance structures across health and environmental institutions. The Ministry of Health, the National Center for Disease Control and Public Health, and environmental authorities operated in largely parallel tracks, with limited formalized coordination mechanisms. This fragmentation resulted in reactive rather than proactive management of ecological risks, particularly concerning biomedical waste, chemical disinfectants, and urban sanitation pressures. These findings are consistent with the politics of small, geopolitically sensitive states, where resource constraints and institutional fragmentation exacerbate vulnerability during complex crises (Delcour, 2020). The lack of integrated intersectoral frameworks hindered the ability to anticipate ecological consequences of public health interventions, such as increased biomedical waste, despite emergency guidelines aimed at mitigating immediate environmental risks.

The surge in medical and laboratory waste represents a critical environmental challenge. In line with global observations, Georgia faced unprecedented accumulation of PPE, testing kits, and chemical disinfectants, which stressed existing waste management systems (Klemeš, et al. 2020). While temporary regulatory measures provided some mitigation, the study indicates that compliance and enforcement were uneven,

leading to potential contamination of water systems and urban ecosystems. This underscores the need to embed environmental monitoring and waste management protocols into pandemic preparedness frameworks, ensuring that ecological risks are systematically assessed and managed alongside epidemiological control measures (European Environment Agency, 2021).

Despite structural limitations, Georgia demonstrated adaptive resilience in several areas. The expansion of epidemiological surveillance and rapid deployment of testing infrastructure facilitated timely detection and response, contributing to disease containment. Emergency environmental guidelines, though reactive, created initial coordination pathways between health and environmental authorities, suggesting a latent capacity for cross-sectoral problem-solving. These adaptive measures align with global lessons emphasizing the importance of flexible governance structures capable of integrating diverse risk domains during complex crises ((Risse, 2021).

In terms of the results of integrated bioecological management, it should be noted that the study highlights the need to move from reactive to proactive management strategies that recognize the interconnected nature of biological and environmental risks. Integrating environmental monitoring into routine public health surveillance, institutionalizing cross-sectoral coordination mechanisms, and developing dynamic regulatory frameworks are critical for enhancing resilience in small states. Moreover, the findings suggest that pandemic preparedness plans should incorporate scenario-based modeling of ecological pressures, enabling policymakers to anticipate potential secondary impacts of public health interventions on environmental systems (Chubinidze, Sh. 2024).

From a theoretical perspective, the results support the adoption of a bio-ecological security paradigm, which conceptualizes health emergencies as inherently intertwined with environmental systems. This approach aligns with the One Health framework, which emphasizes the interconnection between human, animal, and environmental health (Zinsstag, et al. 2020).. Policy implications extend beyond Georgia, offering insights for other small, geopolitically sensitive states that must navigate limited administrative capacities, resource constraints, and regional risk dynamics. Embedding environmental sustainability into pandemic governance frameworks not only mitigates ecological pressures but also strengthens long-term public health resilience, creating feedback loops that reinforce both ecological and societal stability.

Overall, the COVID-19 pandemic in Georgia illustrates the necessity of integrating ecological considerations into public health governance. Fragmented institutional structures, limited intersectoral coordination, and reactive environmental policies constrained the country's ability to address compounded biological and ecological risks. Nevertheless, adaptive measures, including surveillance expansion and emergent coordination mechanisms, indicate pathways for enhancing resilience. Establishing proactive, integrated bio-ecological governance frameworks is essential to navigate future health crises effectively, safeguarding both public health and environmental sustainability in Georgia and comparable states (World Health Organization, 2020).

Conclusion. The COVID-19 pandemic in Georgia serves as a critical case demonstrating the dual nature of global health emergencies as both biological and ecological crises. The study highlights that while the country achieved notable successes in epidemiological surveillance, testing infrastructure, and rapid mobilization of public health resources, environmental considerations remained insufficiently integrated into pandemic planning and crisis management. Biomedical waste accumulation, chemical disinfectant usage, and urban environmental pressures illustrate that biological interventions inevitably generate ecological consequences, underscoring the necessity for integrated governance approaches.

The findings emphasize the importance of institutional coordination across health and environmental authorities. Fragmentation and reactive decision-making limited the capacity to anticipate and mitigate ecological risks, suggesting that effective crisis governance requires formalized intersectoral frameworks.

Embedding environmental monitoring, sustainable waste management practices, and scenario-based ecological risk assessments into pandemic preparedness strategies can strengthen resilience in small states facing complex geopolitical and infrastructural constraints.

Moreover, this study contributes to theoretical discussions on bio-ecological security, aligning with the One Health paradigm that recognizes the interdependence of human, animal, and environmental health. For Georgia, proactive integration of ecological considerations into public health policy is not only essential for managing current and future pandemics but also for ensuring long-term environmental sustainability and societal resilience.

In conclusion, COVID-19 illustrates that biological crises cannot be effectively addressed in isolation from ecological systems. Strengthening cross-sector coordination, institutionalizing integrated bio-ecological governance, and operationalizing environmental monitoring within public health frameworks are critical steps toward sustainable crisis management. Lessons from Georgia offer a valuable model for other small, geopolitically sensitive states, demonstrating that resilience in future health emergencies depends on the simultaneous prioritization of human health and ecological stability.

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