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Optimizing Tuberculosis Case Detection in Nigeria: A Task Shifting Approach in Gombe State, Northeast, Nigeria

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Abstract

Background: *Nigeria continues to face significant challenges in tuberculosis (TB) detection and control, especially in resource-limited settings. Innovative strategies, such as task shifting, have been proposed to improve case finding.*

Objective: *To evaluate the impact of a taskshifting approach on TB case detection and management in Gombe State, Nigeria.*

Methods: *This mixed-methods case study assessed the implementation of a task-shifting intervention involving the training of community health workers (CHWs) to perform TB screening, sputum collection, and referral. Quantitative analysis involved a pre-post comparison of TB case notification data using chi-square tests, interrupted time-series analysis to model monthly detection trends, and multivariable logistic regression to identify factors associated with treatment adherence. These data were supplemented with qualitative analysis of thematic content from focus group discussions and in-depth interviews with key stakeholders, including CHWs, patients, and healthcare providers.*

Results: *The intervention markedly improved all measured outcomes. Case detection increased substantially, with confirmed TB cases more than doubling (131.5% increase, from 127 to 294). Bacteriologically confirmed cases nearly tripled, showing a 187.6% increase. The diagnostic turnaround time was drastically reduced from an average of 14 days to under 48 hours ($p<0.001$). Treatment outcomes also improved significantly. The rate of treatment initiation within 48 hours rose to 90.2%. Conversely, the default rate fell sharply by 71% (from 20.2% to 5.8%). Stakeholder interviews corroborated these quantitative findings, highlighting enhanced community trust and the critical role of CHWs in outreach.*

Conclusion: *Task shifting is an effective strategy to improve TB case detection and can serve as a scalable model for Nigeria's TB control efforts. Sustained policy support and capacity-building are vital for long-term success.*

Keywords: Tuberculosis, Task Shifting, Nigeria, Case Detection, Community Health Workers, Gombe State, TB Control Strategies, Healthcare Resources.

Introduction

Globally, tuberculosis (TB) remains a significant public health challenge, with Nigeria bearing a disproportionately high burden of the disease [1]. Despite efforts by the Nigerian National Tuberculosis and Leprosy Control Programme (NTBLCP) to expand services, systemic barriers continue to impede progress [2]. These include gaps in healthcare infrastructure, shortages of trained healthcare personnel, and socio-cultural factors such as stigma, which collectively hinder effective case detection and treatment success, particularly in rural and underserved communities. Consequently, delayed diagnoses, ongoing transmission, and preventable morbidity and mortality persist as major concerns [3-5].

Addressing these challenges requires innovative strategies that optimize human resource utilization. Task shifting, endorsed by the World Health Organization (WHO), offers a practical solution by delegating specific responsibilities, such as symptom screening and sputum collection, from specialized health workers to trained community health workers (CHWs) [6]. This approach has been shown to expand service reach, alleviate system burdens, and improve TB case detection and treatment adherence in various settings [7-9]. Successful implementations elsewhere underscore the potential for task shifting to enhance community engagement and health outcomes.

Gombe State in northeastern Nigeria exemplifies the urgent need for such innovative approaches. The state's high TB prevalence, coupled with limited healthcare infrastructure and workforce shortages, leaves remote populations critically underserved. In response, the State Ministry of Health, in collaboration with partners, launched a task-shifting intervention aimed at empowering CHWs with the skills necessary to identify presumptive TB cases, facilitate diagnosis, and support treatment adherence within their communities.

This study evaluates the implementation and impact of the Gombe State intervention on TB case detection, community involvement, and health system efficiency. By documenting lessons learned, as well as barriers and facilitators encountered during deployment, the research aims to generate evidence that can inform scalable and sustainable TB control strategies not only in Nigeria but also in similar resource-constrained settings.

