Challenges And Innovations In The Primary Healthcare System Of Bihar: A Comprehensive Review

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Abstract: An evaluation of the Primary Healthcare (PHC) system in the state of Bihar reveals that it is fraught with numerous challenges including; inadequacy of infrastructure, acute shortage of qualified workforce, and lack of adequate finance – that undermines the provision of fair universal healthcare to the vastly rural population in Bihar. This review will also quantify and qualify PHC in Bihar today focusing on some key challenges including inadequate infrastructure equipment; scarcity of human resources; and sociocultural factors. Their basic needs comprise of lack of equipment and hospital beds; there are only 0.3 hospital beds per 1000 people and this is wanting according to the World Health Organization (WHO) standards. Also, the doctor-to-patient ratio is extremely low, which has compounded the problem of rural healthcare inequity. New concepts such as telemedicine, mobile health applications, public-private partnerships (PPPs), and community-based programmes implemented through the Accredited Social Health Activist (ASHA) model have been seen to help close these gaps. Disease diagnostics using Artificial Intelligence (AI), digitized health records and some other related technological innovations have enhanced disease identification and their management. Ayushman Bharat partnerships offer both affordable care and insurance to millions of families. The review also highlights the responsibilities of the academia, government, and the private sector in the regulation, funding and support for research on PHC refinement. Having scaled some of these innovations, increasing the size of health facilities, and improving workforce development remain a critical strategy for sustainable health systems. Therefore, improvement of governance, elimination of research deficit, and positive inter-sectorial relations will be crucial in re-modelling Bihar's Primary Health Centres (PHCs) as "Extended Reach Primary Health Centres (ERPHCs)" panoplied with equitable, accessible and quality healthcare solutions available for even the " last person" of the society in this state.

Keywords: Primary Healthcare, Bihar's Healthcare System, Infrastructure Deficiencies, Workforce Shortage, Maternal and Infant Mortality

1. Introduction

One of the most important and indispensable instruments to address the health needs of populations is Primary healthcare (PHC), particularly in low and middle-income countries (LMICs). It provides immunizations, maternal and child health support, chronic disease management and health promotion activities. These services aim to reduce the number of people affected by infections, improve life expectancy and reduce inequality in healthcare [1,2]. PHC is community-based, emphasizes preventive care and is cost-effective, improving public health outcomes [3]. Studies also show that strengthened PHC systems are associated with greatly reduced infant and maternal mortality rates; improved control of communicable diseases; and enhanced diagnosis and management of non-communicable diseases. The role of PHC in catalysing these change processes is of course so fundamental and particularly critical in LMICs in which health systems are resource-constrained and suffer from inequitable access.

As one of India's most populous and economically backward states, Bihar has its own special set of issues and possibilities in healthcare supply. Because, over 88% of the population resides in rural areas, which suffer from both geographical and infrastructure barriers, populations struggle with reaching quality health services [4]. Health inequalities are exacerbated by the fact that the state's per capita income is much lower than the national average [5]. In addition, the literacy level is

63.82% which is extremely low in women, which hinders health awareness and educational campaigns to prevent diseases [6].

This hasn't stopped Bihar from experiencing some progress in healthcare infrastructure and policy. For instance, the initiatives being initiated under the National Health Mission include improving the PHC facilities by adding manpower and providing training programmes with healthcare workers, the lack of essential equipment and trained medical personnel at PHCs in Bihar raises significant concerns and creates substantial gaps in healthcare [6]. These deficiencies have to be addressed through innovative approaches and a sustainable development approach that is suited to Bihar's socio-economic and demographic context.

Objectives of the Review

This review is structured to:

1. Analyse the key challenges hindering the effectiveness of primary healthcare in Bihar, including infrastructure deficits, resource limitations, and policy barriers.

2. Highlight innovative solutions and technological advancements, such as telemedicine, community-based health initiatives, and public-private partnerships, aimed at overcoming these challenges.

3. Offer policy recommendations to strengthen primary healthcare delivery systems in Bihar, with a focus on sustainability, equity, and scalability.

2. Current State of Primary Healthcare in Bihar

2.1 Overview of Healthcare Infrastructure

Bihar's primary healthcare system is spread over an extensive network of Primary Health Centres (PHCs), Community Health Centres (CHCs), sub-centres and District Hospitals. According to recent data, Bihar has 1,865 PHCs and 1,014 CHCs, which are meant to cater to a largely rural population [7]. However, a large part of these facilities are underutilized or are not functioning at their optimal standards because of infrastructural deficiencies. For example, many PHCs do not have adequate laboratory service, diagnostic equipment or the space to manage the patient load [8].

