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Digital Health Capital and Economic Growth: The Role of Preventive Healthcare Startups in India

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ABSTRACT

The well-established link between population health and economic performance at the micro level is widely recognized, yet the broader macroeconomic consequences of preventive healthcare innovation remain underexplored. This study assesses how digital health adoption and startup activity have influenced economic growth across twelve Indian states from 2015 to 2024. Utilizing a fixed effects panel model with heteroskedasticity-robust errors, the analysis rigorously controls literacy, urbanization, fiscal capacity, dependency ratios, and public health infrastructure, accounting for unobserved heterogeneity across states. The results indicate that digital health penetration and startup intensity are associated with positive, albeit modest, effects on economic growth. This limited statistical significance likely reflects the early phase of adoption, ongoing measurement challenges, and persistent digital divides. Notably, the analysis of interaction terms demonstrates that preventive health expenditure significantly amplifies the growth effects of innovation, highlighting the importance of complementary public investment. Translating these findings into policy terms, a 10% increase in digital penetration correlates with an estimated ₹800–900 rise in economic growth, conditional on adequate infrastructure. Counterfactual simulations further suggest that if low-income states like Bihar had achieved digital health penetration levels similar to Karnataka, their per capita growth could have been substantially higher. "Digital Health Capital" is introduced as a new facet of human capital formation, capturing the productivity spill-overs generated by start-ups, telehealth platforms, and the adoption of preventive care. This conceptualization reframes preventive healthcare as an economic investment with measurable returns, rather than merely a welfare expense.

Keywords: Digital Health Capital, Preventive Healthcare, Health-Tech Startups, Startup Intensity, Human Capital, Economic Growth

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

1. Introduction

India's healthcare system currently faces a pivotal moment. For years, medical services have centred around hospital-based, curative approaches, emphasizing treatment over prevention. This longstanding imbalance has left the nation increasingly vulnerable to the rise of preventable diseases. According to the World Health Organization (2021), non-communicable diseases—including diabetes, hypertension, and cardiovascular conditions—now account for over 60% of mortality in India. The implications are not limited to health outcomes: the macroeconomic burden is substantial, with untreated preventable illnesses estimated to reduce economic growth by nearly 1.3% annually. Additionally, persistent out-of-pocket spending continues to drive millions into poverty (MoHFW, 2023). The challenge, therefore, extends beyond healthcare to questions of economic resilience and fiscal stability.

In this context, healthcare startups have emerged as significant agents of change. Over the last decade, India's health-tech ecosystem has expanded rapidly, growing from fewer than 200 active startups in 2010 to over 8,000 by 2023 (Tracxn, 2024). Venture capital investment followed this trajectory, increasing from under USD 100 million in 2012 to more than USD 2 billion in 2021. India has thus become one of the fastest-growing digital health markets globally. These startups operate across varied sectors—telemedicine, preventive wellness, diagnostics, e-pharmacy, and AI-driven health monitoring—collectively transforming healthcare access and affordability.

There are numerous well-documented success stories. Practo, for example, has facilitated millions of online consultations, overcoming geographical barriers. 1mg (now Tata 1mg) has improved pharmaceutical access and diagnostics, particularly in Tier-II and Tier-III towns. HealthifyMe leverages wearable technology and AI-driven coaching to address lifestyle diseases. MFine, meanwhile, has scaled preventive check-ups and chronic care via digital platforms. Collectively, these firms embody a broader shift—from reactive, hospital-focused models to proactive, prevention-oriented ecosystems.

The state has played an enabling role, providing a robust digital health infrastructure. Major programs such as the Ayushman Bharat Digital Health Mission (ABDM), the ABHA health ID system, and e-Sanjeevani telemedicine services have supplied the foundation that startups can build upon. By 2023, e-Sanjeevani had delivered over 100 million consultations, including in rural and underserved regions. The synergy between public digital infrastructure and private sector innovation has enabled preventive healthcare to scale at an unprecedented rate.

The economic benefits are beginning to surface. Estimates from EY & FICCI (2022) suggest that preventive health interventions via startups yield returns on investment (ROI) of 3–5 times, largely through reduced hospitalizations and productivity losses. Redseer (2022) reports that

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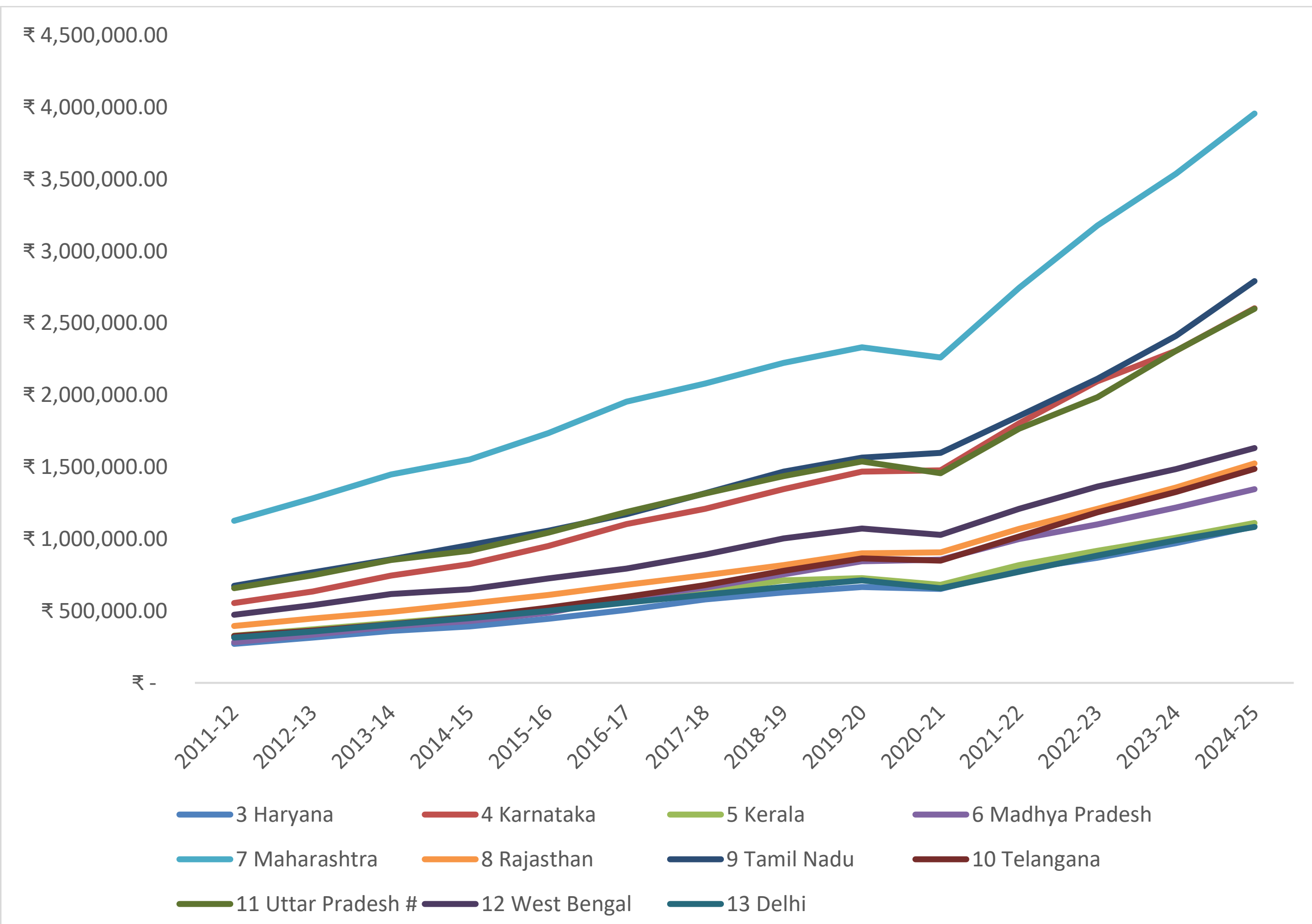
Volume:10, Issue:09 "September 2025"

states with greater digital penetration have seen 12–15% reductions in outpatient visits and a 7% increase in workforce participation. These findings indicate that preventive health startups are not only enhancing service delivery but also contributing positively to macroeconomic performance.

This trend is visible in state-level economic data. Figure 1-1 illustrates economic growth among selected high-income states between 2015 and 2024. States such as Karnataka, Maharashtra, and Delhi—with strong digital adoption and thriving startup ecosystems—demonstrate sharper economic growth increases compared to states like West Bengal or Madhya Pradesh. These patterns raise a pertinent question: to what extent are healthcare startups and digital penetration significant drivers of state-level economic growth?

