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Universal Health Coverage and Labor Productivity in ASEAN: A Lagged Panel Analysis of Health Systems as Economic Infrastructure, 2000–2023

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Abstract

This study analyzes whether universal health coverage (UHC), treated as an indicator of health-system strength, is associated with labor productivity in ASEAN economies. Framed within the view that health systems may function as economic infrastructure, the study examines the relationship between UHC service coverage and GDP per person employed using panel data from the ten ASEAN member states covering 2000 to 2023. The analysis uses descriptive statistics, correlation analysis, pooled ordinary least squares, and two-way fixed-effects (TWFE) panel regression with country and year effects. Lagged models at one-year, two-year, and three-year intervals are estimated to test temporal persistence, while alternative mediation models using life expectancy and tuberculosis incidence are examined. A controlled lagged TWFE specification further incorporates labor force participation, inflation, trade openness, and urban population share. Descriptive results from the balanced core panel of 240 country-year observations show a mean UHC index of 64.31, mean life expectancy of 71.17 years, and mean GDP per person employed of 54,015.41 constant PPP international dollars. Correlation analysis indicates strong positive associations between UHC and life expectancy ($r = 0.9315$) and between UHC and logged productivity ($r = 0.8817$). In the contemporaneous TWFE model, UHC is positively associated with logged GDP per person employed ($\beta = 0.0263$, $p = 0.0020$), implying that a one-point increase in the UHC index is associated with approximately 2.63% higher productivity. The lagged direct models yield highly stable estimates: $\beta = 0.0267$ ($p = 0.0010$) for the one-year lag, $\beta = 0.0273$ ($p = 0.0006$) for the two-year lag, and $\beta = 0.0275$ ($p = 0.0006$) for the three-year lag. In the controlled lagged TWFE models, the coefficients decline but remain statistically significant, at 0.0127 ($p = 0.0463$), 0.0137 ($p = 0.0206$), and 0.0142 ($p = 0.0076$), respectively. UHC also significantly predicts life expectancy and lower tuberculosis incidence, but neither variable emerges as a statistically conclusive mediator of the productivity relationship once UHC is included in the full models. Overall, the findings show that stronger UHC service coverage is robustly associated with higher output per worker in ASEAN, even after lagging the explanatory variable and controlling for key macro-structural conditions. The results support the interpretation that health systems contribute to economic performance not only through welfare improvement but also through the productive conditions that sustain labor efficiency.

Keywords: *universal health coverage; labor productivity; GDP per person employed; ASEAN; panel data; two-way fixed effects; lagged analysis; health systems*

1. Introduction

Health systems are often treated primarily as instruments of welfare, disease control, and social protection. In this conventional framing, their principal purpose is to reduce morbidity, extend life, and ensure equitable access to essential services. While these functions are central, such a perspective can also narrow the developmental significance of health systems by positioning them mainly as social expenditure rather than as productive investment. This distinction matters, particularly in developing and middle-income economies where public spending priorities are frequently assessed through their immediate economic returns. When health is viewed only as a welfare concern, it may be subordinated to sectors more conventionally associated with growth. When it is viewed as part of the productive foundation of society, however, health-system strengthening becomes relevant not only to human well-being but also to economic performance.

This broader interpretation is especially relevant in the context of universal health coverage (UHC). UHC reflects the commitment to ensuring that individuals receive the health services they need without suffering financial hardship. It is not merely a medical or administrative goal; it is a systems-based development objective encompassing service access, continuity of care, treatment capacity,

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prevention, and financial protection. In policy discourse, UHC is strongly associated with the aspiration to make health systems more inclusive, resilient, and equitable. Yet the significance of UHC may extend beyond the health sector itself. A population with broader access to essential health services is less likely to experience untreated illness, avoidable morbidity, and interruptions in work capacity. In this sense, stronger health-system coverage may influence not only survival and well-being, but also the productive functioning of the labor force.

The relationship between health and economic performance has long been acknowledged in development literature, but it is often examined through broad and indirect outcomes such as aggregate GDP growth, mortality decline, or general human development measures. Although these approaches are useful, they do not always capture the more specific economic relevance of a functioning health system. One analytically stronger outcome is labor productivity, particularly when measured as GDP per person employed. Unlike aggregate output, this indicator reflects the productive efficiency of those actually engaged in economic activity. If health systems improve the functional capacity, reliability, and continuity of workers, then their benefits should be visible not only in improved health indicators but also in productivity-oriented economic measures.

This issue is particularly important in the context of the Association of Southeast Asian Nations (ASEAN). ASEAN economies vary widely in income levels, institutional capacity, population health conditions, labor-market structures, urbanization, and health-system development. At the same time, they share a regional context characterized by economic integration, structural transformation, and continuing pressure to balance social investment with productivity and competitiveness. Such variation makes ASEAN an appropriate setting for examining whether stronger UHC service coverage is associated with higher labor productivity across countries and over time. If the relationship is observable across a diverse regional panel, then the argument that health systems operate as a form of productive infrastructure gains stronger empirical credibility.

The concept of economic infrastructure is usually reserved for transportation, energy, communications, water systems, and other foundational facilities that support production and exchange. These are considered infrastructural because they reduce friction, increase efficiency, and sustain the conditions under which economic activity can occur. Yet the same logic can be extended to health systems. Weak health systems generate frictions through untreated disease, preventable disability, workforce instability, reduced physical capacity, and recurring household vulnerability. Stronger health systems, by contrast, help sustain labor participation, reduce avoidable health shocks, and create a more stable and functional workforce. From this perspective, health systems may be understood not merely as support services for social welfare, but as part of the deeper architecture of productive capacity.

Despite the plausibility of this perspective, important analytical gaps remain. First, relatively fewer studies focus specifically on UHC service coverage as a system-level predictor of labor productivity, particularly in a regional developing-economy setting. Second, much of the existing work relies on contemporaneous association, which makes it difficult to determine whether the benefits of health-system strengthening persist over time. Third, although health is often assumed to affect economic performance through improved human capital or reduced disease burden, these mechanisms are not always explicitly tested in panel frameworks. Finally, there remains a need for ASEAN-focused empirical analysis that links health-system strength to productivity-oriented outcomes while accounting for country-specific heterogeneity and common time effects.

It is this gap that gives rise to the present inquiry. The central problem addressed in this study is whether stronger universal health coverage is associated with higher labor productivity in ASEAN economies, and whether this relationship remains observable when examined through lagged and controlled panel specifications. Put differently, the study asks whether health-system strength, as reflected in UHC service coverage, should be understood not only as a social achievement but also as a productive economic factor. It further asks whether the relationship between UHC and productivity may operate through broader population health conditions, represented by life expectancy, or through communicable disease reduction, represented by tuberculosis incidence, and whether the observed association remains robust after accounting for labor force participation, inflation, trade openness, and urbanization.

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Accordingly, this study examines UHC service coverage index as the principal explanatory variable and GDP per person employed as the main outcome variable in an ASEAN panel covering the period 2000 to 2023. More specifically, it seeks to determine whether universal health coverage is positively associated with labor productivity; whether this association persists when UHC is lagged by one, two, and three years; whether life expectancy and tuberculosis incidence function as mediating pathways in the UHC–productivity relationship; and whether the UHC effect remains statistically significant after introducing major macro-structural controls. These objectives allow the study to move from simple association toward a more structured examination of health systems as a form of economic infrastructure.

The significance of the study is both policy-oriented and conceptual. From a policy standpoint, demonstrating that UHC is associated with productivity would support the argument that health-system investment yields economic as well as social returns. This is particularly relevant in settings where health budgets are often judged narrowly as fiscal burdens rather than as strategic investments in workforce quality and economic resilience. From a conceptual standpoint, the study contributes to a broader developmental view in which health systems are treated as part of the institutional and material conditions that sustain productive activity. If roads, power systems, and digital networks are recognized as enabling infrastructure, then health systems may warrant similar consideration insofar as they help maintain the human capacity through which production is carried out.

Methodologically, the study contributes by applying a panel-data framework using two-way fixed-effects models to ASEAN economies over a multi-year period, while also testing lagged relationships and alternative mediating pathways. This design allows the analysis to isolate within-country changes over time while controlling for country-specific characteristics and year-specific shocks. By moving beyond contemporaneous models and introducing both lagged and controlled specifications, the study seeks to provide a more rigorous assessment of the relationship between universal health coverage and productive economic performance.

In sum, the study is guided by the proposition that health systems may function as economic infrastructure, and that universal health coverage may therefore be positively associated with productive capacity in ASEAN economies. By examining this proposition through panel evidence, the study aims to contribute to a more integrated understanding of health, development, and productivity in the region.