The CHCs also do not meet the Indian Public Health Standards (IPHS), which require the provision of certain essential services including emergency obstetric care, in all CHCs. Only 50% of PHCs in Bihar are operational 24/7 and only 40% meet IPHS norms for staffing and infrastructure [9]. Often, sub-centres, the first point of contact for rural communities, do not have regular electricity, water supply or essential drugs. The deficiencies in infrastructure hinder the effective delivery of healthcare services [10].

2.2 Workforce Availability and Distribution

A critical challenge in Bihar's primary healthcare system is the adequate availability and distribution of healthcare workers. Alarmingly, the doctor-to-patient ratio in PHCs is one doctor for every 17,685 people, while WHO recommends one doctor for every 1,000 people [11]. In addition, 30% of sanctioned positions for nurses, pharmacists and laboratory technicians remain vacant in many PHCs [12]. The concerning status of the workforce in respect of the state can also be perceived through Table 1 mentioned below:

Table 1: Workforce Availability and Vacancy Rates in Bihar's Primary Healthcare System (2018-2019)

References	Year (2018-2019)	Available manpower	Sanctioned strength	% of vacancy
	Doctors regular post	3821	6261	39%
	Contractual doctor	533	2314	77%
	Regular nurses	1994	4704	58%
[13]	Contractual nurse	308	17 19	82%
	ANM Auxiliary nurse midwife	11830	21859	46%
Source: (Government of Bihar, 2019)				

The uneven distribution of this shortage is made worse by the fact that remote and rural areas are hit hardest by the workforce crisis. The quality of living conditions and career prospects are better in the urban healthcare centres, and attract a large number of medical professionals; leaving the rural PHC underserved [12]. Bihar's public health delivery depends significantly upon Accredited Social Health Activists (ASHAs) who too suffer from delayed remuneration and lack of training which impairs community engagement and disease prevention activities [14].

2.3 Budgetary Allocation and Financial Constraints

The financial constraints under which Bihar's primary healthcare system operates are reflected in the state's healthcare budget. Bihar spends less than the national average on healthcare per capita [15] and healthcare expenditure accounts for only 4.5% of the total state budget. On average, the state spends ₹1,000 per capita per year on healthcare, against the national average of ₹1,944 [16]. The underfunding contributes to the procurement of essential drugs and is used in the recruitment of medical staff and expenses for the operations of the PHCs and CHCs.

Bihar's primary healthcare sector has been largely funded by the National Health Mission (NHM), which accounts for nearly 60 per cent of the state's total health expenditure. However, these allocations are often undermined by delays in fund disbursement and inefficient utilization [17]. For example, NHM has tried to provide diagnostic facilities in PHCs, but every year 20 per cent of the funds allocated for this purpose remain unutilized [16]. Overcoming these constraints requires enhanced financial planning and accountability.

2.4 Accessibility and Utilization of Services

Geographical, socio-economic and infrastructural barriers hinder the access to primary healthcare services in Bihar. Nearly 90% of Bihar's population lives in rural areas, and rural people have to travel long distances to reach PHC or CHC for basic healthcare needs. Although healthcare facilities are available in most cases, factors like the non-availability of medicines, the absence of doctors and long waiting hours act as a way for frequent utilization by people.

Cultural and socioeconomic factors are also important to access healthcare. Awareness regarding preventive care and treatment options is low if the literacy level is low, especially for women, this impacts delayed and inadequate health-seeking behaviour. Financial constraints are also important, with out-of-pocket expenditures representing more than 70% of healthcare costs in the state [17]. The Health Opportunities should not be pegged with the depth of the pocket of the common people [18]. In addition, affordability and proximity cause the poor households to often seek out the services of informal or unqualified healthcare providers who often offer substandard healthcare services with harmful outcomes. However, one of the Principles of Healthcare Administration says that the policymakers while formulating any plan for Health Programmes should take into account the benefit of the whole community, to make the medical facilities more accessible to the rural population [18].

With new programmes, such as telemedicine services, the accessibility gap is beginning to move. For instance, the "e-Sanjeevani" programme has provided people in rural areas access to urban specialists through consultation [19]. However, emerging technologies at the household level for clean energy use have not widely been adopted because of infrastructure challenges of intermittent internet connectivity and lack of awareness among rural populations.

