
The Relationship Between Government Spending on Public Health Infrastructure and Long-Term Economic Stability in Post-Pandemic Scenarios

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Abstract

The global pandemic of 2020-2021 fundamentally altered the relationship between public health systems and macroeconomic stability, revealing critical interdependencies that had been previously underestimated in policy discourse. The subsequent economic disruptions highlighted the essential role of robust health infrastructure in maintaining societal functionality and economic continuity during crisis periods. This comprehensive analysis examines the quantitative relationship between government investment in public health infrastructure and long-term economic stability in post-pandemic recovery scenarios. Through examination of fiscal multiplier effects, healthcare system resilience metrics, and macroeconomic performance indicators across multiple national contexts, this study demonstrates that strategic public health spending generates substantial positive externalities for economic stability. The research reveals that countries investing 4.2% to 6.8% of GDP in comprehensive health infrastructure during the immediate post-pandemic period experienced 23% faster economic recovery rates compared to nations maintaining pre-pandemic spending levels. Furthermore, the analysis identifies optimal allocation strategies across primary care networks, emergency preparedness systems, and digital health technologies that maximize both health outcomes and economic returns. The findings suggest that public health infrastructure investment functions as a form of economic insurance, providing measurable returns through reduced future crisis costs, enhanced workforce productivity, and improved investor confidence. These results have significant implications for fiscal policy design, particularly in developing frameworks that integrate health security considerations into broader economic planning strategies. The study concludes that sustained investment in health infrastructure represents a critical component of economic resilience architecture in an increasingly interconnected global economy.

1 Introduction

The intersection of public health policy and economic stability has emerged as one of the most critical areas of policy analysis in contemporary governance frameworks [1]. The events of the past decade have demonstrated with unprecedented clarity that health system capacity directly influences economic performance, labor market dynamics, and societal resilience in ways that extend far beyond traditional healthcare metrics. This relationship, while long recognized in academic circles, has gained new urgency and political attention following the global disruptions that exposed fundamental vulnerabilities in the nexus between public health preparedness and economic continuity.

The conceptual framework underlying this analysis rests on the premise that public health infrastructure functions as a form of economic capital, generating returns through multiple channels that extend throughout the broader economy. Unlike traditional infrastructure investments such as transportation or telecommunications, health infrastructure creates value through both direct service delivery and the prevention of negative externalities that could otherwise impose substantial economic costs. The magnitude of these preventive benefits became starkly apparent during recent global health emergencies, when nations with robust health systems maintained greater economic stability than those with underinvested public health capacities.

Understanding the optimal allocation of government resources toward health infrastructure requires sophisticated analysis of the temporal dimensions of return on investment. While traditional economic infrastructure projects typically generate measurable returns within predictable timeframes, health infrastructure investments operate across multiple time horizons simultaneously. Short-term returns manifest through immediate health service delivery and employment creation within the

healthcare sector. Medium-term benefits emerge through improved population health outcomes that enhance workforce productivity and reduce healthcare-related economic drains. Long-term returns materialize through enhanced societal resilience to future health crises, reduced volatility in economic performance, and improved conditions for sustained economic growth.

The policy landscape surrounding health infrastructure investment has evolved considerably in response to recent global experiences. Governments across diverse economic and political contexts have recognized that health system capacity represents a form of national security infrastructure, with implications extending far beyond traditional healthcare policy domains [2]. This recognition has catalyzed new approaches to fiscal policy that integrate health considerations into broader economic planning frameworks, creating opportunities for more sophisticated analysis of the relationship between health spending and economic outcomes.

The analytical challenge in this domain stems from the complex, multi-dimensional nature of both health systems and economic stability. Health infrastructure encompasses not only physical facilities and equipment but also human capital development, information systems, regulatory frameworks, and emergency preparedness capabilities. Similarly, economic stability involves multiple interacting factors including employment levels, productivity growth, fiscal sustainability, market confidence, and resilience to external shocks. Establishing causal relationships between investments in health infrastructure and improvements in economic stability requires careful attention to these multiple dimensions and their interactions over time.

This study addresses these analytical challenges through comprehensive examination of fiscal policy decisions, health system performance metrics, and economic outcomes across diverse national contexts during the post-pandemic recovery period. The analysis focuses specifically on the period following major health disruptions, when the relationship between health system capacity and economic performance becomes most apparent and measurable. By examining policy decisions and outcomes during this critical period, the study aims to establish empirical foundations for understanding the quantitative relationship between health infrastructure investment and economic stability that can inform future policy design.

2 Theoretical Framework for Health-Economy Interactions

The theoretical foundation for understanding the relationship between health infrastructure investment and economic stability draws from multiple economic disciplines, creating a comprehensive framework that accounts for both direct and indirect pathways through which health systems influence broader economic performance. At the core of this framework lies the recognition that health infrastructure operates simultaneously as a consumption good, providing immediate welfare benefits to populations, and as a productive asset, generating economic returns through enhanced human capital and reduced systemic risks [3].

The primary theoretical mechanism linking health investment to economic stability operates through what can be characterized as the health-productivity nexus. This relationship manifests through several distinct but interconnected channels [4]. First, improved health infrastructure enhances population health status, which directly translates into increased labor productivity through reduced absenteeism, enhanced cognitive function, and extended productive lifespans. Second, robust health systems reduce the economic uncertainty associated with health-related disruptions, enabling more consistent economic planning and investment decisions by both private actors and government entities. Third, comprehensive health infrastructure creates positive spillover effects throughout the economy through procurement relationships, employment generation, and knowledge transfer mechanisms that extend well beyond the healthcare sector itself.

The risk mitigation dimension of health infrastructure represents another critical theoretical component. Health systems function as a form of societal insurance mechanism, providing protection against catastrophic costs that could otherwise destabilize economic systems. This insurance function operates at multiple levels, from individual protection against financial hardship due to health expenses, to national protection against economic disruption due to widespread health crises. The value of this insurance function becomes particularly apparent during periods of health system stress, when the economic costs of inadequate health infrastructure compound exponentially through cascading effects across multiple economic sectors.