2. Review of Related Literature

2.1 Universal Health Coverage as Health-System Strength

Universal health coverage (UHC) is increasingly conceptualized not merely as a financing mechanism but as a fundamental indicator of overall health-system strength. Empirical evidence demonstrates that robust UHC frameworks are associated with improved access to essential services, yet progress remains uneven and contingent upon underlying system capacity. Globally, service coverage has stagnated since 2015, particularly for noncommunicable diseases, while financial hardship from out-of-pocket payments has intensified (Tracking Universal Health Coverage, 2023; Chen et al., 2023). In China, substantial UHC advancements have enhanced maternal and child health coverage and reduced income-related inequalities; however, persistent regional disparities and gaps in specific services like cancer screening underscore the need for equitable resource allocation (Feng et al., 2022; Liu & You, 2025; Pan & Chen, 2022). Comparative analyses of systems in Sweden, Canada, and Japan illustrate that well-implemented UHC can mitigate health disparities, yet such outcomes require strong political commitment and sustained investment (Azam et al., 2025; Chen et al., 2023).

Health system functionality—encompassing governance, workforce distribution, infrastructure, and service-delivery capacity—is a critical determinant of UHC achievement, particularly in low- and middle-income settings (Cerf, 2023; Debie et al., 2024; Jaca et al., 2022). Resilience to shocks, such as the COVID-19 pandemic, further depends on integrated primary healthcare and multisectoral collaboration, reinforcing that UHC reflects comprehensive system strength rather than isolated policy interventions (Debie et al., 2024; Karamagi et al., 2021; Lal et al., 2022). Frameworks that integrate clinical and operational data have been proposed to strengthen this capacity, illustrating how health analytics can support dual clinical and business outcomes when governance and alignment are prioritized (Atento, Quinto, Espelita, &

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Castaneda, 2025a). Thus, progress toward UHC necessitates holistic health-system strengthening beyond insurance expansion alone.

2.2 Health Systems and Productive Economic Performance

A growing body of evidence establishes a link between strategic health system investments and improved economic productivity. Macro-level analyses suggest that long-term public spending on healthcare, alongside education, significantly enhances national labor productivity, underscoring health as a critical component of human capital development (Khang, 2025). However, the relationship is nuanced; while reforms like universal health coverage (UHC) aim to improve population health, their immediate impact on health system productivity can vary. For instance, analyses of China's health system reforms revealed periods of productivity decline, highlighting the need for complementary policies such as optimized resource allocation between human resources and infrastructure, and the adoption of cost-effective technologies to boost efficiency (Chai et al., 2021). Case evidence from Philippine retail pharmacy illustrates how firms adapt strategically to UHC-driven market transformation, balancing regulatory compliance with digital modernization and diversification—dynamics that parallel health system adaptation more broadly (Atento & Atento, 2025).

At the operational level, specific interventions demonstrate clear pathways to enhanced productive capacity. Network consolidations of health workers in Thailand, for example, successfully reallocated workforce resources, reducing individual workload and generating substantial allocative efficiency gains (Jithitikulchai, 2021, 2022). Similarly, analyses of routine health data in Ethiopia revealed significant variability in health worker productivity across facilities, pointing to substantial opportunities for efficiency improvement through better workforce management (Hasan et al., 2021). Research also emphasizes the importance of accurate measurement; studies on primary care productivity advocate for advanced approaches that account for interprofessional team dynamics and quality of care to truly capture efficiency improvements (Neri et al., 2021; Rubenstein et al., 2025). Projected global health workforce shortages toward mid-century underscore that supply-side fragility—particularly in major supplier countries like the Philippines—can constrain both domestic service capacity and international deployment readiness, with implications for productivity (Atento, Quinto, & Espelita, 2025b).

Systemic challenges in health professions education—including faculty burnout, clinical placement scarcity, and intergenerational learning gaps—have been identified as constraints on workforce readiness and, by extension, on the productivity of health systems themselves (Bermido, Quinto, & Atento, 2025). Collectively, the evidence indicates that targeted investments and deliberate workforce optimization are essential for transforming health system strengthening into tangible gains in productive economic performance (Mbau et al., 2022; Zeng et al., 2024).

2.3 Life Expectancy, Human Capital, and Productivity

A substantial body of empirical research establishes a positive relationship between higher life expectancy and improvements in human capital, labor productivity, and economic performance. Enhanced longevity is frequently associated with better population health, which fosters human capital development and, in turn, stimulates economic growth, a pattern particularly evident in developing regions undergoing demographic transitions (Awoyemi et al., 2024; Sultana et al., 2022; Turceniuc, 2025). Improved health, driven by factors such as reduced mortality and better nutrition, increases the size of the working-age population and contributes to greater economic efficiency and innovation (Titova, 2025; Youssef & Safiani, 2025). However, the relationship is context-dependent. In developed nations with already high life expectancy, further increases may be associated with slower economic growth due to aging populations and rising dependency ratios (Chen et al., 2024; Sultana et al., 2022).

The mechanisms linking health to productivity are also shaped by health system characteristics. Expanding universal health coverage and investing in healthcare quality, preventive services, and primary care financing strengthens health human capital, which has been directly linked to higher economic output, though regional disparities in resource allocation can moderate these effects (Chillo et al., 2022; Hanson et al., 2022; Liu & Huo, 2024). Within ASEAN, country-specific analyses of macroeconomic trends and child nutrition outcomes reveal that employment expansion does not uniformly translate into improved human capital

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without complementary family-responsive policies and care infrastructure (Quinto & Atento, 2025).

At the individual level, behavioral mechanisms such as sleep quality and self-monitoring have been linked to cognitive performance and task efficiency, suggesting that proximate health behaviors mediate the relationship between broader health conditions and productive capacity (San Juan, Elardo, Atento, & Valderama, 2026). Longitudinal evidence from the Philippines further indicates that women's empowerment—measured through labor force participation, job quality, and institutional inclusion—is positively associated with enterprise dynamism, reinforcing the role of inclusive human capital development in economic performance (Menez & Atento, 2026). Effective governance and strategic investment in health are therefore critical for translating gains in life expectancy into tangible productivity benefits, with the overall impact depending on a country's specific developmental stage and policy environment (Bibi et al., 2025; Kara, 2025; Mubarak & Satria, 2024).

2.4 Disease Burden, Tuberculosis, and Economic Productivity

The burden of communicable diseases, particularly tuberculosis (TB), exerts a multifaceted influence on macroeconomic performance and labor productivity, although the relationship is not always unidirectional. A panel data analysis across African countries revealed a complex dynamic: while HIV prevalence consistently negatively affected GDP, TB incidence demonstrated a statistically positive association with GDP in certain model specifications, suggesting that factors such as health expenditure may mediate this relationship (Brown & Essi, 2021). Systematic reviews have broadly documented that infectious diseases like TB contribute to increased morbidity and mortality, precipitating workforce reductions and employment crises that result in substantial GDP losses from diminished productivity (Samsudin et al., 2024). Ecological studies in China have inversely linked TB incidence with indicators of economic development, including income and employment rates, implying that a higher disease burden is correlated with weaker economic conditions (Lv et al., 2025; Zhang et al., 2022).

Modeling studies projecting macroeconomic losses in India estimate that TB-related productivity reductions and mortality could be significantly mitigated through improved control measures, yielding considerable GDP gains (Keogh-Brown et al., 2024). This negative socioeconomic impact, characterized by reduced labor productivity and economic performance, is particularly pronounced in low-income settings with constrained health resources (Litvinjenko et al., 2023; Manyazewal et al., 2023; Xue et al., 2022). Concurrently, research underscores that robust health-system interventions can ameliorate this burden. Integrated approaches, including expanded diagnostic capacity and community-based strategies addressing social determinants, have proven pivotal in improving TB detection and control (Osei-Wusu et al., 2025; Shafique et al., 2024), with modeling indicating that scaling up treatment and vaccination can substantially lower incidence (Kuddus et al., 2025). The critical importance of resilient health services is further emphasized in conflict-affected settings, where system disruptions exacerbate communicable disease risks (Marou et al., 2024).

2.5 Health Systems as Economic Infrastructure

A growing body of evidence conceptualizes health systems not merely as a social expenditure but as a fundamental component of a nation's productive economic infrastructure. This perspective posits that investments in health generate substantial economic returns by enhancing human capital, stabilizing labor markets, and fostering resilience. Empirical analyses employing dynamic specifications have demonstrated that health expenditure and infrastructure development significantly bolster economic growth by maintaining a skilled and productive workforce (Ullah et al., 2025). Frameworks developed for emerging markets further articulate this mechanism, illustrating how healthcare investments drive growth through improved labor productivity, reduced systemic costs, and multiplier effects from job creation and innovation (Alli et al., 2025). The reciprocal nature of this relationship is also evident; comparative studies indicate that economic growth facilitates improved healthcare access, which in turn sustains the health outcomes necessary for continued development (Kumar et al., 2025).