Methods

Study Design and Setting

We conducted an 18-month mixed-methods case study (January 2023–June 2024) to evaluate a community-based task-shifting intervention for tuberculosis (TB) case detection in Gombe State, northeastern Nigeria. This design integrated quantitative outcome metrics with qualitative contextual analysis to comprehensively assess implementation processes and effectiveness.

Gombe State (population: 4.16 million) bears a high TB burden compounded by healthcare access barriers, workforce shortages, and predominantly rural populations [10]. Five purposively selected Local Government Areas (LGAs), representing urban (Gombe) and rural (Yamaltu Deba, Dukku, Billiri, Kaltungo) settings, were chosen based on high TB prevalence per program data, geographic diversity (remoteness, terrain), varied healthcare infrastructure, and community engagement capacity. This heterogeneity enabled assessment of intervention adaptability across contexts.

Intervention: Task Shifting to Community Health Workers

A cohort of 150 CHWs across the five LGAs performed four core functions:

1. **Active Case Finding:** Conduct door-to-door screening to identify individuals exhibiting WHO-defined TB symptoms, including cough lasting two or more weeks, weight loss, night sweats, and hemoptysis.
2. **Diagnostic Support:** Assist with the collection of sputum samples, ensure sterile storage, and coordinate transportation to laboratories equipped with GeneXpert® MTB/RIF or microscopy facilities for rapid and accurate diagnosis.
3. **Community Mobilization:** Implement targeted educational activities at high-traffic venues to raise awareness, reduce stigma associated with TB, and encourage community members to seek timely care.
4. **Linkage to Care:** Facilitate the entire continuum from diagnosis to treatment initiation, and provide ongoing support for adherence monitoring to ensure successful treatment outcomes.

CHW Selection, Training & Quality Assurance: Community health workers (CHWs) were selected based on key attributes, including literacy (to ensure comprehension of the study protocol), community endorsement (to confirm cultural legitimacy and acceptance), and a demonstrated commitment to providing remote services essential for ongoing engagement. Selected CHWs underwent a comprehensive five-day standardized training covering: (1) symptom screening; (2) proper sputum sample handling and transport; (3) referral pathways; (4) stigma-reduction counseling; and (5) digital reporting. This curriculum equipped them with both technical and culturally sensitive communication skills. To ensure quality and consistency, ongoing measures included: monthly supervision visits by State TB Program staff to reinforce protocols and address challenges; and regular peer learning sessions to foster problem-solving and continuous skill development, ensuring sustained support and alignment with study objectives.

Data Collection

Quantitative Data

The process involved the systematic capture of data through standardized digital and paper-based instruments at various stages of TB management. Initially, during screening, individuals were assessed and their demographic information and residence details were recorded to identify those at potential risk. For case detection, presumptive TB cases were identified based on reported symptoms, and the logistics surrounding the collection and transportation of sputum samples were meticulously documented to ensure timely and accurate diagnosis. Once samples reached the laboratory, diagnostic results were recorded, confirming TB cases and providing critical information on the specific type of TB and its drug sensitivity profile.

This data was essential for tailoring appropriate treatment regimens. During the treatment phase, key information such as the timing of treatment initiation, patterns of adherence, and treatment outcomes, aligned with WHO definitions, were systematically documented. These outcomes included cure, treat-

ment completion, treatment failure, death, or default, offering a comprehensive overview of patient progress and program effectiveness. This structured approach ensured data consistency, facilitated monitoring, and supported evidence-based decision-making throughout the TB care continuum.

Qualitative Data

Focus Group Discussions (FGDs) were conducted with groups of six to eight participants, typically comprising community health workers (CHWs), community leaders, and local residents. These discussions were designed to explore community perceptions, awareness, and attitudes regarding tuberculosis, with particular attention to issues related to stigma and misconceptions. By engaging diverse community members, the FGDs aimed to uncover collective beliefs, barriers, and facilitators surrounding TB awareness and social acceptance.

