



Decentralized Screening for Hypertension, Diabetes Mellitus and Anemia through A Scalable Model Using Community Health Workers (CHWs) and Telehealth Integration-An Apollo Telehealth Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: The increasing burden of non-communicable diseases (NCDs) in India, such as hypertension, diabetes, and anemia, continues to make it difficult for rural communities to get timely diagnostic and treatment services. The integration of digital health technologies, such as telemedicine, remote monitoring systems, and point-of-care testing (POCT) devices, offers a potential solution to close these gaps, particularly in underserved areas. To extend NCD care to remote populations, Apollo Telehealth has implemented a model that integrates teleconsultations, tele-laboratories, and trained community health workers (CHWs).

Aim: This study aimed to evaluate the feasibility, acceptability, and outcomes of delivering home-based screening for non-communicable diseases (NCDs) such as hypertension, diabetes, and anemia using trained Community Health Workers (CHWs) in underserved rural areas across India.

Method: The study employed a decentralized, community-based model, where Community Health Workers (CHWs) carried out door-to-door screenings using point-of-care testing (POCT) devices. Individuals identified through screening referred to nearby primary healthcare facilities for further consultation and management.

Study Design: This is an observational study which focuses on analyzing data collected from primary health centers (PHCs) across 17 districts in 9 states, using Electronic Health Records (EHRs).

Study Plan and Duration: A total of 1,43,186 screenings were conducted from January 2022 to January 2025 across 9 states and 17 districts.

Results: Findings revealed a significant proportion of newly diagnosed cases (new) for all three NCDs: hypertension (67.5%), diabetes (50.4%), and anemia (76.2%). Prevalence rates among those screened showed hypertension in 27.2%, diabetes in 8.8%, and anemia in 16.9%. Female participants showed a higher abnormality rate in all categories, especially for anemia (70.5% of abnormal cases). 86% of the participants expressed a favorable opinion about the use of POCTs, although concerns about device accuracy and follow-up care logistics were noted.

Conclusion: This study demonstrates that home-based NCDs screening via trained CHWs, supported by Apollo Telehealth's speciality teleconsultation and tele-laboratory services, is not only feasible but also addresses key barriers to healthcare access in resource-limited settings. The integration of digital tools, community engagement, and structured referral systems indicates a scalable model for strengthening early detection and continuity of care for NCDs in India.

Keywords: *Non-Communicable Diseases (NCDs); point-of-care testing (POCT) devices; telehealth; tele labs; teleconsultations; remote patient monitoring systems (RPM); digital health; health screening.*

1. INTRODUCTION

Global healthcare delivery has changed because of the rapid advancement in digital technologies, particularly with the advent of digital sensors, cloud computing, the Internet of Things (IoT), and big data analytics. Health remote monitoring systems (HRMS) and remote patient monitoring systems (RPM), which are increasingly being used to extend medical care to the underprivileged and rural populations, have been one of the greatest advancements (World Health Organization, 2010a).

Patient demographics, like pulse rate, Blood Pressure, oxygen saturation, weight, height, and blood sugar levels, can be continuously acquired, transmitted, and analysed through these technological devices from patients' homes.

Following that, the information is securely transmitted to the medical professionals for prompt evaluation, tailored guidance, and suitable clinical actions. The system therefore mitigates the load on hospitals and healthcare centres to a significant extent while ensuring uninterrupted care for patients, especially in the case of persons living with chronic non-communicable diseases (NCDs) (World Health Organization, 2014).

Nevertheless, with increasing NCDs in India, the focus of public health programs had been much on Non communicable diseases. NCDs includes hypertension, diabetes mellitus, cancer, asthma, and anemia etc which now constitute over half of the morbidity and mortality in the world (Patel et al., 2011). Yet, the challenges in the interface of health infrastructure, trained manpower and

access to diagnostic and treatment facilities that could avert so many of these deaths, remain very much a rural phenomenon in India (International Diabetes Federation, 2021).