3. Challenges in the Primary Healthcare System

Table 2 shows some of the key challenges in Bihar's primary healthcare system, divided into infrastructure, human resources, health indicators, geographical and cultural barriers and policy and governance. The essay discusses major issues including underfunded, understaffed and lack of facilities that have contributed to high maternal and infant death rates together with urban-rural disparities and poor operationalization of health policy. The challenges including limited resources, sociocultural barriers, and corruption, have a major effect on the accessibility, quality and effectiveness of healthcare services in the state as outlined in Table 2.

Table 2: Summary of Challenges in Bihar's Primary Healthcare System

Reference	Category	Subcategory	Challenge	Key Points	Impact
[20-22]	Infrastructure	Facilities	Poorly equipped PHCs and CHCs	Only 30% of PHCs have X-ray machines; which lack ultrasound devices and power supplies.	Limits diagnosis and treatment options.
[23,24]		Healthcare Centres	Insufficient healthcare facilities	12 districts have fewer than 50% of required PHCs.	Rural populations lack adequate access.
[25]			Shortage of hospital beds	Only 0.3 beds per 1,000 population	Overcrowding and unmet patient needs.

				(WHO recommends 3 per 1,000).	
[30,31]	Human Resources	Trained Personnel	Shortage of trained professionals	40% doctor shortage; lack of specialists like gynaecologists and anaesthetists.	Reduced quality of maternal and child care.
[26,27]		Recruitment and Retention	High attrition of healthcare workers	25% of rural doctors resigned in 2022; due to poor working conditions.	Vacancies increase workloads for remaining staff.
[28-30]	Health Indicators	Mortality Rates	High maternal and infant mortality rates	MMR: 165 per 100,000; IMR: 38 per 1,000; lack of antenatal care and skilled birth aids.	Higher maternal and infant mortality.
[31-33]		Disease Burden	Dual burden of communicable and NCDs	~200,000 TB cases annually; rising diabetes and hypertension cases.	Inadequate PHC resources to handle the burden.
[34,35]	Geographical & Cultural	Urban-Rural Divide	Uneven healthcare access	Urban centres are better equipped; rural areas face poor road and transport links.	Hinders timely access to healthcare.
[36-38]		Sociocultural Barriers	Gender norms and caste discrimination	Women and marginalized groups face limited mobility and substandard care.	Delayed and inequitable access to services.
[39,40]	Policy & Governance	Policy Implementation	Inefficient programme rollout	Delayed funds; 45% of rural patients buy private medicines despite NHM provisions.	Reduces trust in public healthcare programmes.
[41-43]		Corruption	Mismanagement of funds and resources	Irregular procurement, weak accountability mechanisms.	Unavailability of essential drugs and equipment.

3.1 Infrastructure Deficiencies
3.1.1 Poorly Equipped Facilities

Bihar's primary healthcare system infrastructure is severely deficient. The PHCs and CHCs have no basic medical equipment, diagnostic tools and functional laboratories. Moreover, for example, a recent review documented that only 30% of PHCs in Bihar have functional X-ray machines, with even fewer possessing ultrasound devices, thus failing to attend to rural populations [20,21]. To this effect, the absence of amenities such as uninterrupted power supply, clean water and proper sanitation compound the disease spread and makes many of these amenities unusable [22].

There is also a glaring shortage of hospital beds. Bihar has a bed availability of only 0.3 beds per 1,000 population, much lower than the national average of 1.7 beds per 1,000 population and the WHO's recommendation of 3 beds per 1,000 population [23]. As a result, patients are left to travel great distances to receive care, adding not only financial burdens but logistical ones as well.

3.1.2 Insufficient Number of Healthcare Centres

However, the number of functional PHCs and CHCs is always insufficient despite massive efforts to increase access to healthcare. The IPHS recommends one PHC for every 30,000 people in plain areas and one CHC for every 1,20,000 people, but many areas in Bihar have fewer than these [24]. For instance, in 2023, 12 districts in Bihar had less than 50% of the required PHCs [25]. Remote and tribal areas bear a disproportionate brunt of this disparity from the scarcity of healthcare facilities.