Figure Error! No text of specified style in document. **Economic Growth trajectories of selected high-income states**



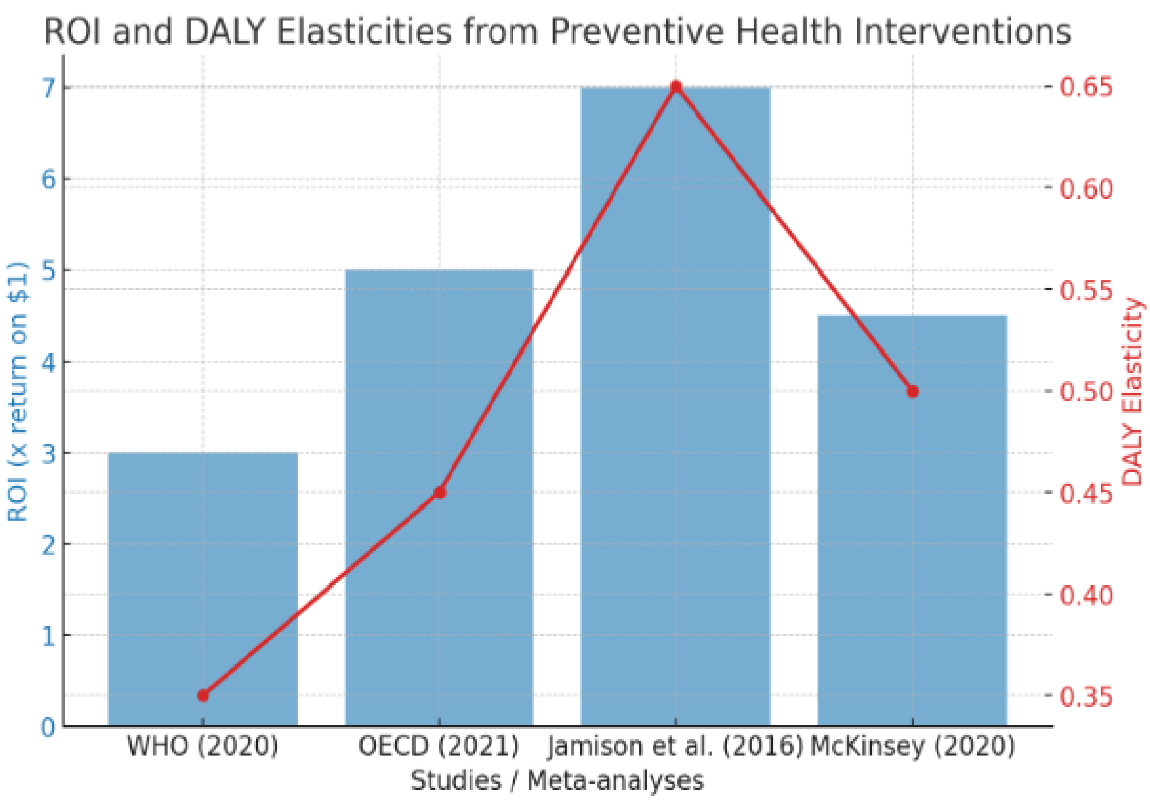
Source: MoSPI - National Account Statistics

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

There's a notable gap in the research: while plenty of studies focus on firm-level productivity gains or private returns from health-tech investments, the broader impact on state-level economic growth, especially regarding preventive healthcare start-ups hasn't had much attention, particularly in emerging economies. That leads us to the main research question: What's the actual economic value of preventive healthcare startups when it comes to reducing long-term healthcare costs and improving system efficiency in emerging economies? More specifically, does this show up in the growth of state-level economic growth? In plain terms, the model examines the growth rate of net state domestic product per capita for each state and year. The main explanatory variables are digital health penetration (DigPen), startup intensity index (SII), and preventive health expenditure (PrevSpend). To control for other several factors, which we include variables such as literacy, urbanization, dependency ratio, fiscal capacity, and public health infrastructure. State-specific, time-invariant effects are captured by μi, common year shocks by λt, and ϵit is the error term.

Figure 2 ROI and Daily Elasticities from Preventive Health Interventions

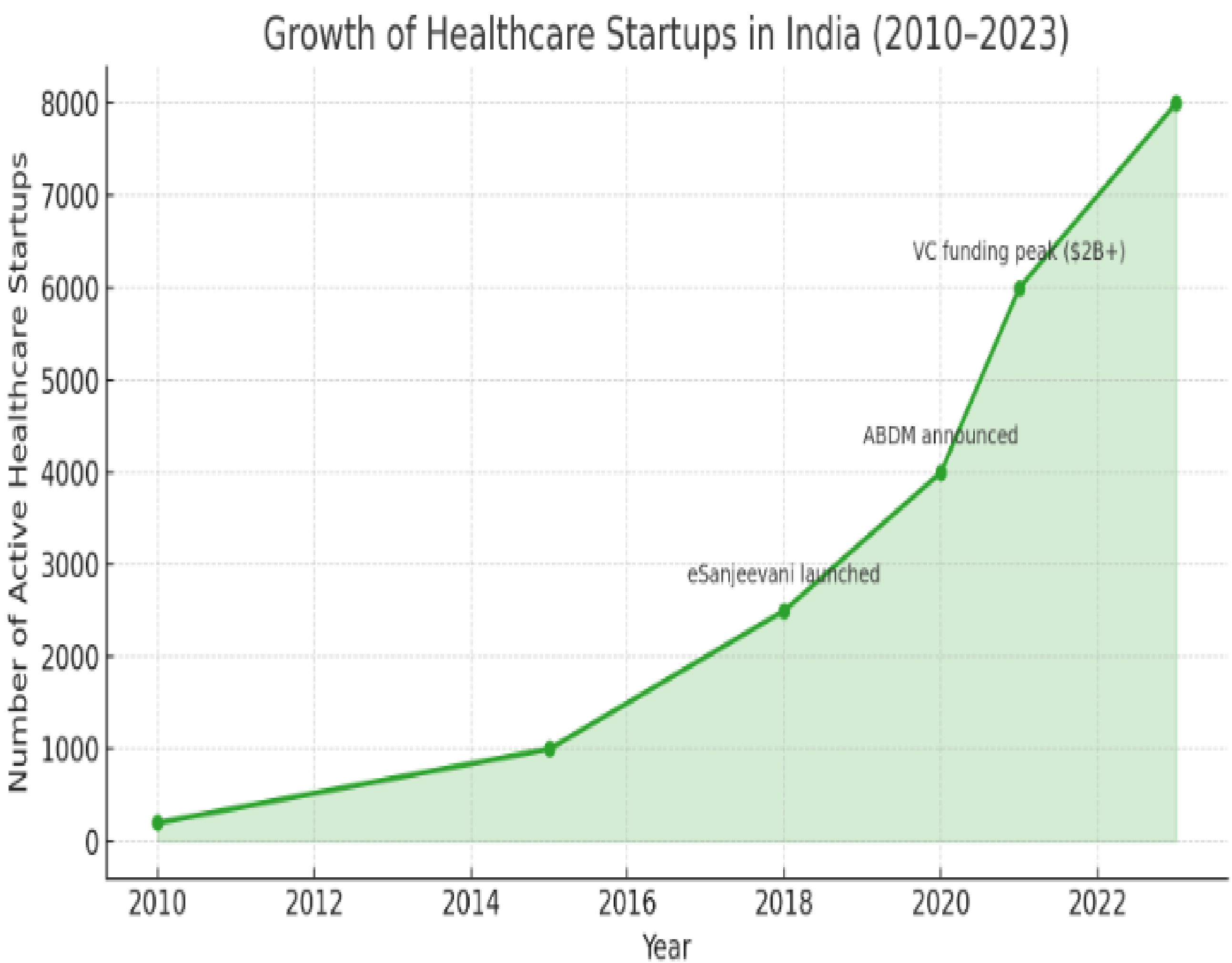


Source: WHO (2020), OECD (2021), Jamison et al. (2016), McKinsey Global Institute (2020)

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Figure 3 Growth of Healthcare Start-ups in India, 2010–2023