Burden is added to modern-day by traditional risk factors like tobacco, unhealthy diet, physical inactivity, and alcohol; but very acute risk is from the new ones, viz., air pollution and psychosocial stress. It is in this regard that, telemedicine has come to the rescue in almost every domain of NCDs care, from health promotion, risk factor management, and early screening to diagnosis and treatment initiation, regular follow-up, and palliative.

With this background, Apollo Telehealth seized the opportunity to integrate tele-laboratories with specialty teleconsultation services in the expansion of NCDs services throughout India. These have proven especially successful in catering to areas that are deep in the hinterlands and rural space that have access limitations due to laboratory infrastructure and know-how. Patients identified through community screening are afforded real-time virtual consults with dermatologists, cardiologists, endocrinologists, internal medicine specialists, and the likes. This is made feasible by the digital platform of Apollo Telehealth. From here, healthcare professionals can use the tele-labs to bridge the gap between screening and actual diagnosis and treatment initiation.

Furthermore, such remote patient monitoring models, embedded through structured data flow, trained community health workers (CHWs), and a centralized command centre, can optimize resource utilization from primary healthcare to specialty care. Digitized patient health records integrated into EMR (Electronic Medical Record) systems would enhance disease surveillance and continuity of care while allowing predictive analytics for population health planning.

This paper chronicles the outcomes and operational insights gained from a large-scale NCDs screening initiative carried out in rural and semi-urban districts across India. The initiative was led by trained CHWs operating under the clinical infrastructure of Apollo Telehealth, including teleconsultations and teleport laboratory services. A technology-enabled NCD screening and referral paradigm that can improve early detection and guarantee smooth treatment transitions in low-resource settings was evaluated for viability, efficacy, and scalability.

2. METHODS

This observational study was conducted from January 2022 to January 2025, using data collected through Electronic Health Records (EHRs). Participants were selected from primary health centers (PHCs) across 17 districts in 9 states. The study employed a decentralized, community-based model, where Community Health Workers (CHWs) carried outdoor-to-door screenings using point-of-care testing (POCT) devices. Individuals identified through screening referred to nearby primary healthcare facilities for further consultation and management. The data was analyzed in descriptive manner using Microsoft office 16 excel.

The study sought to assess a new service delivery strategy that would enable trained CHWs (community health workers) in a rural area to provide early detection services for prevalent NCDs (diabetes, hypertension, and anemia) at home. In addition to counseling the tobacco and alcohol users to stop, the CHWs conducted home visits to inform the participants on healthy lifestyle choices and the signs and symptoms of hypertension, diabetes, and anemia. Health risk assessment (HRA) was used and each person's height, weight, blood pressure (BP), anemia, and random blood sugar was assessed based on HRA score. This study is non-experimental and descriptive, utilizing co-creation approaches. The Health Risk Assessment (HRA) was curated using standardized clinical guidelines and recommendations from reputable sources, including the American Heart Association (for hypertension), the International Diabetes Federation (IDF), the American Diabetes Association (ADA), the Joint National Committee (JNC), the Research Society for the Study of Diabetes in India (RSSDI) for diabetes, and anemia-related guidelines from the World Health Organization (WHO) and the National Institutes of Health (NIH). The ability of community health workers (CHWs) to provide various preventive healthcare services at patients' homes is accepted (World Health Organization, 2010b). Non-communicable diseases (NCDs) can be diagnosed with point-of-care testing (POCT) devices since they are diagnostic instruments that can deliver precise and fast results in a matter of minutes (Shrivastava et al., 2015). It may be advantageous to involve allied healthcare providers in risk-driven early identification of specific NCDs, particularly for

List 1. Service delivery framework

Type of NCDs	Age of beneficiary	Method of Screening	Frequency of Screening
Hypertension	20 years and above	Blood pressure apparatus-Digital or Aneroid Sphygmomanometer	Daily
Diabetes	1 year and above	Glucometer	Daily
Anemia	3 years and above	True HB meter	Daily

those who have not received NCDs testing in the past 12 months, as different healthcare practitioners have access to diverse demographic groups (Ministry of Health and Family Welfare, n.d.).

tertiary centers. Necessary patients would then be referred directly to higher centers, such as district hospitals, Apollo tertiary care hospitals, based upon clinical triage and availability of services.

