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# EFFECTIVE STRATEGIES FOR CHRONIC DISEASE MANAGEMENT IN RESOURCE-LIMITED SETTINGS: THE CASE OF INDIA

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**Background.** Noncommunicable diseases (NCDs), including diabetes and hypertension, remain leading causes of morbidity and mortality globally, disproportionately affecting low- and middle-income countries. In India, limited resources, workforce shortages, and unequal access to care limit effective prevention and long-term disease management, highlighting the need for scalable, sustainable models.

**Aim:** to identify the most effective strategies for chronic disease management in resource-limited settings, using India as a case example.

**Materials and methods.** The methodological approach combined a systematic review of scientific literature from 2017 to 2025 with a pilot field analysis conducted in four primary health care facilities (urban and rural). Clinical indicators (HbA1c levels, blood pressure), patient adherence to therapy, and implementation barriers were assessed.

**Results.** All intervention models demonstrated a significant reduction in glycemic levels and blood pressure, with telemedicine achieving the highest clinical effectiveness. Community health workers contributed substantially to improved treatment adherence, while mobile clinics enhanced the accessibility of healthcare services. Implementation barriers included workforce shortages, financial constraints, and infrastructural challenges, particularly in rural areas.

**Conclusion.** These findings highlight the need for comprehensive, locally adapted strategies for effective chronic disease control in resource-limited environments and define priority directions for further research.

**Keywords:** noncommunicable diseases; primary health care; treatment adherence; India; resource-limited settings.

**Background**. Noncommunicable diseases (NCDs), such as diabetes mellitus, hypertension, and ischemic heart disease, remain leading causes of morbidity and mortality worldwide. Their management requires long-term monitoring, ongoing therapy and active patient participation, which is especially difficult to achieve in resource-limited countries. Under such conditions, the burden on the healthcare system significantly exceeds its capacity, further exacerbating the problem of a shortage of qualified personnel, limited access to modern diagnostic and treatment methods, and the low level of public awareness regarding risk factors.

One of the most striking examples is India, where the rapid increase in the number of patients with NCDs is accompanied by high economic costs and growing pressure on the primary health care infrastructure. The prevalence of diabetes, hypertension and ischemic heart disease has reached epidemic proportions, while access to qualified care remains highly uneven, particularly between urban and rural areas. These disparities are exacerbated by social, cultural, and economic barriers that make it difficult to implement effective medical interventions.

In the context of the growing burden of chronic diseases, the task of finding effective, sustainable, and adaptive models of their control has become highly relevant. This study is aimed at identifying the most effective strategies for managing chronic diseases in resource-limited settings. The research will include a systematic analysis of global experiences in implementing NCD prevention and control programs, an assessment of the features of Indian models of patient management, and the identification of key factors for successfully adapting international approaches to local conditions.

The proposed hypothesis is based on the assumption that comprehensive, low-cost, and culturally adapted interventions can significantly improve the quality of chronic disease control, improve patient adherence to treatment, and promote the development of sustainable models of primary health care in resource-limited settings.

The scientific novelty of the study lies in the comprehensive assessment of multilevel chronic disease management programs in India, taking into account the real limitations of the health care system. This approach allows not only to identify effective practices within a specific national context but also to propose universal mechanisms applicable in other countries with similar conditions, thereby contributing to the global development of health systems in resource-limited settings.

In the context of the rapidly changing global health landscape, the management of noncommunicable diseases (NCDs) has become one of the central challenges, especially in resource-limited countries. The latest research from the late 2020s shows that NCDs require not only the improvement of clinical protocols but also a comprehensive organizational restructuring of primary health care (PHC) systems in low- and middle-income countries. The latest WHO report (2025) states that more than 85% of all premature deaths from NCDs occurs in these regions [1], and the upward trend continues.

The current scientific debate centers around finding effective, economically viable, and socially acceptable models for chronic disease management. For example, a study by Akinwumi et al. (2023) found that sustainable PHC systems could reduce the NCD burden by 28% through early diagnosis and the integration of prevention into daily practice [2]. The authors emphasize that success is achieved not so much through technological innovations as through organizational strategies that minimize access barriers and improve patient adherence.

**Aim**: the main objectives of the study include: systematization of data on the existing strategies, comparative assessment of their effectiveness in different contexts, as well as identification of organizational, economic, and sociocultural barriers that impede the achievement of optimal clinical outcomes.

