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## A comparative analysis of national medical stockpile strategies: Lessons Learned from COVID-19 Pandemic Response

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### Abstract

The COVID-19 pandemic exposed critical vulnerabilities in national medical stockpile strategies worldwide, highlighting the need for resilient, adaptive, and efficient preparedness frameworks. This review paper presents a comparative analysis of national medical stockpile approaches in Australia, the United States, and selected European countries (France, Latvia, Lithuania, the Netherlands, and Norway), focusing on lessons learned from their COVID-19 pandemic responses. Through a qualitative synthesis of government reports, peer-reviewed literature, and policy analyses published between 2018 and 2025, the study examines governance structures, stockpile composition, deployment mechanisms, and operational challenges. Key findings reveal that Australia's federal-state coordination model enhanced distribution agility, while the U.S. Strategic National Stockpile faced supply chain fragility and coordination challenges. European nations demonstrated innovative practices such as stock rotation through partnerships with private wholesalers and integration of hospital-level stockpiles to reduce waste and improve local responsiveness. The pandemic highlighted the imperative for diversified supply chains, domestic manufacturing capacity, and real-time inventory management systems to ensure stockpile sustainability and equitable deployment. Recommendations include establishing clear legal mandates, securing stable funding, adopting hybrid stockpiling models combining physical reserves with surge capacity contracts, and fostering international collaboration for shared learning and joint procurement. By integrating these lessons, national stockpiles can better support rapid, equitable, and sustained responses to future health emergencies, thereby strengthening global health security. This review contributes actionable insights for policymakers, public health officials, and emergency planners committed to enhancing pandemic preparedness and response capabilities.

**Keywords:** National medical stockpile; COVID-19 pandemic; Supply chain resilience; Stockpile governance; Pandemic preparedness

### 1. Introduction

National medical stockpiles have long been recognized as essential components of public health emergency preparedness, serving as repositories of critical medical countermeasures (MCMs) such as antibiotics, vaccines, personal protective equipment (PPE), and specialized medicines. The concept of strategic stockpiling in the United States dates back to the Cold War era, when the government accumulated extensive civil defense medical supplies across 32 storage facilities to prepare for nuclear conflict [1]. However, these early stockpiles degraded over time and were largely dismantled by the mid-1970s due to shifts in defense priorities and public skepticism about nuclear war survivability [2].

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The modern U.S. Strategic National Stockpile (SNS) was established in 1999 as the National Pharmaceutical Stockpile (NPS) following congressional authorization to prepare for biological and chemical threats to civilian populations [3]. This initiative was catalyzed by growing concerns over bioterrorism, particularly after President Clinton's administration responded to the fictional scenario depicted in *The Cobra Event* novel, which highlighted vulnerabilities to viral attacks [1]. The stockpile was designed to rapidly deploy large quantities of medical supplies to affected areas, with its mission expanding over time to include response to pandemics, natural disasters, and other large-scale emergencies [4]. The SNS inventory includes antibiotics, vaccines, antivirals, ventilators, and PPE, organized into "push packages" capable of rapid nationwide deployment [3].

Despite its scale and strategic importance, the SNS faced significant challenges during the COVID-19 pandemic, including insufficient inventory levels and logistical hurdles in distribution. Experts have noted that the SNS's original focus on chemical, biological, radiological, and nuclear (CBRN) threats meant that pandemic preparedness was underfunded and underprioritized prior to COVID-19 [5, 3]. These shortcomings have spurred calls for reforms to diversify supply chains, increase domestic manufacturing, and improve inventory management.

Australia's National Medical Stockpile (NMS) similarly functions as a strategic reserve of drugs, vaccines, antidotes, and PPE, managed by the Department of Health and Aged Care. Established under legislation such as the National Health Security Act (2007), the NMS supplements state and territory stockpiles and is designed to meet surges in demand during national health emergencies [6]. The stockpile's governance framework empowers the Chief Medical Officer and the Secretary of Health to authorize the release of supplies, supported by a network of service providers and suppliers to maintain quality and capacity. During the COVID-19 pandemic, the NMS distributed over 91 million masks and 18 million gowns and gloves, illustrating its critical role in national response efforts [7].