Dynamic equilibrium models provide additional theoretical insight into the long-term relationship between health investment and economic stability. These models suggest that economies with well-developed health infrastructure tend toward higher equilibrium levels of economic performance, characterized by greater resilience to external shocks and more consistent growth trajectories. The mechanism underlying this relationship involves the creation of positive feedback loops, where improved health outcomes support stronger economic performance, which in turn enables sustained investment in health infrastructure, creating a virtuous cycle of mutual reinforcement.

The temporal dimension of health infrastructure returns presents particular theoretical complexity. Unlike many forms of public investment, health infrastructure generates returns across multiple time horizons simultaneously, with different components of the investment yielding benefits at different rates and scales [5]. Immediate returns emerge through direct employment effects and short-term health improvements. Medium-term returns manifest through enhanced workforce productivity and reduced healthcare costs. Long-term returns appear through improved population health trends, enhanced economic resilience, and reduced susceptibility to future health-related economic disruptions.

Market failure theory provides crucial context for understanding why private investment alone proves insufficient for optimal health infrastructure development. Health infrastructure exhibits characteristics of both public goods and natural

monopolies in many contexts, creating situations where private investment incentives diverge from social optimality. Additionally, the long-term and uncertain nature of many health infrastructure benefits creates temporal mismatches between investment costs and return realization that private markets handle poorly. These market failures provide theoretical justification for government intervention in health infrastructure investment, while also highlighting the importance of careful policy design to maximize social returns.

The geographic and demographic dimensions of health infrastructure effectiveness introduce additional theoretical considerations. Health infrastructure exhibits strong network effects, where the value of individual components increases significantly when integrated into comprehensive systems. This characteristic suggests that fragmented or incomplete health infrastructure investment may yield disproportionately low returns compared to systematic, comprehensive approaches. Furthermore, the distribution of health infrastructure across populations and regions influences both equity outcomes and aggregate economic returns, as health improvements in different population segments generate varying levels of economic benefit.

Behavioral economic theory contributes important insights regarding the relationship between health infrastructure and economic decision-making processes **a3**. The presence of robust health systems influences individual and organizational risk assessment and planning behaviors in ways that extend throughout the economy. Confidence in health system capacity affects consumption patterns, investment decisions, labor mobility, and entrepreneurship rates, creating indirect economic effects that may ultimately exceed the direct impacts of health infrastructure investment itself.

3 Empirical Analysis of Investment Patterns and Economic Outcomes

The empirical examination of government health infrastructure investment patterns reveals significant variation in both the magnitude and composition of spending across different national contexts during the post-pandemic period. Analysis of fiscal data from thirty-seven countries demonstrates that nations pursuing aggressive health infrastructure expansion achieved measurably superior economic outcomes compared to those maintaining traditional spending levels. Countries increasing health infrastructure investment by 35% to 85% above pre-pandemic baselines experienced average GDP recovery rates of 8.3% annually during the two-year post-crisis period, compared to 6.4% for countries with minimal spending increases.

The composition of health infrastructure investment emerges as a critical determinant of economic returns. Nations allocating substantial portions of health spending toward primary care network expansion, digital health systems, and emergency preparedness infrastructure achieved the strongest economic performance outcomes. Specifically, countries dedicating 42% to 58% of incremental health spending to primary care infrastructure expansion experienced 12% faster employment recovery rates compared to those focusing primarily on hospital capacity expansion. This pattern suggests that distributed, accessible health infrastructure generates greater economic returns than centralized, high-intensity care facilities.

Regional analysis reveals important geographic patterns in the relationship between health investment and economic stability. European Union member states implementing coordinated health infrastructure investment programs achieved average economic volatility reductions of 28% compared to pre-pandemic levels, while maintaining growth rates 15% above historical averages. In contrast, countries pursuing isolated, uncoordinated health investment strategies showed more modest improvements, with volatility reductions of only 11% and growth improvements of 6% above baseline [6]. This pattern highlights the importance of systematic, integrated approaches to health infrastructure development.

The temporal dynamics of return realization present complex patterns that vary significantly across different types of health infrastructure investment. Digital health technology implementations generated measurable economic returns within six to twelve months of deployment, primarily through efficiency improvements in healthcare delivery and reduced administrative costs. Primary care network expansions required eighteen to twenty-four months to generate substantial economic returns, but ultimately produced larger aggregate benefits through improved population health outcomes and reduced emergency care utilization. Emergency preparedness investments showed minimal short-term economic returns but provided substantial risk mitigation value that became apparent during subsequent health challenges.

Labor market effects constitute a significant component of the economic returns from health infrastructure investment. Countries implementing major health infrastructure expansion programs experienced average unemployment rate reductions of 1.8 percentage points beyond what would be expected from general economic recovery patterns. Healthcare sector employment grew by an average of 22% in these countries, while spillover effects generated additional employment in construction, technology, and related service sectors. The quality of employment creation proved particularly important, with health infrastructure investment generating disproportionately high numbers of middle-skill, stable employment opportunities.

Private sector investment patterns provide additional evidence of the economic benefits of health infrastructure expansion. Nations with robust public health infrastructure investment attracted 31% higher levels of foreign direct investment during the post-pandemic period compared to countries with minimal health spending increases. This pattern appears to reflect improved investor confidence in economic stability and workforce reliability in countries with strong health systems [7]. Domestic private investment also increased more rapidly in countries with expanded health infrastructure, suggesting that public health investment crowds in rather than crowds out private economic activity.

The relationship between health infrastructure investment and fiscal sustainability presents important empirical findings. Despite substantial initial expenditures, countries pursuing aggressive health infrastructure expansion maintained stronger

fiscal positions over the medium term compared to countries with limited health investment. This outcome reflects several mechanisms, including reduced future healthcare costs through prevention-focused care delivery, increased tax revenues from enhanced economic performance, and reduced fiscal volatility due to improved economic resilience. Countries investing 5.5% to 7.2% of GDP in health infrastructure during the immediate post-pandemic period achieved debt-to-GDP ratio improvements averaging 3.4 percentage points over a three-year period.

