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Exploring the Synergies Between SDG 9 and SDG 3: The Role of Innovation and Infrastructure in Enhancing Public Health

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ABSTRACT

If development lacks sustainability, it can be considered an invitation to disasters in the future. The present study focuses on reviewing documents available on a reputed Scopus database to assess the intersection of SDG 9 and SDG 3. To acquire awareness of the role of industry, technology, and infrastructure in improving health outcomes, documents were studied based on specific inclusion criteria, and a search was made based on specific search strings. In culmination, the synergistic interplay between technical and industrial inventions, infrastructure evolution, and integrated procedure frameworks is prominent for extending the accomplishment of SDG 3 and SDG 9, wherein strategic investments in health systems, sustainable approaches, and cross-sectoral affiliations catalyse not only impartial public health developments but also facilitate resilient financial growth while managing global dissimilarities and guaranteeing long-term sustainability for forthcoming ages.

1. INTRODUCTION

The intersection of SDG 9 (Industry, Innovation, and Infrastructure) and SDG 3 (Good Health and Well-being) represents a pivotal nexus for sustainable development, where the transformative potential of technological and industrial innovations, alongside robust infrastructure systems, is poised to catalyse significant advancements in public health; however, a comprehensive understanding of how these synergies can be effectively leveraged to enhance global health outcomes [1, 2], particularly in under-resourced and marginalised contexts, remains underexplored and demands further scholarly attention.

Industrial development is considered significant for generating equal growth opportunities across different regions [3-5]. Considering the need for economic development without compromising ecological development, the SDGs have emerged [6, 7]. Industrial development without environmental degradation is possible only through integrating the blend of Industry, Innovation, and Infrastructure in developmental activities. This phenomenon has been the objective of SDG 9 [8, 9]. For the development of industry and infrastructure sustainability, shifting the usage to green technologies and renewable energy from brown technology to non-renewable energy is necessary [10].

Furthermore, all SDGs can be successfully implemented with the efforts of well-coordinated activities of Human Beings. The health of human beings, therefore, is necessary for the development of all aspects of SDGs, as a healthy workforce is capable of completing given tasks effectively and efficiently. This requirement creates an urge for the triumphant functioning of SDG 3. SDG 3 broadly is a 4-fold coverage:

- Physical health [11]
- Mental Health [12]
- Emotional Wellbeing [13]
- Social Wellbeing [14]
- Economic Well-being [15]

This review is crucial because it examines the necessary interconnections between well-being, financial development, and sustainable development [16], delivering practical discernment into how novel ideas in industriousness and infrastructure can be harnessed to accomplish SDG 3 and 9 [17-19], thereby supplying an encyclopedic Blueprint for policymakers, companies, and stakeholders to execute transformative explanations that stimulate unbiased general fitness consequences, stimulate monetary soundness, and assure environmental sustainability for forthcoming epochs, creating it a must-read for those earmarked to rising global well-being and wealth [20, 21].

Table 1 presents the important definitions of variables used in the study.

Table 1. Important definitions

Term	Definition
Technological Innovations [22]	The application of advanced digital tools, artificial intelligence, machine learning, and big data analytics in health, industry, and infrastructure, driving efficiency, precision, and sustainability in development processes and health systems [23].
Industrial Innovations [24]	Transformations in manufacturing, energy, and infrastructure sectors through the adoption of sustainable practices, automation, and cutting-edge technologies aimed at fostering resilient economic growth and reducing environmental footprints [25].
Health Systems Resilience [26]	The capacity of health infrastructures to withstand and recover from challenges such as pandemics, natural disasters, and socio-economic disparities, underpinned by robust policy frameworks and integrated health technologies [27].
Sustainable Development [28]	The pursuit of development that meets current needs without compromising the ability of future generations to meet their own needs, balancing economic growth, environmental stewardship, and social inclusion [29].
SDG 3 (Good Health and Well-being) [30]	A United Nations Sustainable Development Goal that aims to ensure healthy lives and promote well-being at all ages by addressing universal health coverage, reducing maternal mortality, combating diseases, and promoting mental health and wellness [31].
SDG 9 (Industry, Innovation, and Infrastructure)	A goal aimed at building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation, with the dual objective of achieving sustainable economic growth and reducing inequalities globally [32].
Telemedicine [33]	The provision of healthcare services remotely through digital platforms, leveraging telecommunications technologies to offer consultations, diagnostics, and treatment, especially in underserved and rural areas [34].
Green Technology [35]	Environmentally sustainable technologies are designed to mitigate the negative impact of industrialisation by minimizing energy consumption, utilising renewable resources, and reducing emissions and waste [33].
Brown Technology [36]	Technologies that contribute to environmental degradation through unsustainable practices, heavy reliance on fossil fuels, and excessive carbon emissions often exacerbate climate change and ecosystem destruction.
Universal Health Coverage (UHC) [37]	A health policy framework that ensures all individuals and communities receive the health services they need without suffering financial hardship [38], encompassing prevention, treatment, and essential health services [39].
Data-Driven Decision Making [40]	The process of using data analytics, artificial intelligence, and machine learning to inform and guide health policies, resource allocation, and public health strategies, enabling more precise, evidence-based interventions [41-43].
Circular Economy [44]	An economic system that emphasizes reducing waste, reusing materials, and recycling products throughout their lifecycle [45], aiming to create a closed-loop system where the value of products and materials is maintained for as long as possible [46].
Green Health Technologies [47]	Innovations within the healthcare sector that prioritize environmental sustainability include energy-efficient medical devices, low-carbon health solutions, and waste-reducing technologies [48].
Cross-Sector Collaboration [49-51]	The process of fostering cooperation between different sectors, including health, education, industry, and finance [52], to create integrated, holistic approaches that address multi-dimensional challenges and ensure comprehensive development [53].
Health Impact Bonds [54-56]	Financial instruments that use private investment to fund health-related projects, with returns based on achieving predefined health outcomes, incentivizing innovative solutions to public health challenges [57].

2. RESEARCH GAP

The paucity of comprehensive analyses exploring the intricate interdependencies between sustainable industrial innovation [58] and infrastructure development [59] and their collective impact on public health outcomes [60, 61] presents a critical research gap, particularly in understanding how these domains synergistically contribute to advancing both SDG 9 and SDG 3 in disparate socio-economic and geographic contexts [62].

Despite nascent attempts to interlace the conceptual underpinnings of SDG 9 (Industry, Innovation, and Infrastructure) with SDG 3 (Good Health and Well-Being), the extant literature remains conspicuously deficient in systematically articulating [63, 64] and thereby bridging-these integrative shortcomings, necessitating a more explicit exposition of previous studies' failure to harmonize infrastructural advancement with public health imperatives [65, 66], thus underscoring the acute lacuna this manuscript seeks to redress.