Beyond conventional metrics, frameworks that integrate patient narratives with computational analytics illustrate how health systems can function as learning infrastructures, translating experiential data into quality improvement signals while maintaining ethical safeguards (Atento, Quinto, Espelita, & San Juan, 2025c). Beyond direct growth

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metrics, health systems yield extensive co-benefits that align with broader socio-economic objectives. Investments generate significant employment and contribute to gross value added across multiple sectors, demonstrating spillover effects that enhance economic competitiveness (Atun et al., 2025). These secondary benefits include poverty reduction, women's empowerment, and strengthened social capital, positioning health as a driver of inclusive development (Francis et al., 2023). Integrated health system strengthening, as opposed to siloed interventions, has been shown to amplify both health impact and economic returns by improving overall delivery and workforce capacity (Mangal et al., 2025). Theoretical advancements, such as the Human Economics Systems Theory and the Brazilian Health Economic-Industrial Complex concept, reinforce this paradigm by framing health as inseparable from economic structure and essential for sustainable, equitable well-being (Gadelha, 2022; Hascalovitz & Deonandan, 2025).

2.6 Synthesis of the Literature and Research Gaps

The reviewed literature collectively supports the proposition that universal health coverage should be understood as more than a financing arrangement or insurance mechanism. Across diverse country settings, UHC is increasingly treated as a systems-level indicator reflecting the broader strength of health governance, service delivery capacity, workforce adequacy, infrastructure, and resilience. The literature shows that stronger UHC frameworks are generally associated with improved access to essential services and reductions in inequality in health access, although progress remains uneven across regions and service categories (Chen et al., 2023; Feng et al., 2022; Liu & You, 2025). At the same time, the evidence makes clear that UHC outcomes depend heavily on deeper institutional and structural capacities within health systems, particularly in low- and middle-income contexts where service reach, workforce distribution, and system resilience remain uneven (Cerf, 2023; Debie et al., 2024; Jaca et al., 2022). This body of work provides a strong foundation for treating UHC service coverage as a legitimate indicator of health-system strength rather than a narrow proxy for insurance expansion alone.

The literature also indicates that health systems have meaningful economic relevance. Studies examining public health spending, system reforms, workforce efficiency, and service optimization suggest that stronger health systems can contribute to labor productivity and broader economic performance, especially when investments are strategically organized and supported by sound management practices (Chai et al., 2021; Hasan et al., 2021; Jithitikulchai, 2021, 2022; Khang, 2025). At the macro level, health investment has been linked to long-term productivity growth through human capital enhancement, while at the operational level, better workforce allocation and improved efficiency generate measurable productivity gains within health service delivery itself (Mbau et al., 2022; Neri et al., 2021; Rubenstein et al., 2025; Zeng et al., 2024). Taken together, these studies imply that health-system strengthening has consequences not only for health outcomes but also for productive capacity, thereby supporting the core logic of this study.

The reviewed literature further establishes a plausible human-capital pathway linking better health conditions to stronger economic performance. Higher life expectancy is widely associated with better population health, stronger human capital formation, greater labor efficiency, and improved economic outcomes, especially in developing or transitioning economies (Awoyemi et al., 2024; Sultana et al., 2022; Turceniuc, 2025). This line of research suggests that gains in longevity may reflect improvements in the underlying health environment that support a healthier and more productive workforce. However, the literature also cautions that this relationship is context-specific. In more advanced economies, longer life expectancy may coincide with aging pressures, dependency burdens, and slower growth, which complicates any linear interpretation of the health–growth nexus (Chen et al., 2024; Sultana et al., 2022). Thus, while life expectancy is theoretically relevant as a possible channel between health-system strength and productivity, the literature suggests that its economic role is shaped by developmental stage, demographic structure, and policy context.

In a more disease-specific line of inquiry, the literature on communicable disease burden—especially tuberculosis—shows that poor population health can weaken labor productivity and macroeconomic performance, although the empirical relationship is not always uniform across contexts. Systematic and country-specific studies generally show that TB imposes losses through morbidity, mortality, reduced labor participation, and lower economic output, particularly in resource-constrained settings (Keogh-Brown et al., 2024;

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Litvinjenko et al., 2023; Manyazewal et al., 2023; Samsudin et al., 2024). At the same time, some macro-level models suggest more complex or mediated relationships, indicating that disease burden may interact with public spending and other structural conditions in ways that do not always produce simple negative coefficients in aggregate models (Brown & Essi, 2021). The literature nevertheless converges on the view that stronger health systems and more effective disease-control interventions can reduce TB incidence and mitigate its economic burden (Kuddus et al., 2025; Osei-Wusu et al., 2025; Shafique et al., 2024). This reinforces the relevance of communicable disease burden as a plausible, though not exclusive, transmission channel through which health systems may affect productivity.

Perhaps the most important integrative theme in the literature is the growing conceptualization of health systems as a form of economic infrastructure. This literature argues that health should not be confined to the category of social expenditure because it contributes to the productive functioning of economies by strengthening human capital, stabilizing labor markets, generating employment, enhancing resilience, and reducing systemic losses (Alli et al., 2025; Atun et al., 2025; Francis et al., 2023; Ullah et al., 2025). Theoretical perspectives such as the Human Economics Systems Theory and the Health Economic-Industrial Complex further reinforce the argument that health is embedded in the structure of development itself rather than standing outside it as a purely redistributive concern (Gadelha, 2022; Hascalovitz & Deonandan, 2025). This perspective is particularly important for the present study because it provides the conceptual bridge connecting UHC, health outcomes, and productivity-oriented economic performance.

Viewed together, the reviewed studies suggest a coherent but still incomplete analytical picture. The literature strongly supports the legitimacy of UHC as an indicator of health-system strength, affirms the economic importance of health investment, and provides plausible mechanisms through which better health coverage may contribute to productivity. It also shows that life expectancy and tuberculosis incidence are theoretically relevant pathways connecting health systems to economic performance. At the same time, the literature indicates that these relationships are context-sensitive, multidimensional, and sometimes difficult to isolate empirically. Thus, while prior research supports the general proposition that stronger health systems can generate economic benefits, there remains a need for more focused evidence linking UHC service coverage specifically to labor productivity, especially in a regional panel setting such as ASEAN and under models that test both lagged effects and alternative mediating pathways.

2.7 Research Gaps

Despite the richness of the literature, several gaps remain that justify the present study.

First, although many studies examine the relationship between health and development, relatively fewer studies directly assess universal health coverage service coverage as a system-level predictor of labor productivity. Much of the existing literature focuses on health expenditure, mortality, health reforms, service access, or broad economic growth. While these are important, they do not fully address whether UHC itself, as a composite indicator of health-system strength, is associated with output per worker. This leaves a gap in the literature concerning the productivity implications of UHC as a measurable systems variable.

Second, the literature tends to examine the health–economy relationship either at a broad macroeconomic level or within specific operational settings, but fewer studies connect these two levels through a productivity-oriented national indicator such as GDP per person employed. Aggregate growth measures can obscure the specific role of labor efficiency, while facility-level productivity studies may not capture macro-developmental significance. The present study addresses this gap by using a productivity measure that directly reflects output generated per employed person.

Third, there is limited empirical work that examines these relationships in the ASEAN regional context using a multi-country longitudinal panel. ASEAN presents a particularly important analytical setting because of its diversity in income levels, institutional development, demographic structures, health-system capacities, and labor-market conditions. Yet much of the existing literature is country-specific or focused on regions outside Southeast Asia. As a result, there remains insufficient panel evidence on whether stronger UHC is associated with higher productivity across ASEAN economies over time.

Fourth, while the literature identifies several possible mechanisms linking health systems to

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economic performance, these mechanisms are often discussed conceptually rather than tested explicitly within the same empirical framework. In particular, life expectancy and tuberculosis incidence are both plausible mediators, but the literature provides limited evidence testing them as alternative pathways between UHC and productivity within a unified panel model. This creates a gap in understanding whether the effect of health-system strength on productivity is direct, indirect, or distributed across multiple overlapping channels.

Fifth, many studies rely on contemporaneous relationships, which may not adequately capture the delayed economic effects of health-system strengthening. Improvements in service coverage may not translate into measurable gains in productivity within the same year, especially when the mechanism involves improved health status, reduced disease burden, or accumulated human-capital gains. Thus, there is a need for studies that incorporate lagged specifications to determine whether the economic relevance of UHC persists over time.