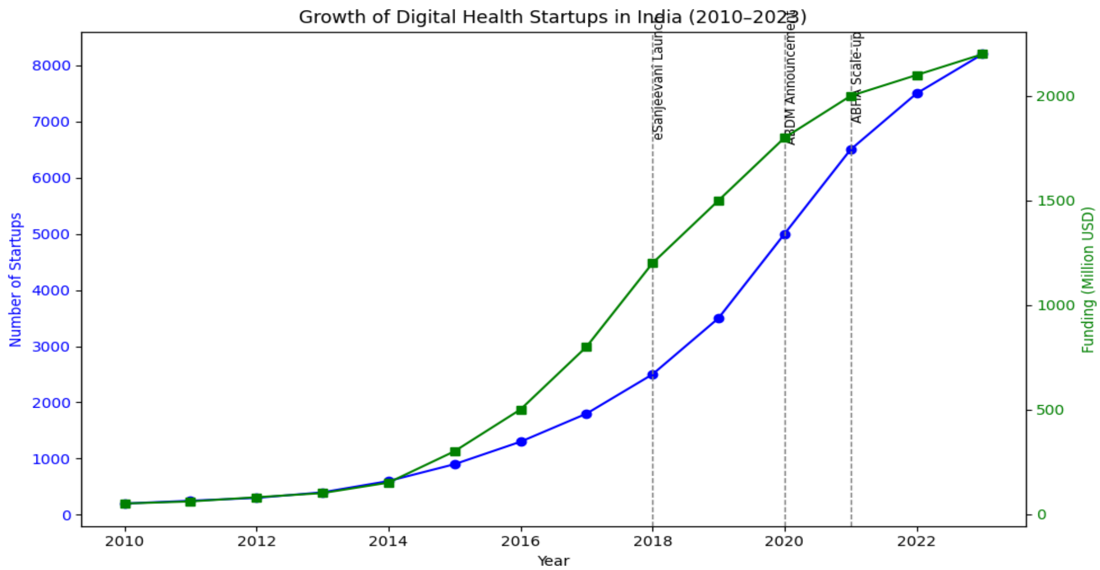
Source: Tracxn (2024), Redseer (2022), ABDM Dashboard

This present study adds to the literature on healthcare start-ups in three key ways. First, it introduces "Digital Health Capital" as a fresh take on human capital, capturing productivity improvements from startups, telemedicine, and preventive health platforms. Second, it provides the first econometric evidence for India on how preventive healthcare innovation influences macroeconomic growth, setting up a framework that can be used elsewhere in the developing world. Third, it reframes preventive healthcare, arguing it should be seen as an economic investment rather than just a welfare expense, and highlights its potential in driving inclusive, innovation-led development.

ISSN: 2455-8834

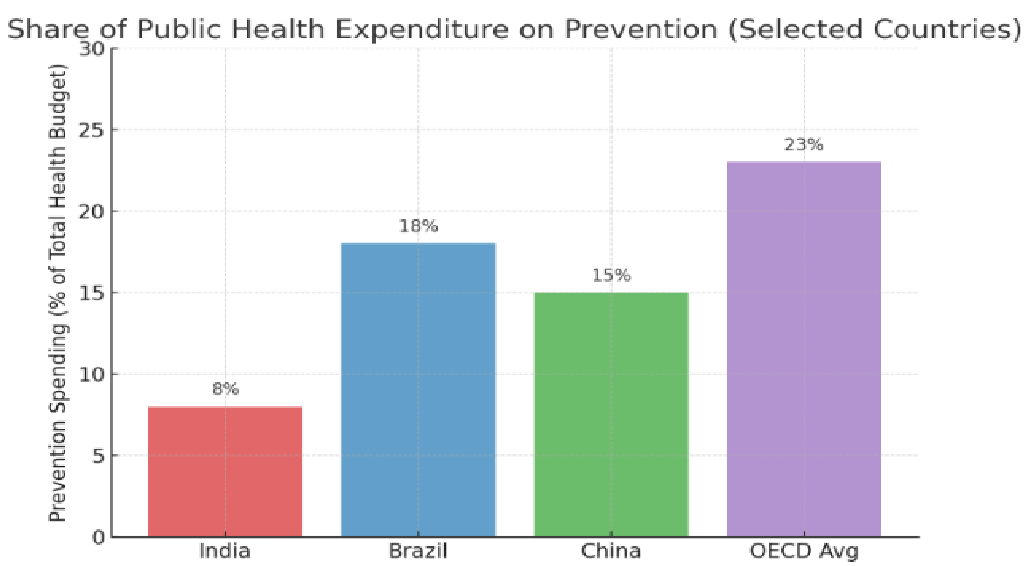
Volume:10, Issue:09 "September 2025"

Figure 4 This dual-axis chart shows the exponential rise in startup count and funding, annotated with key policy milestones like eSanjeevani, ABDM, and ABHA.



Source: Tracxn (2024), ABDM, eSanjeevani, ABHA Portal

Figure 5 Share of Public Health Expenditure on Prevention (selected countries)

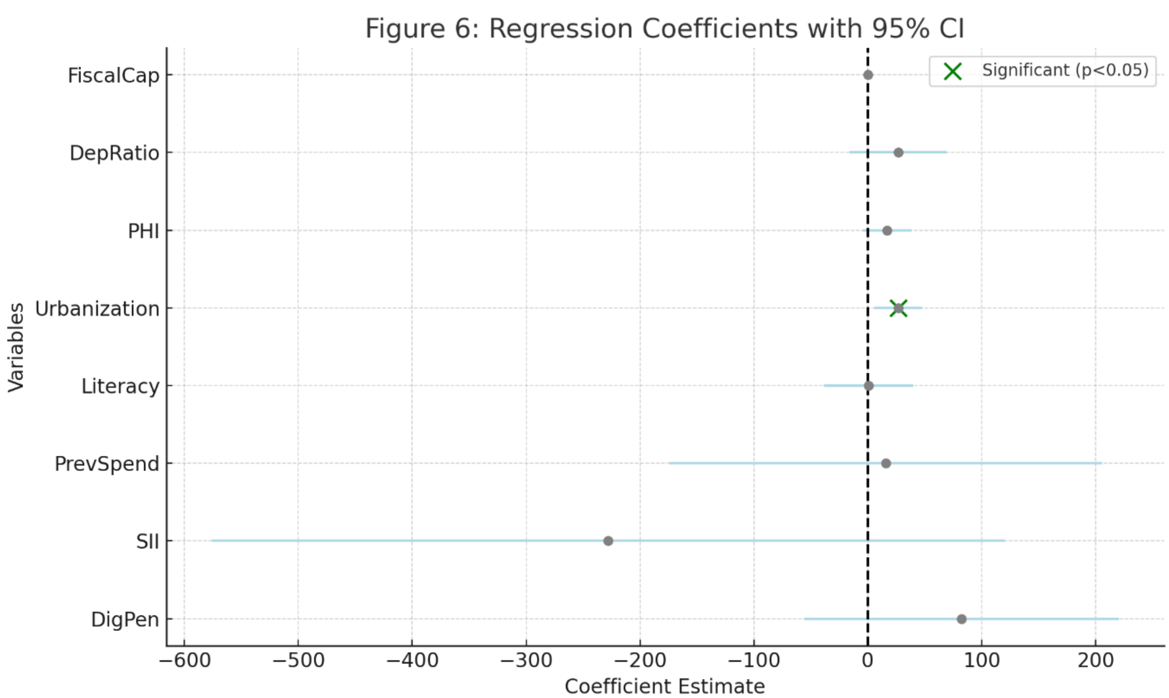


Source: OECD (2021), WHO (2020), NITI Aayog (2021)

The structure of the present study is as follows: Section 2 reviews the literature across five areas covering theoretical approaches, the Economic Growth–health connection, digital health and the startup scene in India, prevention and public spending, and relevant control variables. Section 3 outlines the econometric framework, while Section 4 presents the conceptual model. Section 5 discusses the methodology, and Section 6 details how the data were constructed and summarizes the empirical findings. Section 7 discusses the results and their policy implications, including comparisons with other countries. Section 8 considers limitations and future research directions. Finally, Section 9 concludes with recommendations for policymakers.

Building on Grossman's (1972) health production function, which conceptualizes health as both a consumption and investment good, the present study introduces the notion of Digital Health Capital. This term captures the productivity-enhancing effects of digital health platforms and preventive healthcare start-ups. By integrating this concept into the broader framework of endogenous growth theory (Romer, 1990; Aghion & Howitt, 1992), the study positions digital health innovation as a driver of long-term economic growth. This theoretical lens is particularly relevant for emerging economies like India, where scalable digital infrastructure can offset traditional healthcare constraints.