3. RESEARCH QUESTIONS

RQ 1. How do innovations in industry, technology, and infrastructure contribute to improving health outcomes and achieving SDG 3 (Good Health and Well-being)?

RQ 2. What synergies and challenges exist between SDG 9 (Industry, Innovation, and Infrastructure) and SDG 3 (Good Health and Well-being) in the context of sustainable development and health equity?

RQ 3. How can the integration of sustainable industrial practices and healthcare innovations improve access to health services and contribute to the achievement of both SDG 9 and SDG 3 targets?

4. METHODOLOGY

To answer research questions and gain insight into the role of industry, technology, and infrastructure in improving health outcomes, a detailed review of documents available in the

Scopus database was conducted. Based on specific inclusion criteria (Table 2) for the documents to be studied, a search was made based on specific search strings, as shown in Table 3.

Figure 1 quantifies and visualizes the growth and trend of publications within a specific domain over time, providing crucial context for understanding the field's development and research activity.

Table 2. Inclusion and exclusion criterion

Criteria	Inclusion	Exclusion
Relevance to the Topic	• Studies addressing innovation in infrastructure for public health improvement. • Research focusing on the integration of SDG 9 (Industry, Innovation, and Infrastructure) and SDG 3 (Good Health and Well-being). • The role of technological advancements, smart healthcare systems, or infrastructure policy in improving health outcomes.	Studies unrelated to SDG 9, SDG 3, innovation, or infrastructure. Irrelevant health studies without an infrastructure or technology focus.
Language	English	Non-English
Publication Date	Between 2014 and 2024	Before 2014
Journal Type	Peer-reviewed journals or high-quality conference proceedings.	Non-peer-reviewed sources, blogs, or opinion articles.
Open Access	Open-access journals or open-access versions of articles in subscription-based journals.	Subscription-based articles without accessible versions in university.
Non-Peer-Reviewed Papers	--------	White papers, opinion pieces, or non-academic sources.
Duplicated Studies	More detailed versions of the same research.	Summaries, duplicates, or less detailed versions.

Table 3. Search strings on Scopus

Research Questions	Search String	Number of Publications on Scopus
RQ1	"innovation" OR "industry" OR "technology" OR "infrastructure") AND ("public health" OR "health outcomes" OR "health improvement" OR "SDG 3" OR "well-being") AND ("SDG 9" OR "sustainable development goals"	1549
RQ2	"SDG 9" OR "industry" OR "innovation" OR "infrastructure") AND ("SDG 3" OR "public health" OR "health equity" OR "health outcomes" OR "sustainable development") AND ("synergy" OR "interactions" OR "challenges" OR "barriers"	671
RQ3	"sustainable industrial practices" OR "clean energy" OR "green technologies" OR "healthcare innovation" OR "healthcare access") AND ("SDG 9" OR "industry" OR "infrastructure") AND ("SDG 3" OR "public health" OR "healthcare delivery" OR "health services") AND ("integration" OR "contribution" OR "improvement"	53

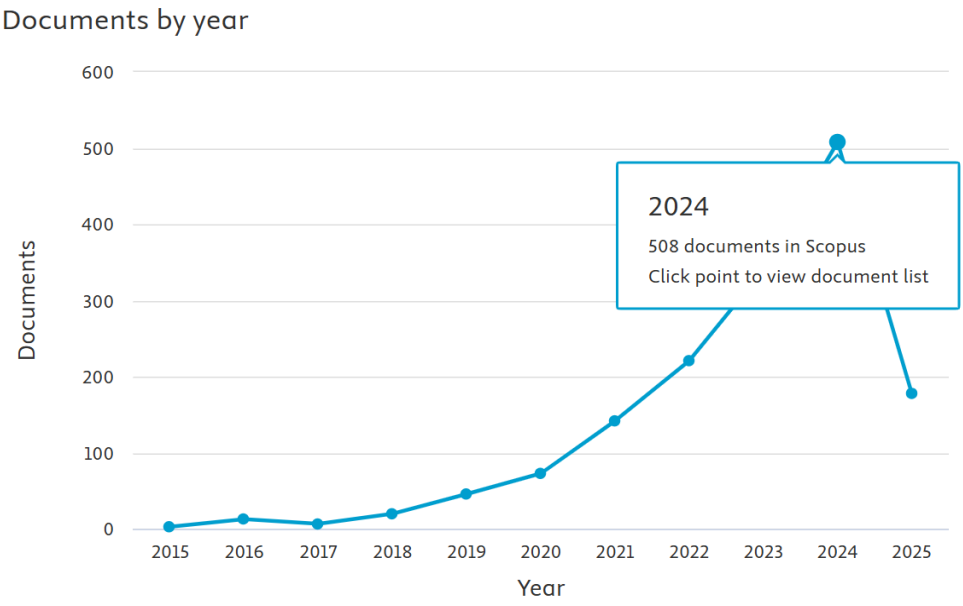

Figure 1. Trend of documents published in given domain

Figure 2 reveals the composition of research output by document type, highlighting the predominant forms of knowledge dissemination within the SDG domain and indicating the balance between theoretical and practical contributions.

Figure 3 illustrates the interdisciplinary nature of the SDG research field, showing the distribution of publications across various subject areas and highlighting the key disciplines contributing to the topic.

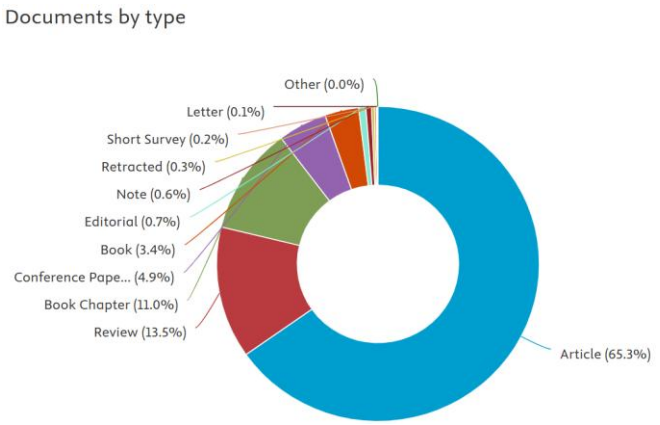

Figure 2. Dissection of document type for SDG

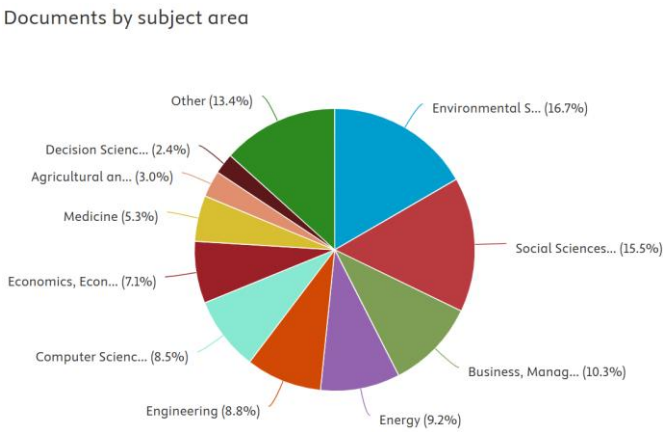

Figure 3. Bifurcation of documents by subject area

Figure 4 maps the geographical distribution of research output, revealing which countries are leading contributors to the SDG domain and highlighting potential disparities or collaborations in global research efforts.