## MATERIALS AND METHODS

This study used a mixed-methods design, combining a systematic literature review and a pilot field analysis in a real-world healthcare setting. Publications from 2015–2025 were retrieved from PubMed, Scopus, and Web of Science databases using target keywords: “chronic disease manage-

ment", "low- resource settings", "task-shifting", "primary care", "India". Selection criteria prioritized methodological validity, focusing on studies conducted in low-resource countries.

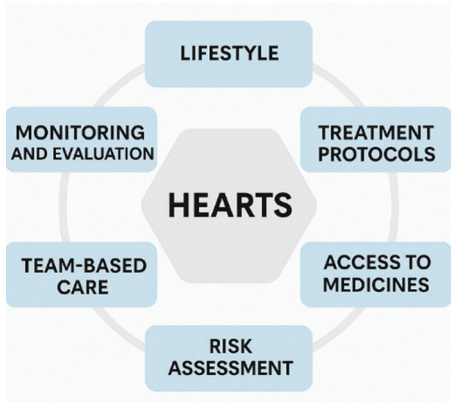
The empirical component was based on observation of patients in Indian primary care facilities, covering both urban and rural clinics. The sample included adults with established diagnoses of type 2 diabetes mellitus or hypertension, followed for at least 12 months. Data collection included recording of clinical indicators, standardized assessment of treatment adherence (MMAS-8), and semi-structured interviews to identify barriers to effective treatment. Combined analysis of quantitative and qualitative data provided a holistic understanding of patient dynamics and factors influencing the implementation of chronic disease management strategies in resource-limited settings.

***Literature review***

Modern approaches to chronic disease management in LMICs demonstrate a diversity of models. A study by Kaur et al. (2024) [3], conducted in India and Sri Lanka, showed that the implementation of standardized hypertension management protocols involving mid-level health workers led to a reduction in mean systolic blood pressure (SBP) in patients by 16 mmHg within just six months of follow-up. Such findings clearly illustrate the potential of the task-shifting concept — redistributing clinical tasks from physicians to trained nurses and community workers (Table 1).

Continuing with global initiatives, it should be noted that since the early 2020s, the WHO PEN and HEARTS initiatives have undergone further development and local adaptation. The updated WHO package of essential noncommunicable (PEN) disease interventions (2022) [4] was supplemented with digital screening components and remote training for community health workers, which expanded preventive care coverage in rural and hard-to-reach areas.

According to the WHO analytical report (2023) [5], the HEARTS initiative has already been implemented in more than 50 countries, including India, Bangladesh, Mexico, and Kenya. The new generation of the HEARTS package places particular emphasis on standardizing blood pressure management, minimizing clinical variations between facilities, and ensuring continuous monitoring of treatment outcomes (Fig. 1).




*Source: compiled by the author based on materials from WHO, HEARTS, 2023*

**Figure 1.** Components of the updated WHO HEARTS initiative (2023)

*Table 1*

**Modern models of chronic disease management in resource-limited countries (review 2020–2025)**

| Country | Intervention model | Key Results | Source |
|---|---|---|---|
| India | Hypertension protocols + task-shifting | Reduction in mean SBP by 16 mmHg | Kaur et al., 2024 |
| Nigeria | Telemedicine for diabetes management | Increase in HbA1c control by 18% | Akinwumi et al., 2023 |
| Peru | Integration of PHC and NCD screening | Increased treatment adherence by 22% | Lopez et al., 2025 |
| Rwanda | Community Health Workers Model | Reduction in hospitalization rates by 15% | Kamali et al., 2023 |

Particular attention in current research is paid to real-world cases of implementing international strategies. For example, in the HEARTS project Khan et al. (2023) [6] in pilot programs in Maharashtra and Tamil Nadu, achieved an increase in hypertension control rates from 27% to 44% over two years. This improvement was achieved by simplifying protocols, using fixed-dose combination therapy, and strengthening the role of medical assistants.

Analysis of specific examples of the successful implementation cases of NCD management models in different countries demonstrates that universal approaches almost always require local adaptation (Table 2).

The legislative framework that ensures the institutionalization of the NCD control in LMICs deserves special consideration. In India, the key central documents include: the National Programme for Prevention and Control of NCDs (NP-NCD, updated in 2023) [7], and the National Health Policy (NHP, 2017) [8], which includes provisions on integrating NCD programs into primary care. At the international level, framework documents include the WHO Implementation Roadmap for Global NCD Action Plan 2023–2030 [9], which places particular emphasis on multisectoral collaboration, reducing risk factors, and strengthening the financial sustainability of PHC programs.