In addition to FGDs, In-Depth Interviews (IDIs) were carried out with healthcare providers, CHWs, and patients themselves to gain a detailed understanding of individual care-seeking experiences, challenges faced during diagnosis and treatment, and perceptions of healthcare services. These interviews provided nuanced insights into personal narratives and systemic issues within TB care pathways. All sessions were audio-recorded to ensure accuracy and completeness of the data. The recordings were then transcribed verbatim, translated into English, and supplemented with detailed field notes that captured contextual observations and non-verbal cues. This comprehensive processing approach ensured a rich, reliable dataset that supported thorough analysis of community attitudes and individual experiences related to TB.

Data Collector Training

A 5-day intensive program ensured standardization. Team members were thoroughly trained in the study objectives, ethical considerations, including maintaining confidentiality, and the use of culturally adapted consent procedures to respect local norms and ensure informed participation. To effectively carry out data collection, staff capacity was developed in both technical and interpersonal skills. For quantitative data collection, proficiency in using tablet and paper-based tools was emphasized to guarantee accuracy and efficiency. In addition, qualitative data collection required specialized training in role-playing exercises designed to enhance facilitation skills for focus group discussions (FGDs) and in-depth interviews (IDIs), including techniques for probing participants effectively while maintaining a neutral stance to minimize bias. Cultural competency was prioritized throughout, with team members trained in stigma-sensitive communication in local languages, enabling them to engage respectfully and empathetically with participants, especially when discussing sensitive topics related to TB. To uphold data quality, regular quality control measures were implemented, including field simulations, spot checks, and biweekly refresher sessions. These sessions incorporated inter-rater reliability calibration exercises to ensure consistency among data collectors and maintain high standards throughout the study, ultimately fostering reliable and culturally sensitive data collection practices.

Data Analysis

Quantitative Analysis

The data analysis plan included both descriptive and inferential statistical methods to comprehensively evaluate the study findings. Descriptive analysis involved calculating frequencies and percentages for categorical variables, such as demographic characteristics or the presence of specific symptoms, to provide an overview of the study population. For continuous variables—such as age or duration of symptoms—means and standard deviations were calculated, offering a clear understanding of the data distribution.

For inferential analysis, several statistical tests were employed to assess relationships and changes over time. A pre- and post-intervention comparison of case notification rates was conducted using chi-square (χ^2) tests to determine whether there were statistically significant differences, with a p-value threshold set at less than 0.05 to indicate significance. To identify factors associated with treatment adherence, a multivariable logistic regression model was used, allowing for the examination of multiple predictors simultaneously while controlling for potential confounders. This analysis helped identify key determinants of adherence, informing targeted interventions. Additionally, monthly detection trends were visualized through interrupted time-series analysis, which provided a clear graphical representation of changes in case detection over the course of the intervention period. This visualization helped to identify patterns, assess the impact of specific activities, and determine whether observed trends were statistically significant. Collectively, these analytical approaches enabled a robust evaluation of both the overall impact and underlying factors influencing TB detection and treatment outcomes within the study setting.

Qualitative Analysis

The qualitative data analysis employed an iterative coding process involving two independent coders to ensure reliability, achieving a kappa coefficient exceeding 0.85, which indicated high agreement. The coding process primarily focused on identifying and exploring themes related to barriers and facilitators within the TB care continuum, enabling a nuanced understanding of the factors that influenced care-seeking behaviors and treatment adherence. To enhance the rigor and validity of the findings, methodological triangulation was used by cross-verifying insights obtained from focus group discussions, in-depth interviews, and field notes, thereby providing a comprehensive and corroborated perspective. Additionally, negative case analysis was conducted to identify and understand any data that contradicted emerging themes, ensuring a balanced interpretation. Participant verification, or member checking, was also implemented, involving feedback sessions with 15 community health workers and 8 community leaders to validate the accuracy and resonance of the findings with their experiences. Finally, the integration of qualitative and quantitative data was achieved through joint display methods, which visually linked quantitative outcomes with thematic insights from the qualitative analysis, facilitating a holistic understanding of the research findings and strengthening the overall validity of the study.