European countries have developed varied stockpile models, often integrating hospital-level caches and partnerships with private wholesalers to maintain stock rotation and reduce waste [8]. These approaches emphasize geographic coverage and operational flexibility, contrasting with the more centralized U.S. SNS model.

Together, these historical and policy perspectives provide a foundation for understanding the evolution, strengths, and weaknesses of national medical stockpiles. The COVID-19 pandemic has exposed the urgent need to modernize these systems to ensure rapid, equitable, and sustainable access to essential medical supplies in future health crises.

This review paper aims to provide a comprehensive comparative analysis of national medical stockpile strategies, focusing on Australia, the United States, and selected European countries, including France, Latvia, Lithuania, the Netherlands, and Norway. These countries were selected due to their varied approaches to stockpile management and their documented experiences during the COVID-19 pandemic. The analysis will explore governance structures, stockpile composition, deployment mechanisms, and the operational challenges faced during the pandemic response. By examining these diverse strategies, the paper seeks to identify best practices, common pitfalls, and innovative solutions that emerged during the crisis.

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## 2. Method

This review employs a qualitative comparative analysis framework to evaluate national medical stockpile strategies across selected countries, including Australia, the United States, and European nations such as France, Latvia, Lithuania, the Netherlands, and Norway. The comparative approach focuses on key dimensions: governance structures, stockpile composition, deployment mechanisms, supply chain management, and pandemic response outcomes. This framework enables identification of common challenges and best practices while accounting for contextual differences in health systems and threat environments.

Data sources include government reports, official audits, peer-reviewed journal articles, and policy analyses published between 2018 and 2025. Emphasis was placed on documents that provide empirical evidence of stockpile performance during the COVID-19 pandemic. The selection of countries was based on their documented COVID-19 responses and the availability of detailed stockpile information, ensuring a balanced representation of different health governance models and geographic regions.

The analysis synthesizes qualitative data to highlight operational strengths and weaknesses, supply chain vulnerabilities, and innovations such as stock rotation and digital inventory management. This methodology supports a nuanced understanding of how national stockpiles functioned under pandemic stress and informs recommendations for future improvements.

### 3. National Stockpile Structures and Governance

#### 3.1. Australia's National Medical Stockpile (NMS)

Australia's National Medical Stockpile is managed by the Department of Health and serves as a centralized repository of essential medical countermeasures designed to support the states and territories during public health emergencies. The governance framework is characterized by a clear federal mandate, with operational oversight vested in the Chief Medical Officer, who authorizes stockpile deployment in coordination with state health authorities. This structure facilitates a balance between centralized control and state-level responsiveness, enabling tailored distribution based on regional needs [9].

The composition of the NMS includes a broad range of items such as antiviral drugs, vaccines, PPE (including masks, gowns, and gloves), ventilators, and specialized medicines for chemical, biological, radiological, and nuclear (CBRN) threats. Importantly, the exact locations of stockpile warehouses are undisclosed to enhance security and prevent potential sabotage or theft [10]. During the COVID-19 pandemic, the NMS played a critical role by distributing approximately 91 million masks and 18 million gowns and gloves to states and territories, supplementing their own stockpiles and addressing acute shortages in frontline healthcare settings [7].

#### 3.2 United States Strategic National Stockpile (SNS)

The U.S. Strategic National Stockpile is one of the largest and most comprehensive national reserves globally, designed to provide rapid access to large quantities of medical supplies during emergencies. However, the COVID-19 pandemic revealed significant challenges in the SNS's ability to meet demand. Early in the pandemic, the SNS was criticized for insufficient inventory levels, particularly of PPE, and logistical difficulties in distributing supplies efficiently to states [5]. The stockpile's governance involves multiple federal agencies, including the Department of Health and Human Services (HHS) and the Federal Emergency Management Agency (FEMA), which sometimes complicates coordination and decision-making.

In response to these challenges, several reforms have been proposed and partially implemented, including diversifying supplier bases to reduce reliance on foreign manufacturers, increasing stockpile funding, and improving inventory tracking systems [11]. The SNS also maintains a broad inventory that includes vaccines, antiviral drugs, ventilators, and CBRN antidotes, but the pandemic underscored the need for dynamic inventory management and surge capacity planning.