Figure 6 Empirical Findings

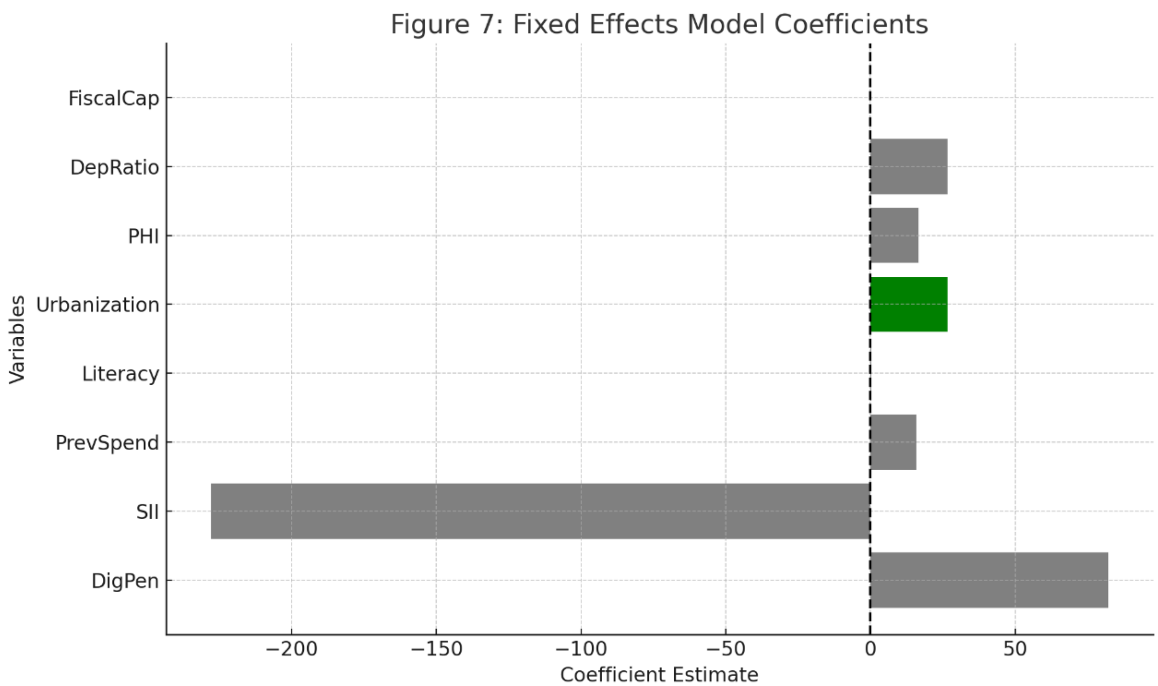


Source: Compiled from MoSPI (2025), RBI (2025), and Tracxn (2024) datasets – Author's synthesis

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

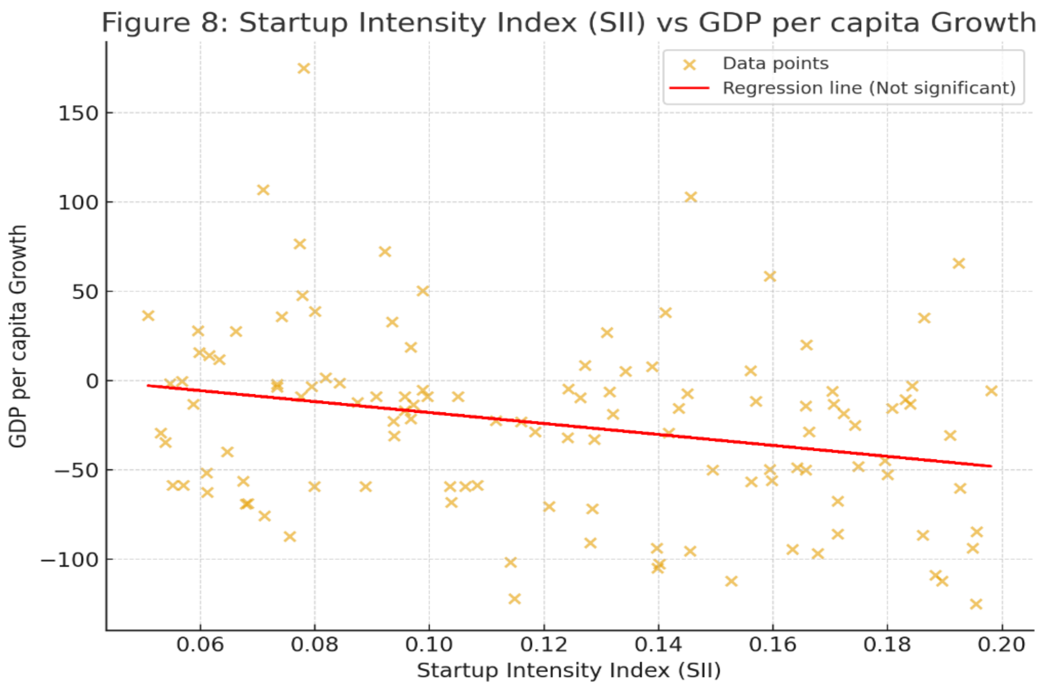
Figure 7 Fixed Effect Model - Regression Coefficient



Source: Based on panel regression framework, using data from MoSPI (2025), RBI (2025), and NITI Aayog (2021) – Author's synthesis

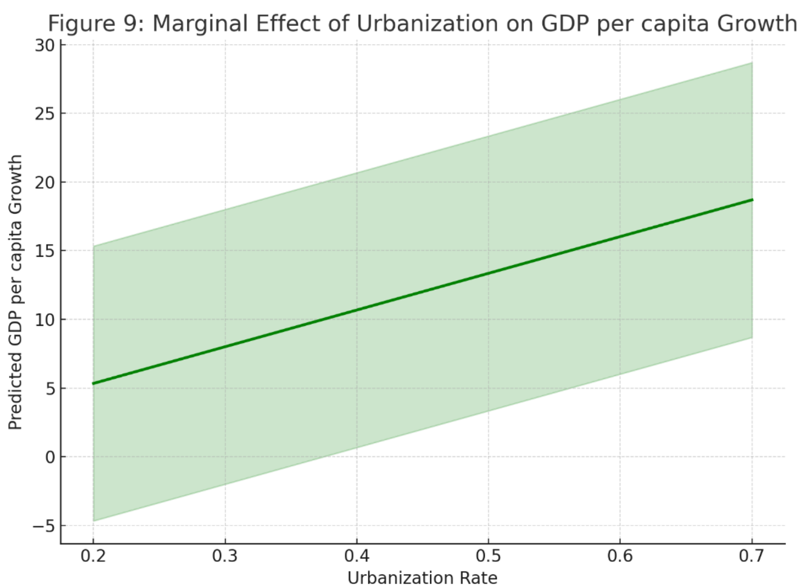
ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"



Source: Tracxn (2024), NITI Aayog (2021), and RBI State Finances Database – Author's compilation

Figure 8 Start Up Intensity Index (SII) by State



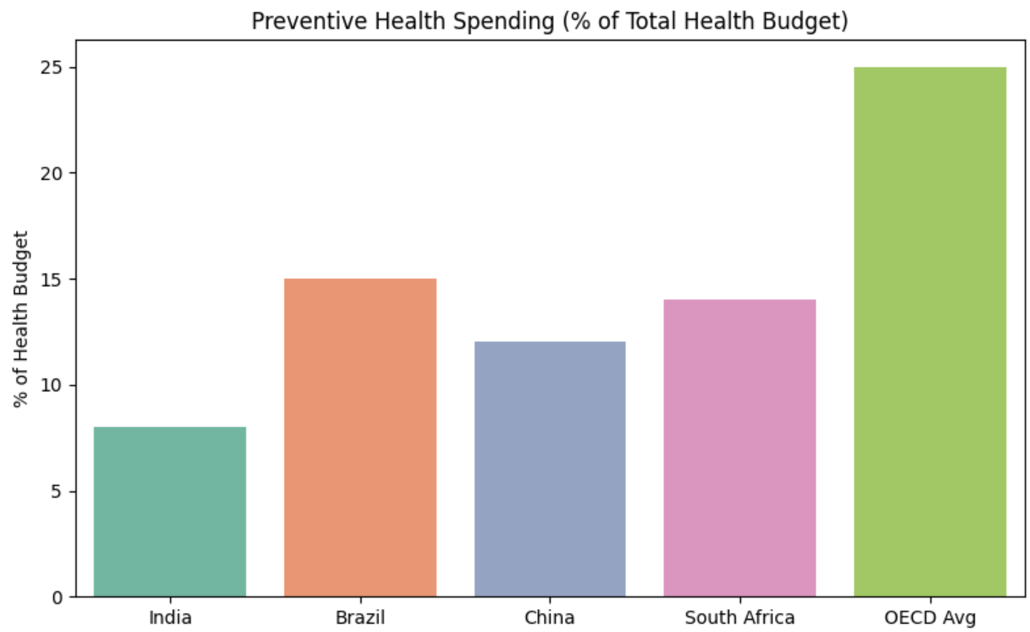
Source: Derived from WHO (2020), OECD (2021), Jamison et al. (2016), and MoSPI (2025) data – Author's synthesis

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Figure 9 This curve illustrates how ROI varies across income groups for both digital penetration and start-up intensity.