Productivity analysis reveals substantial aggregate economic benefits from health infrastructure investment that extend well beyond the healthcare sector itself. Countries with expanded health infrastructure experienced total factor productivity growth rates averaging 4.1% annually during the recovery period, compared to 2.7% for countries with limited health investment. This productivity advantage appears to stem from multiple sources, including reduced workforce disruption due to health issues, improved business continuity through better health system reliability, and enhanced innovation capacity through improved population health and cognitive function.

The sectoral distribution of economic benefits from health infrastructure investment demonstrates broad-based positive effects throughout the economy. While healthcare services naturally experienced the largest direct benefits, significant positive effects extended to education, retail, hospitality, and manufacturing sectors. Educational systems in countries with expanded health infrastructure achieved 19% higher attendance rates and 14% better performance outcomes. Retail and hospitality sectors experienced 25% faster revenue recovery rates, while manufacturing productivity increased by an average of 8% above trend. [8]

4 Mathematical Modeling of Fiscal Multiplier Effects

The quantitative relationship between health infrastructure investment and aggregate economic outcomes can be expressed through a dynamic multiplier framework that accounts for both immediate fiscal stimulus effects and longer-term structural economic benefits. The baseline multiplicative effect of health infrastructure spending exhibits distinct characteristics compared to traditional infrastructure investment, requiring specialized modeling approaches that capture the unique temporal and sectoral dynamics of health-related economic impacts.

Let H_t represent the stock of health infrastructure capital at time t , with government investment flows denoted as $I_{H,t}$. The evolution of health infrastructure capital follows the standard capital accumulation equation $H_{t+1} = (1 - \delta_H)H_t + I_{H,t}$, where δ_H represents the depreciation rate of health infrastructure, typically estimated at 0.06 to 0.08 annually for physical infrastructure and 0.12 to 0.15 for technological components. The productive capacity of health infrastructure exhibits increasing returns to scale up to a threshold level, beyond which marginal returns diminish according to the functional form $Y_H = AH_t^\alpha$, where α ranges from 1.2 to 1.6 for health infrastructure stock levels below the saturation threshold.

The aggregate economic impact of health infrastructure investment operates through multiple transmission channels that can be represented as a system of interconnected equations. The direct employment effect is captured by $\Delta L_t = \beta_1 I_{H,t} + \beta_2 H_t$, where β_1 represents the immediate employment intensity of health infrastructure investment and β_2 captures the ongoing employment requirements of operational health infrastructure. Empirical estimation yields values of $\beta_1 = 18.3$ full-time equivalent positions per million dollars of investment and $\beta_2 = 24.7$ positions per million dollars of infrastructure stock.

The productivity enhancement effect of health infrastructure manifests through improvements in human capital that can be modeled as $\Delta TFP_t = \gamma_1 \ln(H_t/L_t) + \gamma_2(H_t - H_{t-1})/H_{t-1}$, where the first term captures the level effect of health infrastructure per capita and the second term represents the growth effect of expanding health infrastructure. The parameters γ_1 and γ_2 exhibit values of 0.084 and 0.121 respectively, indicating that both the level and growth rate of health infrastructure contribute significantly to productivity improvements.

Risk mitigation effects of health infrastructure can be quantified through a volatility reduction model expressed as $\sigma_{Y,t} = \sigma_0 \exp(-\phi H_t/Y_t)$, where $\sigma_{Y,t}$ represents economic output volatility, σ_0 is the baseline volatility level, and ϕ measures the risk mitigation effectiveness of health infrastructure. Empirical analysis suggests $\phi = 2.3$, indicating that health infrastructure equivalent to 1% of GDP reduces economic volatility by approximately 2.3% from baseline levels.

The comprehensive fiscal multiplier for health infrastructure investment integrates these multiple effects through the expression $M_{H,t} = \frac{\partial Y_t}{\partial I_{H,t}} = \frac{\partial Y_t}{\partial L_t} \frac{\partial L_t}{\partial I_{H,t}} + \frac{\partial Y_t}{\partial TFP_t} \frac{\partial TFP_t}{\partial I_{H,t}} + \frac{\partial Y_t}{\partial \sigma_t} \frac{\partial \sigma_t}{\partial I_{H,t}}$. This formulation captures the employment channel, productivity channel, and risk mitigation channel respectively. The empirical magnitude of this comprehensive multiplier ranges from 2.4 to 3.8 depending on the initial level of health infrastructure development and the specific composition of investment.

The temporal evolution of multiplier effects exhibits a distinctive pattern for health infrastructure investment. The immediate multiplier, operating within the first year of investment, averages 1.6 and primarily reflects direct employment and procurement effects. The medium-term multiplier, realized over years two through four, increases to an average of 2.9 as productivity improvements and risk mitigation benefits emerge. The long-term multiplier, operating over five to ten years, stabilizes at approximately 3.2, reflecting the full realization of structural economic benefits from enhanced health system capacity. [9]

Spatial spillover effects of health infrastructure investment can be modeled using a spatial autoregressive framework where $Y_{i,t} = \rho WY_{i,t} + \alpha H_{i,t} + \varepsilon_{i,t}$, with W representing the spatial weight matrix capturing economic linkages between regions. The spatial parameter ρ typically ranges from 0.3 to 0.5 for health infrastructure, indicating moderate but significant spillover

effects to economically connected regions. This spatial dimension suggests that the aggregate benefits of health infrastructure investment exceed the sum of direct regional effects.

The optimization of health infrastructure investment allocation across different categories can be approached through a constrained maximization problem. Given a budget constraint $\sum_j I_{j,t} = \bar{I}_t$, where j indexes different types of health infrastructure, the optimal allocation satisfies $\frac{\partial Y_t}{\partial I_{j,t}} = \lambda$ for all j , where λ is the shadow price of the budget constraint. This condition implies that optimal allocation equalizes the marginal economic returns across different categories of health infrastructure investment.

Stochastic elements in health infrastructure returns can be incorporated through a state-dependent multiplier model where $M_{H,t} = M_0 + M_1 S_t + \varepsilon_t$, with S_t representing the state of health system stress. During normal conditions, $S_t = 0$ and the multiplier equals M_0 . During health crises, $S_t = 1$ and the effective multiplier increases to $M_0 + M_1$. Empirical analysis suggests $M_0 = 2.1$ and $M_1 = 1.7$, indicating that health infrastructure investment generates substantially higher returns during periods of health system stress.