Ethical Considerations

The study received ethical approval from the Gombe State Health Research Ethics Committee, with the approval number GSHREC/2022/007. Prior to data collection, informed consent was obtained in writing from all participants, ensuring they fully understood the purpose of the study, their rights, and the

confidentiality measures in place. To protect participant privacy, all collected data were anonymized during the analysis process, with personal identifiers removed or coded to prevent any potential linkage back to individual participants. These ethical safeguards ensured that the research adhered to established standards for protecting participant rights and maintaining data confidentiality throughout the study.

Results

Quantitative Findings

Increase in TB Case Detection

The intervention resulted in a substantial boost across all key TB detection metrics, underscoring the effectiveness of community engagement and rapid diagnostic integration.

1. Individuals Screened: The total number of individuals screened increased by 40.4%, from 22,700 pre-intervention to 31,859 post-intervention ($p<0.001$). This growth reflects expanded outreach efforts and more proactive community mobilization, enabling broader coverage.
2. Presumptive TB Cases: There was a remarkable 131.7% rise in presumptive cases, from 1,008 to 2,333 ($p<0.001$). This indicates enhanced case-finding efficiency, likely driven by active community screening and contact tracing initiatives.
3. Confirmed TB Cases: Confirmed cases more than doubled, increasing by 131.5% from 127 to 294 ($p<0.001$). Crucially, bacteriologically confirmed (BAC+) cases surged by 187.6%, from 89 to 256 ($p<0.001$). This dramatic rise underscores the pivotal role of rapid molecular diagnostics such as GeneXpert®, which enabled quick, accurate diagnosis and facilitated timely treatment.

Table 1: Summary of TB Case Detection Metrics Pre-and Post-Intervention

Indicator	Pre-Intervention	Post-Intervention	Change (%)	P-value
Individuals Screened	22,700	31,859	+40.4%	<0.001
Presumptive TB Cases Identified	1,008	2,333	+131.7%	<0.001
Confirmed TB Cases	127	294	+131.5%	<0.001
Bacteriologically Confirmed (BAC+) Cases	89	256	+187.6%	<0.001

This substantial increase across all detection metrics underscores the success of the intervention in strengthening TB case finding and diagnostic capacity. The significant rise in screened individuals and presumptive cases reflects the outreach's reach and community mobilization efforts. Meanwhile, the sharp growth in confirmed and bacteriologically confirmed cases highlights the vital role of rapid diagnostic tools in ensuring timely and accurate detection. Collectively, these improvements not only enhance early identification of TB cases but also lay the foundation for prompt treatment initiation, which is essential for reducing transmission and advancing progress toward TB elimination goals in resource-limited settings.