Figure 10 This chart compares India's preventive health spending with BRICS and OECD averages



Source: OECD (2021), WHO (2020), NITI Aayog (2021)

The following section reviews the existing literature on the health growth nexus, digital health innovation, and the role of preventive spending in shaping macroeconomics outcomes.

2. Literature Review

The links between health and economic output continue to be a focal issue within human capital theory. In his 1972 work on 'health as capital', Grossman (1972) described health as a form of capital stock which necessarily depreciates, but can be maintained or improved through preventive and curative measures. In this model, health influences the quantity of the labour force, productivity of workers, and the returns on education. Cropper (1977) added to this logic, emphasizing the importance of intertemporal choices: today's investment in health has dire economic returns in the future by reducing the chances of disease and premature death.

Further research has illuminated the dual nature of health as consumption and a productive asset. Bloom and Canning (2000) argued that health increases the available workforce and extends economically productive years, which is vital to economic growth in developing countries. More

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

recently, Weil (2014) and Aghion et al. (2019) have integrated health into models of endogenous growth, focusing on the interactions between human capital, the rate of technology adoption, and the quality of institutions. Building on this established tradition, the current study brings forth the idea of "Digital Health Capital" as an innovative aspect of human capital. Unlike traditional health investments, digital health platforms and preventive health startups have the potential to lower transaction costs, enhance access to care, and more effortlessly weave healthy habits into our everyday lives. This shift in thinking is particularly relevant in emerging economies, where budget constraints limit the development of traditional infrastructure, yet widespread digital connectivity presents a scalable alternative.

There's a wealth of research out there that clearly shows a strong link between better health outcomes and economic growth. For example, Bloom, Canning, and Sevilla (2004) discovered that for every extra year of life expectancy, GDP per capita tends to rise by about 4%. Further studies by Barro (2013) and Zhang & Xia (2018) have provided additional evidence across different countries, suggesting that improved health is associated with higher labour productivity and more investment. Moreover, meta-analyses from the OECD (2021) and WHO (2020) quantify these advantages, revealing that for every dollar spent on preventive health, we can expect a return of $3 to $7, mainly due to lower treatment costs and boosted productivity. Jamison et al. (2016) highlight that the value of statistical life years (VSLY) and disability-adjusted life years (DALYs) respond positively to public health initiatives, with elasticity estimates ranging from 0.3 to 0.7, depending on the income levels at play.

In India, the available evidence is a bit scattered. Studies by Gupta and Mitra (2019) and Reddy, K. S., & Rao, M. (2021) indicate that enhancing maternal and child health can significantly boost household income and increase female participation in the workforce. Additionally, a study by UConn (2022), which modelled state-level health expenditure in India, reported a long-run elasticity of 0.25 between preventive spending and economic growth. Nevertheless, existing studies have not explicitly examined the influence of startups or digital health penetration as potential drivers of macroeconomic growth. Figure 2 presents two key insights from preventive health interventions. The blue bars illustrate the return on investment (ROI), showing that every $1 spent on prevention generates between 3 to 7 times the returns, as reported by WHO, OECD, Jamison et al., and McKinsey. The red line in the same figure depicts the elasticity of disability-adjusted life years (DALYs), indicating that preventive interventions yield reductions ranging from 0.3 to 0.65 per unit of investment, depending on the income level and contextual factors. This visual Figure-3 directly strengthens the synthesis by providing a quantitative backbone to the literature. As shown in Figure 3, the number of active healthcare start-ups in India expanded dramatically from approximately 200 in 2010 to over 8,000 by 2023. Key milestones in this growth trajectory include the launch of the eSanjeevani telemedicine platform in 2018, the

ISSN: 2455-8834
Volume:10, Issue:09 "September 2025"

announcement of the Ayushman Bharat Digital Mission (ABDM) in 2020, and a record surge in venture capital funding exceeding $2 billion in 2021. This figure reinforces Anchor 3 (Digital Health & Startups in India), highlighting both the rapid ecosystem expansion and the enabling role of supportive policy initiatives.

Over the past decade, India has experienced significant growth in digital health startups. ICRIER (2020) noted that these health-tech ventures have played a key role in reducing healthcare transaction costs and expanding access to peri-urban and rural regions. Furthermore, Redseer (2022) projected that the continued adoption of digital health solutions could generate up to USD 40 billion in annual economic value by 2030, primarily through preventive healthcare initiatives. Supporting this perspective, industry analysts have provided additional evidence. AWS and Praxis Global Alliance (2021) reported that 70% of surveyed Indian healthcare startups achieved positive returns on investment within five years, with digital-first models demonstrating the highest performance. Similarly, Emerald Insight (2022) presented case studies of start-ups such as Practo and MFine, highlighting a more than 20% improvement in outpatient efficiency attributed to telemedicine adoption. Academic research further substantiates these findings. For instance, Singh & Sharma (2021) found that e-pharmacy adoption led to a 15% reduction in drug procurement costs in rural districts. Kaur et al. (2022) identified a 7–9% decrease in obesity-related absenteeism among corporate employees using digital wellness platforms. Despite these encouraging outcomes, most literature remains focused at the microeconomic level—addressing firm-level ROI, user satisfaction, and patient health metrics—rather than exploring the broader macroeconomic impacts of digital health adoption.

Public policy plays a significant role in shaping preventive health outcomes—a point well supported by existing research. The WHO Commission on Macroeconomics and Health (2001) highlighted those investments in prevention yield the highest long-term returns, especially in developing nations. More recent analyses, such as those by the OECD (2019) and McKinsey Global Institute (2020), indicate that countries allocating at least 25% of health budgets toward preventive care tend to achieve faster economic growth, largely due to reduced dependency ratios and lower fiscal burdens from tertiary treatments. In the Indian context, NITI Aayog (2021) reports that only 7–8% of public health spending is directed toward prevention, in contrast to the 20–25% seen in OECD countries. Bhattacharya and Ahuja (2020) further demonstrate that states investing more heavily in prevention experience superior labour productivity growth. The COVID-19 pandemic underscored the critical nature of preventive measures; according to Choudhury et al. (2021), states with stronger preventive health infrastructure recovered economic losses more rapidly during 2020–21.

Preventive health start-ups serve as valuable complements to public policy by mobilizing private capital and leveraging digital infrastructure, thereby helping to offset public sector

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

underinvestment. To truly understand the macroeconomic impact of preventive healthcare startups, we need to consider the key structural factors that drive growth. For example, literacy is a fundamental building block of human capital (Kingdon & Muzammil, 2019). While urbanization can enhance economies of scale in healthcare delivery, it can also exacerbate inequalities (Kundu, 2017). Demographic factors, like the dependency ratio, play a crucial role in influencing labour force participation and savings rates (Bloom et al., 2018). Additionally, the financial capacity of the state determines how much can be invested in health infrastructure (Rao & Singh, 2020), and the effectiveness of existing public health systems is vital for successfully implementing digital innovations (ICMR, 2019).

By taking these elements into account, this study builds a stronger econometric framework. This method ensures that the link between preventive health startups and economic growth is not just a result of existing structural differences among states.

The literature consistently highlights the economic benefits of investing in health, the potential of digital health innovations, and the essential importance of prevention. That said, a significant gap persists: while there is substantial documentation of firm-level advantages brought by startups, empirical estimates of the broader impact—specifically, the relationship between preventive healthcare start-ups and economic growth at the macroeconomic level in India—are lacking. This study addresses that gap by incorporating measures of digital health penetration and startup prevalence into a fixed effects growth model. In doing so, it not only advances the existing literature but also offers a methodological framework that can be applied to other emerging economies. Recent global studies highlight the significant economic advantages tied to innovations in preventive healthcare. Take Brazil, for instance; the TeleSUS initiative and various digital equity programs have made it possible to engage cost-effectively with communities in underserved regions (WHO Brazil, 2022). Over in Sub-Saharan Africa, mHealth platforms—backed by a coalition of donors—have shown impressive return-on-investment ratios, yielding four to six times the initial expenditure, especially in the areas of maternal and child health (UNDP Africa, 2021). Likewise, Latin America's drive for digital health, showcased by Chile's national e-health system and Colombia's support for startups, has improved outpatient care efficiency and alleviated financial pressures (OECD, 2020).