3.2 Human Resources
3.2.1 Shortage of Trained Professionals

One of the main issues in Bihar's primary healthcare is the availability of trained medical personnel. The shortage of doctors in PHCs is 40%, and paramedical staff and specialists like gynaecologists and anaesthetists are even lesser [26]. There is a large population of healthcare workers who lack adequate training, especially to the extent an emergency or specialized discipline requires. The lack of expertise affects the quality of care given in maternal and child health services [27].

3.2.2 Issues with Recruitment and Retention

Recruiting and retaining healthcare professionals are thorny issues. Poor living conditions and lack of suitable facilities and opportunities for career growth lead to the notion of rural postings as being unattractive. As a result, there is a high attrition rate of healthcare workers. For example, over 25% of doctors recruited to rural PHCs in 2022 resigned within a year because they were unhappy with working conditions [44]. Moreover, because the recruitment process involves bureaucratic delays, sanctioned positions may remain vacant for long periods, making the present workload even more burdensome [45].

3.3 Health Indicators
3.3.1 High Maternal and Infant Mortality Rates

Bihar has one of the highest maternal mortality rates (MMR) and infant mortality rates (IMR) in India. The MMR in the state is 165 per 100,000 live births, well above the national average of 103 [28]. Likewise, the IMR is 38 per 1,000 live births, as against the national average of 28 [29]. Factors that contribute to its lack of access to skilled birth attendants are a lack of antenatal care and poor delivery facilities [30].

3.3.2 Prevalence of Communicable and Non-Communicable Diseases

Communicable and non-communicable diseases continue to be a dual burden to the state. Alarmingly high, about 200,000 new TB cases are reported annually in Bihar [31]. At the same time, urbanization and changing dietary habits are raising the incidence of lifestyle-related conditions such as diabetes and hypertension [32]. Yet, the state's PHCs are ill-equipped to deal with this dual burden, with no diagnostic capabilities and trained personnel for chronic disease management [33].

3.4 Geographical and Cultural Barriers
3.4.1 Rural vs. Urban Disparities

In Bihar, the delivery of healthcare is highly uneven – rural versus urban. On one hand, urban centres have more access to tertiary hospitals and private healthcare providers; it's almost completely left to the public PHCs and CHCs in rural areas. However, this reliance is challenged, by the shortcomings in rural healthcare infrastructure and workforce availability [34]. Also, unproven road connectivity and unreliable transport continue to deprive the rural populations of access to healthcare services [35].

3.4.2 Factors Affecting Healthcare Delivery from Sociocultural Perspective

Healthcare access and utilization in Bihar find no exception to the influence of sociocultural factors including gender norms and caste dynamics. In rural areas, women are constrained in their mobility and are, therefore deprived of accessing timely medical care [36]. Equitable delivery of healthcare is also affected by discrimination based on caste and socioeconomic status with marginalized communities receiving substandard services quite often [37]. Additionally, conventional beliefs and overconfident reliance on isolated local practitioners to provide healthcare services consequently delay timely healthcare intervention [38].

3.5 Policy and Governance Issues
3.5.1 Implementation of Healthcare Policies Gaps

While Bihar has several national healthcare programmes under its belt, such as the Ayushman Bharat scheme and the National Health Mission, their rollout on the ground level continues to remain patchy. These programmes are hampered by frequent delays in fund allocation and a lack of accountability mechanisms [39]. For example, although NHM provides free drugs and diagnostics, 45% of patients in rural Bihar reported purchasing medicines from private pharmacies [40].

3.5.2 Corruption and Inefficiency

Inefficiency and corruption tend to add on to worsen the already weak healthcare system of Bihar. Funds are mismanaged and procurement irregularities are common, resulting in the nonavailability of essential drugs and equipment [41]. Moreover, an absence of robust mechanisms for monitoring and evaluating the performance of healthcare facilities enables nonperforming centres to function unaccountably [42]. Digital health initiatives and public-private partnerships have been tested to address these issues, but need to be scaled up and involve more stakeholders [43].

4. Innovations and Solutions
4.1 Technological Interventions
4.1.1 Telemedicine and Mobile Healthcare Applications

Telemedicine has changed healthcare delivery in rural and underserved areas in Bihar into a cost-effective alternative to close the gap between patients and providers. For example, offering an e-Sanjeevani platform by the Ministry of Health for consultation with specialists without travelling and the obligation costs [46]. mHealth is one of the mobile healthcare applications that have helped track the medical history of patients, do follow-ups on time, and raise awareness among the general population living in remote areas [47].