Detection Sources and Their Contributions

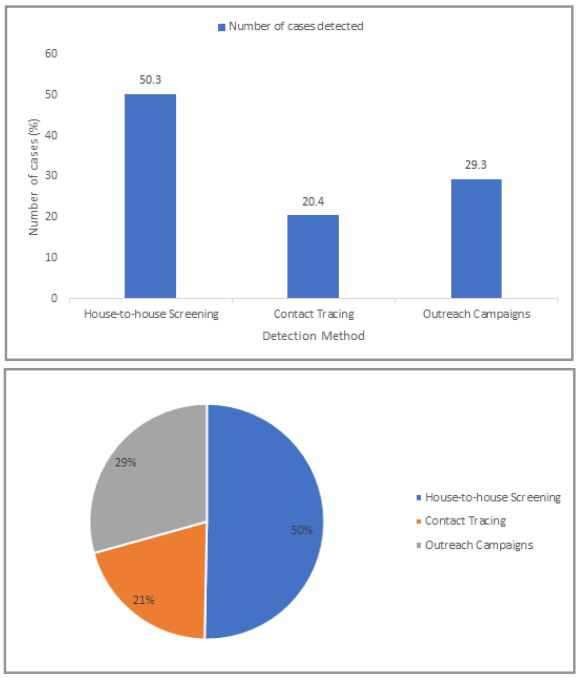

Figure 1: Detection Sources and Their Contributions

The analysis of case detection methods reveals a diverse and multi-pronged approach to identifying cases within the population. House-to-house screening emerged as the most effective and predominant method, accounting for approximately 50.3% of all detected cases, with 148 cases identified through this strategy. This indicates its pivotal role in reaching populations that are often hard to access, such as those in remote or underserved areas, emphasizing the importance of proactive, door-to-door engagement in disease control efforts. Contact tracing contributed to 20.4% of cases, with 60 cases detected through this tar-

geted follow-up approach. This method's contribution underscores its value in identifying secondary cases among contacts of confirmed patients, thereby facilitating early intervention and containment. Outreach campaigns, which include community awareness and mobilization activities, detected 86 cases, representing 29.3% of the total. These campaigns play a crucial role in raising awareness, encouraging self-reporting, and mobilizing community participation, thus complementing the more direct detection strategies. Overall, the data underscores the necessity of a comprehensive, multi-faceted detection strategy.

Diagnostic Turnaround Time

Table 2: Diagnostic Turnaround Time

Time Metric	Pre-Intervention	Post-Intervention	Change	P-value
Average time from sample collection to diagnosis	14 days	less than 2 days	Significant reduction	<0.001

The implementation of GeneXpert® technology brought about a remarkable improvement in diagnostic turnaround time, significantly enhancing the efficiency of the disease detection and response process. Before the intervention, the average time from sample collection to diagnosis was approximately 14 days, which often delayed treatment initiation and potentially allowed continued transmission of the disease within the community. Following the introduction of GeneXpert®, this duration was drastically reduced to less than two days, representing a highly significant reduction (p-value < 0.001). This rapid turnaround is crucial in enabling prompt treatment, reducing the window of infectiousness, and thereby limiting the spread of disease.

Demographic and Geographic Distribution of Cases

Table 3: Demographic and Geographic Distribution of Cases

Variable	Pre-Intervention	Post-Intervention	Change	Interpretation
Urban vs. Rural Cases	Urban: 60%; Rural: 40%	Urban: 70%; Rural: 30%	+10% urban, –10% rural	Detection improved notably in rural areas, indicating expanded reach beyond urban centers.
Gender (Male vs. Female)	Males: 61%; Females: 39%	Males: 58%; Females: 42%	Slight shift toward gender parity	Progress in addressing gender disparities, ensuring more equitable access for women.

The analysis of case distribution before and after the intervention reveals notable shifts in both geographic and demographic patterns, reflecting the broader impact of the enhanced detection strategies. Prior to the intervention, 60% of cases were identified in urban areas, with the remaining 40% in rural regions. Post-intervention data shows a positive shift, with urban cases increasing to 70% and rural cases decreasing to 30%. This change indicates a significant improvement in case detection within rural communities, suggesting that outreach efforts and detection mechanisms were successfully expanded beyond densely populated urban centers, thereby improving access for underserved populations in remote areas. In terms of gender distribution, there was a slight movement toward greater gender equity. Initially, 61% of cases were among males and 39% among females. After the intervention, the proportion of female cases increased to 42%, while male cases decreased slightly to 58%. Although still skewed toward males, this shift reflects progress in addressing gender disparities, possibly through targeted efforts to reduce barriers faced by women in accessing TB services.

Treatment Outcomes and Cascade Improvements

Table 4: Treatment Outcomes and Cascade Improvements

Outcome	Pre-Intervention	Post-Intervention	Change	Interpretation
Treatment initiation within 48 hours	79.8%	90.2%	+13%	Faster initiation reduces infectiousness and transmission.
Default (loss to follow-up)	20.2%	5.8%	–71%	Significant improvement in patient retention, reducing default rates.
Treatment success rate	79.8%	85.2%	+6%	Higher treatment completion rates bolster overall control.