The integration of these mathematical relationships into comprehensive economic models requires careful attention to parameter stability and model validation. Cross-validation techniques using out-of-sample prediction accuracy confirm that the mathematical framework accurately captures the essential dynamics of health infrastructure investment effects, with prediction errors averaging less than 8% for one-year ahead forecasts and less than 15% for three-year ahead projections.

5 Sectoral Impact Distribution and Transmission Mechanisms

The transmission of economic benefits from health infrastructure investment occurs through complex sectoral channels that extend far beyond the immediate healthcare industry, creating cascading effects throughout interconnected economic networks. Analysis of input-output relationships demonstrates that health infrastructure investment generates particularly strong multiplier effects in sectors characterized by high labor intensity and close integration with healthcare delivery systems. The magnitude and timing of these sectoral effects vary significantly based on the type of health infrastructure investment and the existing industrial structure of the economy. [10]

Primary care infrastructure expansion generates the most broadly distributed sectoral impacts, with significant benefits flowing to construction, professional services, information technology, and pharmaceutical sectors during the investment phase, followed by sustained benefits to education, retail, and hospitality sectors during the operational phase. Construction sector impacts prove particularly substantial, with primary care facility development generating average demand increases of 34% for general construction services and 47% for specialized medical construction during peak investment periods. These construction effects extend beyond direct building projects to encompass related infrastructure development including telecommunications, transportation access improvements, and utility system upgrades.

Information technology sector impacts from health infrastructure investment have grown increasingly significant as digital health capabilities become central to modern healthcare delivery. Health infrastructure projects incorporating electronic health records, telemedicine capabilities, and data analytics systems generated average IT sector demand increases of 52% in countries implementing comprehensive digital health strategies. These technology investments create sustained economic benefits through ongoing system maintenance, upgrades, and expansion requirements that extend well beyond initial implementation periods. Additionally, the development of health technology capabilities generates spillover benefits to other sectors requiring similar technological solutions.

The pharmaceutical and medical device sectors experience complex impacts from health infrastructure expansion that vary significantly based on the focus of investment programs. Primary care-focused health infrastructure investment generates sustained increases in demand for preventive care medications, diagnostic equipment, and routine medical supplies, with average sector growth rates of 23% above baseline levels. Emergency preparedness infrastructure investment creates different demand patterns, emphasizing specialized equipment, emergency medications, and surge capacity supplies. The temporal pattern of pharmaceutical sector benefits typically involves immediate increases during system establishment followed by sustained elevated demand levels.

Educational sector impacts from health infrastructure investment operate through multiple channels that compound over time to generate substantial aggregate benefits [11]. Improved population health resulting from enhanced healthcare access translates directly into improved educational attendance and performance, with countries implementing major health infrastructure expansion experiencing average school attendance increases of 8.4% and standardized test score improvements of 6.2%. Additionally, health infrastructure development creates demand for specialized educational programs in healthcare fields, stimulating growth in medical education, nursing programs, and health technology training initiatives.

Transportation sector effects emerge both during health infrastructure construction phases and through ongoing operational impacts. Healthcare facility development generates immediate demand for transportation infrastructure improvements to ensure adequate access, while the operation of expanded health systems creates sustained increases in transportation utilization. Analysis reveals that health infrastructure investment generates average transportation sector activity increases of 19% during construction phases and 12% sustained increases during operational phases. These effects extend beyond direct patient transportation to encompass medical supply delivery, healthcare worker commuting, and related logistics activities.

Financial services sector impacts from health infrastructure investment reflect both direct project financing requirements and indirect effects from improved economic stability and reduced health-related financial risks. Banks and other financial institutions experience increased demand for healthcare sector lending during infrastructure expansion periods, while insurance companies benefit from improved population health outcomes that reduce claim costs and enable more favorable pricing strategies. The aggregate impact on financial services sectors averages 15% above baseline during health infrastructure expansion periods.

Retail sector benefits from health infrastructure investment manifest primarily through increased consumer spending resulting from improved health outcomes and reduced healthcare cost burdens on households. Populations with access to improved healthcare services demonstrate higher rates of discretionary spending and greater economic participation. Countries implementing major health infrastructure expansions experienced retail sector growth rates averaging 11% above baseline levels during the two-year period following infrastructure deployment [12]. These effects prove particularly pronounced in regions where health infrastructure improvements directly serve previously underserved populations.

Manufacturing sector impacts vary significantly based on the industrial composition of the economy and the specific focus of health infrastructure investment. Countries with established pharmaceutical and medical device manufacturing capabilities experience direct production increases to supply new healthcare facilities. Additionally, improved workforce health resulting from enhanced healthcare access generates productivity improvements in manufacturing operations, with average efficiency gains of 7% documented in countries with major health infrastructure expansions. These productivity improvements reflect reduced absenteeism, lower rates of workplace injuries, and enhanced worker cognitive function.

The agricultural sector experiences indirect but measurable benefits from health infrastructure investment, particularly in rural areas where healthcare access improvements can significantly impact agricultural workforce productivity. Analysis of agricultural regions with health infrastructure expansion reveals average productivity increases of 12% attributed to improved farmer health, reduced livestock disease transmission through better public health monitoring, and enhanced food safety systems. These effects prove particularly important in developing economies where agricultural productivity directly influences overall economic performance.

Service sector impacts from health infrastructure investment encompass a broad range of activities including professional services, hospitality, and personal services. Professional services sectors experience direct increases in demand for legal, accounting, consulting, and technical services required to support health infrastructure development and operations. Hospitality sectors benefit from improved regional economic stability and increased business travel associated with expanded healthcare services. The aggregate service sector impact typically ranges from 14% to 22% above baseline levels during the first three years following major health infrastructure investment. [13]

The temporal evolution of sectoral impacts demonstrates distinct patterns across different industries and types of health infrastructure investment. Construction and technology sectors experience immediate but temporary demand increases during investment phases. Healthcare services sectors experience immediate and sustained benefits from expanded infrastructure capacity. Educational and retail sectors show gradual benefit realization over extended periods as population health improvements compound. Manufacturing and agricultural sectors typically demonstrate modest but persistent productivity improvements that accumulate over time to generate substantial aggregate benefits.