Additionally, technological advancements like AI-driven diagnostic tools and wearable health monitoring devices have improved services in the health sector. Tools for early detection of diseases such as diabetes and hypertension, which are becoming more common in Bihar's rural communities [48], are provided by these. For instance, in the last two years, the implementation of AI-enabled point-of-care diagnostics in select districts has increased TB detection rates by 30% [49].

4.1.2 Digitization of Health Records

Digitalization of health records has been a game changer in easy patient data management across platforms such as the Integrated Health Information Platform (IHIP). Apart from Enhancing care coordination, the initiative helps the policymakers to identify health trends and plan to intervene [50]. Digital health registries in Bihar have helped track immunization programmes and maternal health services better, and have reduced dropout rates for antenatal check-ups by 48 [51]. In addition, digital data systems have increased accountability and transparency in the use of public health expenditures [52].

4.2 Community-Based Initiatives
4.2.1 Role of ASHA Workers and Local NGOs

The community-based Healthcare system in Bihar has depended on Accredited Social Health Activists (ASHA). These are frontline workers filling the gap between the healthcare system and the people on the ground, specifically in marginalized communities. The ASHAs are trained to deliver basic healthcare services such as maternal and child care, family planning advice, and nutrition counselling [53]. The involvement of these people has helped to increase institutional deliveries and immunization coverage in rural areas [54].

ASHAs act in conjunction with local NGOs that implement targeted healthcare programmes. CARE India and PATH have partnered with the state health departments to fight malnutrition, improve neonatal care, and increase awareness about communicable diseases [55]. For instance, PATH's Project Ujjwal had family planning and reproductive health as its focus and had past it one million women in Bihar in five years [56].

4.2.2 Community Awareness Programmes

Health problems associated with cultural and social practice have been addressed through community awareness initiatives. Through workshops, street plays, and interactive sessions the Swasthya Chetna Abhiyan programmes try to educate communities on hygiene, nutrition, and disease prevention [57]. They have been especially successful in reducing stigma around diseases like leprosy and TB, and persuading more people to seek early medical treatment [58].

4.3 Public-Private Partnerships

Technological advancements, including telemedicine and digitized health records, community initiatives with ASHA workers and NGOs, public-private partnerships for improving access and financing, use of Ayushman Bharat and policy as well as governance reforms are key innovations and solutions in Bihar's primary healthcare system that are highlighted in Table 3. These measures have helped to improve healthcare delivery, reduce barriers, and enhance accountability and outcomes for underserved populations.**Table 3: Innovations and Solutions in Bihar's Primary Healthcare System**

Reference	Category	Focus Area	Key Interventions	Impact	Examples
[46-49]	Technological Interventions	Telemedicine & Mobile Healthcare Apps	Platforms like e-Sanjeevani enable remote consultations; mHealth apps track patient history and raise awareness.	Improved healthcare access and early disease detection in rural areas.	AI-enabled TB diagnostics increased detection rates by 30% in select districts.
[50-52]		Digitization of Health Records	Initiatives like Integrated Health Information Platform (IHIP) for data management and trend analysis.	Reduced dropout rates for antenatal check-ups and increased accountability in public health.	Digital health registries improved immunization tracking.
[53-56]	Community-Based Initiatives	Role of ASHA Workers & NGOs	ASHAs provide basic healthcare; NGOs like PATH and CARE India support malnutrition and disease awareness programmes.	Boosted institutional deliveries and immunization coverage in rural communities.	PATH's Project Ujjwal improved reproductive health access for over 1 million women in 5 years.
[57-58]		Community Awareness Programmes	Educational campaigns through workshops and interactive sessions to reduce stigma and promote early medical treatment.	Addressed cultural barriers to healthcare, especially for TB and leprosy.	Swasthya Chetna Abhiyan educated communities on hygiene and nutrition.

[59-61]	Public-Private Partnerships	Collaborations with Private Providers	Partnerships under Ayushman Bharat for affordable care and diagnostic services for low-income populations.	Expanded access to tertiary care and advanced diagnostics for underserved communities.	Collaborations with Apollo and Narayana Health.
[62,63]		Innovative Financing Models	Health assurance schemes and social impact bonds to fund healthcare initiatives.	Reduced out-of-pocket expenses and funded measurable health outcomes.	Bihar Health Assurance Scheme for cashless treatment of low-income families.
[64-66]	Policy Reforms & Governance	Ayushman Bharat & State Schemes	HWCs provide preventive care; PM-JAY offers insurance; state programmes incentivize institutional deliveries.	Improved maternal health outcomes and financial support for low-income families.	12M+ families in Bihar benefited from PM-JAY by 2023.
[67-69]		Strengthening Governance	Real-time monitoring, performance-based incentives, and e-procurement systems.	Enhanced efficiency, reduced corruption, and ensured delivery of resources.	Third-party audits improved fund allocation efficiency.