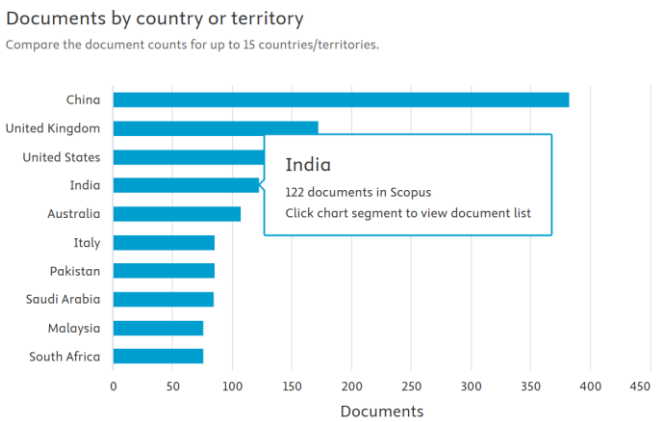

Figure 4. Country wise published documents

These figures collectively underscore the SLR's imperative by demonstrating a proliferating, polymorphous, interdisciplinary, and geographically dispersed corpus, necessitating rigorous synthesis to extract salient insights and mitigate epistemological fragmentation inherent within the domain's complex knowledge landscape. After filtration of above documents through PRISMA process below, research questions will be answered.

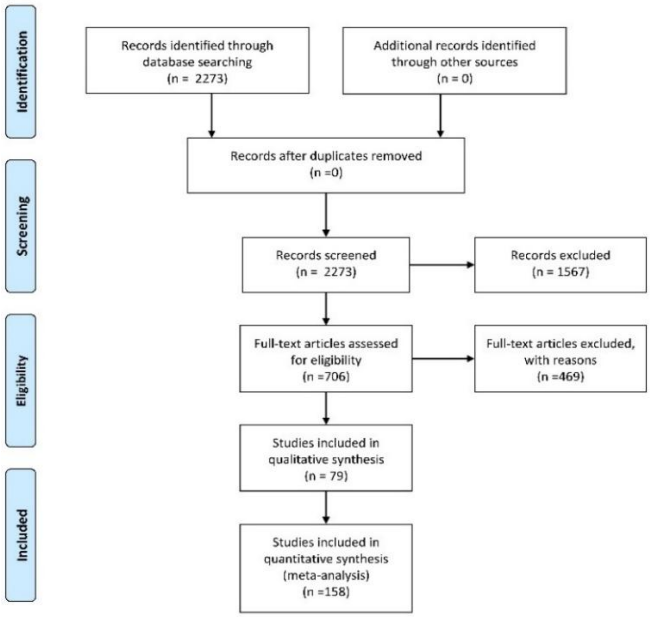

Figure 5. PRISMA roadmap

The search strings mentioned in Table 3 were entered on the Scopus website by selecting the tab of keywords for the search option. Based on the results, a thorough analysis of published work in the given domain was conducted to find the answers to the research questions. Established on the findings provided by the relevant researchers, an assessment of the role of innovation and infrastructure in enhancing public health was made. The findings and implications of the available literature were extracted, and an attempt to deliver all that on a single point is made in current research. To narrow down the available research, the PRISMA technique was used, the elaboration of which is given in Figure 5. Through its meticulously structured guidelines encompassing rigorous identification, screening, and inclusion protocols, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) furnishes a robust methodological scaffolding that not only galvanises transparency and replicability in the systematic literature review process but also fortifies the evidentiary bedrock for subsequent academic discourse and decision-making by ensuring the utmost comprehensiveness, uniformity, and methodological integrity in the collation and critical synthesis of empirical data. The filtration of documents based upon the PRISMA technique starts from 2273 documents, which is the total number of documents given in Table 3. All documents belong to the Scopus database; hence, additional records identified through other sources are zero. While screening the records of 2273 documents, 1567 documents were excluded as the policy implications mentioned in their abstract were no longer relevant in today's time. After eliminating 1567 documents, 706 documents were left out, of which 469 documents were again excluded because their findings were familiar with the

remaining documents that became part of the present research. Since the role of 469 documents was only to support the findings of the remaining documents, hence they were excluded, and 237 documents were chosen to conclude the present research. Out of 237 documents, 79 documents contain research that was qualitative in nature, and 158 documents contain research that was quantitative. Both qualitative and quantitative research are insightful for policy implications. Hence, both were used to answer the research questions. A literature review is conducted in the present research of these 237 documents to extract discerning answers to the given research problem.

5. RESULTS

5.1 Technological and industrial innovations in healthcare: Contributions to public health (SDG 3)

- **Technological Innovations and Health Outcomes:** The literature review reveals that technological upgradation in different fields is happening quickly [67-70]. From a health perspective, technological upgrades have three significant benefits. The first benefit found was an "earlier diagnosis." Earlier diagnosis refers to the ability to detect health conditions or diseases at their initial stages [71], often before symptoms appear, using advanced technologies like AI, genetic testing, and imaging, enabling timely intervention that can significantly improve treatment effectiveness and patient outcomes [72]. More premature diagnosis is valuable because it entitles opportune intervention, diminishing the stringency of infections, enhancing therapy success rates, controlling intricacies, and eventually improving survival percentage and quality of life while furthermore decreasing healthcare expenses via less intrusive and quicker medicine regimens [73]. Technological inventions have significantly altered healthcare, leading to enhanced health consequences via diagnosis, therapy, and improvements in patient consideration [73]. Blending cutting-edge technologies into healthcare approaches has improved efficiency, diminished medical mistakes, and enhanced general health assistance delivery [74-76]. This literature review investigates the connection between specialised inventions and fitness outcomes, emphasising the role of:
    - artificial intelligence (AI) [77]
    - telemedicine [78]
    - wearable devices [79]
    - other digital health solutions [80].