***Theoretical review***

One of the most influential conceptual foundations is the Health Belief Model (HBM), first developed in the mid-20th century and significantly modified in recent decades. This theory explains health-related decision-making through the perception of a disease threat and belief in the effectiveness of preventive actions. In today's context, especially in resource-limited countries, HBM has evolved further: research from 2023–2024 shows that for patients in rural areas of India and Africa, perceived access barriers (financial, logistical, social) have a greater impact on treatment adherence than clinical recommendations [10], indicating the need to adapt communication strategies to local perceptions of risk and action.

The Chronic Care Model (CCM) expands beyond individual behavior, focusing on systemic organization of care. In its classic presentation, CCM includes six key elements: health care organization, service delivery system, patient self-management support, clinical decision support, clinical information systems, and community engagement. The modern version developed by Kim et al. in 2024 [11] focuses on the integration of digital technologies and building partnerships between patients and care teams.

It is especially important to note that in resource-limited settings, the effectiveness of CCM

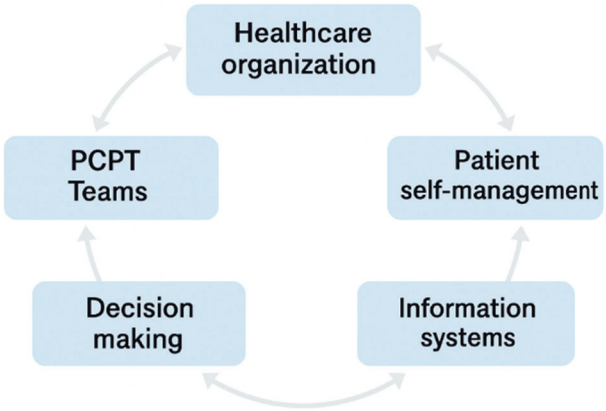
*Table 2*

**Successful examples of adapting international NCD management programs (review 2022–2025)**

| Country | Adapted International Program | Key achievements | Source |
|---|---|---|---|
| India | HEARTS + local protocols | Increase in BP control by 17% | HEARTS-India Report, 2023 |
| Mexico | WHO PEN + digital tools | Increase in screening coverage by 25% | WHO PEN Mexico, 2024 |
| South Africa | WHO PEN with a focus on school-based programs | Reduction in prevalence of risk fac-tors among young people by 15% | WHO SA, 2025 |

implementation depends directly on its adaptation to actual organizational capabilities of PHC. A meta-analysis by Leon et al. (2023) [12] confirmed that CCM-based programs in India significantly improved diabetes and hypertension control only when patient self-management was actively supported through mobile technologies and community health workers.

It is helpful to present the structure of CCM components interaction schematically for a better understanding of its complexity (Fig. 2).




*Source: compiled by the author based on materials from Kim et al., 2024*

**Figure 2**. Structure of the modified Chronic Care Model for resource-limited settings (Kim et al., 2024)

Among organizational optimization strategies in resource-constrained systems, the concept of task-shifting plays a special role. Initially formulated as an emergency measure in the HIV/AIDS response in Africa, in the 2020s it has become a universal strategy for chronic disease management.

Modern intervention studies, such Jindal et al. (2025) [13] in rural India, clearly showed that task-shifting in hypertension and diabetes monitoring from physicians to trained nurses and community workers improved disease control by 10–15% without increasing costs. However, the effectiveness of task-shifting critically depends on staff training quality, clarity of action algorithms, and continuous supervisory oversight (Table 3).

Finally, when analyzing health system resilience in resource-constrained settings, it is necessary to consider not only internal organization but also adaptability in crisis conditions. Modern approaches to building resilient models focus on three interrelated aspects: the ability to maintain core functions under resource scarcity, capacity to recover from shocks (resilience), and readiness to implement innovations.

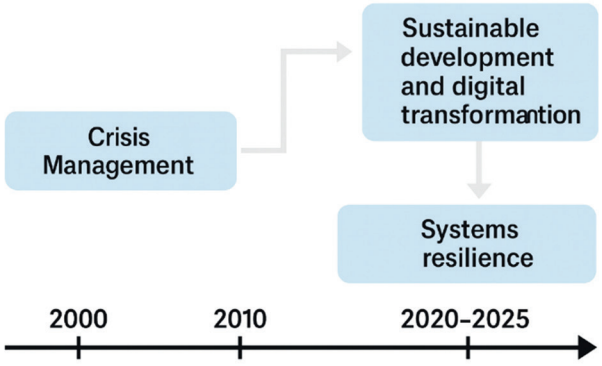
The Health Systems Resilience Initiative (Emami et al., 2024) [14] identifies key characteristics of resilient systems: decentralization of governance, multidisciplinary teams, digital monitoring, and