#### 3.2. European National Stockpile Models

European countries exhibit diverse approaches to medical stockpiling, reflecting differences in health system organization, resource availability, and threat perceptions. France, Latvia, Lithuania, the Netherlands, and Norway maintain national stockpiles that include a mixture of pharmaceuticals, PPE, ventilators, and CBRN countermeasures. Notably, many European nations have integrated hospital-level stockpiles into their preparedness frameworks, enabling rapid local deployment and reducing reliance on centralized reserves [8].

A common innovation among these countries is the use of wholesalers and private sector partners to maintain geographic coverage and facilitate stock rotation, thereby minimizing waste due to expiration. For example, the Netherlands employs a system where private wholesalers hold stockpile items under contractual agreements, ensuring rapid replenishment and distribution capabilities [12]. Norway and the Baltic states have similarly adopted hybrid models combining centralized stockpiles with decentralized caches in healthcare facilities.

##### 3.2.1. Comparative Insights

The comparative analysis reveals that while all countries maintain stockpiles with broadly similar compositions, governance structures and operational models differ significantly. Australia's federal-state coordination model promotes flexibility and responsiveness, whereas the U.S. SNS's multi-agency governance has at times hindered rapid decision-making. European countries' integration of private sector partnerships and hospital-level stockpiles enhances distribution agility and waste reduction but requires robust coordination mechanisms.

**Table 1** A summary of key features of national stockpile structures and governance across the studied countries

Country	Governance Structure	Stockpile Composition	Deployment Model	Innovations/Challenges
Australia	Federal Department of Health; Chief Medical Officer oversight	PPE, vaccines, antivirals, CBRN antidotes	Federal-state coordinated distribution	High-volume PPE distribution; undisclosed warehouse locations
United States	Multi-agency (HHS, FEMA)	Broad MCMs including ventilators, vaccines, PPE	Centralized with state requests	Supply chain fragility; reforms underway
France	National health agency oversight	Pharmaceuticals, PPE, ventilators	Centralized with hospital caches	Integration with hospital stockpiles
Latvia	Ministry of Health	CBRN antidotes, PPE	Centralized with decentralized caches	Use of wholesalers for stock rotation
Lithuania	Ministry of Health	Pharmaceuticals, PPE	Similar to Latvia	Emphasis on stock rotation
Netherlands	Public health institute + private wholesalers	Broad MCMs including vaccines, PPE	Hybrid centralized-private sector	Contractual stock rotation model
Norway	Ministry of Health	Pharmaceuticals, PPE, ventilators	Centralized with hospital caches	Hybrid stockpile model

#### 4. Key Lessons from COVID-19

The COVID-19 pandemic served as a stress test for national medical stockpiles worldwide, revealing critical lessons that have shaped current and future preparedness strategies. One of the most salient lessons concerns supply chain vulnerabilities. Many countries, including the United States and Australia, experienced severe shortages of PPE and other essential supplies early in the pandemic due to overreliance on foreign manufacturers and “just-in-time” inventory systems that minimized stock levels to reduce costs [13]. This exposed the fragility of global supply chains and underscored the need for diversified sourcing and increased domestic production capabilities. For example, Australia’s efforts to expand local manufacturing of masks and gowns during the pandemic helped alleviate shortages and demonstrated the value of supply chain resilience [7].

Waste reduction emerged as another critical area for improvement. Many stockpiles faced significant losses due to expiration of medical countermeasures, particularly vaccines and pharmaceuticals, which have limited shelf lives. The pandemic highlighted the importance of stock rotation strategies, where expiring stockpile items are integrated into routine healthcare supply chains to minimize waste [8]. European countries such as the Netherlands and Latvia have successfully implemented stock rotation programs by partnering with wholesalers and hospitals, ensuring that supplies are used before expiration while maintaining readiness for emergencies [12]. This approach not only reduces financial losses but also ensures that stockpiles remain current and effective.

Deployment and equity issues were also prominent during the COVID-19 response. In many countries, delays in distributing stockpile supplies to frontline healthcare workers and vulnerable populations exacerbated the public health crisis [14]. Australia’s federal-state coordination model proved effective in accelerating PPE distribution to states and territories, demonstrating the importance of clear governance and communication channels [9]. Additionally, the pandemic underscored the need for real-time inventory tracking systems to improve transparency and facilitate rapid decision-making. Digital tools that provide up-to-date stock levels and distribution status can help prevent bottlenecks and ensure equitable allocation of resources [15].