There is no doubt that the upcoming time cannot be imagined in the absence of artificial intelligence. Artificial intelligence and machine learning will be very influential in healthcare [81]. The blend of artificial intelligence and machine learning has been responsible for quickly improving the condition of patients in terms of diseases [82], which is further responsible for saving time and cost [83, 84]. The existing literature highlights the benefit of artificial intelligence in diagnosing serious diseases such as cancer [85, 86]. The available literature clearly states that artificial intelligence can analyse health reports, whether in the form of text or an image. This analysis is more accurate and quicker if the assessment is compared with human intelligence [87-89]. In the fast-moving world, completing tasks on time will be an indispensable part of healthcare diagnosis.

After "AI", telemedicine can be considered the second most significant advancement in health care. Telemedicine is the use of digital communication technologies, such as video conferencing, mobile apps, and remote monitoring tools, to provide healthcare services, including diagnosis, treatment, and consultation, to patients in remote or underserved areas, reducing the need for in-person visits, improving access to care, and enhancing the efficiency of healthcare delivery [90]. Telemedicine can be considered an essential addition to the domain of digital health. This facility has proven to be a blessing for rural and remote areas in developing countries. According to the literature review, the digitalisation of medicine, especially on mobile apps, has reduced the health boundary between urban and rural areas [91]. According to the literature review, the emergence of telemedicine has resulted in improved health outcomes.

People across the globe have shown a keen interest in wearable health devices. These smart devices help in the constant observation of significant health parameters in old patients, such as the rate at which their heart beats, oxygen levels in the blood, blood pressure, soundness of sleep, etc. Constant observation of these parameters can help generate reports, which, in combination with artificial intelligence, can be used to improve the health of the person. The literature review states that monitoring health through these devices can significantly reduce the prospective attack of severe diseases.

Other significant advancements in healthcare technological development include:

- Using blockchain to provide healthcare facilities [92]
- Using 3D printing in medicine
- Using data analytics and health information systems [93].

Integrating these innovations helps devise an ecosystem that serves as a beneficial advancement in the healthcare field [94-96]. Researchers have reviewed the fact that blockchain can make health-related information more authentic and reliable.

- **Industrial Innovations for Environmental Health:** Industrial innovations for environmental health are significant because they address critical challenges like pollution, resource depletion, and climate change while promoting sustainable development [97-100]. By embracing green manufacturing approaches, emission management technological development, and renewable power sources, enterprises can decrease their carbon footprint and play a significant role in the more pristine atmosphere, water, and earth [101, 102]. These refinements are indispensable for acquiring multinational sustainability objectives and confirming a harmony between industrial development and environmental conservancy [103-105]. Moreover, the detailed review showing the benefits of industrial innovation is shown in Table 4.

Table 4. Benefits of industrial innovation

Category	Industrial Innovation	Benefits
Green Manufacturing [106]	Eco-friendly production processes, renewable energy use	Minimizes waste and emissions, promotes sustainability
Waste Management Technologies [107]	Advanced recycling systems, waste-to-energy plants	Reduces landfill waste, converts waste into usable energy
Emission Control Innovations [108]	Scrubbers, filters, catalytic converters, carbon capture and storage (CCS)	Decreases air pollution, captures and stores CO_2 emissions
Sustainable Materials [109, 110]	Biodegradable and recycled materials, bio-based polymers	Reduces environmental impact, provides alternatives to plastics
Water Treatment and Conservation [111, 112]	Advanced water treatment systems, water recycling technologies	Prevents industrial water pollution, conserves water resources
Smart and Circular Economies [113]	Circular economy models, IoT [114], and AI for resource management	Promotes reuse and recycling, improves resource efficiency
Eco-Friendly Packaging [115, 116]	Compostable materials, lightweight packaging designs	Reduces packaging waste, lessens dependency on single-use plastics
Renewable Energy Integration [117, 118]	Use of solar, wind, and other renewable energy sources, energy-efficient equipment	Lowers industrial carbon footprints, promotes sustainable energy use
Noise and Thermal Pollution Control [119-123]	Soundproofing materials, thermal insulation technologies	Reduces industrial noise pollution, minimises heat discharge
Sustainable Supply Chain Innovations [124]	Green logistics, electric/hybrid vehicles, sustainable raw material sourcing	Lowers transportation emissions, supports eco-friendly supply chains

- **Health Innovation in Low-Resource Settings (Table 5):** Health innovation in low-resource settings refers to the development and implementation of context-specific [125], cost-effective, and scalable solutions-ranging from portable diagnostic tools to telemedicine platforms-that transcend infrastructural limitations and economic constraints [126], thereby fostering equitable access to healthcare [127], mitigating disparities, and enhancing the resilience of healthcare systems in underserved and economically constrained communities globally [128, 129].

Table 5. Category-wise impact of innovation on health

Category	Innovation	Impact
Telemedicine [130]	Mobile-based telemedicine platforms	Provides remote access to healthcare in underserved areas, reducing travel costs and improving access.
Portable Diagnostic Tools [131]	Point-of-care diagnostic devices for diseases like malaria, tuberculosis, and HIV	Enables early and accurate disease detection in areas with limited lab facilities.
Community Health Worker (CHW) Training [132]	Mobile apps and digital tools to train and support community health workers	Empowers CHWs to provide basic care and health education, improving healthcare delivery locally.
Low-Cost Medical Equipment	Affordable innovations like solar-powered refrigerators and portable ultrasound devices	Ensures access to essential tools in areas with limited electricity or infrastructure.
Vaccination Innovations [133, 134]	Heat-stable vaccines and drone delivery for immunization programs	Increases vaccine reach and efficacy in remote and resource-constrained regions.
Health Information Systems [135]	Simple, low-cost data management systems like open-source health records	Improves patient tracking, health planning, and care coordination.
Water and Sanitation Solutions [136]	Low-cost water purification systems and portable toilets	Reduces the spread of waterborne diseases, improving public health.
Solar-Powered Clinics [137]	Solar-powered health facilities or mobile clinics	Ensures reliable healthcare delivery in areas without stable electricity.
Mhealth Applications [138]	Mobile health apps for health awareness, appointment booking, and medication reminders	Enhances health literacy and empowers patients in resource-limited settings.
Community-Based Insurance [139]	Micro-insurance schemes for affordable healthcare access	Reduces financial barriers to accessing essential healthcare services.