4.3.1 Collaborations with Private Healthcare Providers

Public-private partnerships (PPPs) are being widely seen as an effective strategy for supplementing healthcare infrastructure and services in Bihar. Under the Ayushman Bharat scheme, collaborations have increased with private hospitals and diagnostic centres to avail special care for low-income populations [59]. Partnerships with Apollo Hospitals and Narayana Health have notably offered tertiary care services to patients referred from government facilities, at reduced rates [60].

At the same time, private sector engagement in the areas of telemedicine and health technology has accelerated the uptake of innovative solutions. With increasingly affordable diagnostic and consultation services offered by companies such as Practo and 1MG on their online platforms, thousands of rural households are getting benefits [61].

4.3.2 Innovative Financing Models

In addition, innovative financing mechanisms (social impact bonds and health insurance schemes) have helped overcome financial barriers that prevent many from accessing healthcare. For instance, the Bihar Health Assurance Scheme covers cashless treatment of low-income families and consequently bring down the out-of-pocket expenditure [62]. Districts such as Gaya have also tried using social impact bonds to fund initiatives related to maternal and child health, where financial returns depend on measurable health outcomes [63].

4.4 Policy Reforms and Government Initiatives
4.4.1 Ayushman Bharat and Other State-Led Schemes

Bihar's primary healthcare system has been greatly strengthened by the Ayushman Bharat initiative through the creation of Health and Wellness Centres (HWCs) and by making insurance for secondary and tertiary care available. By 2023, 12 million and 61-plus families in Bihar will be able to receive quality healthcare services under Pradhan Mantri Jan Arogya

Yojana (PM-JAY) [64]. HWCs have played a significant role in providing comprehensive primary care including preventive and promotive health services to rural populations [65].

Improvements in health outcomes are also attributable to state-led schemes such as the Mukhyamantri Balak/Balika Cycle Yojana and programmes of the Bihar State Health Society on nutrition and maternal health. For example, the Janani Suraksha Yojana protects financially and provides cash incentives for institutional deliveries especially in areas already suffering from economic disadvantage [66].

4.4.2 Strengthening of Healthcare Governance

Healthcare governance has seen reform around creating more accountability, transparency, and efficiency in service delivery. Performance-based incentives for healthcare workers and real-time monitoring of health programmes through digital dashboards have been successful [67]. Decentralized planning and health committee participation enabled local bodies to respond to their context-specific health issues [68].

Additionally, E-procurement systems and third-party audits have also been strengthened to combat corruption in procurement and fund allocation. This guarantees that the resources are delivered to the intended beneficiaries and that healthcare programmes realize their intended result [69].

5. Impact Assessment of Innovations
5.1 Evaluation of Health Outcomes Post-Implementation of Innovations

Technological, community-based, and governance innovations have been implemented in Bihar's healthcare system which has significantly improved health outcomes. A major achievement is lowering maternal and infant mortality rates. For example, digitized health records linked to telemedicine have made it possible to monitor women in prenatal care, reducing maternal mortality by 20 per cent between 2018 and 2023 [70]. Likewise, infant mortality is lowered because immunization tracking and community-level interventions, such as ASHA work, have improved [71].

Better management of chronic conditions like diabetes and hypertension has also been achieved by the Ayushman Bharat Health and Wellness Centres (HWCs) as well. In rural areas of Bihar, these centres have raised early diagnosis rates by 40% and have helped in early medical intervention and better patient outcomes [72]. In addition, public-private partnership-based financing strategies have provided economically weaker sections with access to quality healthcare services, thereby improving health equity [73].

Threats to health from communicable diseases are being countered with the success by technological solutions like AI-driven diagnostic tools. Pilot studies of AI-aided TB diagnostics for Bihar, for instance, have resulted in a 30% increase in case detection and more accurate treatment regimens with consequent disease spread reduction [74].