Sixth, the literature increasingly argues that health systems should be viewed as economic infrastructure, yet this framing is still more developed conceptually than empirically. Existing studies support the idea that health investment contributes to resilience, labor stability, and economic capacity, but there remains a need for empirical models that directly test this proposition using productivity-centered outcome variables and rigorous panel methods. In this sense, the conceptual claim that health systems are productive infrastructure still requires more systematic quantitative support.

Finally, many prior studies do not adequately account for broader macro-structural factors that may shape productivity alongside health-system variables. Labor force participation, inflation, trade openness, and urbanization may influence economic output independently and may also interact with health-system development. Without incorporating these factors, the estimated relationship between health variables and productivity may be overstated or insufficiently specified. The present study addresses this gap by testing whether the UHC–productivity relationship remains robust after introducing key macroeconomic and structural controls.

In response to these gaps, the present study examines whether universal health coverage is associated with labor productivity in ASEAN economies from 2000 to 2023, whether this relationship persists when lagged over time, whether it may be transmitted through life expectancy or tuberculosis incidence, and whether it remains robust after accounting for selected macro-structural conditions. In doing so, the study contributes empirical evidence to the growing argument that health systems are not only instruments of well-being, but also productive foundations of economic development.

3. Methodology

3.1 Research Design

This study employed a quantitative longitudinal panel design to examine whether improvements in universal health coverage are associated with productivity growth across ASEAN economies. The design was appropriate because the analysis sought to estimate within-country changes over time while controlling for unobserved country-specific and time-specific influences. The panel structure also allowed the testing of lagged relationships, consistent with the expectation that the economic effects of health-system strengthening may not be immediate.

3.2 Data Source and Study Coverage

The dataset was derived from the World Development Indicators (WDI) database and covered the ten ASEAN member states: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam. The core analysis used annual observations from 2000 to 2023. For the core three-variable panel, the dataset was balanced, yielding 240 country-year observations. Some controlled models used slightly smaller estimation samples due to missing observations in selected control variables and the construction of lagged terms.

3.3 Variables of the Study

The study used the following core variables:

3.3.1 Independent Variable

Universal Health Coverage (UHC) service coverage index, which captures the extent of essential health service provision and serves as the principal indicator of health-system strength.

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3.3.2 Dependent Variable

GDP per person employed (constant PPP international dollars), used as a productivity-oriented measure of economic performance. To reduce skewness and permit semi-elastic interpretation, this variable was transformed into its natural logarithm.

3.3.3 Mediator Variables

Two alternative mediators were tested:

a. Life expectancy at birth, representing a broad human-capital and population-health channel;

b. Tuberculosis incidence per 100,000 population, representing a disease-burden channel more directly sensitive to public-health service capacity.

3.3.4 Control Variables

To reduce omitted-variable bias, the controlled models included:

- labor force participation rate,
- inflation,
- trade openness, and
- urban population share.

These controls were included because productivity may also be influenced by labor-market participation, macroeconomic stability, openness to trade, and structural transformation associated with urbanization.

3.4 Data Treatment and Transformation

The productivity indicator exhibited a highly right-skewed distribution. Accordingly, GDP per person employed was transformed using the natural logarithm. This transformation improved model stability and permitted the coefficients of explanatory variables to be interpreted approximately as percentage changes in productivity associated with one-unit changes in the predictors.

Lagged versions of the UHC variable were also generated at 1-year, 2-year, and 3-year intervals. These lag structures were introduced to test whether improvements in health-system coverage were associated with subsequent, rather than merely contemporaneous, changes in productivity and health outcomes.

3.5 Statistical Treatment of Data

The study employed a sequence of descriptive and inferential statistical procedures to examine the relationship between universal health coverage and labor productivity in ASEAN economies. Since the dataset consisted of annual observations across multiple countries over time, panel-data techniques were used to account for both temporal variation and cross-country heterogeneity.

Descriptive statistics were first computed for the principal study variables, namely universal health coverage service coverage index, life expectancy at birth, tuberculosis incidence, GDP per person employed, and the natural logarithm of GDP per person employed. The descriptive summary included the number of observations, mean, standard deviation, minimum, median, and maximum values. These measures were used to characterize the distributional properties of the variables and to determine whether transformation of the economic outcome variable was necessary. Because GDP per person employed exhibited substantial right skewness, its natural logarithm was used in the regression analysis to improve model stability and facilitate coefficient interpretation in percentage terms.

A correlation matrix was then generated to determine the direction and magnitude of the bivariate relationships among the core variables. This procedure provided an initial assessment of whether universal health coverage was associated with the proposed mediator variables and with productivity. It also served as a diagnostic tool for identifying possible multicollinearity, particularly between universal health coverage and life expectancy.

To establish a baseline reference, pooled ordinary least squares regression was first estimated using logged GDP per person employed as the dependent variable and universal health coverage as the predictor. The baseline model may be expressed as:

$$\ln(\text{Productivity}_{it}) = \beta_0 + \beta_1 \text{UHC}_{it} + \varepsilon_{it} \quad (1)$$

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where ln(Productivity_it) denotes the natural logarithm of GDP per person employed for country i in year t, UHC_it refers to the universal health coverage service coverage index, β_0 is the intercept, β_1 is the slope coefficient, and ε_it is the error term. However, pooled estimation was not treated as the preferred approach because it does not control for unobserved country-specific characteristics or year-specific shocks that may influence both health-system performance and productivity.

The principal estimators of the study were two-way fixed-effects panel regressions, which included both country fixed effects and year fixed effects. Country fixed effects were incorporated to control for all time-invariant characteristics of ASEAN member states, such as geography, institutional structures, and cultural features, while year fixed effects were included to account for common external shocks and period trends affecting all countries simultaneously. To address potential heteroskedasticity and serial correlation within countries, standard errors were clustered at the country level. The core fixed-effects model was specified as:

$$\ln(\text{Productivity}_{it}) = \beta_0 + \beta_1 \text{UHC}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where μ_i represents country fixed effects, λ_t represents year fixed effects, and ε_it is the idiosyncratic disturbance term.

To test delayed effects, lagged fixed-effects models were estimated using one-year, two-year, and three-year lags of universal health coverage. The generic lagged specification was expressed as:

$$\ln(\text{Productivity}_{it}) = \beta_0 + \beta_1 \text{UHC}_{(i,t-k)} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

where k corresponds to the lag length of one, two, or three years.

Two alternative mediation pathways were then examined. In the first, life expectancy at birth was treated as a broad population-health and human-capital channel. In the second, tuberculosis incidence per 100,000 population was treated as a disease-burden channel more directly sensitive to public-health service capacity. For each mediator, the analysis first estimated the effect of universal health coverage on the mediator:

$$\text{Mediator}_{it} = \alpha_0 + \alpha_1 \text{UHC}_{it} + \mu_i + \lambda_t + \nu_{it} \quad (4)$$

where Mediator_it refers either to life expectancy at birth or tuberculosis incidence, α_0 is the intercept, α_1 is the effect of universal health coverage on the mediator, and ν_it is the disturbance term.

The mediated productivity equation was then estimated as:

$$\ln(\text{Productivity}_{it}) = \beta_0 + \beta_1 \text{UHC}_{it} + \beta_2 \text{Mediator}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

For the lagged mediation analysis, the same structure was retained but the lagged values of universal health coverage were introduced in accordance with the empirical design.

Finally, a controlled lagged two-way fixed-effects specification was estimated by introducing labor force participation rate, inflation, trade openness, and urban population share as control variables. This specification was treated as the preferred empirical model because it subjected the central relationship to a more rigorous test by accounting for labor-market conditions, macroeconomic stability, external openness, and structural transformation. The full controlled model was written as:

$$\ln(\text{Productivity}_{it}) = \beta_0 + \beta_1 \text{UHC}_{(i,t-k)} + \beta_2 \text{Mediator}_{it} + \beta_3 \text{LFPR}_{it} + \beta_4 \text{Inflation}_{it} + \beta_5 \text{Trade}_{it} + \beta_6 \text{Urban}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

where LFPR_it denotes labor force participation rate, Inflation_it denotes the inflation rate based on the GDP deflator, Trade_it denotes trade as a percentage of GDP, and Urban_it denotes the urban population share.

3.6 Decision Rule and Interpretation

A coefficient was treated as statistically significant when its p-value was below the conventional threshold of 0.05. Because the dependent variable in the productivity models was log-transformed, the coefficient of universal health coverage was interpreted as the approximate percentage change in GDP per person employed associated with a one-point increase in the UHC service coverage index.