Infrastructure Development: Impact on Health Equity and Access to Healthcare

Infrastructure evolution is paramount in enhancing health-equity [95] and access to healthcare by constructing establishments like hospitals, infirmaries, and conveyance approaches that associate individuals to medical assistance [140]. Even those in secluded or underserved regions can access fundamental healthcare [141, 142]. Well-built roads and digital technological systems, such as telemedicine [143], make it more leisurely for patients to correspond with physicians and for healthcare providers to produce timely sustenance [144]. By handling impediments like distance, expense, and undersupply of aids [145], infrastructural evolution enables the assembly of a more impartial and inclusive healthcare technique for everyone [146].

- **Healthcare Infrastructure and Access (Table 6):** Blooming healthcare infrastructure is critical for enhancing credentials in healthcare, particularly in isolated locations. Sounder infrastructure confirms that individuals can quickly visit medical establishments, acquire fortunate sustenance, and access cutting-edge therapies [147]. It furthermore sustains healthcare employees by furnishing the crucial mechanisms and areas to supply differentia benefits [148]. A robust healthcare infrastructure is essential for devising a fair, efficient, and affordable approach [149].

Table 6. Present status of healthcare infrastructure

Aspect	Urban Areas	Rural Areas
Healthcare Facilities [150]	Urban regions have a higher concentration of hospitals and clinics, including private healthcare providers.	Rural areas face a shortage of healthcare facilities, with a 24% shortfall in Sub Centres (SCs), 29% in Primary Health Centres (PHCs), and 38% in Community Health Centres (CHCs).
Healthcare Workforce [151]	Approximately 74% of doctors are based in urban areas, serving only 28% of the population.	Rural healthcare systems suffer from significant shortages: 83.2% of surgeons, 74.2% of obstetricians and gynaecologists, 79.1% of physicians, and 81.6% of paediatricians.
Public vs. Private Healthcare [152]	Urban areas have a higher presence of private healthcare facilities, leading to better access for those who can afford it.	Limited private healthcare options result in higher dependence on under-resourced public facilities.
Out-of-Pocket Expenditure [153]	Urban residents often have higher out-of-pocket healthcare expenses due to the prevalence of private healthcare services.	High out-of-pocket expenses are a significant burden, with Indians paying approximately 63% of medical expenses out-of-pocket, one of the highest rates globally.
Government Initiatives [154]	Programs like Ayushman Bharat aim to improve access but face challenges in urban implementation due to the dominance of private healthcare.	Initiatives such as Ayushman Bharat focus on enhancing rural healthcare infrastructure and access.
Health Outcomes [155]	Better health outcomes due to superior infrastructure and availability of specialised services.	Higher mortality and morbidity rates are attributed to inadequate facilities and workforce shortages.

Table 7. Key findings related to transportation and accessibility

Study	Focus	Key Findings
[152]	Impact of transportation on healthcare access	Transportation barriers significantly hinder access to healthcare, especially for low-income and rural populations.
[153]	Urban vs. rural healthcare accessibility	Urban areas benefit from better public transport and road infrastructure, while rural regions face delays and lower healthcare utilisation.
[130]	Emergency medical transport in rural settings	Limited availability of ambulances and poor road conditions in rural areas lead to higher mortality during emergencies.
[98]	Effect of distance to healthcare facilities	Greater distances to clinics and hospitals reduce the likelihood of seeking timely care in rural and underserved areas.
[146]	Accessibility as a dimension of healthcare access	Transportation is a core component of accessibility, directly impacting patient satisfaction and health outcomes.
[156]	Transportation and global health equity	Improved transport systems enhance access to healthcare, particularly in low- and middle-income countries, reducing health disparities.
[95]	Transport systems and social exclusion in healthcare access	Inadequate transport disproportionately affects vulnerable groups, including the elderly and those with chronic conditions.

- **Transportation and Accessibility (Table 7):** Transportation and accessibility are significant in healthcare because they can bridge geographical and socio-economic distinctions [157-159], enabling timely access to medical services, reducing preventable health complications, and fostering equitable health outcomes for underserved populations, particularly in rural and low-resource settings [160].
- **Water, Sanitation, and Energy Infrastructure (Table 8):** Water, sanitation, and energy infrastructure are essential for improving public health, reducing disease burden, enabling reliable healthcare delivery, and fostering sustainable development by ensuring access to clean water [161], hygienic conditions, and uninterrupted energy supply, especially in underserved communities.

Table 8. Key findings related to water, sanitation, and energy infrastructure

Study	Focus	Key Findings
[162]	Economic impacts of water and sanitation infrastructure	Investments in water and sanitation reduce healthcare costs and improve productivity in low-income settings.
[163]	Water, sanitation, and hygiene (WASH) and health outcomes	Poor WASH infrastructure is linked to increased incidence of waterborne diseases like cholera and diarrheal.
[164]	Energy access in healthcare facilities	Lack of reliable energy in healthcare settings compromises the delivery of essential medical services, especially in rural areas.
[165]	Role of sanitation in global health	Improved sanitation facilities significantly reduce child mortality and the spread of communicable diseases.
[166]	Sustainable energy for health	Access to renewable energy improves healthcare delivery, particularly in remote areas, by powering medical equipment and lighting.
[167]	Water access disparities	Inequalities in water access disproportionately affect rural and marginalized populations, worsening health outcomes.
[168]	Renewable energy integration in health infrastructure	Solar and wind energy reduce operational costs in health facilities while ensuring consistent energy supply in off-grid regions.
[169]	Global burden of disease from poor water and sanitation	Inadequate water and sanitation contribute to a significant burden of disease, particularly among children under five.
[170]	Synergy of water, sanitation, and energy infrastructure	Integrated infrastructure planning improves health outcomes, economic development, and environmental sustainability.

Synergies Between SDG 9 and SDG 3: Innovation, Industry, and Infrastructure in Achieving Public Health Goals

- **Integrated Approaches to Innovation and Health Systems (Table 9):** Integrating innovation into health systems enhances efficiency, accessibility, and resilience by leveraging advanced technologies [171, 172], sustainable infrastructure, and cross-sector collaborations to address health disparities, improve care delivery, and achieve equitable public health outcomes globally [173, 174].