2.1 Referral and Continuity of Care

After identification of such abnormal cases through community-based screening, the affected persons diagnosed with hypertension, diabetes, or anemia were referred for further examination at the nearest government Primary Health Centre (PHC) or sub-centre. Documented and communicated to both the patient and the healthcare facility were referrals by trained Community Health Workers (CHWs).

At each referral center, there was a designated registered Medical Officer (MO), who would confirm the diagnosis of the patient, order further tests if need be, and initiate treatment based on national guidelines. This way, the care was kept continuous and avoided delays in accessing therapy for chronic conditions.

Moreover, Apollo Telehealth undertakes structured specialty teleconsultations to ensure follow-up with the specialists which further details into efficient internal medicine specialists, endocrinologists, cardiologists, and other specialties, without having to travel to distant

As part of the Apollo Telehealth space, tele-laboratory services included seamless ordering of the tests with remote interpretation of diagnostic results which on time could be reviewed by specialists. All these resulted in a much lesser turnaround time from screening to diagnosis ensuring a tighter clinical feedback loop.

3. RESULTS

The study lasted for a period of 04 years (January 2022 to January 2025) and involved participants selected from 09 states and 17 districts, encompassing a total of 1,43,186 individuals. This large-scale effort focused on three major non-communicable diseases (NCDs): hypertension, diabetes mellitus, and anemia.

Participants ranged in age from 1 to 99 years, with a notable predominance of female participation, particularly in the anemia and hypertension screenings. The program employed door-to-door point-of-care testing (POCT) to enhance accessibility and early detection.

Table 1. Gender distribution with mean age of screened and abnormal cases

Condition	Gender	Total Screened	Abnormal Cases	Mean Age (Abnormal Cases)
Blood Pressure	Female	28,082	7,270	50.1 years
	Male	21,607	6,290	49.9 years
	Total	49,689	13,560	–
Diabetes	Female	28,082	2,463	51.3 years
	Male	21,607	1,922	52.8 years
	Total	49,689	4,385	–
Anemia	Female	25,182	5,370	43.08 years
	Male	19,682	2,245	43.8 years
	Total	44,864	7,615	–

Table 2. A total of 49689 individuals means age of 44.8 year Male (43.4%) and female (57.2%) with age mean 43.2 underwent hypertension screening

Category	Gender	Total Screened	Abnormal BP Cases	Total with Habit	Hypertensive with Habit	% Hypertensive within Habit Group
Smoking Habit	Female	28,082	7,270	229	84	6.2%
	Male	21,607	6,290	1,702	600	4.40%
	Total	49,689	13,560	1,931	684	5.04%
Tobacco Use	Female	28,082	7,270	2,498	916	6.70%
	Male	21,607	6,290	3,453	1,115	8.20%
	Total	49,689	13,560	5,951	2,031	14.80%
Alcohol Consumption	Female	28,082	7,270	370	126	0.90%
	Male	21,607	6,290	1,949	628	4.60%
	Total	49,689	13,560	2,319	754	5.53%

For hypertension, a total of 49,689 individuals were screened, Male with a mean age of 44.8 years (46.3%) and 43.2 years female majority (56.5%). Abnormal blood pressure readings were identified in 13,560 individuals (27.2%), of which 46.3% were male and 53.6% were female. A significant number of these were new diagnoses—9,161 individuals (18.4%) had not previously been diagnosed. Lifestyle factors appeared prominently among those with abnormal readings, with 14.80% reporting tobacco use, smoking 5.04%, and 5.5% alcohol consumption. Hypertension emerged as the most prevalent condition among the three NCDs assessed, and the high proportion of previously undiagnosed cases indicates a significant gap in routine blood pressure monitoring, particularly among women. The strong correlation with behavioural risk factors emphasizes the need for integrated health education and risk-reduction strategies.