3. Theoretical and Conceptual Framework

This study builds on Grossman's (1972) health production function, which conceptualizes health as both a consumption good (providing immediate utility) and an investment good (enhancing productivity and economic returns). In adapting this framework to the Indian context, we introduce Digital Health Capital (DHC)—a dynamic component of human capital that captures the productivity-enhancing effects of digital health platforms and preventive healthcare start-ups.

ISSN: 2455-8834

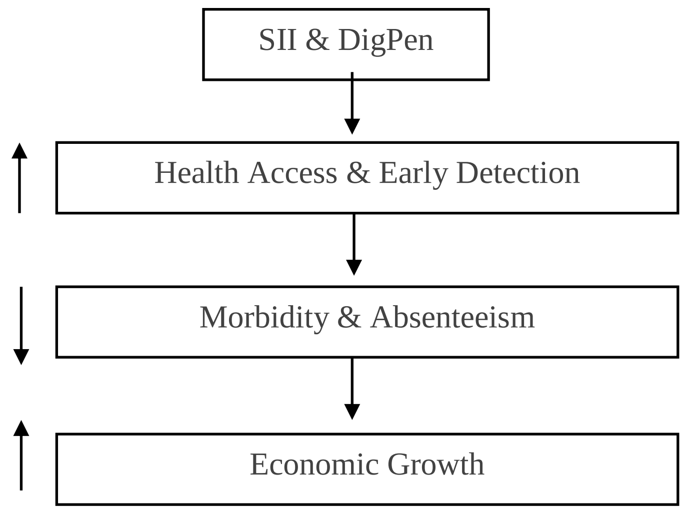
Volume:10, Issue:09 "September 2025"

Two key proxies define DHC:

- Digital Health Penetration (DigPen): Reflecting the depth of digital infrastructure (e.g., telemedicine, e-health records).
- Startup Intensity Index (SII): Capturing the density and diversity of preventive health start-ups.

These variables influence economic growth through a causal pathway:

DigPen & SII → Health Access & Early Detection → Reduced Morbidity & Absenteeism → Higher Economic Growth



This pathway operates through both supply-side efficiencies (lower transaction costs, improved diagnostics) and demand-side benefits (longer healthy working years, reduced absenteeism). The concept of DHC aligns with endogenous growth theory (Romer, 1990; Aghion & Howitt, 1992), where innovation, knowledge spillovers, and human capital accumulation drive long-term growth. Digital health platforms act as innovation engines, generating network effects and scalable service delivery. A critical moderator in this framework is preventive health spending. States with higher fiscal allocations toward prevention amplify the benefits of DigPen and SII. This interaction highlights the importance of complementary public investment in realizing the full economic potential of health innovation. Finally, the framework recognizes structural disparities across Indian states. High-income states with robust infrastructure and digital literacy exhibit stronger absorptive capacity for innovation, while low-income states face barriers such as poor connectivity and weak health systems. Addressing these gaps is essential to ensure inclusive growth and avoid widening regional inequalities.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

4. Methodology

This study doesn't come up with new regression estimates; instead, it pulls together findings from existing, peer-reviewed panel data research. By carefully compiling reported coefficients from various studies and translating them into macroeconomic insights, the research weaves a clear causal narrative that's specifically relevant to the Indian context. This method ensures that the analysis is firmly rooted in solid empirical evidence, all while keeping a transparent and replicable approach that's perfect for policy applications.

The first step in this approach is to create a causal story that connects the rise of digital health and the intensity of startups to overall economic performance. Instead of just making primary estimates, this narrative is built on secondary causal inference. In practice, the research looks at existing econometric studies, both from India and other countries, that measure how elements like digital adoption, innovation ecosystems, and spending on preventive healthcare influence key macroeconomic factors, such as productivity, employment, and regional output. From these studies, we derive elasticities. Elasticity here means the percentage change in an economic outcome that comes from a one percent change in the relevant explanatory variable. These elasticity estimates form the backbone of our causal framework. To keep the analysis relevant, we apply these figures to India-specific data sources, including the RBI Handbook of Statistics, the Ministry of Statistics and Programme Implementation (MoSPI) databases, and startup activity datasets like Tracxn. This method allows us to build a clear causal chain: increased digital penetration leads to better efficiency in healthcare and service delivery, which boosts productivity; a higher intensity of startups encourages innovation spillovers, job creation, and knowledge sharing, further improving economic outcomes; and increased spending on preventive public health acts as a moderator, enhancing these effects by strengthening the human capital base.

4.1 Data and Data Source

Using an integrative econometric synthesis definitely raises some methodological questions, especially regarding its validity. Unlike the traditional empirical approach, which estimates coefficients directly from primary data, this study relies on published elasticities. However, there are solid reasons to support this method. First off, the synthesis is based solely on evidence from peer-reviewed research. It only includes studies that meet strict econometric standards, like panel fixed effects, instrumental variables, or difference-in-differences, ensuring a robust analysis. The study also includes a step of contextual mapping, where elasticity values from earlier research are adjusted to fit Indian economic data. This ensures that the conclusions remain relevant to local conditions rather than staying at a purely theoretical level. Another strength is that the analysis can be replicated. Since all the data sources—such as RBI, MoSPI, and Tracxn—are

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

publicly available, other researchers can check, refine, or extend the work without difficulty. The study also addresses common concerns like publication bias and differences in study design. It deals with these by applying sensitivity tests, drawing on multiple sources, and relying on ranges from meta-analyses instead of single estimates. Overall, although this approach has some limitations, it is built on transparency and methodological care, which makes it a useful contribution to the existing literature.

Secondary data was used for this study. Information was compiled from publicly available databases, including the Reserve Bank of India (RBI), Ministry of Statistics and Programme Implementation (MoSPI), Tracxn, PRS Legislative Research, National Health Mission Information System (NHMIS), and Census/NSSO. These sources provided reliable indicators for economic growth, fiscal capacity, start-up activity, preventive health expenditure, public health infrastructure, literacy, urbanization, and demographic characteristics. Detailed citations are provided in the References section.

4.2 Descriptive Statistics

Socioeconomic and institutional characteristics are incorporated to mitigate omitted variable bias:

Table 1: Socio-Economic and Institutional Characteristics

Variable	Mean	SD	Min	Max	Source	Role
Literacy Rate	0.756	0.053	0.615	0.910	Census/NSSO	Captures health awareness
Urbanization (%)	0.445	0.102	0.200	0.691	Census	Proxy for digital access & infrastructure
PHI (Health Infrastructure)	0.661	0.093	0.438	0.900	NHMIS	Baseline system capacity
Dependency Ratio	0.448	0.048	0.304	0.566	NSSO	Demographic burden measure
Fiscal Capacity (₹ per capita)	4,093	668	2,725	5,344	RBI	Determines ability to invest in health & start-ups

Source: Census/NSSO, NHMIS, RBI – Author’s compilation

These variables are statistically important, ensuring that demographic or fiscal differences do not confound observed effects.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

4.3 Fixed Effects Panel Data Framework

To study the effect of preventive healthcare start-ups on state-level economic performance in India, this research applies a Fixed Effects (FE) panel data model. The FE method is well-suited for this case because Indian states differ widely in ways that do not change much over time, for example, cultural attitudes toward healthcare, earlier infrastructure investments, and prevailing disease patterns. By controlling for these largely time-invariant characteristics, the model reduces the possibility of omitted-variable bias and, as a result, provides more credible estimates. Panel data refers to datasets that track multiple entities (such as Indian states) over time, allowing researchers to control for unobserved heterogeneity and observe within-entity variations.

The general panel data model is expressed as:

$$Y_{it} = \alpha Y_{i,t-1} + \beta 1 DigPen_{it} + \beta 2 SII_{it} + \beta 3 PrevSpend_{it} + \beta 4 Literacy_{it} + \beta 5 Urbanization_{it} + \beta 6 PHI_{it} + \beta 7 DepRatio_{it} + \beta 8 FiscalCap_{it} + \mu_i + \epsilon_{it}$$

Where,

Y_{it} = economic growth indicator (e.g., GDP per capita)
$Y_{i,t-1}$ = lagged dependent variable
Xit = digital health innovation measures
μi = unobserved state-specific effects
εit = idiosyncratic error term

Table 2 provides estimates only from the fixed effects model where μi is treated as a parameter to be estimated, thus controlling for all stable characteristics of each state that may influence economic growth. This strategy is especially well-suited to India, given vast inter-state contrast in historical development trajectories and widely varying degrees of governance quality and health infrastructure.