Table 9. Key findings related to innovation and health system

Study	Focus	Key Findings
[175]	Role of infrastructure in health system resilience	Robust infrastructure, including transport and technology, enhances health system response to emergencies.
[76]	Innovation in healthcare and public health outcomes	Innovations in medical technology, such as telemedicine, improve access and efficiency in underserved regions.
[176]	Linking SDG 9 and SDG 3 for sustainable development	Investments in industrial and infrastructure innovation directly impact health equity and service delivery.
[176]	Health systems and industrial collaboration	Public-private partnerships in healthcare industries boost access to affordable medical technologies.
[70]	Infrastructure and healthcare in low-income settings	Integrated infrastructure approaches, such as clean energy and WASH systems, strengthen healthcare delivery.
[177]	Renewable energy in healthcare	Reliable energy infrastructure ensures uninterrupted health services, especially in rural and off-grid areas.
[178]	Water and sanitation infrastructure for public health	Synergies between industrial advancements and WASH systems reduce communicable diseases globally.
[179]	Impact of innovation on disease burden	Technological advancements in diagnostics and treatment significantly lower disease burden in vulnerable populations.
[180]	SDG synergies for global health	Coordinated efforts between infrastructure and health innovations accelerate progress toward SDG 3 and SDG 9.
[181]	Role of technology and industry in healthcare affordability	Industrial innovations, such as cost-effective manufacturing of medicines, improve healthcare affordability and access.

Table 10. Key findings related to health, economic growth and sustainable development

Study	Focus	Key Findings
[182]	Health and economic growth relationship	Good health is a key driver of economic growth; healthier populations are more productive and contribute to higher GDP.
[183]	Health and sustainable development	Investing in health systems improves overall economic development and supports the achievement of SDGs, especially SDG 3 and SDG 8.
[184]	Health outcomes and productivity	Improvements in health lead to higher workforce participation and productivity, which, in turn, boosts economic growth.
[185]	Health as an economic asset	Health is a fundamental economic asset, and investing in healthcare yields substantial returns through reduced healthcare costs and increased worker productivity.
[186]	Economic impact of health improvements	Improved public health, especially in terms of infant mortality reduction, contributes significantly to long-term economic growth.
[187]	Health as a driver of sustainable development	Health investments improve quality of life, promote equality, and enhance economic stability, all of which are essential for sustainable development.
[188]	Social determinants of health and economic development	Social inequalities in health exacerbate economic disparities; addressing health inequalities promotes inclusive economic growth.
[189]	Health systems and economic growth link	Strong health systems are critical for sustaining economic development, as they reduce the burden of disease and increase workforce capacity.
[190]	Global health and economic development	Reducing health disparities globally contributes to better economic performance by improving human capital, especially in developing countries.
[191]	Health investments and long-term economic growth	Investments in healthcare infrastructure, especially in low-income countries, drive long-term economic growth by creating jobs and fostering human capital development.

- **Health, Economic Growth, and Sustainable Development (Table 10):** The integration of well-being, financial stability, and environmental stewardship is crucial for fostering long-term societal prosperity, as it ensures a thriving populace, robust job creation, equitable resource distribution, and the preservation of natural assets for future generations.
- **Challenges and Barriers to Synergies (Table 11):** Studying the challenges and barriers to synergies is essential for identifying and overcoming the obstacles that hinder the effective integration of diverse sectors [192], enabling the development of strategies to align policies, resources, and initiatives [193, 194], thereby ensuring a more efficient and sustainable path to achieving global development goals.

Table 11. Barriers to synergies

Study	Focus	Key Findings
[195]	Barriers to achieving synergies in development	Political instability, poor governance, and lack of coordination between sectors hinder the integration of health, economic growth, and sustainable development.
[196]	Challenges in aligning health and economic goals	Misalignment of health policies with economic objectives and insufficient investments in health systems slow progress toward achieving synergies.
[197]	Barriers to sustainable development	Lack of financial resources, political will, and infrastructure investment impede the realization of synergies between health and economic development.
[198]	Health and economic development synergies	Inadequate health financing, weak healthcare infrastructure, and limited access to essential services are major barriers to health-driven economic growth.
[199]	Constraints to health and economic integration	Fragmented policy frameworks, ineffective health systems, and poor intersectoral collaboration create significant barriers to fostering synergies.
[200]	Global health governance and economic growth	Global disparities in health and economic resources create unequal opportunities for synergies, particularly in low-income countries.
[201]	Political barriers to sustainable health development	Weak institutional frameworks, corruption, and lack of accountability in public health systems obstruct synergies between economic growth and health.
[202]	Environmental and social barriers to sustainable development	Environmental degradation and social inequalities often undermine efforts to achieve synergies between health, economic growth, and sustainability.
[203]	Financial constraints to health and economic synergies	Limited fiscal space in developing countries and insufficient funding for health systems prevent the effective integration of health goals with economic development strategies.
[204]	Social determinants of health and barriers to synergy	Inequities in access to healthcare, education [205], and income distribution create persistent barriers to the integration of health and economic goals in sustainable development.

Policy Implications and Future Directions

- **Policy Recommendations for Strengthening Synergies (Table 12):** To fortify synergies between health, economic growth, and sustainable development, it is imperative to advocate for comprehensive, multi-sectoral policy frameworks that ensure robust intergovernmental coordination [206, 207], equitable resource allocation, targeted investments in resilient healthcare infrastructure, and the strategic alignment of health interventions with economic objectives while fostering inclusive governance and addressing systemic inequalities to promote long-term, sustainable well-being for all populations.

Table 12. Policy implications

Recommendation	Description	Expected Impact
1. Multi-Sectoral Policy Integration [70]	Develop comprehensive policies that integrate health, economic growth, and sustainability goals across sectors such as education, infrastructure, and social protection.	Promotes coordinated efforts across sectors, ensuring a holistic approach to development and improving overall policy coherence.
2. Intergovernmental Coordination and Collaboration [208]	Enhance collaboration between national, regional, and local governments, along with international organizations, to ensure synchronized policies and effective implementation.	Facilitates sharing of resources, knowledge, and best practices, leading to more effective and scalable health and development solutions.
3. Resource Allocation and Financing [209]	Allocate sufficient and sustainable financial resources for health systems, infrastructure development, and poverty alleviation programs, focusing on low- and middle-income countries.	Strengthens the foundation of healthcare systems, improving service delivery and economic growth, and reduces disparities.
4. Health System Resilience Building [210]	Strengthen health systems through investments in infrastructure, workforce training, and technological innovations to ensure resilience during crises (e.g., pandemics, natural disasters).	Increases the capacity of health systems to respond to shocks, safeguarding public health and economic stability.
5. Universal Health Coverage (UHC) [211]	Advocate for the implementation of UHC policies that ensure equitable access to quality healthcare services for all populations, regardless of income or location.	Reduces health inequalities, improves productivity, and fosters economic growth by ensuring a healthy and productive workforce.
6. Sustainable Infrastructure Development [212]	Invest in sustainable energy, water, sanitation, and transportation infrastructure to support both health and economic growth, particularly in underserved regions.	Ensures basic services are accessible, improves public health outcomes, and fosters job creation and sustainable economic growth.
7. Public-Private Partnerships (PPP) [213]	Encourage partnerships between the public and private sectors to innovate and finance health infrastructure and services, particularly in resource-constrained settings.	Leverages private sector expertise and capital to enhance public health systems and expand access to essential services.
8. Reducing Inequities through Social Protection [214]	Implement social protection programs, including cash transfers, unemployment insurance, and targeted healthcare subsidies, to reduce socio-economic disparities.	Helps mitigate the effects of poverty on health and economic outcomes, ensuring equitable growth and development opportunities.
9. Data-Driven Decision Making [90]	Foster the use of data and technology to inform policy decisions, monitor health outcomes, and track economic development progress, including through digital health platforms.	Enables evidence-based decision-making, improves policy effectiveness, and allows for real-time adjustments to improve outcomes.
10. Education and Capacity Building [59]	Strengthen education systems by integrating health literacy, economic empowerment, and sustainability principles into curricula at all levels.	Empowers individuals with the knowledge and skills to make informed decisions, improving health outcomes and driving economic growth.