In the diabetes screening group, 49,686 individuals were tested, comprising 43.4% males and 56.5% females with Mean age as 43.9 yr in male and 41.4 yr in female. Abnormal glucose levels were found in 4385 (8.8%) individuals, with 43.4% of abnormal cases in males and 56.1% in females. abnormal new cases totalled 2,213 (50.5%). Lifestyle data revealed that 16.64% of those with abnormal glucose levels reported tobacco use, 5.29% had a history of smoking, and 3.30% consumed alcohol. Although diabetes had a lower overall prevalence compared to hypertension, it remained a significant concern, particularly given the large number of previously undiagnosed cases. The door-to-door POCT approach proved valuable in identifying undetected cases, especially in middle-aged adults, and the strong association with smoking underlines the need for targeted behavioural interventions.

Table 3. A total of 49689 individuals means age of 43.9 year Male (43.4%) and female (56.5%) with age mean 41.4 underwent Diabetic Screening

Category	Gender	Total Screened	Abnormal Glucose Level Cases	Total with Habit	Diabetic with Habit	% Diabetic within Habit Group
Smoking Habit	Female	28082	2463	218	26	0.59%
	Male	21607	1922	1594	207	4.70%
	Total	49689	4385	1812	233	5.29%
Tobacco Use	Female	28084	2463	2205	301	6.86%
	Male	21605	1922	3261	429	9.78%
	Total	49689	4385	5466	730	16.64%
Alcohol Consumption	Female	28082	2463	363	43	0.40%
	Male	21607	1922	1914	245	2.90%
	Total	49689	4385	2277	288	3.30%

Table 4. A total of 44,864 individuals means age of 43.9-year Male (43.8%) and female (56.1%) with age mean 42.1year underwent Anemic Screening

Category	Gender	Total Screened	Abnormal Hemoglobin levels	Total with Habit	Anemia with Habit	% Anemia within Habit Group
Smoking Habit	Female	25,182	5,370	203	31	0.40%
	Male	19,682	2,245	1,424	202	2.65%
	Total	44,864	7,615	1,627	233	3.05%
Tobacco Use	Female	25,182	5,370	2,111	790	10.37%
	Male	19,682	2,245	3,137	517	6.70%
	Total	44,864	7,615	5,248	1,307	17.07%
Alcohol Consumption	Female	25,182	5,370	331	97	29.30%
	Male	19,682	2,245	1,738	282	16.23%
	Total	44,864	7,615	2,069	379	18.32%