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4. Results and Discussion

4.1 Descriptive Statistics

Universal health coverage service coverage index had a mean of 64.31 and a standard deviation of 15.74, with observed values ranging from 26.00 to 88.00. This indicates substantial cross-country and intertemporal variation in health-system service coverage across ASEAN. Life expectancy at birth had a mean of 71.17 years and a standard deviation of 5.76, with a minimum of 56.36 years and a maximum of 83.60 years. These values reflect meaningful diversity in population health outcomes across the region.

GDP per person employed had a mean of 54,015.41 constant 2021 PPP international dollars, but the distribution was highly dispersed, with a standard deviation of 67,738.46 and a maximum value of 225,785.22. Because of this pronounced right skewness, the variable was transformed into its natural logarithm prior to regression estimation. The logged version exhibited a more stable distribution, with a mean of 10.2155 and a standard deviation of 1.1347. The descriptive profile suggests that ASEAN economies differ considerably in both health-system strength and productive economic performance, making panel estimation appropriate for identifying within-country relationships over time.

4.2 Correlation Analysis

Table 2 presents the correlation matrix for the core variables. The results indicate that universal health coverage is positively associated with both life expectancy and productivity. The correlation between universal health coverage and life expectancy was 0.9315, indicating a very strong positive association. Universal health coverage also showed a strong positive correlation with logged GDP per person employed, with a coefficient of 0.8817. Life expectancy was likewise positively associated with logged productivity, with a correlation coefficient of 0.8164.

These bivariate findings are consistent with the theoretical expectation that stronger health-system coverage is linked to better human development conditions and greater productive efficiency. However, the exceptionally high correlation between universal health coverage and life expectancy also signals the likelihood of multicollinearity when both variables are entered simultaneously in the same regression equation. This consideration is important in interpreting the mediation analysis using life expectancy.

4.3 Baseline and Contemporaneous Two-Way Fixed-Effects Results

A pooled ordinary least squares model was first estimated as a baseline, followed by two-way fixed-effects models that included both country and year effects. In the pooled model, universal health coverage exhibited a strong positive association with logged productivity. However, greater analytical weight was placed on the fixed-effects estimates because these control for unobserved country-specific and time-specific influences.

In the direct contemporaneous two-way fixed-effects model, universal health coverage remained positive and statistically significant, with a coefficient of 0.0263 and a p-value of 0.0020. This implies that a one-point increase in the universal health coverage index was associated with an approximately 2.63 percent increase in GDP per person employed, net of country and year fixed effects. The result provides initial evidence that stronger health-system coverage is linked to higher labor productivity across ASEAN economies.

The mediator equation showed that universal health coverage also had a positive and statistically significant association with life expectancy. The coefficient of 0.2116, with a p-value of 0.0342, suggests that a one-point increase in the universal health coverage index was associated with approximately 0.21 additional years of life expectancy. This is directionally consistent with the proposition that broader health-system coverage improves population health conditions.

However, when life expectancy was entered together with universal health coverage in the productivity equation, life expectancy did not attain statistical significance. Its coefficient was 0.0393 with a p-value of 0.1623, while the coefficient of universal health coverage remained positive and significant at 0.0180 with a p-value of 0.0004. Thus, the contemporaneous mediation test did not provide sufficient evidence that life expectancy serves as a clear mediating pathway between universal health coverage and labor productivity.

4.4 Lagged Two-Way Fixed-Effects Results

To test whether the relationship between health-system coverage and productivity persists

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over time, lagged versions of the universal health coverage variable were introduced at one-year, two-year, and three-year intervals. The direct lagged two-way fixed-effects models yielded a highly stable pattern.

For the one-year lag, the coefficient of universal health coverage was 0.0267 with a p-value of 0.0010. For the two-year lag, the coefficient increased slightly to 0.0273 with a p-value of 0.0006. For the three-year lag, the coefficient was 0.0275 with a p-value of 0.0006. Across all three lag structures, the estimates indicate that a one-point increase in lagged universal health coverage is associated with approximately 2.7 percent higher GDP per person employed.

The stability of these results across lag lengths is substantively important. It suggests that the relationship between health-system strength and productivity is not limited to same-year association but continues into subsequent years. This temporal persistence supports the argument that health systems function as a form of economic infrastructure whose benefits are not merely immediate but may accumulate over time.

4.5 Mediation Analysis Using Life Expectancy

The lagged mediation analysis using life expectancy produced a similar pattern to the contemporaneous estimates. Universal health coverage significantly predicted life expectancy at all lag structures. The coefficient was 0.2013 at the one-year lag, 0.1968 at the two-year lag, and 0.1980 at the three-year lag, all statistically significant at the 5 percent level. These estimates indicate that improvements in universal health coverage are systematically associated with subsequent gains in life expectancy.

Nevertheless, in the corresponding mediated productivity models, life expectancy remained statistically non-significant. At the one-year lag, the coefficient of life expectancy in the productivity equation was 0.0393. At the two-year lag, the coefficient was 0.0382. At the three-year lag, the coefficient was 0.0362. In all cases, the coefficient of universal health coverage remained positive and statistically significant.

These findings indicate that although universal health coverage is associated with both higher life expectancy and higher productivity, the current fixed-effects specifications do not isolate life expectancy as a statistically supported mediator of the UHC–productivity relationship. One plausible explanation is that life expectancy is a slow-moving indicator that overlaps conceptually and empirically with universal health coverage, making independent estimation difficult within a fixed-effects framework.

4.6 Mediation Analysis Using Tuberculosis Incidence

Given the weak life-expectancy mediation results, tuberculosis incidence was tested as an alternative mediator representing a more disease-specific pathway. The lagged mediator equations showed that universal health coverage significantly predicted lower tuberculosis incidence across all three lag structures. The coefficient of lagged universal health coverage was -12.3528 at the one-year lag, -12.2721 at the two-year lag, and -11.8576 at the three-year lag, all statistically significant. These estimates indicate that a one-point increase in universal health coverage is associated with approximately 12 fewer tuberculosis cases per 100,000 population.

This result suggests that stronger health-system coverage is meaningfully associated with lower communicable disease burden. However, when tuberculosis incidence was included in the productivity equations alongside lagged universal health coverage, the TB coefficient did not reach statistical significance. Although the sign of the coefficient was negative, which is theoretically consistent with the expectation that higher disease burden lowers productivity, the p-values remained above conventional significance thresholds in all lagged models. At the same time, the coefficient of universal health coverage remained positive and significant.

Accordingly, the tuberculosis pathway strengthened the substantive interpretation that better health-system coverage is associated with improved health conditions, but it did not establish tuberculosis incidence as a statistically confirmed mediator of the productivity effect.

4.7 Controlled Lagged Two-Way Fixed-Effects Results

The most stringent robustness test involved estimating lagged two-way fixed-effects productivity models while controlling for labor force participation rate, inflation, trade openness, and urban population share. These variables were introduced to determine whether the universal health

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coverage effect would persist after accounting for major labor-market, macroeconomic, and structural influences.

The results confirmed that the universal health coverage effect remained positive and statistically significant across all lag structures. In the one-year lag model, the coefficient of universal health coverage was 0.0127 with a p-value of 0.0463. In the two-year lag model, the coefficient was 0.0137 with a p-value of 0.0206. In the three-year lag model, the coefficient was 0.0142 with a p-value of 0.0076. These estimates imply that a one-point increase in lagged universal health coverage is associated with approximately 1.28 percent, 1.37 percent, and 1.43 percent higher GDP per person employed, respectively.

Although the coefficient size declined relative to the uncontrolled lagged models, the persistence of statistical significance is analytically important. It indicates that universal health coverage is not merely acting as a broad proxy for general development or modernization. Rather, even after accounting for labor participation, inflation, trade exposure, and urbanization, universal health coverage retains an independent positive association with productivity.

It should also be noted that the controlled models were estimated on slightly smaller samples due to missing observations in some control variables and the construction of lagged terms. The estimation sample declined to 200 observations for the one-year lag, 191 for the two-year lag, and 182 for the three-year lag. However, a same-sample comparison between controlled and uncontrolled models showed that the reduction in the universal health coverage coefficient reflected substantive adjustment after controls rather than merely sample change.

4.8 Discussion of Findings

The findings of the study provide empirical support for the proposition that health systems may be understood not only as social institutions but also as part of the productive infrastructure of an economy. Across the baseline, lagged, and controlled two-way fixed-effects specifications, universal health coverage consistently exhibited a positive and statistically significant association with labor productivity in ASEAN economies. This pattern aligns with the broader literature suggesting that health-system investment contributes to productive capacity by strengthening human capital, stabilizing labor participation, and improving the conditions under which economic activity takes place (Alli et al., 2025; Atun et al., 2025; Ullah et al., 2025). In this sense, the present findings reinforce the conceptual argument that health systems generate economic value beyond their direct welfare function.