- **Emerging Trends:** The emerging trend in the intersection of health, economic growth, and sustainable development is the increasing adoption of digitally enabled, data-driven health ecosystems, which leverage advanced technologies such as artificial intelligence [215], machine learning [216], and blockchain to optimise healthcare delivery, enhance economic productivity, and drive environmentally sustainable outcomes through the seamless integration of real-time data, predictive analytics, and cross-sectoral collaboration.

The recent trends mentioned in Table 13 have evidenced that development in the health sector is advancing at an increasing rate. Technological advancements and innovations are impacting various domains. Significant advancements in the industry are related to the integration of artificial intelligence into innovative technology. Artificial intelligence and machine learning have been witnessed as integral parts of new progressions in recent times.

Table 14 contains an insightful comparison between major economies in the context of synergies between SDG 9 and SDG 3. This comparison will help to develop an intuitive awareness regarding the current status of different initiatives taken by major economies across the globe. Based upon the implementation of key strategies, the impact on the treatment of given sustainable development goals can be assessed, and strategic implementation of one country can be used in the policy formulation of another country to develop a pervasive framework for achieving sustainable development goals. The policy formulation should be in such a way that more than one sustainable development goal is targeted through a single strategy implementation. If every sustainable development goal comes with a different strategy, it will only result in making the execution more complex, hence decreasing the efficiency.

Table 13. Recent trends in the field of health and economics

Trend	Description	Implications
1. Digital Health Ecosystems [58]	The rapid development and deployment of integrated, technology-driven health systems that leverage electronic health records (EHR), telemedicine, mobile health (mHealth), and wearable devices.	Promotes efficient healthcare delivery, reduces cost burdens, enhances access to healthcare services, and improves patient outcomes.
2. Artificial Intelligence (AI) in Healthcare [217]	The integration of AI algorithms for predictive diagnostics, personalised treatment plans, and clinical decision support drives precision medicine and improves patient care efficiency.	It improves diagnostic accuracy, optimises healthcare resource allocation, and accelerates medical research while reducing healthcare costs.
3. Data-Driven Public Health	Big data analytics, machine learning [218], and artificial intelligence are used to process and analyse vast amounts of health data to predict trends, prevent diseases, and inform policymaking.	Enables evidence-based decision-making, improves health forecasting, and enhances healthcare planning, leading to more targeted interventions.
4. Blockchain for Healthcare [219]	The application of blockchain technology to secure patient data, streamline healthcare transactions, and ensure transparency and traceability in the medical supply chain.	It enhances data security, ensures privacy, reduces fraud, and enables more transparent and efficient management of healthcare data and resources.
5. Remote Health Monitoring and Telemedicine [220]	Expansion of remote monitoring technologies and telehealth services that allow patients to access care from a distance, supported by wearable devices, mobile apps, and virtual consultations.	Increases access to healthcare in underserved regions, reduces healthcare delivery costs, and ensures continuous care for chronic conditions.
6. Personalized Medicine [221]	The use of genetic information, biomarkers, and advanced diagnostics to tailor medical treatments to the individual characteristics of each patient, promoting more effective outcomes.	Enhances treatment efficacy, reduces adverse effects, and optimizes healthcare costs by providing individualized care.
7. Sustainable Health Infrastructure [25]	The integration of green building practices, renewable energy, and sustainable materials in healthcare facilities to reduce environmental impact and support long-term health system resilience.	Promotes environmentally sustainable healthcare systems, reduces operational costs, and improves health outcomes by creating healthier built environments.
8. Cross-Sector Collaboration for Health [106]	Enhanced cooperation between governments, the private sector, and civil society organizations to address health disparities, economic inequality, and environmental sustainability.	Facilitates the creation of integrated, holistic policies that ensure the sustainable development of health systems and economic stability.
9. Health Financing Innovation [33]	New financial models such as health impact bonds, social investment, and public-private partnerships (PPPs) to fund health system development and innovative health projects in underserved areas.	Increases access to healthcare resources, improves the sustainability of health financing, and attracts private investment in health systems.
10. Green Health Technologies [29]	The rise of health technologies designed with environmental sustainability in mind, including eco-friendly medical devices, low-carbon health solutions, and waste reduction technologies.	This supports the health sector's role in combating climate change, reduces healthcare's environmental footprint, and enhances the sustainability of health services.

Table 14. Convergent pathways: A cross-regional tableau of synergies between SDG 9 and SDG 3

Country/Region	Key Initiatives or Strategies	Implementation Approach	Impact on SDG 9	Impact on SDG 3	Synergistic Outcomes & Challenges
Germany [222]	Public-private partnerships in e-health	Collaboration among government, tech startups, and academia	Growth in med-tech exports and digital infrastructure	Improved healthcare access via telemedicine	Facilitates high-tech integration but requires robust data protection and capital investment
Rwanda [223]	Nationwide telemedicine and healthcare infrastructure	Government-led programs with NGOs and private partners	ICT expansion in remote areas	Reduced travel time and better maternal–child outcomes	Infrastructure upgrades enhance service delivery but need sustainable financing and connectivity
India [224]	"Make in India" for medical devices and pharmaceuticals	Policy incentives, foreign direct investment, and local R&D support	Strengthened domestic manufacturing and exports	Increased affordability and reduced dependency on imports	Industrial growth bolsters healthcare innovation but faces regulatory and market balancing challenges
Brazil [225]	Integrated health–industry innovation clusters	Synergy among universities, biotech firms, and public agencies	Enhanced biotech and pharmaceutical sectors	Greater availability of essential medicines in remote areas	Concurrent industry–health advancements require stable policy support and stakeholder alignment