5.2 Economic and Social Benefits
5.2.1 Economic Impacts

These healthcare innovations have many economic benefits. With telemedicine and mobile health applications, rural populations have been spared to pay for travel to access some services, hence reducing the associated expenses. According to a study, telemedicine services saved families INR 1,000 on average per medical consultation in Bihar [75]. On the other hand, digitization of health records has also streamlined administrative processes such as reducing the wastage of resources and therefore enhancing the efficiency of healthcare delivery system [76].

Investments in healthcare infrastructure came via public-private partnerships that have also fostered economic growth. Modern diagnostic centres and speciality hospitals have been established through collaborations with private entities and have created employment opportunities for skilled and semi-skilled workers [76]. Ayushman Bharat's expansion of coverage of health insurance has in turn further strengthened the economic resilience of the families not only by reducing the out-of-pocket health expenditure which is a key driver of households entering into poverty but also by utilizing a large number of jobs under the programme [77].

5.2.2 Social Benefits

On the social side, community-based initiatives have brought up healthcare awareness and behavioural change. Thousands of households must have learned about hygiene practices and preventive health measures through programmes such as the Swasthya Chetna Abhiyan, which brought about a change in the culture, which is of health consciousness [78]. ASHA workers have played an active part in allowing the people of the country to trust the public health systems by breaking the distance between communities and healthcare providers [79].

In addition, the spread of healthcare services has made it to become accessible and affordable, hence, contributing to social equity. Targeted interventions have benefited significantly vulnerable groups such as women, children, and the elderly.

For instance, indirectly, it helped improve adolescent health outcomes in that it encouraged school attendance and decreased dropout rates [80], notably among girls.

Additionally, healthcare governance reform policies have infused more transparency and accountability in service delivery. Based on the initiatives of e-procurement and digital dashboards, corruption has been curbed to a greater extent and resources end up with the intended beneficiaries boosting public trust in Government programmes [81].

6. Future Directions

6.1 Recommendations for Scaling Up Innovations

Scaling up the innovations introduced in Bihar's primary healthcare system will require a multi-pronged approach. Expansion of telemedicine and mobile health application coverage and reach is the first step. These platforms help the rural population get linked to healthcare services. This scaling process can be accompanied by expanding mobile coverage and enhancing internet connectivity in remote areas allowing more people access to teleconsultations, remote diagnostics, and health monitoring [82]. In addition, digital literacy in rural areas will be improved to overcome this technological divide, so that the gains of these advancements become available to all populations [83].

Another important area of scaling up relates to the Ayushman Bharat Health and Wellness Centres (HWCs). More easily accessible primary healthcare services, including maternal and child care, immunizations, and screening for chronic diseases, could be provided in underserved rural areas if the network of these centres were to be expanded. Such government partnerships with local NGOs can further enhance community outreach, most particularly in remote settings, so that the healthcare services can reach the most marginalized population [84]. Finally, mobile clinics should expand to supplement the fixed HWCs in reaching out to areas that do not have good infrastructure [85].

Finally, public-private partnership (PPP) building is central to scaling up healthcare innovations. Government can incentivize private healthcare providers to invest in rural healthcare infrastructure, to leverage the expertise and funds of the private sector in addition to their efforts. Advanced healthcare technologies can also be introduced and specialized care options will be created through these partnerships [86].

6.2 Strategies to Address Existing Challenges

Several strategies need to be implemented to address the ongoing challenges in Bihar's healthcare system:

6.2.1 Infrastructure Improvements: Infrastructure deficiencies should be given priority. Upgrading existing Primary Health Centres (PHCs) and Community Health Centres (CHCs) so that they get equipped with basic medical supplies, diagnostic tools, and trained healthcare personnel. Moreover, constructing new healthcare facilities in underserved places will help decongest overcrowding at current spots and guarantee equal opportunity for health services [87].

6.2.2 Addressing Workforce Shortages: There is a great dearth of trained healthcare professionals in Bihar, especially in rural areas. A solution is making greater investments in medical education and training programmes geared at healthcare delivery in rural communities. Enhanced government initiatives, such as—exemplified by incentives for healthcare workers to serve in remote areas—salary increases, housing allowances, and advancement in career [88]. Additionally, telemedicine could help relieve some of the pressure on healthcare workers by enabling specialists to provide remote consultations with local healthcare providers [89].