The positive association between UHC and productivity is particularly meaningful because the independent variable used in the study was not a narrow measure of health expenditure or insurance enrollment, but the UHC service coverage index itself. This is important in light of the literature showing that UHC is increasingly regarded as a systems-level indicator reflecting broader health-system strength, including service availability, institutional functionality, workforce capacity, and resilience (Cerf, 2023; Debie et al., 2024; Jaca et al., 2022). The present results are therefore consistent with the view that stronger service coverage is a meaningful proxy for a more capable health system. The finding also complements studies showing that progress in UHC is associated with improved access to essential services and reduced inequalities, although such gains remain dependent on deeper structural capacities and sustained public commitment (Chen et al., 2023; Feng et al., 2022; Liu & You, 2025). Thus, the productivity gains associated with UHC in the present study are plausibly rooted in the broader functional strength of the health system rather than in isolated policy expansion alone.

The study's lagged models provide a particularly important contribution. The fact that the positive UHC coefficient remained statistically significant at one-year, two-year, and three-year lags suggests that the relationship between health-system strength and labor productivity is not confined to same-year co-movement. Rather, the association appears to persist over time, which is more consistent with a structural interpretation of health systems as productive infrastructure. This temporal persistence aligns with the broader literature linking strategic health investment to longer-term gains in labor productivity and economic performance (Khang, 2025; Mbau et al., 2022; Zeng et al., 2024). It also supports the argument that health-system strengthening may yield delayed returns through improved functional health, reduced work disruption, and a more stable labor force. In this

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regard, the present findings extend the literature by showing that UHC service coverage, specifically, is associated with later productivity gains in a multi-country ASEAN panel.

At the same time, the decline in coefficient size once labor force participation, inflation, trade openness, and urbanization were introduced is analytically instructive. The smaller but still significant UHC effect indicates that part of the raw UHC–productivity association may be shared with broader development conditions, but not all of it. Even after accounting for major labor-market, macroeconomic, and structural factors, UHC retained an independent positive association with productivity. This strengthens the interpretation that health-system strength is not simply a passive reflection of overall development, but may hold distinct economic relevance of its own. Such a finding is consistent with the literature arguing that health systems contribute to productive performance not only through direct health gains but also through broader system-level effects such as resilience, labor stability, and reduced systemic losses (Francis et al., 2023; Mangal et al., 2025). The controlled lagged models therefore provide the strongest empirical basis for the study's central claim.

The mediation results, however, complicate the interpretation in a theoretically useful way. Life expectancy was significantly associated with UHC in both contemporaneous and lagged models, which is consistent with the large body of literature linking better health conditions and improved longevity to stronger human capital and economic performance (Awoyemi et al., 2024; Sultana et al., 2022; Turceniuc, 2025). Yet life expectancy did not emerge as a statistically significant mediator in the productivity equation once UHC was included. This suggests that, within the present fixed-effects framework, the productivity relevance of UHC cannot be reduced to a simple life-expectancy channel. One plausible explanation is that life expectancy is a slow-moving and highly cumulative measure of population health, one that overlaps substantially with the broader health-system environment represented by UHC itself. The literature already indicates that the economic role of life expectancy is context-dependent and mediated by development stage, demographic structure, and institutional environment (Chen et al., 2024; Kara, 2025; Mubarak & Satria, 2024). The current findings are therefore not necessarily inconsistent with the literature; rather, they suggest that life expectancy may be too broad and too closely correlated with UHC to function as a clean standalone mediator in this type of panel specification.

A similar pattern emerged in the tuberculosis pathway. Lagged UHC significantly predicted lower TB incidence, which is fully consistent with the literature showing that stronger health systems, better diagnostic capacity, and more integrated public-health interventions contribute to reduced communicable disease burden (Kuddus et al., 2025; Osei-Wusu et al., 2025; Shafique et al., 2024). This result confirms that UHC is linked not only to service coverage in the abstract but also to meaningful disease-related outcomes. However, tuberculosis incidence did not significantly explain productivity once UHC was included in the same equation. Although the TB coefficient was directionally negative, as theory would predict, the mediated pathway was not statistically supported. This finding suggests that while reduced communicable disease burden is one plausible benefit of stronger health systems, it may represent only one dimension of a wider mechanism connecting UHC to productivity. This interpretation is consistent with the mixed literature on disease burden and macroeconomic performance, where communicable diseases often impose substantial economic costs but may not always appear as neat or dominant channels in aggregate models (Brown & Essi, 2021; Keogh-Brown et al., 2024; Samsudin et al., 2024).

Taken together, the mediation findings point toward a broader conclusion: the productivity effect associated with UHC may be distributed across multiple overlapping pathways rather than transmitted through one single, easily isolatable mechanism. The literature supports such a reading. Health systems influence not only survival and disease incidence, but also continuity of care, untreated morbidity, work attendance, financial protection, workforce reliability, and social resilience. These dimensions are not fully captured by life expectancy or TB incidence alone. Thus, the inability of the current mediation tests to confirm a single dominant pathway does not weaken the main contribution of the study. Instead, it suggests that the economic significance of health-system strengthening is likely broader and more integrated than a one-mediator model can capture.

In this respect, the study's findings strongly support the conceptual literature framing health systems as economic infrastructure. Existing

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scholarship argues that health investment should not be interpreted merely as redistributive expenditure because it contributes to labor-market performance, resilience, value creation, and inclusive development (Alli et al., 2025; Atun et al., 2025; Francis et al., 2023; Hascalovitz & Deonandan, 2025). The present results provide quantitative support for that perspective within ASEAN. By showing that UHC remains positively associated with labor productivity even under lagged and controlled panel specifications, the study lends empirical weight to the proposition that health-system strength is part of the deeper enabling structure of economic performance. In this sense, the findings help move the concept of health systems as economic infrastructure from theoretical plausibility toward measurable panel evidence.

The ASEAN context makes this conclusion especially relevant. Because ASEAN economies vary widely in income levels, institutional development, health-system maturity, and structural economic conditions, a positive within-country association between UHC and productivity across the region carries greater analytical significance than a single-country result alone. The findings suggest that despite differences in scale and context, improvements in health-system coverage are consistently aligned with stronger productive performance. This regional consistency lends support to policy arguments that health-system strengthening should be integrated more directly into economic planning, labor strategy, and development frameworks in Southeast Asia.

Overall, the discussion points to a clear interpretation: universal health coverage appears to matter economically not only because it improves health in a narrow clinical sense, but because it strengthens the broader conditions under which labor productivity can be sustained. The study therefore contributes to a growing literature that seeks to bridge health policy and development economics by demonstrating that stronger health systems are linked to stronger productive capacity. While future work is still needed to identify the specific pathways more precisely, the present evidence is sufficient to support the argument that health systems should be treated as part of the infrastructure of development rather than as a secondary social afterthought.

4.9 Concluding Statement on the Empirical Findings

Overall, the results show that universal health coverage is positively associated with labor productivity in ASEAN economies, both contemporaneously and across one-year, two-year, and three-year lag structures. This relationship remains statistically significant even after accounting for labor force participation, inflation, trade openness, and urbanization, indicating that the productivity relevance of UHC is not reducible to broader macro-structural change alone. While life expectancy and tuberculosis incidence were both significantly associated with UHC, neither emerged as a statistically conclusive mediator of the productivity relationship in the estimated models. In light of both the empirical findings and the reviewed literature, the most defensible conclusion is that stronger UHC service coverage is linked to higher productive capacity in ASEAN, consistent with the view that health systems function as a form of economic infrastructure.

5. Conclusions and Recommendations

This chapter presents a synthesis of the major findings of the study, the conclusions drawn from the evidence, the implications of the results for policy, theory, and methodology, and the recommendations arising from the analysis. The study examined whether universal health coverage, treated as an indicator of health-system strength, is associated with labor productivity in ASEAN economies from 2000 to 2023. Using panel data from the ten ASEAN member states, the study estimated baseline, lagged, mediated, and controlled two-way fixed-effects models to test the proposition that health systems may be understood not only as social institutions but also as a form of economic infrastructure.

5.1 Summary of Findings

The study produced several key findings.

First, the descriptive results showed substantial variation across ASEAN countries in terms of universal health coverage, life expectancy, tuberculosis incidence, and productivity. This variation confirmed the suitability of a regional panel framework for examining how within-country changes in health-system strength are associated with changes in economic performance over time. The productivity indicator, measured as GDP per person employed, also displayed a highly dispersed distribution, thereby justifying the use of a logarithmic transformation in the regression models.