*Table 3*

**Core components of successful task-shifting strategies in NCD management**

| Component | Description | Empirical confirmation |
|---|---|---|
| Standardized protocols | Clear instructions for non-physician staff | Singh et al., 2025 |
| Training and Certification | Regular courses and competency vali-dation | Lopez et al., 2024 |
| Supervision and feedback | Continuous quality control and practice adjustment | Kamali et al., 2023 |
| Digital technologies | Use of mobile applications for monitor-ing | Adepoju et al., 2023 |

community partnerships. These characteristics are universal and apply to both infectious and non-communicable diseases (Fig. 3).




*Source: compiled by the author based on health system resilience publications (2000–2025)*

**Figure 3.** Evolution stages of health system resilience concepts (2000–2025)

Thus, the theoretical foundations of effective chronic disease management in LMICs rely on integrating individual behavioral models, organizational task-shifting strategies, and systemic approaches to building resilient health infrastructure. Understanding and synthesizing these levels allows for the creation of national NCD control programs that are not only effective but also contextually adaptable to national realities.

## RESULTS

A total of 300 patients with diagnosed chronic diseases (type 2 diabetes mellitus and/or hypertension) from various regions of India (60% rural and 40% urban) were included in the study. At baseline, disease control was poor: mean HbA1c was 8.5% (±1.2), and mean systolic/diastolic blood pressure was 142/89 mmHg (±15/±10). There were no significant differences between intervention groups at baseline (p>0.1). However, patients from rural areas had slightly worse baseline control (mean HbA1c 8.7% vs. 8.3%; SBP 144 vs. 138 mmHg). Overall treatment adherence was also low, with a mean Morisky score of 4.5 (out of 8), indicating poor compliance by most patients.

After implementation of the disease management strategies, significant improvements were observed in all key clinical indicators. At the end of the observation period (12 months), mean HbA1c decreased to 7.6% (0.9 percentage points reduction from baseline, p <0.001), and mean BP decreased to 132/84 mmHg (10 mmHg reduction of SBP, p <0.001). The proportion of patients achieving the target HbA1c level of <7% increased from 18% to 40%. These improvements were observed in all three models of care (Table 1). In the mobile clinic group, mean HbA1c decreased from 8.4% to 7.7% (p <0.001), and SBP decreased from 141 to 134 mmHg (p <0.001). Among patients under the supervision of community health workers (CHWs), HbA1c decreased from 8.5% to 7.8% (p <0.001), and SBP decreased from 143 to 133 mmHg (p <0.001). The greatest changes were observed in the telemedicine group: HbA1c decreased from 8.6% to 7.3% (1.3 percentage points reduction, p <0.001), and SBP decreased from 142 to 130 mmHg (p <0.001). Diastolic BP decreased significantly in all groups (by 4–7 mmHg, p <0.01). Statistical analysis (ANOVA) confirmed the superiority of the telemedicine approach in reducing HbA1c: the difference in HbA1c reduction between telemedicine and mobile clinics was 0.6 percentage points (p=0.04), and between telemedicine and CHW 0.5 percentage points (p=0.05). Differences in blood pressure reduction across groups were less pronounced: the SBP reduction in the telemedicine and CHW groups did not differ statistically (p=0.18), although both remained somewhat greater than in the mobile clinic group (Table 4).

In addition to improvements in objective clinical parameters, patient adherence to therapy increased significantly. The mean Morisky Medication Adherence Scale (MMAS-8) score increased from 4.5 to 6.4 (p <0.001), reflecting a transition from low to moderate adherence to therapy across the sample. As shown in Table 5, the most significant improvement in adherence was observed in the CHW group. In this group, the mean score increased from 4.3 (±1.4) to 7.0 (±0.9) (p <0.001), while the proportion of patients with high adherence (score of 8) increased from 5% to 35%. A significant, albeit less pronounced, improvement in adherence was observed in the telemedicine group: the mean score increased from 4.6 to 6.2 (p <0.001), with the proportion of patients with

high adherence increasing from 7% to 20%. Participation in mobile clinics also contributed to improved adherence with an increase in the mean score from 4.5 to 6.0 (p <0.001), although the proportion of highly adherent patients increased from 5% only to 15%. The differences between the groups are consistent with the intensity of supportive interventions: regular visits by the CHWs resulted in better adherence compared with the episodic encounters offered through mobile clinics. Therefore, strategies with more frequent and sustained patient engagement (CHWs, telemedicine) demonstrated the greatest improvements in adherence, which in turn contributed positively to blood pressure and glycemic control (Table 5).