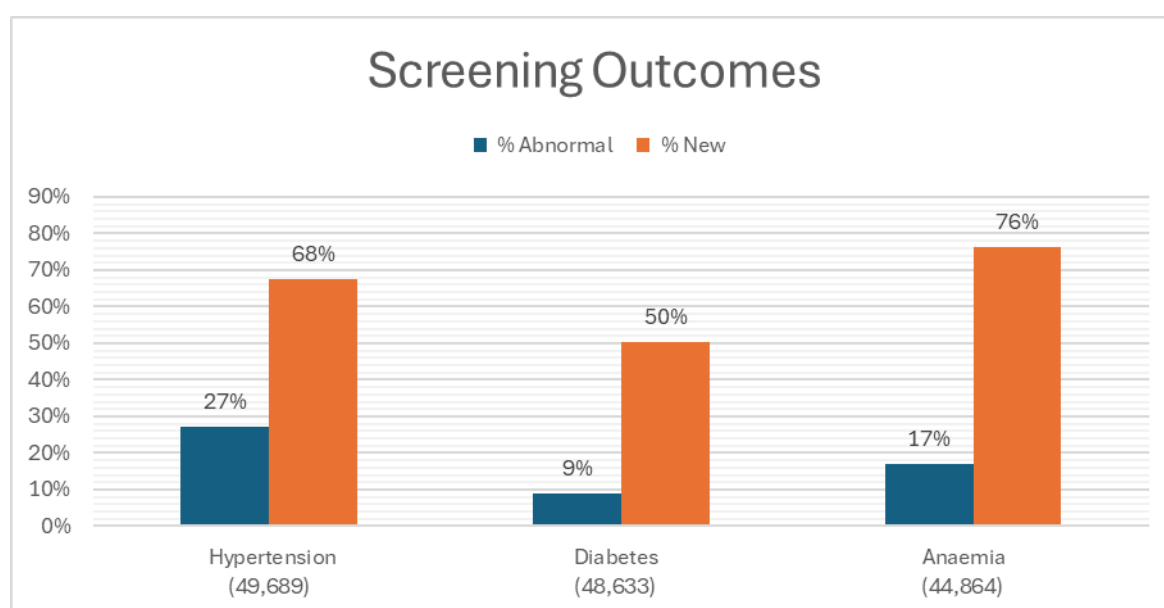


Fig. 1. Across disease screening outcomes

Anemia screening covered 44,864 individuals, with 36.2% males and 63.8% females. Abnormal haemoglobin levels were found in 7,615 participants (17%), with women accounting for a 70.5% of these cases and male 29.4%. Of the abnormal cases, 5,803 (76.2%) were newly diagnosed, suggesting that anemia often remains unnoticed, particularly in women of reproductive age. The data suggests nutritional deficiencies and menstrual health issues may play a significant role. Tobacco and alcohol consumption was reported in 17.07% and 18.32% respectively of those with abnormal readings, while smoking was lower 3.05% indicating weaker lifestyle

correlations compared to hypertension and diabetes.

The comparative analysis revealed a significant proportion of newly diagnosed cases (new) for all three NCDs: hypertension (67.5%), diabetes (50.4%), and anemia (76.2%). Prevalence rates among those screened showed hypertension in 27.2%, diabetes in 8.8%, and anemia in 16.9%. Female participants showed a higher abnormality rate in all categories, especially for anemia (70.5% of abnormal cases). In all three NCDs, women consistently accounted for a greater share of the abnormal findings, suggesting both increased health-seeking behaviour and possibly

a higher underlying disease burden. Tobacco and alcohol use showed stronger correlations with hypertension and diabetes than with anemia.

The operational outcomes derived from feedback calls were promising. On average, the time between screening and consultation was approximately one hour. Community feedback was highly favourable, with 86.3% of participants reporting that home-based POCT screening was beneficial. However, concerns were raised regarding the accuracy of handheld diagnostic devices and the need for confirmatory laboratory testing and clearer guidance on post-screening care. These were mitigated through referral pathways supported by Apollo Telehealth, which facilitated teleconsultations and seamless referrals to higher centres. Additionally, tele-laboratory integration helped minimize diagnostic delays and supported timely initiation of treatment when necessary.

In summary, this multi-state, community-based screening initiative successfully identified many previously undiagnosed NCD cases, particularly among women, and demonstrated the utility of home-based POCT in enhancing early detection and healthcare access in rural and underserved areas.

4. DISCUSSION

This large-scale community-based screening initiative demonstrated that early detection of non-communicable diseases (NCDs) using point-of-care tools and trained Community Health Workers (CHWs) is both operationally feasible and clinically impactful in underserved rural areas of India (World Health Organization, 2010b). Hypertension was still the most prevalent Noncommunicable disease among the three NCDs evaluated. A notable finding from screening is, the high percentage of unreported instances, which indicates the gap in traditional blood pressure monitoring. Women constituted most abnormal cases, suggesting either better outreach among women or potential gender-based differences in hypertension prevalence and detection. The strong association with tobacco, alcohol, and smoking history suggests behavioral risk modification should be a primary focus in follow-up care (Gupta & Xavier, 2018).

Despite having a lower prevalence than hypertension, diabetes still poses a significant burden. The majority of abnormal cases occurred

in middle-aged individuals, with women making up a larger proportion of them. The noteworthy fact that more than half of the aberrant cases had never been diagnosed before supports the use of door-to-door POCT-based detection. Since smoking appears to be strongly related to abnormal glycemic status, targeted therapy is necessary (International Diabetes Federation, 2021). The high number of undiagnosed instances of anemia, particularly among women (71% of abnormal cases), confirms that iron-deficiency anemia continues to be a significant public health concern for women of reproductive age. The 27% prevalence of hypertension, 17% prevalence of diabetes, and 17% for anemia, with a high proportion of new diagnoses particularly for anemia (76%) highlights the significant burden of undiagnosed NCDs in the community suggesting that anemia frequently goes unnoticed in rural populations. Nutritional and menstrual health variables are likely important contributors (International Institute for Population Sciences [IIPS] & ICF, 2021). These figures are particularly concerning in light of the fact that a majority of these conditions are asymptomatic in their early stages and, if left untreated, can lead to severe complications including cardiovascular events, renal failure, and diminished quality of life. The data underscores the urgent need for proactive, community-level screening and timely intervention strategies (Garg et al., 2021).