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Second, the correlation analysis indicated that universal health coverage was strongly and positively associated with both life expectancy and labor productivity. This initial pattern was consistent with the literature portraying UHC as a broad indicator of health-system strength rather than a narrow financing measure alone (Cerf, 2023; Debie et al., 2024; Jaca et al., 2022). At the same time, the very high correlation between UHC and life expectancy suggested that disentangling the independent contribution of each variable within a single mediated model might be methodologically difficult.

Third, the baseline contemporaneous two-way fixed-effects model showed that universal health coverage had a positive and statistically significant association with labor productivity. This result provided initial evidence that stronger health-system coverage is linked to higher output per worker even after controlling for country-specific and year-specific influences. The finding is consistent with prior literature arguing that health-system strengthening contributes to productive capacity by improving the conditions under which labor is sustained and utilized (Khang, 2025; Mbau et al., 2022; Zeng et al., 2024).

Fourth, the lagged direct models strengthened the baseline result. Across the one-year, two-year, and three-year lag structures, universal health coverage remained positively and significantly associated with logged GDP per person employed. The stability of these coefficients suggests that the UHC–productivity relationship is not merely contemporaneous but persists over time. This is an important finding because it supports the broader interpretation advanced in the literature that health investment generates benefits that accumulate through stronger human capacity, improved resilience, and reduced disruptions to productive activity (Alli et al., 2025; Ullah et al., 2025).

Fifth, the life expectancy mediation analysis yielded only partial support for the proposed pathway. Universal health coverage significantly predicted life expectancy, which is consistent with studies linking health-system improvement to better population health and stronger human-capital conditions (Awoyemi et al., 2024; Sultana et al., 2022; Turceniuc, 2025). However, life expectancy did not emerge as a statistically significant predictor of productivity once UHC was included in the same equation. Thus, although UHC was associated with better health conditions and higher productivity, the evidence did not confirm life expectancy as a clean mediating channel in the current model.

Sixth, the alternative mediation analysis using tuberculosis incidence produced a similar pattern. Universal health coverage significantly predicted lower TB incidence, consistent with literature showing that stronger health systems and public-health interventions reduce communicable disease burden (Kuddus et al., 2025; Osei-Wusu et al., 2025; Shafique et al., 2024). However, tuberculosis incidence did not significantly predict productivity once UHC was included in the productivity equation. The sign of the coefficient remained theoretically consistent, but the mediated effect was not statistically established. This result suggests that TB reduction may be one consequence of stronger UHC without necessarily serving as the single dominant economic pathway captured by the model.

Seventh, the controlled lagged two-way fixed-effects models provided the strongest evidence for the study's main proposition. After introducing labor force participation, inflation, trade openness, and urban population share, the coefficient of lagged universal health coverage remained positive and statistically significant across all lag structures. Although the magnitude of the UHC effect declined relative to the uncontrolled models, it did not disappear. This indicates that the observed relationship between UHC and productivity is not merely a reflection of broader structural development but retains an independent association with output per worker.

Overall, the findings consistently show that universal health coverage is positively associated with labor productivity in ASEAN economies and that this relationship remains robust under lagged and controlled specifications. At the same time, the mediation tests indicate that the economic benefits of UHC may operate through multiple overlapping mechanisms rather than through a single pathway that can be cleanly isolated using life expectancy or tuberculosis incidence alone.

5.2 Conclusions

Based on the empirical evidence, the study draws several conclusions.

First, the study concludes that universal health coverage is positively associated with labor productivity in ASEAN economies. Across baseline, lagged, and controlled two-way fixed-effects models, stronger UHC service coverage consistently

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corresponded with higher GDP per person employed. This supports the view that health-system strength holds measurable economic relevance and should not be interpreted solely in welfare terms.

Second, the study concludes that health systems may be meaningfully conceptualized as economic infrastructure. The persistence of the UHC effect across one-year, two-year, and three-year lag structures indicates that stronger health-system coverage is linked not only to immediate health outcomes but also to later productive performance. This pattern is consistent with the broader literature arguing that health contributes to the functional, institutional, and human foundations of economic activity (Alli et al., 2025; Atun et al., 2025; Hascalovitz & Deonandan, 2025). In this sense, health systems operate in a manner analogous to other enabling infrastructures that sustain production and reduce systemic friction.

Third, the study concludes that the positive relationship between UHC and productivity remains robust even after major macro-structural controls are introduced. Once labor force participation, inflation, trade openness, and urbanization were included, the UHC coefficient declined but remained statistically significant. This indicates that UHC is not merely a residual proxy for overall modernization or development level. Rather, it appears to exert a distinct and policy-relevant association with productive economic performance.

Fourth, the study concludes that the productivity effect associated with UHC is broader than any single mediator tested in the present models. While UHC significantly predicted both higher life expectancy and lower tuberculosis incidence, neither variable emerged as a statistically conclusive mediator once UHC was included in the productivity equation. This suggests that the economic contribution of health-system strength may be distributed across several overlapping channels, including reduced morbidity, improved work continuity, greater functional capacity, better treatment access, and stronger financial protection.

Fifth, the study concludes that the strongest empirical contribution of the paper lies in demonstrating a robust ASEAN panel association between UHC service coverage and output per worker. Existing scholarship has often examined health expenditure, broad growth, or mortality outcomes, but fewer studies have directly linked UHC service coverage to a productivity-oriented measure such as GDP per person employed within a regional panel setting. The study therefore adds empirical support to the growing argument that health systems are part of the structural foundations of development.

Overall, the study concludes that universal health coverage should be regarded not only as a health and equity objective but also as a productive development investment. In the ASEAN setting, stronger UHC appears to be associated with stronger labor productivity, thereby reinforcing the idea that health-system strengthening contributes to both social well-being and economic performance.

5.3 Implications

The findings of the study carry important implications for policy, theory, and methodology.

Policy Implications

The policy implications of the findings are substantial. The results indicate that universal health coverage should not be framed solely as a moral, redistributive, or service-delivery objective. It should also be treated as part of long-term productivity strategy. When UHC is associated with higher output per worker, investments in service coverage, treatment access, preventive care, and system capacity can be understood as investments in the productive reliability of the labor force. This supports a broader development perspective in which health ministries, finance agencies, planning bodies, and labor institutions do not operate in isolation but as parts of an integrated productivity architecture.

For ASEAN governments, the implication is that strengthening health systems may contribute not only to better health outcomes but also to more stable and efficient economic performance. This is particularly relevant in rapidly transforming economies where competitiveness, workforce resilience, and human-capital quality are central concerns. The findings suggest that policies designed to expand UHC may yield returns beyond the health sector by supporting continuity of work, reducing avoidable health-related productivity losses, and stabilizing labor capacity.

The results also imply that policy evaluation frameworks should move beyond narrow budgetary views of health spending. If stronger UHC is associated with later productivity gains, then health expenditure should not be judged only in terms of

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immediate fiscal cost. It should also be evaluated in relation to its contribution to labor efficiency, economic resilience, and inclusive development. This position is consistent with the growing literature that treats health as part of the enabling structure of development rather than merely as a consumption-oriented public service (Francis et al., 2023; Mangal et al., 2025).

Theoretical Implications

The study contributes theoretically to the expanding view that health systems are part of the productive infrastructure of society. Traditional development frameworks often separate "economic" sectors from "social" sectors, implicitly treating health as secondary to growth-producing activities. The present findings challenge this distinction. By showing that stronger UHC service coverage is positively associated with output per worker, the study supports the argument that health systems belong within the wider architecture of production, labor stability, and structural development.

The results also refine the conceptual relationship between health-system strength and economic performance. The lack of statistically conclusive mediation through life expectancy or tuberculosis incidence suggests that the economic contribution of health systems may be diffuse, cumulative, and multidimensional. This supports a systems perspective rather than a narrowly linear one. The theoretical implication is that the health–productivity relationship may operate not through one isolated channel, but through an integrated set of mechanisms that include disease reduction, functional health improvement, service continuity, financial protection, and institutional resilience.

In this regard, the study helps move the "health systems as economic infrastructure" argument from conceptual assertion toward empirical support. It contributes to a more integrated theory of development in which health systems are not external to production, but part of the conditions that make sustained productivity possible.

Methodological Implications

Methodologically, the study demonstrates the value of lagged two-way fixed-effects models for examining the relationship between health-system strength and productivity. The lagged models were especially informative because they showed that the positive UHC–productivity relationship persists over one to three years, thereby offering a stronger basis for interpretation than purely contemporaneous models alone.