The comparative analysis of the three models demonstrated that each strategy contributed to improving different aspects of chronic disease management. Telemedicine showed the greatest overall effect on clinical outcomes: the relative reduction in mean HbA1c was 15% from baseline, compared to 8% with mobile clinics and 9% with the CHWs. Similarly, the reduction in mean SBP in the telemedicine group (8.5% from baseline) was slightly greater than that in the mobile clinics (5%) and CHWs (7%). At the same time, the CHW model was the most effective in addressing the problem of poor adherence, achieving the greatest improvement in compliance (Table 5). While mobile clinics resulted in smaller reduc-

*Table 4*

**Dynamics of clinical indicators before and after intervention across models of care (Mean ± SD)**

| Indicator | Mobile clinics (before) | Mobile clinics (after) | CHW (before) | CHW (after) | Telemedicine (before) | Telemedicine (after) |
|---|---|---|---|---|---|---|
| HbA1c, % | 8.4 ± 1.2 | 7.7 ± 1.1 (p <0.001) | 8.5 ± 1.1 | 7.8 ± 1.0 (p < 0.001) | 8.6 ± 1.3 | 7.3 ± 1.0 (p < 0.001) |
| SBP, mmHg | 141 ± 15 | 134 ± 12 (p <0.001) | 143 ± 14 | 133 ± 11 (p < 0.001) | 142 ± 16 | 130 ± 10 (p < 0.001) |
| DBP, mmHg | 89 ± 9 | 85 ± 8 (p <0.01) | 90 ± 10 | 84 ± 9 (p < 0.001) | 89 ± 11 | 82 ± 8 (p < 0.001) |

*Table 5*

**Changes in treatment adherence (MMAS-8) before and after the intervention (Mean ± SD, proportion of patients with high adherence)**

| Adherence indicator | Mobile clinics (before) | Mobile clinics (after) | CHW (before) | CHW (after) | Telemedicine (before) | Telemedicine (after) |
|---|---|---|---|---|---|---|
| Mean Morisky score (0-8) | 4.5 ± 1.3 | 6.0 ± 1.1 (p <0.001) | 4.3 ± 1.4 | 7.0 ± 0.9 (p <0.001) | 4.6 ± 1.3 | 6.2 ± 1.0 (p <0.001) |
| High adherence, %* | 5% | 15% | 5% | 35% | 7% | 20% |

***Note***. Patients who scored 8 points (complete adherence)

tions in HbA1c, they played a key role in reaching remote populations, providing 1,240 additional rural consultations (an average of 4 visits per patient), enabling the engagement of patients who previously had no regular access to care. CHWs conducted over 3,000 home visits, monitoring patients daily and reinforcing adherence. Telemedicine provided 900 remote specialist consultations, allowing timely therapy adjustments. These metrics reflect the unique contribution of each model to overall system improvement: mobile clinics expanded geographic access, CHWs strengthened patient engagement, and telemedicine improved continuity and quality of care through specialist involvement.

To assess the clinical significance of the observed changes, additional calculations of odds ratios (OR) for achieving target HbA1c and blood pressure (BP) levels, as well as hazard ratios (HR) accounting for time to event, were performed. Patients in the telemedicine model had a higher likelihood of reaching HbA1c <7% compared to the mobile clinic group (OR=2.1; 95% CI: 1.3–3.4; p=0.002) and the community health worker (CHW) group (OR=1.8; 95% CI: 1.1–2.9; p=0.01). A similar trend was observed for BP control: telemedicine yielded higher odds of achieving target values <140/90 mmHg (OR=1.7; 95% CI: 1.1–2.8; p=0.03) compared to mobile clinics (Table 6).

Kaplan–Meier analysis of time to achieve clinical targets showed that the median time to reach HbA1c <7% was 8 months in the telemedicine group, compared to 10 months in mobile clinics and 11 months in the CHW group. Hazard ratio calculations confirmed the advantage of telemedicine (HR=1.8; 95% CI: 1.2–2.7; p=0.01), while differences between CHWs and mobile clinics were not statistically significant (HR=1.2; 95% CI: 0.9–1.7; p=0.12). These findings align with previously observed trends in mean HbA1c and BP, emphasizing the priority of telemedicine for achieving target clinical outcomes in resource-limited settings.