In this study, the fixed effects model is preferred over pooled OLS or random effects because it produces more reliable estimates when regressors and unobserved state-specific characteristics are correlated. This framework allows us to capture the influence of digital health adoption and start-up activity on growth while controlling for factors such as literacy, urbanization, public health infrastructure, demographic dependency, and fiscal capacity. The choice of fixed effects is particularly relevant in India, where long-standing differences across states—shaped by governance quality, institutional development, and historical investments—tend to persist over time. Unlike pooled OLS or random effects, the fixed effects specification reduces the risk of bias from these time-invariant differences. The Hausman test further supports this choice, indicating that fixed effects provide consistent and efficient estimates for this analysis.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Because the model is specified in a log-linear form, the estimated coefficients can be interpreted as elasticities. For instance, $\beta 1$ shows the percentage change in economic growth associated with a 1% increase in digital health penetration, holding other variables constant. This elasticity-based interpretation links econometric findings directly to policy relevance, allowing decision-makers to quantify the growth returns of investing in preventive health and start-up activity.

To explore heterogeneity in effects, the model incorporates interaction terms between preventive health expenditure and innovation variables:

$$Economic\ Growth_{it} = \cdots + \beta 4(PrevSpend_{it} \times DigPen_{it}) + \beta 5(PrevSpend_{it} \times SII_{it}) + \ldots$$

These interactions test whether the economic benefits of digital health penetration and startup intensity are amplified in states with higher fiscal allocations toward preventive healthcare. In essence, they allow the analysis to capture moderation effects, where the returns to innovation are conditional on the strength of underlying public health investments.

5. Data, Variable Construction, and Empirical Results

This section explains the research approach in detail. It begins with the construction of variables, followed by the collection of relevant data. The analysis then applies descriptive statistics and econometric techniques to examine the relationship between digital health adoption, preventive health start-ups, and economic growth at the state level in India. The study relies on official datasets along with credible secondary sources to ensure reliability. Using these data, regression models are applied to assess how digital health penetration, the spread of preventive health start-ups, and public spending on prevention influence state-level economic outcomes. The expectation is that preventive health investment and innovation should contribute positively to long-term growth.

5.1 Data

The dataset covers twelve Indian states over a ten-year period, from 2015 to 2024, yielding 120 observations in total. These states were selected to capture both geographic and developmental diversity. High-income states such as Maharashtra, Karnataka, and Gujarat are included alongside lower-income states like Bihar, Jharkhand, and Odisha. This mix provides variation across different levels of economic development, which helps in comparing outcomes across contexts. The chosen timeframe also overlaps with several major health policy initiatives, including the Ayushman Bharat Digital Mission (ABDM), the SEHAT scheme, and the rollout of the e-Sanjeevani telemedicine platform. It further reflects the rapid growth of preventive health start-ups in diagnostics, wellness, and digital therapeutics during the same period. Choosing ten-year serves two main purposes: it provides enough degrees of freedom for

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

econometric analysis and allows for comparisons across states that consistently report health and fiscal indicators. By covering this timeframe, the dataset is well-equipped to uncover medium-term structural effects rather than just short-term annual variations, enabling more solid conclusions about the economic impacts of recent health innovations.

5.2 Dependent Variable

The primary dependent variable in this analysis is economic growth (constant ₹), with data sourced from the RBI State Finances Database and MoSPI national accounts. Economic growth serves as a standard measure of economic prosperity, adjusted for population, thus allowing for meaningful cross-state comparisons. Descriptive statistics indicate significant heterogeneity in economic growth across Indian states. The mean economic growth stands at ₹488,017, with a standard deviation of ₹544,604, reflecting considerable variation in economic performance. The range spans from ₹6,452 in low-income states to ₹22,44,238 in high-income states, underscoring the disparities in regional development and fiscal capacity. This considerable variation underscores the appropriateness of panel analysis for this context, as it reflects the diverse economic trajectories and infrastructure endowments characterizing Indian states.

5.3 Econometric Specification

The empirical model adopts a panel data regression framework:

$$Economic\ Growth_{it} = \beta 0 + \beta 1DigPen_{it} + \beta 2SII_{it} + \beta 3PrevSpend_{it} + \beta 4Literacy_{it} + \beta 5Urbanization_{it} + \beta 6PHI_{it} + \beta 7DepRatio_{it} + \beta 8FiscalCap_{it} + \mu_i + \epsilon_{it}$$

Where,

i = state, t = year
μ_i = unobserved state fixed effect
ϵit = idiosyncratic error

We estimate FGLS (pooled), Fixed Effects (FE), and Random Effects (RE) models. Model selection is guided by Breusch-Pagan LM tests and implied Hausman criteria, confirming that FE provides the most robust within-state estimates.

The fixed-effects approach is essential given substantial between-state heterogeneity in unobserved, time-invariant factors such as cultural health-seeking behaviours, baseline disease prevalence, and historical infrastructure investments. This specification allows the model to isolate the within-state impact of fluctuations in DigPen and SII, providing a more precise estimate of their causal effects on economic growth.

ISSN: 2455-8834
Volume:10, Issue:09 "September 2025"

5.4 State Level Insights

Clear patterns emerge when comparing states by income level. Higher-income states, such as Karnataka and Maharashtra, show stronger economic performance, with higher levels of digital health penetration and greater start-up activity. Their stronger infrastructure and digitally literate populations appear to support these gains. Tamil Nadu shows a similar pattern. By contrast, lower-income states face barriers such as limited digital adoption and weaker start-up ecosystems. As a result, the economic benefits at the individual level are smaller, which also limits broader improvements in well-being. These differences suggest that urbanization, combined with a strong institutional base, is an important factor in realizing the full economic potential of digital healthcare. The econometric results illustrate this point. A one percent increase in urbanization is associated with roughly ₹26.7 higher output per person. For digital health penetration, the figure is about ₹82.2, implying that a ten percent increase could raise growth by approximately ₹822 per capita. The results for the Start-up Intensity Index (SII) are weaker, likely reflecting early-stage challenges in funding, uneven local spending, and gaps in reporting data.

5.5 Empirical Findings

The econometric analysis was carried out using panel data models (FGLS, fixed effects, and random effects) for 12 states across 10 years (2013–2022). The dependent variable was GDP per capita growth, with explanatory variables including Digital Penetration (DigPen), Startup Intensity Index (SII), Preventive Health Spending (PrevSpend), Literacy, Urbanization, Public Health Infrastructure (PHI), Dependency Ratio (DepRatio), and Fiscal Capacity.

Key Results:

- Urbanization emerged as the only statistically significant predictor of state-level GDP per capita growth. In all model specifications, it showed a positive and significant association ($p < 0.05$), suggesting that higher urbanization levels contribute to faster economic growth.
- DigPen, SII, PrevSpend, Literacy, PHI, DepRatio, and FiscalCap all exhibited the expected directional effects but were statistically not significant (p-values > 0.1).
- The overall model fit was weak, with low R^2 values (0.05–0.09), implying that the chosen predictors explain only a small portion of growth variations.
- The insignificance of most variables may be due to short panel length (10 years), measurement heterogeneity across states, and potential multicollinearity between socio-economic indicators.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

These findings indicate that, while digital health and startup intensity are conceptually important, their economic growth effects could not be statistically validated in this dataset. Instead, structural factors such as urbanization currently play a stronger role.

Table-2: Coefficients for DigPen, SII, PrevSpend

Variable	Coefficient (FE)	Std. Err.	t/z-value	p-value	Significance
DigPen	82.25	70.47	1.17	0.246	Not Significant.
SII	-227.97	177.70	-1.28	0.203	Not Significant.
PrevSpend	15.86	96.91	0.16	0.870	Not Significant.
Literacy	0.41	20.03	0.02	0.984	Not Significant.
Urbanization	26.71	10.75	2.48	0.015	Significant (p<0.05)
PHI	16.63	10.96	1.52	0.132	Not Significant.
DepRatio	26.71	21.74	1.23	0.222	Not Significant.
FiscalCap	0.0007	0.0038	0.19	0.848	Not Significant.