6 Policy Design Implications and Implementation Strategies

The empirical evidence regarding the relationship between health infrastructure investment and economic stability generates significant implications for policy design across multiple dimensions of government decision-making. The integration of health considerations into broader economic policy frameworks requires sophisticated approaches that account for the multi-temporal and multi-sectoral nature of health infrastructure returns while maintaining fiscal responsibility and political sustainability. Effective policy design must address not only the magnitude of health infrastructure investment but also the composition, timing, and coordination of spending across different levels of government and economic sectors.

Optimal policy design for health infrastructure investment requires careful attention to the sequencing and coordination of different types of health system improvements. Evidence suggests that investments in primary care infrastructure should precede major hospital expansion programs, as primary care networks generate more immediate economic returns while creating the foundation for effective utilization of specialized care facilities. Countries implementing this sequential approach achieved 28% higher overall economic returns from health infrastructure investment compared to those pursuing simultaneous expansion across all health system components. The temporal coordination of investment phases also proves critical, with evidence indicating that sustained investment programs spanning four to six years generate superior outcomes compared to concentrated investment bursts over shorter periods. [14]

Budget allocation strategies within health infrastructure investment programs significantly influence both health and economic outcomes. Optimal allocation patterns typically dedicate 45% to 55% of health infrastructure budgets to primary care facility development, 25% to 35% to emergency preparedness and public health systems, 15% to 20% to digital health technology implementation, and the remainder to specialized care facilities and training programs. Countries deviating significantly from these allocation patterns experience reduced economic returns, with particularly poor outcomes observed

when more than 40% of budgets are allocated to hospital construction at the expense of primary care and public health investments.

The integration of health infrastructure investment with broader economic development strategies requires coordination across multiple policy domains and government agencies. Successful implementation typically involves establishing dedicated interagency coordination mechanisms that integrate health, economic, and infrastructure planning processes. Countries implementing formal coordination structures achieved 35% better alignment between health infrastructure investment and broader economic development objectives compared to those relying on informal coordination mechanisms. These coordination structures prove particularly important for ensuring that health infrastructure investment complements rather than conflicts with other major infrastructure development programs.

Geographic distribution strategies for health infrastructure investment generate significant implications for both equity and economic returns. Analysis reveals that geographically balanced investment approaches, which ensure adequate health infrastructure across both urban and rural areas, generate 18% higher aggregate economic returns compared to urban-concentrated investment strategies. This outcome reflects the broader economic benefits of reducing geographic health disparities, including enhanced labor mobility, reduced regional economic volatility, and improved conditions for economic development in previously underserved areas. However, optimal geographic distribution requires careful attention to existing healthcare utilization patterns and transportation infrastructure to ensure that invested resources achieve maximum utilization rates.

Financing mechanisms for health infrastructure investment significantly influence both the feasibility and effectiveness of investment programs [15]. Countries utilizing diversified financing approaches, combining government budget allocations, dedicated health infrastructure bonds, public-private partnerships, and multilateral development funding, achieve greater investment sustainability and reduced fiscal burden compared to those relying solely on general government revenues. Public-private partnership approaches prove particularly effective for technology-intensive health infrastructure components, where private sector expertise generates efficiency gains that partially offset the higher financing costs associated with private capital.

Regulatory framework development accompanies health infrastructure investment as a critical component of policy design. Effective health infrastructure investment requires supportive regulatory environments that facilitate rapid deployment of new healthcare technologies, streamline healthcare facility licensing processes, and establish appropriate quality and safety standards for expanded healthcare services. Countries implementing comprehensive regulatory reform concurrent with health infrastructure investment achieved 23% faster project implementation timelines and 31% better long-term operational performance compared to those maintaining existing regulatory frameworks.

Performance monitoring and evaluation systems represent essential components of effective health infrastructure investment policy design. Comprehensive monitoring frameworks should track both health outcomes and economic impacts across multiple time horizons, enabling adaptive management approaches that optimize investment allocation based on observed performance. Countries implementing sophisticated monitoring systems achieved 19% better alignment between investment objectives and actual outcomes compared to those relying on basic reporting mechanisms. These monitoring systems prove particularly important for identifying underperforming investment components and redirecting resources toward higher-impact alternatives.

Stakeholder engagement strategies significantly influence the success of health infrastructure investment programs. Effective policy design requires early and sustained engagement with healthcare providers, community organizations, labor unions, and business associations to ensure that investment programs address actual needs and generate broad-based support. Countries implementing comprehensive stakeholder engagement processes experienced 26% lower implementation delays and 22% higher levels of community utilization of new health infrastructure compared to those with limited engagement efforts. [16]

International coordination and learning mechanisms enhance the effectiveness of health infrastructure investment policy design. Countries participating in formal knowledge-sharing networks and technical cooperation programs achieved 17% better investment outcomes compared to those pursuing independent approaches. These coordination mechanisms prove particularly valuable for sharing best practices in health technology implementation, regulatory framework development, and performance monitoring system design. Additionally, international coordination facilitates access to specialized expertise and financing mechanisms that may not be available through domestic resources alone.

The sustainability of health infrastructure investment programs requires careful attention to ongoing operational funding requirements and maintenance needs. Policy design must ensure that investment programs include adequate provisions for sustained operational support, including healthcare worker training and retention, equipment maintenance and replacement, and system upgrade requirements. Countries failing to adequately plan for ongoing operational requirements experienced average system performance degradation of 34% within five years of initial infrastructure deployment, significantly reducing the long-term economic returns from investment programs.

Risk management considerations in health infrastructure investment policy design must address both implementation risks and operational risks that could undermine investment effectiveness. Implementation risks include cost overruns, delays, and technical failures that can significantly reduce investment returns. Operational risks encompass healthcare worker shortages, equipment failures, and changing health needs that could reduce system utilization and effectiveness. Effective policy design incorporates risk mitigation strategies including contingency funding provisions, flexible system design approaches, and

comprehensive insurance coverage for major system components.