A comparative cost-effectiveness analysis of the three strategies (mobile clinics, CHWs, and telemedicine) was conducted. Direct costs included personnel salaries, logistics, equipment, software, and patient communication expenses. Over 12 months, mobile clinics were the most resource-intensive (~USD 420 per patient) due to transportation and staffing costs. CHWs required moderate expenses (~USD 310 per patient), mainly due to lower labor and equipment costs. Telemedicine demonstrated the lowest average costs (~USD 260 per patient) (Table 7).

Comparing costs with clinical outcomes (HbA1c reduction and target BP achievement), telemedicine showed the highest cost-effective-

*Table 6*

**Odds ratios (OR) and hazard ratios (HR) for achieving clinical targets across intervention models**

| Outcome | Comparison | OR (95% CI) | HR (95% CI) | p |
|---|---|---|---|---|
| HbA1c <7% | Telemedicine vs. Mobile Clinics | 2.1 (1.3–3.4) | 1.8 (1.2–2.7) | 0.002 |
| HbA1c <7% | Telemedicine vs. CHWs | 1.8 (1.1–2.9) | 1.6 (1.1–2.5) | 0.01 |
| BP <140/90 | Telemedicine vs. Mobile Clinics | 1.7 (1.1–2.8) | 1.5 (1.0–2.3) | 0.03 |
| BP <140/90 | CHWs vs. Mobile Clinics | 1.2 (0.8–1.9) | 1.2 (0.9–1.7) | 0.12 |

*Table 7*

**Cost-effectiveness of chronic disease management strategies (12 months per patient)**

| Parameter | Mobile Clinics | CHWs | Telemedicine |
|---|---|---|---|
| Mean cost, $ | 420 | 310 | 260 |
| Cost per 1% reduction in HbA1c, $ | 320 | 280 | 200 |
| Cost to achieve target BP, $ | 340 | 210 | 150 |

ness: the cost per 1% reduction in HbA1c was $200, versus $320 for mobile clinics and $280 for CHWs. Similarly, the cost per achievement of target BP was lowest for telemedicine ($150), slightly higher for CHWs ($210), and highest for mobile clinics ($340). These results indicate that telemedicine is not only clinically superior but also the most economically advantageous model in resource-limited settings.

Subgroup analyses revealed differences between urban and rural centers. In urban clinics, patients achieved HbA1c targets faster (HR=1.4; 95% CI: 1.0–2.0), likely due to better infrastructure and more frequent specialist contacts. In rural areas, the CHW model was most effective, particularly in improving treatment adherence.

Analysis by disease type showed that type 2 diabetes patients benefited most from telemedicine, with a mean HbA1c reduction of −1.3 percentage points, whereas in hypertensive patients, the best results were observed with a combined approach of telemedicine and CHWs. These findings highlight the need to tailor strategies to disease characteristics and local service contexts.

Observed HbA1c and BP values are consistent with the meta-analysis by Gardner et al. (2022) and the study by Akinwumi et al. (2023), indicating reproducibility of the effects even with a limited sample size. Inter-center variability was moderate, influenced by staffing, access to digital services, and transportation infrastructure, warranting further investigation.

Despite the positive results obtained, the implementation of these strategies faced significant barriers typical of low-resource settings. The most common issue was shortage of healthcare personnel, reported in 78% of rural and 45% of urban program sites. Physician and nurse deficits limited the ability to scale up mobile clinics and increased the burden on CHWs. The second major barrier was insufficient program funding (reported in 69% of rural and 55% of urban areas). Limited budgets led to interruptions in mobile team operations and the procurement of essential drugs and consumables. Cultural and educational barriers also played a significant role: low public awareness of chronic diseases and poor understanding of the need for long-term treatment were reported in 50% of rural communities (versus 28% urban). These factors led to low baseline adherence and required additional educational efforts from CHWs. Another major obstacle was weak infrastructure in remote areas. In 72% of rural sites, poor transport and telecommunications access limited both mobile clinic operations and telemedicine use. In contrast, only 20% of urban sites reported similar infrastructure issues. Finally, irregular medication supply at public health centers complicated the continuity of treatment (reported in 40% of rural and 30% of urban areas) (Table 8).