The study also highlights the limitations of mediation analysis in macro-panel settings when mediators are either highly correlated with the main predictor or too narrow to represent the full transmission process. Life expectancy, while theoretically relevant, may be too cumulative and closely tied to UHC to emerge as a distinct mediator in fixed-effects models. Tuberculosis incidence, while responsive to health-system improvement, may capture only one segment of a broader health-productivity pathway. The implication is that future panel studies should consider wider sets of mediators, more proximate labor-related health indicators, or more dynamic estimation techniques.

Finally, the study demonstrates the analytical usefulness of using GDP per person employed as the economic outcome variable. This measure is especially appropriate because it captures output per worker rather than aggregate output alone, thereby aligning more closely with the proposition that health systems affect the productive quality and continuity of labor.

5.4 Recommendations

In light of the findings, conclusions, and implications of the study, the following recommendations are offered.

First, ASEAN governments should strengthen universal health coverage as part of long-term productivity and development strategy. Policies that improve essential service coverage, primary care access, preventive care, treatment continuity, and service quality should be viewed not only as health reforms but also as investments in the productive efficiency of the workforce.

Second, public policymakers should adopt a broader economic framing of health-system investment. Budgetary and institutional support for health services should be justified not only on ethical and welfare grounds, but also on the basis of their contribution to labor productivity, resilience, and inclusive growth. This reframing may help position health more centrally in fiscal and development planning.

Third, national and regional development dashboards should include health-system indicators alongside economic performance measures. If UHC

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is associated with productivity, then service coverage indicators should be monitored together with labor, competitiveness, and growth indicators rather than being confined to the health sector alone. This would promote more integrated and evidence-based planning.

Fourth, future research should examine broader and more proximate mediators of the UHC–productivity relationship. Since life expectancy and tuberculosis incidence did not emerge as statistically conclusive mediators, future studies may test variables such as healthy life expectancy, disability burden, absenteeism, catastrophic health expenditure, out-of-pocket expenditure, treatment continuity, work-loss days, or broader morbidity indicators. These may capture the productivity pathway more directly than the mediators used in the present study.

Fifth, future studies should extend the present work using more advanced econometric approaches. Dynamic panel estimators, instrumental-variable methods, panel vector autoregression, and country-specific time-series designs may help examine persistence, endogeneity, and directional structure more deeply. These approaches may also provide more refined estimates of how health-system changes translate into economic outcomes over time.

Sixth, a Philippines-focused extension of the study is recommended. Since the present analysis was conducted at the ASEAN regional level, a follow-up national study may provide more specific policy insight into how UHC implementation, health-system reform, and productivity-related outcomes interact within the Philippine setting. Such a study would be especially relevant given the country's continuing efforts to deepen universal health coverage.

Finally, scholarly work should continue refining the concept of health systems as economic infrastructure. The present study provides empirical support for this framing, but further theoretical and applied work is still needed to specify its mechanisms, operational dimensions, and policy applications. A more developed conceptual vocabulary in this area would help bridge the artificial divide that often separates health policy from development economics.

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7. Tables

Tables for the ASEAN UHC–Productivity Study
Prepared from the ASEAN-10 panel, 2000–2023

Table 1. Descriptive Statistics of the Main Study Variables

Variable	N	Mean	SD	Min	Median	Max
UHC service coverage index	240	64.3125	15.7445	26.0	66.0	88.0
Life expectancy at birth (years)	240	71.1719	5.7578	56.364	71.1755	83.5951
GDP per person employed (constant 2021 PPP $)	240	54015.41	67738.46	2965.62	20344.64	225785.22
ln(GDP per person employed)	240	10.2155	1.1347	7.9948	9.9206	12.3273

N = 240 country-year observations for the balanced core panel. GDP per person employed is reported in constant 2021 PPP dollars.

Table 2. Correlation Matrix of the Core Variables

Variable	UHC	Life expectancy	GDP per person employed	ln(GDP per person employed)
UHC	1.0	0.9315	0.7	0.8817
Life expectancy	0.9315	1.0	0.6843	0.8164
GDP per person employed	0.7	0.6843	1.0	0.9202
ln(GDP per person employed)	0.8817	0.8164	0.9202	1.0

Correlations are Pearson coefficients. The very high UHC–life expectancy correlation suggests potential multicollinearity in mediated models.

Table 3. Baseline and Contemporaneous Two-Way Fixed-Effects Estimates

Variable	(1) Pooled OLS ln(Productivity)	(2) TWFE Direct ln(Productivity)	(3) TWFE Mediator Life expectancy	(4) TWFE Mediated ln(Productivity)
UHC service coverage index	0.0635*** (0.0089)	0.0263*** (0.0085)	0.2116** (0.0999)	0.0180*** (0.0051)
Life expectancy at birth				0.0393 (0.0281)
Country fixed effects	No	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes
Observations	240	240	240	240
R-squared	0.777	0.986	0.966	0.988

*Standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels.*

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Table 4. Lagged Two-Way Fixed-Effects Direct Models

Variable	(1) UHC(t-1) ln(Productivity)	(2) UHC(t-2) ln(Productivity)	(3) UHC(t-3) ln(Productivity)
Lagged UHC service coverage index	0.0267*** (0.0086)	0.0273*** (0.0086)	0.0275*** (0.0088)
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	230	220	210
R-squared	0.988	0.989	0.991

Dependent variable is ln(GDP per person employed). Standard errors in parentheses and clustered at the country level.

Table 5. Lagged Two-Way Fixed-Effects Mediation Models Using Life Expectancy

Variable	(1) Life expectancy UHC(t-1)	(2) ln(Productivity) UHC(t-1)+LifeExp	(3) Life expectancy UHC(t-2)	(4) ln(Productivity) UHC(t-2)+LifeExp	(5) Life expectancy UHC(t-3)	(6) ln(Productivity) UHC(t-3)+LifeExp
Lagged UHC service coverage index	0.2013** (0.0974)	0.0188*** (0.0054)	0.1968** (0.0938)	0.0198*** (0.0057)	0.1980** (0.0906)	0.0203*** (0.0059)
Life expectancy at birth		0.0393 (0.0277)		0.0382 (0.0272)		0.0362 (0.0264)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	230	230	220	220	210	210
R-squared	0.967	0.989	0.968	0.990	0.971	0.992

Life expectancy does not emerge as a statistically significant mediator once UHC is included in the productivity equation.

Table 6. Lagged Two-Way Fixed-Effects Mediation Models Using Tuberculosis Incidence

Variable	(1) TB incidence UHC(t-1)	(2) ln(Productivity) UHC(t-1)+TB	(3) TB incidence UHC(t-2)	(4) ln(Productivity) UHC(t-2)+TB	(5) TB incidence UHC(t-3)	(6) ln(Productivity) UHC(t-3)+TB
Lagged UHC service coverage index	-12.3528** (5.1012)	0.0195** (0.0082)	-12.2721*** (4.6239)	0.0199** (0.0078)	-11.8576*** (4.2360)	0.0200*** (0.0072)
Tuberculosis incidence		-0.0006 (0.0005)		-0.0006 (0.0005)		-0.0006 (0.0005)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	230	230	220	220	210	210
R-squared	0.956	0.988	0.962	0.990	0.965	0.991

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Tuberculosis incidence is responsive to UHC but does not emerge as a statistically significant mediator in the productivity equation.

Table 7. Preferred Controlled Lagged Two-Way Fixed-Effects Models

Variable	(1) Controlled TWFE UHC(t-1)	(2) Controlled TWFE UHC(t-2)	(3) Controlled TWFE UHC(t-3)
Lagged UHC service coverage index	0.0127** (0.0064)	0.0137** (0.0059)	0.0142*** (0.0053)
Labor force participation rate	0.0262 (0.0223)	0.0209 (0.0196)	0.0156 (0.0166)
Inflation	-0.0041 (0.0045)	-0.0056 (0.0050)	-0.0059 (0.0049)
Trade openness	0.0006 (0.0014)	0.0002 (0.0014)	-0.0002 (0.0015)
Urban population share	0.0198 (0.0155)	0.0183 (0.0148)	0.0168 (0.0142)
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Clustered standard errors	Yes	Yes	Yes
Observations	200	191	182
R-squared	0.993	0.994	0.994

Controlled models include labor force participation, inflation, trade openness, and urban population share. Standard errors are clustered at the country level.

Notes for Tables 3–7:
1. Standard errors are shown in parentheses.
2. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
3. TWFE refers to two-way fixed effects with country and year fixed effects.
4. Standard errors are clustered at the country level.
5. Dependent variable in productivity regressions is ln(GDP per person employed).
6. ASEAN sample covers Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam, 2000–2023.