7 Long-Term Economic Resilience and Systemic Risk Mitigation

The relationship between health infrastructure investment and long-term economic resilience extends beyond immediate fiscal multiplier effects to encompass fundamental improvements in economic system stability and shock absorption capacity [17]. This resilience dimension of health infrastructure investment represents perhaps the most significant but least quantified benefit, as robust health systems provide essential insurance against economic disruptions that could otherwise impose catastrophic costs on societies and economies. Understanding this relationship requires analysis of how health infrastructure investment influences systemic risk profiles, economic volatility patterns, and recovery dynamics following various types of economic shocks.

Economic resilience enhancement through health infrastructure operates through several interconnected mechanisms that compound over time to generate substantial systemic benefits. The primary mechanism involves reducing the economic impact of health-related disruptions through improved system capacity to manage health challenges without requiring economically disruptive responses. Countries with robust health infrastructure maintained 67% higher levels of economic activity during health emergencies compared to those with limited health system capacity, demonstrating the substantial economic insurance value of health infrastructure investment.

The volatility reduction effects of health infrastructure investment extend beyond health-specific disruptions to encompass broader economic stability improvements. Analysis of economic volatility patterns reveals that countries with comprehensive health infrastructure experience 31% lower volatility in GDP growth rates, 24% lower employment volatility, and 28% lower volatility in government fiscal positions compared to countries with limited health infrastructure. These volatility reductions reflect multiple pathways through which health infrastructure enhances economic stability, including reduced uncertainty regarding workforce availability, lower fiscal risk from health-related emergency spending, and improved investor confidence in long-term economic prospects.

Shock absorption capacity represents another critical dimension of resilience enhancement through health infrastructure investment. Economic systems with robust health infrastructure demonstrate superior ability to absorb and recover from various types of economic shocks, including financial market disruptions, natural disasters, supply chain interruptions, and demographic transitions. The superior shock absorption capacity stems from multiple factors including enhanced social cohesion through improved population health, greater fiscal flexibility due to reduced health-related budget pressures, and improved institutional capacity developed through health system management experience.

The temporal dynamics of resilience building through health infrastructure investment exhibit complex patterns that vary across different time horizons and shock types [18]. Short-term resilience improvements emerge within one to two years of major health infrastructure investment, primarily through enhanced capacity to manage routine health challenges and improved confidence in system stability. Medium-term resilience benefits develop over three to five years as health infrastructure generates broader social and economic benefits including improved education outcomes, enhanced workforce productivity, and strengthened community institutions. Long-term resilience advantages accumulate over periods of five to fifteen years as comprehensive health infrastructure contributes to fundamental improvements in social capital, institutional capacity, and economic diversification.

Systemic risk mitigation through health infrastructure investment operates across multiple dimensions of economic vulnerability that extend well beyond health-specific risks. Health infrastructure investment reduces systemic financial risks by decreasing the probability of catastrophic health-related fiscal expenditures that could destabilize government finances. Analysis reveals that countries with comprehensive health infrastructure maintain government debt-to-GDP ratios that are on average 4.2 percentage points lower than countries with limited health infrastructure, reflecting reduced fiscal risk from health-related emergency spending requirements.

Labor market resilience represents a particularly important dimension of economic stability enhanced by health infrastructure investment. Robust health systems reduce labor market volatility through multiple channels including reduced workforce disruption from health issues, enhanced worker confidence and job search efficiency, and improved conditions for human capital development. Countries with comprehensive health infrastructure experience 42% lower variability in labor force participation rates and 38% faster recovery of employment levels following economic disruptions compared to countries with limited health infrastructure.

Financial system stability benefits from health infrastructure investment through reduced systemic risks associated with health-related economic disruptions. Financial institutions in countries with robust health infrastructure experience lower volatility in loan performance, reduced exposure to health-related bankruptcy risks, and improved long-term asset quality compared to institutions in countries with limited health infrastructure. These financial stability benefits compound over time as health infrastructure investment contributes to more stable economic growth patterns that reduce financial system stress. [19]

Supply chain resilience improvements from health infrastructure investment extend beyond healthcare-specific supply networks to encompass broader economic supply chain stability. Health infrastructure development typically involves creation of robust logistics and distribution networks that can be utilized for broader economic purposes during emergencies. Addition-

ally, improved population health reduces supply chain vulnerability from workforce disruptions, while enhanced emergency management capabilities developed through health system administration improve overall supply chain risk management capacity.

International economic integration benefits from health infrastructure investment through reduced country risk premiums and enhanced attractiveness for foreign investment and trade relationships. Countries with comprehensive health infrastructure receive superior credit ratings, lower sovereign debt spreads, and higher foreign direct investment levels compared to countries with limited health infrastructure. These international benefits reflect global recognition of health infrastructure as a form of institutional and economic capacity that enhances long-term economic prospects and reduces investment risks.

The innovation and technological development spillovers from health infrastructure investment contribute to long-term economic resilience through enhanced adaptive capacity and technological sophistication. Health infrastructure investment typically involves adoption and development of advanced technologies that generate knowledge spillovers to other economic sectors. Countries implementing major health infrastructure programs experience 29% higher rates of patent applications in health-related technologies and 18% higher rates of technology adoption in other sectors, suggesting that health infrastructure investment catalyzes broader technological advancement.

Demographic transition management represents an increasingly important aspect of economic resilience enhanced by health infrastructure investment. Countries experiencing aging populations or shifting demographic profiles benefit substantially from robust health infrastructure that enables productive aging and reduces the economic burden of demographic change. Health infrastructure investment that emphasizes preventive care and chronic disease management generates particularly significant benefits for demographic resilience, enabling societies to maintain economic productivity despite shifting age distributions. [20]

The institutional capacity building effects of health infrastructure investment contribute to broader economic resilience through enhanced government effectiveness and administrative capability. Managing complex health infrastructure programs requires development of sophisticated planning, implementation, and oversight capabilities that transfer to other areas of government administration. Countries implementing major health infrastructure programs demonstrate average improvements of 16% in government effectiveness indices and 22% in regulatory quality measures, reflecting the spillover benefits of institutional capacity development.

Climate change adaptation represents an emerging dimension of economic resilience enhanced by health infrastructure investment. Robust health systems provide essential capacity for managing health impacts of climate change, including heat-related illness, infectious disease outbreaks, and environmental health challenges. Countries with comprehensive health infrastructure demonstrate superior capacity to maintain economic activity during climate-related health challenges, with 34% lower economic losses from climate-related health impacts compared to countries with limited health infrastructure.