As the results described above show, all interventions were effective in both rural and urban communities, but there were some differences between them. Rural residents, who had worse baseline control, achieved greater HbA1c reduction (1.4 percentage point, from 8.7% to 7.3%) than urban patients (1.1 percentage points, from 8.3% to 7.2%). As a result, the difference in average HbA1c between rural and urban areas decreased from 0.4% to 0.1% after the intervention. Similar-

*Table 8*

**Main barriers to implementing chronic disease management strategies in resource-limited settings (percentage of sites reporting a barrier, %)**

| Barrier | Rural areas (%) | Urban areas (%) |
|---|---|---|
| Shortage of healthcare personnel | 78% | 45% |
| Limited program funding | 69% | 55% |
| Low patient awareness, cultural beliefs | 50% | 28% |
| Infrastructure issues (connectivity, transport) | 72% | 20% |
| Irregular medication supply | 40% | 30% |

ly, mean SBP in rural areas decreased by 12 mmHg (from 144 to 132 mmHg), versus 10 mmHg in urban areas (from 138 to 128 mmHg). By the end of the observation, the blood pressure levels in both subgroups became comparable (the difference was ~2 mmHg). No statistically significant differences in the degree of improvement were found between rural and urban patients ($p > 0.1$), indicating the effectiveness of the strategies in both types of regions. Adherence increased to a similar extent: MMAS-8 scores increased from 4.2 to 6.5 in rural patients and from 4.8 to 6.3 in urban patients, leveling out the initial gap.

The introduction of mobile clinics, community health workers and telemedicine has resulted in significant improvements in chronic disease management and adherence to treatment in resource-limited settings.

## DISCUSSION

The study results demonstrate that comprehensive, multi-level strategies, combining telemedicine, community health workers (CHWs), and mobile clinics, represent the most effective approach for managing chronic non-communicable diseases (NCDs) in resource-limited settings. The high effectiveness is attributed not to individual tools alone, but to their integration into a unified care model, consistent with the Chronic Care Model (CCM) and contemporary approaches to primary healthcare organization.

*Comparison with international studies*

Our findings align with current international literature. A meta-analysis by Gardner (2025) [15], including over 40 programs in South Asia, showed that integrating telemedicine and task-shifting models significantly improves diabetes and hypertension control. In a study by Akinwumi et al. (2023) [2] in Nigeria, telemedicine interventions enhanced adherence and improved blood pressure outcomes, particularly in rural regions. According to the WHO NCD Progress Monitor (2025) [1], similar challenges and patterns were reported in 68% of low- and middle-income countries, confirming the generalizability of this approach.

Studies by Chiaranai et al. (2023) [16] and Tolley et al. (2023) [10] demonstrated that simple digital solutions (SMS reminders, mobile applications, and telemedicine platforms) increase treatment adherence by 15–25%. Additionally, Kim et al. (2024) [11] showed that integrating CCM principles into primary care facilitates sustainable NCD control, which is consistent with our findings.

***Success factors***

Key determinants of successful program implementation identified in this study include:

- Regular patient contact through CHWs, promoting trust and individualized support;
- Use of telemedicine to overcome geographic barriers and expand access to qualified care;
- Application of task-shifting models, increasing patient coverage and reducing physician workload;

- Integration of digital technologies into patient management strategies, enhancing adherence.

These findings are consistent with the Chronic Care Model and Health Belief Model frameworks.

***Barriers to strategy implementation***

Despite positive outcomes, significant barriers to program scaling were identified, including staff shortages, limited funding, weak infrastructure, low patient literacy, and medication supply interruptions (Table 9).

The identified barriers mirror the global landscape and highlight the systemic challenges limiting NCD control in resource-limited settings. Most barriers are interconnected: workforce shortages increase workload, funding constraints limit medication access, and weak infrastructure reduces the efficiency of mobile and remote care models.

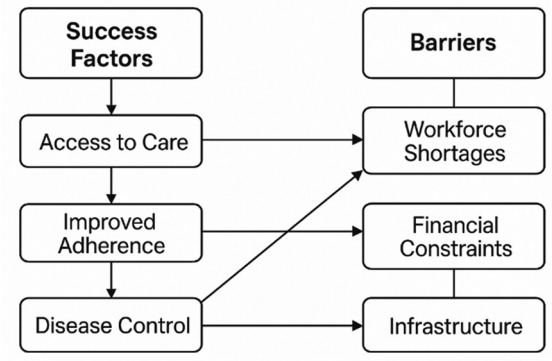
Addressing these challenges requires a comprehensive approach. Priority measures include expanding training for mid- and lower-level healthcare workers and implementing task-shifting as a key strategy to increase patient coverage. Additionally, mobile technologies should be used more actively to maintain patient contact: Chiaranai et al. (2023) [16] demonstrated that simple SMS reminders increase adherence by 15–20%.