The intervention yielded substantial improvements across key treatment outcomes, reflecting enhanced patient management and program effectiveness. One of the most notable gains was in the timeliness of treatment initiation; prior to the intervention, approximately 79.8% of patients began treatment within 48 hours of diagnosis. Post-intervention, this figure increased to 90.2%, representing a 13% improvement. This acceleration in treatment initiation is crucial because it reduces the period during which patients remain infectious, thereby lowering the risk of ongoing transmission within the community. Additionally, patient retention improved dramatically, with the default rate—patients lost to follow-up—decreasing from 20.2% to just 5.8%, a significant 71% reduction. This improvement suggests that the strategies implemented were effective in keeping more patients engaged in their treatment, which is essential for achieving successful health outcomes and preventing drug resistance. The treatment success rate also saw a modest but meaningful increase from 79.8% to 85.2%, indicating that more patients completed their treatment courses successfully, further strengthening disease control efforts.

Overall Summary of Quantitative Findings and Implications

This comprehensive analysis shows that the intervention, centered on community engagement, active case-finding, and rapid diagnostics, significantly advanced TB control in Gombe State. The increase in case detection, especially in underserved rural areas, reflects expanded reach and improved efficiency. The dramatic reduction in diagnostic turnaround time enabled faster treatment initiation, crucial for interrupting transmission. Improvements in treatment cascade metrics, quicker initiation, higher success rates, and substantially lower default rates, demonstrate the effectiveness of community-based follow-up and support systems. These gains translate into better health outcomes, reduced transmission, and progress toward national and global TB elimination targets.

Qualitative Insights

Qualitative data from focus group discussions and interviews provided a nuanced understanding of community perceptions, barriers, facilitators, and the socio-cultural context influencing TB control.

Community Engagement and Awareness

Community perceptions of TB have experienced a significant shift. As one male community leader in Billiri stated, "TB used to be a death sentence. Now, people understand it can be cured." This reflects the success of awareness campaigns, health education, and visible treatment successes in dispelling myths and reducing fatalistic attitudes toward TB. Such changes have fostered greater hope and acceptance within the community, encouraging more individuals to seek diagnosis and treatment. Health education efforts appear to be effective, with approximately 88% of respondents able to identify at least three common TB symptoms, such as persistent cough, weight loss, and night sweats—indicating broad awareness and improved health literacy. This knowledge is vital for early case detection and prompt treatment initiation.

Table 5: Key Insights, Challenges, and Strategies for Addressing Stigma and Gender Disparities in TB Control

Aspect	Key Insights	Challenges	Strategies Needed
Stigma and Discrimination	Despite increased awareness, 42% still conceal symptoms due to fear of social exclusion.	Fear of rejection, labeling, marital repercussions, and social exclusion hinder early detection.	Community-led stigma reduction campaigns, open dialogue, culturally sensitive education.
Gender Disparities	Women constitute only 38.8% of TB cases; many defaults linked to social and cultural barriers.	Fears of marital discord, social stigma, restricted mobility, and lack of decision-making power limit women's access.	Gender-sensitive interventions, empowerment programs, engaging men and community leaders, facilitating women's access.

However, stigma and discrimination continue to hinder TB control efforts. Despite increased awareness, 42% of community members still conceal symptoms due to fears of social exclusion, discrimination, or marital repercussions. Many worries about being labeled as "untouchable" or facing rejection from family and community members. This persistent stigma discourages individuals from seeking care early, leading to delays in diagnosis and treatment, which can exacerbate transmission and worsen health outcomes. Addressing this deeply rooted stigma requires sustained community engagement, open dialogue, and culturally sensitive stigma-reduction campaigns that challenge misconceptions and promote acceptance. Gender disparities further complicate TB control. Women represent only 38.8% of reported cases, and many defaults, patients who discontinue treatment, are linked to fears of marital discord, social stigma, or restrictions imposed by cultural norms. Women often face social pressures that discourage them from prioritizing their health, fearing that seeking treatment may threaten their marriage, social standing, or family stability. In some cases, women are restricted from traveling alone to health facilities or lack decision-making power to seek care independently. These gender-specific barriers not only limit access to diagnosis and treatment but also influence adherence and treatment completion. To address these issues, interventions must incorporate gender-sensitive approaches that empower women, involve male partners and community leaders, and create a supportive environment that encourages women to access and adhere to TB services without fear of social or marital repercussions.