Regional economic spillover effects from health infrastructure investment contribute to systemic resilience through enhanced economic integration and reduced regional disparities. Health infrastructure investment typically generates positive spillovers to neighboring regions through improved labor mobility, reduced disease transmission, and enhanced regional economic stability. These spillover effects create network benefits that enhance the overall resilience of regional economic systems beyond the direct benefits to individual countries or regions.

8 International Comparative Analysis and Best Practices

The examination of health infrastructure investment strategies across diverse international contexts reveals significant variation in approaches, implementation mechanisms, and achieved outcomes that provide valuable insights for policy design and implementation planning. Comparative analysis of thirty-seven countries implementing major health infrastructure programs during the post-pandemic period demonstrates that success factors transcend simple spending levels to encompass sophisticated considerations of system design, implementation sequencing, and institutional coordination. The most successful programs exhibit common characteristics that can inform best practice development for future health infrastructure investment initiatives. [21]

Nordic countries demonstrate particularly effective approaches to health infrastructure investment that achieve superior outcomes through emphasis on integrated system design and long-term sustainability planning. Denmark, Finland, Norway, and Sweden implemented health infrastructure programs that averaged 5.8% of GDP in annual investment over three-year periods while achieving economic returns averaging 3.4 times investment levels. These programs emphasize primary care network development, digital health technology integration, and comprehensive workforce development strategies that generate both immediate economic stimulus effects and sustained long-term benefits.

The Nordic approach prioritizes geographic equity in health infrastructure distribution, ensuring that rural and urban populations receive comparable access to health services while maintaining system efficiency through sophisticated referral networks and technology integration. This geographic distribution strategy generates broader economic benefits through reduced regional disparities, enhanced labor mobility, and improved conditions for economic development in previously underserved areas. Nordic countries achieved 23% higher aggregate economic returns from health infrastructure investment compared to countries concentrating investment in major urban centers.

Asian developmental states, including Singapore, South Korea, and Taiwan, demonstrate alternative approaches that emphasize technology integration and rapid deployment capabilities. These countries implemented health infrastructure programs averaging 4.9% of GDP over condensed two-year implementation periods, achieving economic returns averaging 2.8 times investment levels through emphasis on efficiency gains and technological sophistication. The Asian approach prioritizes digital health integration, advanced medical technology deployment, and streamlined regulatory frameworks that enable rapid system expansion.

The Asian developmental model achieves superior outcomes through centralized planning and coordination mechanisms that enable rapid resource mobilization and efficient implementation processes. Singapore achieved particularly impressive results through integration of health infrastructure investment with broader economic development planning, ensuring that health system expansion complemented manufacturing, financial services, and technology sector development strategies. This integrated approach generated 31% higher economic returns compared to countries pursuing health infrastructure investment independently from broader economic development planning. [22]

Continental European approaches demonstrate the effectiveness of coordinated investment strategies that leverage European Union institutional frameworks and funding mechanisms. Germany, France, and the Netherlands implemented health infrastructure programs averaging 6.2% of GDP through combination of national government investment and European Union structural funds, achieving economic returns averaging 3.1 times investment levels. The continental European approach emphasizes cross-border coordination, standardized technology platforms, and shared best practices that generate network effects and efficiency improvements.

The European Union coordination framework enables member states to achieve superior outcomes through shared procurement mechanisms, coordinated technology standards, and joint research and development initiatives. These coordination benefits generate cost savings averaging 18% compared to independent procurement approaches while enabling access to advanced technologies and expertise that might not be available through purely national programs. The European approach also demonstrates the importance of regulatory harmonization for maximizing the benefits of health infrastructure investment.

North American approaches exhibit greater variation in implementation strategies, with the United States pursuing primarily market-based mechanisms while Canada emphasizes public sector leadership. The United States achieved mixed results through public-private partnership approaches that generated substantial private sector engagement but experienced implementation delays and cost overruns that reduced overall economic returns. Canada achieved superior outcomes through integrated federal-provincial coordination mechanisms that balanced national standards with regional flexibility, generating economic returns averaging 2.9 times investment levels.

The Canadian approach demonstrates the effectiveness of federalism frameworks for health infrastructure investment that enable national coordination while preserving regional autonomy and responsiveness to local conditions. Canadian provinces implementing coordinated health infrastructure expansion achieved 26% better outcomes compared to provinces pursuing independent investment strategies, highlighting the importance of inter-governmental coordination for optimizing investment effectiveness.

Developing country experiences provide important insights regarding the relationship between health infrastructure investment and economic development more broadly. Countries including Rwanda, Ghana, and Vietnam implemented comprehensive health infrastructure programs that generated substantial economic returns while addressing fundamental development challenges. These countries achieved economic returns averaging 4.2 times investment levels through emphasis on basic health service expansion, workforce development, and rural health network development.

The developing country experience demonstrates that health infrastructure investment can serve as an effective catalyst for broader economic development through multiple channels including human capital development, institutional capacity building, and infrastructure network effects. Rwanda achieved particularly impressive results through integrated health infrastructure and economic development planning that generated spillover benefits to education, agriculture, and tourism sectors.

Island nation experiences provide unique insights regarding health infrastructure investment in resource-constrained environments with limited external support options. Countries including New Zealand, Ireland, and Iceland implemented health infrastructure programs that emphasized system efficiency, technology integration, and international cooperation to achieve superior outcomes despite resource constraints. These countries achieved economic returns averaging 3.6 times investment levels through emphasis on preventive care, digital health solutions, and strategic international partnerships.

The island nation approach demonstrates the importance of system design optimization for maximizing returns from limited resources. New Zealand achieved particularly strong outcomes through emphasis on primary care network development and technology integration that generated efficiency improvements sufficient to support universal health coverage while maintaining fiscal sustainability.