6.2.3. Health Education and Awareness: To increase awareness about preventive healthcare, sanitation, and early detection of diseases, the primary intervention could be in terms of utilization of ASHA workers, local NGOs, and school-based health education programmes at the community level to strengthen health education. In doing so, these same efforts can also cut, sometimes significantly, the occurrence of preventable diseases such as malaria, tuberculosis, and diarrhoea that continue to be pressing problems, especially in rural Bihar [90].

6.2.4 Governance and Policy Implementation: To deal with the policy and governance challenges, the capacity of the state health department to run healthcare programmes has to be strengthened. This encompasses responsible use of funding, and getting rid of corruption in addition to the establishment of strong monitoring and evaluation mechanisms for tracking the progress of schemes such as Ayushman Bharat. Through regular audits and feedback loops, one can easily isolate and correct inefficiencies in healthcare service delivery [91].

6.2.5 Improving Healthcare Financing: Health savings accounts and micro-insurance schemes can be built to introduce new innovative financing models to bridge the financial gaps for families that cannot afford private healthcare services.

Financial access to healthcare in Bihar will be improved with the use of these models, which have been successful in other parts of India [92].

6.3 Role of Academia, Government, and Private Sectors in Improving Healthcare
The role of the academia, government, and private sectors is pivotal in improving Bihar's primary healthcare system. Their collaboration can lead to innovations in healthcare delivery, better policy-making, and sustainable financing solutions.

6.3.1 Academia's Role
Research and development on the part of universities and research institutions can play a large part in developing areas of healthcare innovation. Academia can offer evidence-based solutions related to Bihar's healthcare challenges by carrying out research that suggests efficient healthcare models, disease prevention, and public health strategies. Besides, educational institutions can impart training to the healthcare practitioners or improve the level of medical education in the state [93]. And development of health technologies like AI-assisted diagnostics or telemedicine platforms that are suited for rural Bihar [94] can be promoted by collaborations between the government and universities.

6.3.2 Government's Role
The policy framework, funding, and institutional support required for driving healthcare innovations can only come from the state and central governments. Already, Ayushman Bharat and National Health Mission are the government-led initiatives that have shown the good being done by the state. For the government to continue investing in healthcare infrastructure, handling the problems of rural healthcare workers, and formulating adequate healthcare policies, ensuring equitable access to services will remain necessary [95]. In addition, scaling innovations like telemedicine and mobile healthcare also needs government support, to make sure that they are integrated properly in the larger healthcare system.

6.3.3 Private Sector's Role
Private capital and technology, and innovative service solutions that accompany private capital are vital for improving healthcare delivery [96]. In the areas where there is little or no access to quality healthcare, the private sector is most often the only one able to build new healthcare facilities and bring in innovative technologies and services. Engagement of the private sector in particular forms of PPP improves service provision, increases access to certain types of care, and leads to better health outcomes [97]. The study also shows that low-cost health insurance plans provided by private insurance companies can expand access to care for at-risk groups [98]. Intersectoral cooperation for health development is a sustainable and holistic process of enhancing Bihar's healthcare system. With the help of the unique advantages of each of the sectors, Bihar can solve the problems it faces today and move towards the optimization of healthcare for all the inhabitants.

7. Conclusion
This paper could conclude that primary healthcare in Bihar is challenged deeply by the factors that are vast rural-oriented population, constrained physical infrastructure and resources. While the country has over 1 PHC/1000 population and 200/100,000 CHCs, there is a critical shortage of health workforce together with inadequate equipment leaving the scope to improve healthcare delivery. The high maternal and infant mortality remains an indication of the need to redouble efforts on health interventions, especially for the vulnerable populations in the hard-to-reach regions of the country. The engagement of telemedicine, mobile health apps and roles played by the auxiliary nurse midwife also known as ASHA workers have made significant progress. For example, telemedicine has improved healthcare access by 35% in the pilot districts, while community-based programmes have created health awareness among 60 % of rural households. Ayushman scheme and tie-ups with private hospitals have benefited millions of families besides enabling them to get access to highly end provisions. Nevertheless, there are still some gaps, for example, in relation to the urban/ rural split and other sociocultural issues. Sustained progress will therefore involve a multi-sectoral approach that will require the coordinated effort of government, business and academia. Health system improvement, human resources development and the expansion of digital health solutions should be pursued. However, sound governance and effective management of resources are prerequisites for making healthcare for the population of Bihar equitable, and high-quality. As there are continuous innovations and specific reforms made, the primary healthcare of Bihar can change to cater for the needs of the residents and contribute to the improvement of the health of the population.

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