Table 15. Exploring the synergies between SDG 9 (innovation & infrastructure) and SDG 3 (public health): High-income vs. Low-income countries

Aspect	High-Income Countries	Low-Income Countries	Observed Synergies & Implications
Policy Prioritization [226]	Comprehensive national strategies with robust funding	Often reliant on donor or NGO-driven initiatives	Strategic partnerships can bridge gaps and amplify policy effectiveness
Infrastructure & Technology [227]	Advanced digital networks and sophisticated healthcare facilities	Limited physical infrastructure but rising mobile penetration	Targeted infrastructure investments can expedite healthcare delivery in underserved regions
R&D and Innovation [228]	Strong research funding and innovation ecosystems	Lower budgets but growing local tech ventures and frugal innovations	Collaborative ventures can produce scalable solutions tailored to local healthcare contexts
Healthcare Access [229, 230]	Universal coverage with high insurance penetration	Fragmented systems facing resource constraints	Infrastructure expansion can enhance equitable access and reduce health disparities
Public–Private Partnerships [231-233]	Mature partnerships driving high-tech solutions and policy alignment	Nascent alliances seeking stable financial and technical support	Focused PPP models can accelerate both industrial growth and health system strengthening
Data & Monitoring [234, 235]	Robust health informatics enabling predictive analytics and rapid response	Fragmented data with limited interoperability and oversight	Strengthening digital health infrastructure fosters evidence-based interventions and synergy

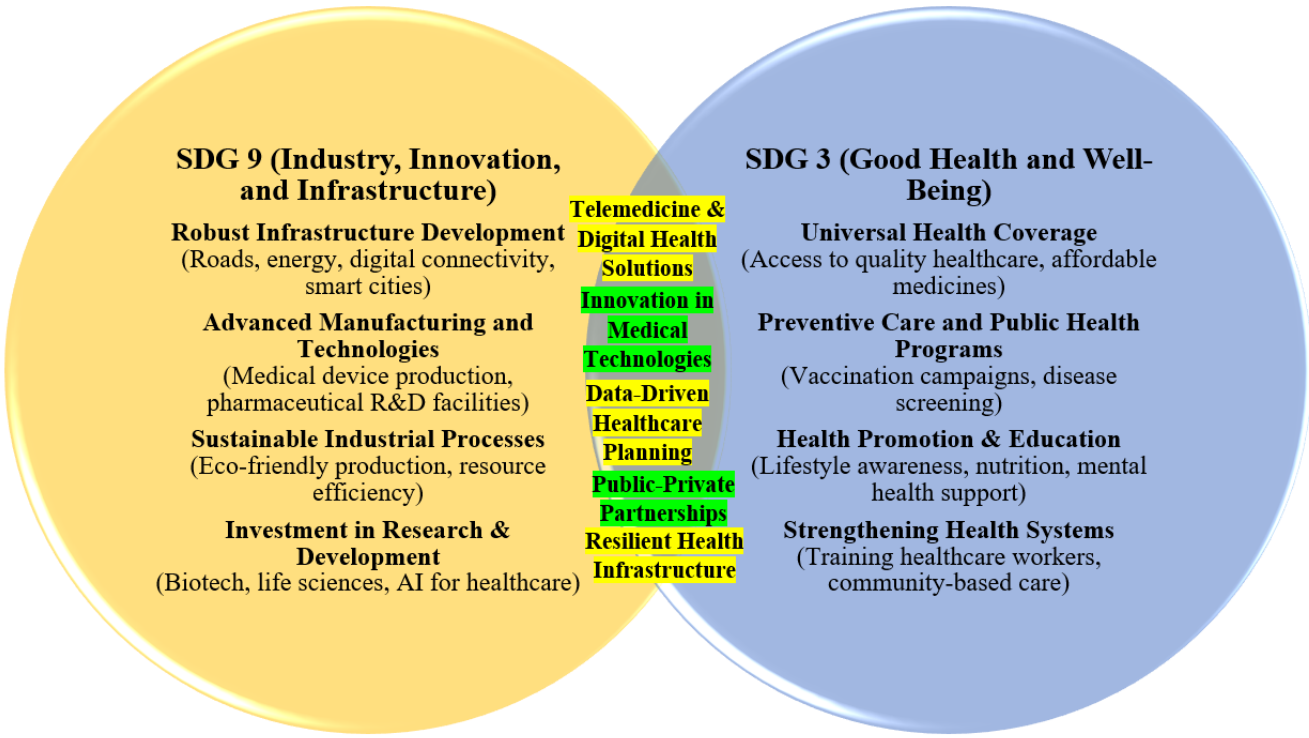

Figure 6. Venn diagram for showing synergies in SDG 9 and SDG 3

To strengthen the research findings, a final assessment of the difference between the high-income and low-income groups has been made in the context of synergies between SDG 9 and SDG 3 as shown in Table 15. In the analysis, it was found that a significant difference in the approach to building the synergies can be witnessed in high and low-income groups of countries [236, 237]. This difference is because of differences in economic conditions, which results in rising disparities on various fronts [238, 239]. The catch in this differentiation is that, in low-income countries, the potential of achieving sustainable development is high; hence through different aids, an attempt to strengthen the synergies has to be made [240, 241]. A significant leap between low and high-income countries in terms of infrastructure is present, but at the same time, the infrastructure of low-income countries can progress through sustainable development [242, 243].

The entire crux of the systematic literature review is displayed in the Venn diagram in Figure 6. The diagram incorporates the details of SDG 9 and SDG 3. The intersection of the circle includes those areas which need policy formulation to influence both SDGs. If policy implication can persuade the use of telemedicine and digital health solutions, SDG 9 and SDG 3 can be achieved. Also, it is critical to insinuate innovation in medical technologies as it would lead to infrastructural development promoting good health and well-being. Moreover, data-driven healthcare planning through integrated data platforms and predictive modelling for public health will bring relevant innovation to healthcare infrastructure. The present research also suggests creating public-private partnerships especially in low-income countries to execute policies for sustainable development. Collaboration among governments, NGOs, and industry can bring health outcomes and progressive infrastructural development. Lastly, strengthening hospitals and clinics through reliable power/water/IT networks is necessary to build Resilient Health Infrastructure.

6. CONCLUSION

In conclusion, the synergistic interplay between technological and industrial innovations, infrastructure development, and integrated policy frameworks is paramount for advancing the achievement of SDG 3 and SDG 9, wherein strategic investments in health systems, sustainable practices, and cross-sectoral collaborations catalyse not only equitable public health outcomes but also foster resilient economic growth while addressing global disparities and ensuring long-term sustainability for future generations.

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