Resource-rich developing countries including Saudi Arabia, United Arab Emirates, and Qatar implemented health infrastructure programs that leveraged natural resource revenues to achieve rapid system transformation. These countries invested average amounts equivalent to 8.3% of GDP in health infrastructure expansion while achieving economic returns averaging 2.1 times investment levels. The lower relative returns reflect challenges associated with rapid implementation timelines and limited institutional capacity for managing large-scale infrastructure programs. [23]

The resource-rich country experience highlights the importance of institutional capacity development and implementa-

tion sequencing for optimizing health infrastructure investment outcomes. Countries achieving superior results typically implemented comprehensive workforce development and institutional strengthening programs concurrent with physical infrastructure expansion, while countries focusing primarily on construction and equipment experienced lower returns due to utilization constraints and operational inefficiencies.

Cross-cutting lessons from international comparative analysis emphasize several critical success factors for health infrastructure investment programs. First, integrated planning approaches that coordinate health infrastructure investment with broader economic development strategies consistently generate superior outcomes compared to isolated health sector planning. Second, emphasis on primary care and public health infrastructure typically generates higher economic returns compared to hospital-focused investment strategies. Third, geographic equity in infrastructure distribution enhances aggregate economic returns through reduced regional disparities and enhanced system utilization.

Fourth, sustained investment programs spanning multiple years generate superior outcomes compared to concentrated investment bursts, reflecting the importance of system development time and learning effects. Fifth, comprehensive workforce development and institutional capacity building prove essential for realizing the potential benefits of physical infrastructure investment. Sixth, international cooperation and knowledge sharing mechanisms enhance investment effectiveness through access to best practices, advanced technologies, and specialized expertise.

9 Conclusion

The comprehensive analysis presented in this study establishes definitive evidence that government investment in public health infrastructure generates substantial and measurable benefits for long-term economic stability that extend far beyond traditional healthcare sector impacts. The empirical evidence demonstrates that countries implementing strategic health infrastructure expansion programs achieve superior economic performance across multiple dimensions including growth rates, employment levels, productivity improvements, and economic resilience to external shocks. These findings have profound implications for fiscal policy design and economic development planning in contemporary governance contexts. [24]

The quantitative relationships identified through this analysis reveal that health infrastructure investment operates through multiple transmission mechanisms that compound over time to generate aggregate economic returns substantially exceeding initial investment costs. Countries investing 4.2% to 6.8% of GDP in comprehensive health infrastructure during post-pandemic recovery periods achieved economic returns averaging 2.8 to 3.4 times investment levels while simultaneously improving population health outcomes and enhancing economic system resilience. These return rates compare favorably to traditional infrastructure investment categories and demonstrate the economic efficiency of health infrastructure as a form of productive public investment.

The sectoral distribution analysis reveals that health infrastructure investment generates broad-based economic benefits that extend throughout interconnected economic networks rather than concentrating narrowly within healthcare industries. Construction, information technology, education, retail, and manufacturing sectors all demonstrate measurable positive impacts from health infrastructure investment programs. This broad distribution of benefits suggests that health infrastructure investment functions effectively as economic stimulus policy while simultaneously building long-term productive capacity and system resilience.

The mathematical modeling framework developed in this study provides policymakers with quantitative tools for optimizing health infrastructure investment allocation and predicting economic returns across different investment scenarios. The dynamic multiplier models demonstrate that health infrastructure investment exhibits distinctive temporal patterns of return realization, with immediate employment effects, medium-term productivity improvements, and long-term resilience enhancements that justify sustained investment approaches rather than concentrated spending bursts.

The international comparative analysis identifies specific policy design characteristics that consistently generate superior outcomes across diverse economic and political contexts. Successful health infrastructure investment programs emphasize integrated planning approaches that coordinate health investment with broader economic development strategies, prioritize primary care and public health system development over hospital construction, maintain geographic equity in infrastructure distribution, and implement comprehensive workforce development concurrent with physical infrastructure expansion.

The resilience and risk mitigation dimensions of health infrastructure investment represent particularly significant findings with important implications for economic policy design. Countries with robust health infrastructure demonstrate measurably superior capacity to absorb and recover from various types of economic shocks while maintaining lower levels of economic volatility and fiscal risk [25]. These resilience benefits justify health infrastructure investment as a form of economic insurance that generates positive returns even without considering direct health and productivity benefits.

The policy implications emerging from this analysis suggest that health infrastructure investment should be recognized as an essential component of comprehensive economic development strategies rather than a separate healthcare policy domain. The integration of health considerations into broader fiscal policy frameworks requires institutional coordination mechanisms, sophisticated performance monitoring systems, and long-term investment planning approaches that account for the multi-temporal nature of health infrastructure returns.

The sustainability considerations identified through this research emphasize the importance of comprehensive operational planning that ensures continued system effectiveness following initial infrastructure deployment. Successful health infras-

structure investment programs require sustained commitments to workforce development, system maintenance, technology upgrades, and adaptive management approaches that enable systems to evolve in response to changing health needs and technological opportunities.

Future research priorities emerging from this analysis include investigation of optimal health infrastructure investment strategies for different stages of economic development, analysis of climate change adaptation requirements for health infrastructure systems, examination of emerging technology integration opportunities, and development of more sophisticated modeling frameworks for predicting health infrastructure returns across diverse economic contexts.

The evidence presented in this study supports policy recommendations for substantially increased government investment in public health infrastructure as an economically efficient strategy for enhancing both population health and economic performance. The documented economic returns, combined with the substantial resilience and risk mitigation benefits, justify health infrastructure investment as a high-priority policy intervention that generates benefits across multiple policy domains simultaneously.

The transformation of economic policy frameworks to incorporate health infrastructure as a central component will require sustained political commitment, institutional innovation, and international cooperation to share best practices and coordinate investment strategies. However, the substantial economic and social benefits documented through this analysis provide compelling justification for the policy changes and resource commitments necessary to realize the full potential of health infrastructure investment as a driver of economic stability and prosperity.

The relationship between health infrastructure investment and economic stability represents a fundamental policy challenge and opportunity for contemporary governments. The evidence demonstrates that strategic health infrastructure investment generates measurable economic returns while simultaneously improving population health, enhancing economic resilience, and building institutional capacity for addressing future challenges. Recognition of these relationships should catalyze policy innovations that position health infrastructure investment as an essential component of sustainable economic development strategies for the twenty-first century [26].

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