Another key lesson relates to the importance of integrating stockpiles with broader health system preparedness. Stockpiles alone cannot address all challenges; they must be part of a comprehensive strategy that includes surge capacity planning, workforce training, and public communication. Countries that successfully managed COVID-19

stockpile deployment often had robust emergency response frameworks that enabled coordination across multiple sectors and levels of government [16].

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## 5. Recommendations for Future Strategies

Building upon the lessons learned from the COVID-19 pandemic, several key recommendations emerge to enhance the effectiveness and resilience of national medical stockpiles. These recommendations span policy, governance, operational improvements, and risk mitigation to ensure that stockpile systems are better prepared for future health emergencies.

### 5.1. Policy and Governance

A foundational recommendation is the establishment of clear legal and policy mandates that define the roles, responsibilities, and authority of stockpile management bodies. For example, Australia's *National Health Security Act* provides a legislative framework that clarifies stockpile governance and facilitates coordinated federal-state action [9]. Countries lacking such frameworks should prioritize enacting legislation that supports stockpile sustainability, transparency, and rapid deployment authority.

Stable and predictable funding is essential to maintain adequate inventory levels and invest in modernization efforts. Multi-year budget commitments can prevent the cyclical underfunding that often leads to stockpile depletion or expiration of supplies [5]. Governments should also explore innovative financing mechanisms, such as public-private partnerships, to leverage additional resources.

### 5.2. Operational Improvements

Technological integration is critical for enhancing stockpile management. Implementing end-to-end digital inventory management systems enables real-time tracking of stock levels, expiration dates, and distribution status, improving transparency and decision-making [15]. Such systems can also facilitate demand forecasting and optimize stock rotation to reduce waste.

Operationally, countries should adopt hybrid stockpiling models that combine physical reserves with contractual surge capacity agreements with manufacturers and suppliers. This approach balances the cost of maintaining large inventories with the flexibility to scale up rapidly during crises [8]. Furthermore, integrating stockpiles with hospital-level caches and regional partners can enhance distribution speed and equity.

### 5.3. Risk Mitigation

To mitigate supply chain risks, diversification of suppliers is paramount. Countries should prioritize developing domestic manufacturing capabilities for critical items such as PPE and essential medicines, reducing dependence on international supply chains vulnerable to disruption [13]. Additionally, stockpiles should maintain a diversified inventory that includes general medicines and equipment beyond pandemic-specific items, ensuring broader utility during various emergencies.

Waste reduction strategies must be institutionalized through mandatory stock rotation policies, whereby expiring stockpile items are cycled into routine healthcare use and replaced with fresh supplies. This practice not only preserves the value of stockpiled goods but also maintains readiness with up-to-date products [12].

### 5.4. International Collaboration

Finally, fostering international cooperation on stockpile management can enhance global health security. Sharing best practices, coordinating procurement during crises, and participating in joint stockpiling initiatives can improve efficiency and reduce duplication [16]. Collaborative risk assessments and information exchange platforms can also support early warning and rapid response.

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## 6. Conclusion

The comparative analysis of national medical stockpile strategies during the COVID-19 pandemic reveals critical insights into the strengths and weaknesses of different governance models, inventory compositions, and deployment mechanisms. Australia's coordinated federal-state approach demonstrated agility in distributing vast quantities of PPE, while the United States' Strategic National Stockpile highlighted challenges related to supply chain fragility and multi-

agency coordination. European countries showcased innovative partnerships with private wholesalers and hospital-level stockpiles that improved stock rotation and local responsiveness.

Key lessons from the pandemic emphasize the importance of supply chain diversification, waste reduction through stock rotation, transparent and equitable deployment, and integration of stockpiles within broader health emergency preparedness frameworks. Future strategies must incorporate robust legal mandates, stable funding, technological enhancements, and international collaboration to build resilient and adaptive stockpile systems.

By applying these lessons, policymakers and public health officials can strengthen national preparedness, ensuring that medical stockpiles effectively support rapid and equitable responses to future health emergencies, ultimately safeguarding population health and mitigating the impact of crises.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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