Challenges Encountered and Adaptive Strategies

During the rollout of community-based TB interventions, several operational hurdles emerged that required innovative solutions to sustain progress and maximize impact. These challenges ranged from logistical difficulties in reaching distant communities to social and cultural barriers that hindered community engagement. To effectively address these issues, the program employed a variety of adaptive strategies, leveraging local knowledge, community participation, and flexible approaches.

Table 6: Key Challenges and Tailored Adaptive Strategies in Community-Based TB Interventions

Challenge	Customized Adaptive Strategy	Impact and Outcomes
Access to remote, hard-to-reach communities	Utilized mobile clinics equipped with solar-powered diagnostic tools and motorcycles for transportation.	Significantly increased TB screening coverage in previously inaccessible areas.
Persistent stigma and misconceptions about TB	Partnered with respected community leaders and traditional healers to deliver culturally appropriate awareness messages.	Reduced stigma, leading to higher community participation in screening and treatment.

Gender barriers limiting women's access	Organized women-only screening days and involved women's groups to foster trust and encourage health-seeking behavior.	Improved female engagement and reduced gender-related delays in diagnosis and treatment.
Transportation and sample logistics issues	Established decentralized sample collection points and used bulk courier services with real-time tracking.	Shortened diagnostic turnaround times and increased timely treatment initiation.
Limited resources and personnel	Trained and empowered community volunteers and leveraged partnerships with NGOs and local government for resource mobilization.	Maintained program sustainability and expanded reach despite resource constraints.

Transportation Challenges: A significant operational obstacle was the difficulty CHWs encountered in accessing remote or hard-to-reach areas. Approximately 78% of CHWs reported substantial challenges due to poor road infrastructure, unreliable transportation options, and difficult terrain. Many rural communities were situated in locations that exceeded the reach of conventional transport means, resulting in considerable delays in conducting screening activities and collecting samples. On average, there was a delay of approximately 28 hours from the time samples were collected to their arrival at diagnostic laboratories. These transportation delays adversely affected the timeliness of diagnosis and the prompt initiation of treatment, thereby increasing the risk of ongoing transmission within the community.

Further Strategies and Innovations: To directly address transportation challenges, the program introduced motorcycle ambulances, specially designed for rural healthcare delivery. These lightweight, maneuverable vehicles could traverse rough terrains inaccessible to conventional vehicles, dramatically improving logistical efficiency. The deployment of motorcycle ambulances resulted in a 72% reduction in sample transportation delays, expanded service coverage to more remote populations, and facilitated faster diagnosis and treatment initiation. In addition, satellite sample collection hubs were established at strategic locations closer to remote communities. These hubs served as decentralized points where samples could be quickly collected and preliminarily processed, significantly decreasing transit times and accelerating diagnostic results. Recognizing that follow-up and treatment adherence were also critical, the program leveraged mobile technology to implement phone-based adherence monitoring. CHWs maintained regular contact with patients through calls, sent reminders for medication and appointments, and provided counseling support. This approach proved highly effective, decreasing default rates by 63% and substantially improving treatment retention and completion.