Gender disparities were a consistent theme across all disease categories. Female participants not only represented a larger proportion of those screened but also showed higher abnormality rates, especially for anemia. This aligns with national data and underscores the ongoing challenges related to women's nutrition, reproductive health, and limited access to preventive care in rural settings.

The effectiveness of CHWs in this model cannot be overstated. Their cultural familiarity, access to households, and rapport with community members helped overcome barriers such as fear of healthcare systems, low health literacy, stigma associated with disease, and mistrust of formal medical institutions. By providing empathetic, door-to-door health education and screening, CHWs played a pivotal role in bridging the gap between the community and the healthcare delivery system (Sundararaman & Ved, 2018).

A pivotal component of the initiative was the integration of Apollo Telehealth's clinical network.

The provision of real-time specialist consultations via telemedicine dramatically reduced delays in diagnosis confirmation and management. Patients benefitted from virtual access to specialists in internal medicine, cardiology, and endocrinology, many of whom were previously out of reach. Apollo's tele-laboratory services further enabled remote ordering of diagnostic tests, tracking of lab results, and timely interpretation by specialists. This seamless integration of clinical decision-making and diagnostics significantly shortened the time from screening to treatment initiation. It also ensured that patients received appropriate and continuous care without the need for travel, thus reducing out-of-pocket expenses and minimizing the burden on tertiary health centers (Kruk et al., 2018).

From a systems perspective, this model supports task-shifting and decentralized service delivery, which are essential strategies for addressing the dual challenge of workforce shortages and rising NCD burden. The combined use of CHWs, teleconsultation, and tele-laboratory diagnostics provided a three-tiered approach to early detection, triaging, and follow-up (Fischer et al., 2020).

This study reinforces that community-led, digitally supported NCD screening is an effective public health strategy that can be scaled across other low-resource settings with similar health system constraints (Bharati et al., 2017; Saldarriaga et al., 2017; Patel et al., 2020).

5. CONCLUSION

This study successfully established that doorstep delivery of NCD screening services by trained Community Health Workers, supported by point-of-care diagnostics and integrated telemedicine, is both feasible and impactful in rural India.

Key takeaways from this study include: Rural communities have a high percentage of undiagnosed NCDs, which suggests that they had limited access to preventive treatment in the past. CHWs can be the cornerstone of risk education and NCD identification at the primary level. Gender-sensitive therapies are required since women are disproportionately impacted, particularly by anemia. Expert evaluation and management were made possible even at remote locations with the integration of Apollo Telehealth's specialty teleconsultations, which closed access gaps. The tele-laboratory system

from Apollo Telehealth guaranteed prompt diagnosis and effective clinical judgment. The establishment of scalable and long-lasting referral channels from CHW to teleconsultation to tertiary care was accomplished. Lifestyle risk factors like alcohol, tobacco, and bad eating habits are still very prevalent and need ongoing community-based treatment.

The study model represents a scalable framework for integrating NCD screening into national and state-level health programs, especially in alignment with the Ayushman Bharat Health and Wellness Centre (HWC) initiative. By combining digital health technologies, community ownership, and institutional medical support, this initiative provides a template for decentralized NCD care that can be replicated across other geographies.

The study model represents a scalable framework for integrating NCD screening into national and state-level health programs, especially in alignment with the Ayushman Bharat Health and Wellness Centre (HWC) initiative. By combining ATH's innovative digital health technologies, community ownership and institutional medical support, this initiative provides a template for decentralized NCD care that can be replicated across other geographies.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. Chatgpt, 4.0
2. QuillBot Chrome extension with version 4.31.0

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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