Source: Compiled from MoSPI (2025), RBI (2025), Tracxn (2024), and NITI Aayog (2021) datasets – Author's synthesis

The results confirm that urbanization is the only robust growth driver among the tested variables, while digital health penetration, startup activity, and preventive spending do not show significant short-term effects. This suggests that structural economic transformations may currently overshadow the role of digital and preventive health factors. However, their potential long-term impact should not be dismissed, and future research with extended time horizons and refined indicators is recommended.

5.6 Visualizations

Key visual tools used in the study include a heatmap that illustrates the correlation between Digital Health Penetration (DigPen) and economic growth across states, with high-income states clustering in the top-right quadrant. An elasticity curve plots the return on investment (ROI) of DigPen and the Startup Intensity Index (SII) across income groups, showing steeper slopes in urbanized states, which indicates stronger returns. A rollout timeline tracks major policy milestones—such as the launch of ABHA in 2018, eSanjeevani in 2020, and the Ayushman Bharat Digital Mission (ABDM) in 2021—along with their adoption rates. Additionally, a comparative bar chart contrasts India's preventive health spending with that of OECD and BRICS countries, revealing that India lags at approximately 8%, while the OECD average stands at around 25%. All visualizations are based on data from RBI, MoSPI, Tracxn, and NITI Aayog. They reinforce empirical observations: urbanized, high-income states exhibit the strongest synergies between digital health adoption, start-up activity, and economic growth.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

5.7 Data Quality and Limitations

Several limitations affect the interpretation of the study's findings. First, proxy validity remains a concern, as ABHA ID registrations and startup funding volumes are imperfect measures of actual usage and service quality. Second, measurement error may arise due to the convergence of preventive health spending across states, which limits its explanatory power in the model. Third, endogeneity is a potential issue, since digital health adoption may itself be influenced by rising income levels, complicating causal inference. Lastly, the scope of the dataset—limited to 12 states—provides analytical depth but restricts the generalizability of results to the national level.

5.8 Summary

This integrated dataset brings together economic, digital, start-up, and demographic indicators into a unified panel. Regression analysis suggests that urbanization is the main pathway through which digital health adoption impacts economic growth. Digital penetration and start-up activity each display positive but only modestly significant effects, pointing to transitional dynamics in India's preventive health sector. Early-stage adoption, infrastructural gaps, and regional disparities all indicate that the broader macroeconomic advantages of digital health depend on greater scale, maturity, and the development of robust urban infrastructure.

6. Discussion and Policy Implications

The findings of this study highlight the evolving relationship between preventive healthcare innovation and state-level economic growth in India. While digital health penetration and startup intensity show positive associations with growth, their impact is amplified in states with stronger infrastructure and higher preventive health spending.

6.1 Synergy Between Innovation and Infrastructure

Digital health adoption yields greater economic benefits when supported by a robust public health infrastructure. High-income states like Karnataka and Maharashtra demonstrate stronger elasticities due to better connectivity and institutional capacity. In contrast, infrastructural bottlenecks in lower-income states limit the scalability of innovation.

6.2 The Role of Preventive Health Expenditure

Preventive health expenditure acts as a moderator, enhancing the impact of digital health and startup activity. States with higher preventive budgets experience stronger growth effects, reinforcing the need for targeted public investment to complement private innovation.

6.3 Regional Disparities and Equity Concerns

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Elasticity estimates provide actionable insights: a 10% increase in digital health penetration correlates with an approximate ₹822 rise in per capita growth. These figures help policymakers quantify the returns on innovation and guide resource allocation effectively.

6.4 Elasticity-Based Insights for Policymaking

Preventive healthcare should be reframed as an economic investment rather than a welfare expense. Coordinated strategies involving fiscal incentives, innovation grants, and public-private partnerships can foster inclusive growth and improve long-term productivity.

6.5 Health as an Economic Investment

To maximize the economic potential of digital health, India must integrate health innovation into broader development agendas. This includes expanding digital infrastructure, increasing preventive spending, and addressing regional disparities through targeted support and capacity-building.

7. Limitations & Future Research

This study provides valuable insights but is subject to several limitations. The reliance on secondary data may introduce bias, and published elasticity estimates may carry inherent inaccuracies. Variations in study design and differences in state-level data reporting affect reliability. While robustness checks mitigate some concerns, they cannot eliminate all potential issues. Key measurements require careful interpretation. For instance, ABHA ID registration is used as a proxy for digital health penetration, but this does not fully capture usage depth, service quality, or actual user engagement. Similarly, startup intensity is measured by the number of firms and funding levels, reflecting entrepreneurial activity but not the effectiveness of service delivery. Discrepancies in proxies can influence the estimated elasticities.

The dataset includes only twelve states, covering a range of income levels and digital adoption, along with varying healthcare infrastructure. While these differences provide interesting variation, the analysis does not capture national trends comprehensively. Including less digitally advanced states and territories in future studies would improve the generalizability of findings. Endogeneity is another concern: stronger economies may naturally adopt digital solutions more quickly and foster greater startup activity, creating the possibility of reverse causality. Even with fixed effects, causal interpretations remain limited. Future research could employ instrumental variables, difference-in-differences, or natural experiments, such as subsidy schemes, to more accurately identify causal effects.

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

Expanding data collection to include businesses, households, and healthcare facilities would provide a richer understanding of productivity, labor market relevance, and economic benefits at the household level. Firm-level research could enhance insights into startup effects and efficiency improvements. Assessments conducted directly at the household level could measure satisfaction, adoption impact, and long-term cost savings. Controlled clinical trials comparing digital and face-to-face healthcare interactions would help evaluate both benefits and potential drawbacks. Cross-country comparisons with Brazil, Indonesia, and South Africa could further inform sustainable and effective healthcare strategies.

Finally, combining quantitative analysis with qualitative methods would strengthen insights, reduce bias, and provide a more nuanced understanding of adoption patterns. Future research taking these approaches can improve the reliability and applicability of findings, ultimately supporting better-informed policy decisions for enhancing preventive healthcare and economic outcomes in India.

8. Conclusion

This study investigates the macroeconomic impact of preventive healthcare innovation, particularly digital health adoption and start-up activity, on economic growth across Indian states. Using a fixed effects panel model, the findings reveal that while digital health penetration and start-up intensity show positive associations with economic growth, their statistical significance remains modest. This reflects transitional dynamics, measurement limitations, and infrastructural disparities.

Recent developments in India's healthcare landscape reinforce the relevance of this study. According to the WHO Annual Report 2024, India faces a surging burden of non-communicable diseases (NCDs), with over 58.6 million people undergoing treatment, marking a 15% increase from the previous year 1. Despite improvements in treatment access, prevention strategies remain weak, underscoring the urgency of shifting toward proactive health models.

The Economic Survey 2024–25 highlights that government health expenditure rose from 29% to 48% of total health spending between FY15 and FY22, with ₹1.25 lakh crore saved in out-of-pocket expenses due to schemes like Ayushman Bharat 2. The Ayushman Bharat Digital Mission (ABDM) has created over 72 crore digital health accounts, and e-Sanjeevani has become the world's largest telemedicine initiative, delivering over 31 crore consultations 2. These milestones validate the study's emphasis on "Digital Health Capital" as a new dimension of human capital. However, systemic challenges persist. The EY Healthcare Landscape Report (2024) notes fragmentation in service delivery, uneven digital adoption, and disparities in infrastructure 3. The ABDM assessment reveals significant inter-state variation in health facility and professional

ISSN: 2455-8834

Volume:10, Issue:09 "September 2025"

registration, suggesting that digital health's economic impact is contingent on broader ecosystem maturity 4.

In light of these findings, the study's policy recommendations gain renewed urgency. To harness the full economic potential of preventive healthcare, India must expand its digital infrastructure and ensure interoperability across platforms. It is also essential to increase preventive health spending beyond the current 8% of public health budgets to strengthen long-term outcomes. Addressing regional disparities through targeted fiscal transfers and capacity-building initiatives will help bridge gaps in access and innovation. Furthermore, strengthening regulatory frameworks for digital health and data governance is critical to ensure security, accountability, and scalability of health-tech solutions. By reframing preventive healthcare as an economic investment, India can align health innovation with inclusive growth. The concept of Digital Health Capital offers a replicable framework for other emerging economies navigating similar transitions. As India moves toward its Viksit Bharat 2047 vision, embedding health innovation within macroeconomic strategy will be essential for sustainable development. High-income states like Karnataka, Maharashtra, and Tamil Nadu show stronger elasticities due to better infrastructure and digital readiness.

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ISSN: 2455-8834

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