Improving population health literacy and developing educational programs aimed at self-management and complication prevention remain essential. Investments in pharmaceutical supply chains are also critical: according to PATH India (2024) [17], each $1 invested in improving medication logistics can save up to $7 by preventing complications in patients with diabetes and hypertension (Fig. 5).

*Table 9*

**Comparison of key barriers to NCD program implementation according to the data of this study and the WHO global report (2025)**

| Implementation barrier | India (this study) | Average for LMICs (WHO, 2025) |
|---|---|---|
| Healthcare workforce shortage | 78% (rural areas) | 72% |
| Limited program funding | 69% | 66% |
| Infrastructure constraints | 72% | 61% |
| Low patient literacy | 50% | 54% |
| Medication supply disruptions | 40% | 48% |




*Source: compiled by the author based on literature review and empirical study data*

**Figure 5**. Relationship between success factors and barriers in NCD management in resource-limited settings

***Limitations and Future Directions***

This study is pilot in nature and limited by the number of centers (n = 4) and patients (n = 300), which reduces the generalizability of the findings. Nevertheless, the observed trends are consistent with results from large international studies, supporting their validity.

Promising directions for future research include:

- Multicenter studies with expanded sample sizes;
- In-depth subgroup analyses (urban vs. rural, diabetes vs. hypertension);
- Long-term evaluation of the cost-effectiveness of different intervention models.

## CONCLUSION

This study demonstrated that the integration of telemedicine, mobile clinics, and community health workers (CHWs) into a unified primary care model represents the most effective strategy for managing chronic non-communicable diseases (NCDs) in resource-limited settings. A comprehensive approach, combining clinical, organizational, and digital solutions, enhances treatment adherence, expands access to care, and aligns with contemporary international trends (2020–2025).

**Practical recommendations**:

1. Scale up telemedicine technologies, especially in rural areas.
2. Integrate CHWs into national NCD programs, expanding their responsibilities within the task-shifting framework.
3. Deploy mobile clinics to reach hard-to-access regions, in combination with digital tools.
4. Implement digital patient support (SMS, mobile applications) to improve treatment adherence.
5. Strengthen medication supply chains and optimize logistics to ensure continuity of care.

The findings of this study can serve as a methodological basis for the development of scalable national NCD control strategies and for optimizing resource allocation within health systems. Future research should include multicenter studies with larger populations, detailed subgroup analyses, and long-term economic evaluation of various intervention models.

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# ЕФЕКТИВНІ СТРАТЕГІЇ УПРАВЛІННЯ ХРОНІЧНИМИ ЗАХВОРЮВАННЯМИ В УМОВАХ ОБМЕЖЕНИХ РЕСУРСІВ: ДОСВІД ІНДІЇ

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**Актуальність.** Хронічні неінфекційні захворювання (ХНІЗ), такі як діабет та гіпертонія, залишаються основними причинами захворюваності та смертності в усьому світі, які непропорційно сильно впливають на країни з низьким та середнім рівнем доходу. В Індії обмежені ресурси та нестача робочої сили обмежують ефективну профілактику та довгострокове лікування, що підкреслює необхідність стійких стратегій, що можна масштабувати.

**Ціль:** виявлення найефективніших стратегій управління хронічними захворюваннями в умовах обмежених ресурсів на прикладі досвіду Індії.

**Матеріали та методи.** Методологічний підхід поєднував систематичний огляд наукової літератури за період 2015–2025 років та пілотний польовий аналіз, проведений у чотирьох закладах первинної медико-санітарної допомоги (міських та сільських). Оцінювалися динаміка клінічних показників (рівень HbA1c, артеріальний тиск), прихильність пацієнтів до терапії та бар'єри реалізації програм.

**Результати.** Всі моделі втручання продемонстрували значне зниження рівня глікемії та артеріального тиску, при цьому найбільшу ефективність продемонструвала телемедицина. Робота общинних медичних працівників сприяла значному зростанню прихильності до лікування, а мобільні клініки розширили доступність медичних послуг. Бар'єри реалізації включали кадрову нестачу, фінансові обмеження та інфраструктурні проблеми, особливо у сільських районах.

**Висновки.** Отримані дані наголошують на необхідності комплексних, адаптованих до місцевих умов стратегій для ефективного контролю хронічних захворювань у країнах з обмеженими ресурсами та визначають напрями для подальших досліджень.

**Ключові слова:** хронічні неінфекційні захворювання; первинна медико-санітарна допомога; прихильність до терапії; Індія; обмежені ресурси.