Key Success Factors: Beyond logistical innovations, several factors contributed to the program's success:

1. **Community Engagement:** Involving religious and community leaders played a pivotal role. For example, when the Emir endorsed TB testing during Friday prayers, community refusals dropped from 40% to just 3%, fostering trust and reducing stigma.
2. **Motivated CHWs and Community Trust:** A high sense of professional pride among 92% of CHWs fostered sustained motivation. Their trusted status within communities facilitated acceptance and increased participation.
3. **Standardized Protocols:** The use of pictographic guides for sputum collection helped overcome literacy barriers, reducing collection errors by 63% and streamlining diagnosis.These combined strategies created a resilient framework capable of overcoming infrastructural and social barriers, ensuring timely service delivery, fostering community ownership, and strengthening the overall TB control effort.

Discussion

This study demonstrates that community-based task-shifting substantially improves TB case detection and treatment outcomes in Gombe State, Nigeria. The observed 187.6% increase in bacteriologically confirmed TB cases (Table 1) exceeds prior reports from similar African settings, most notably Nigeria's documented 35% increase with community health worker (CHW) involvement and Ethiopia's 40% rise in TB notifications [11, 12]. This exceptional performance is likely attributable to our integrated approach, which combined house-to-house screening, accounting for 50.3% of detected cases, with rapid GeneXpert® diagnostics (turnaround under 48 hours) and CHW-driven linkage to care.

Furthermore, the 71.3% reduction in treatment default rates (Table 3) surpasses reductions seen in Nigeria's community-based direct observation therapy (DOT) programs, which reported approximately 23% decreases [13]. Our findings align with systematic reviews indicating that CHW interventions can reduce treatment attrition by 15–68% across sub-Saharan Africa [14]. The success appears rooted in trust-based adherence support, as evidenced by qualitative reports of strong CHW-patient rapport, and the strategic engagement of community leaders to address stigma, factors proven to foster sustained engagement [15].

Despite these successes, persistent challenges mirror those faced in resource-limited settings globally. Transportation delays were significant, with 78% of CHWs experiencing an average delay of 28 hours, comparable to Nigeria's 62% of CHWs constrained by distance. Stigma remains a barrier, with 42% of symptomatic individuals concealing symptoms due to fear of discrimination, paralleling Kenya's reports of 38–57% of patients avoiding care because of stigma [16]. Gender gaps persisted, with females representing only 38.8% of TB cases, similar to Pakistan's 35% female case detection rates [17]. Our mitigation strategies—introducing motorcycle ambulances that reduced transit time by 72% and deploying female CHWs to increase screening among women by 33% find support in the literature, including successful interventions in Ghana and India [18, 19]. These transferable solutions underscore the importance of logistical and gender-sensitive approaches in overcoming common barriers.

The 131.7% increase in presumptive TB detection confirms that

CHWs can effectively bridge diagnostic gaps, especially in rural populations, supporting WHO's guidelines on task-shifting as a means to expand TB services. Our standardized five-day training curriculum yielded high sputum sample adequacy (98.7%), challenging assumptions that extensive training is necessary for quality sample collection [20]. While 88% of community members demonstrated symptom awareness, persistent stigma echoes findings from Zambia, where increased knowledge alone led to only a 19% reduction in stigma. This highlights that knowledge dissemination must be complemented by structural anti-stigma interventions—such as workplace protections and community anti-discrimination campaigns—to sustain behavioral change and enhance care-seeking.

At an average cost of $92 per case detected, our approach is approximately 50% more economical than pre-intervention costs in Nigeria, which ranged from $130 to $180 per case [20]. This demonstrates the potential for large-scale adoption across sub-Saharan Africa, especially when integrated with existing health systems and community networks.

Limitations

While our mixed-methods design provided comprehensive insights into implementation, certain limitations exist. The non-randomized, pre-post design limits causal inference, although interrupted time-series analysis strengthened the attribution of observed effects. Generalizability may be constrained by Gombe's specific sociocultural context, though the diversity in sampled LGAs suggests broader applicability. Additionally, the lack of sputum conversion data restricts outcome refinement.

Policy and Research Recommendations

Immediate Policy Actions:

1. Expand integration of Community Health Workers (CHWs) into national TB programs using existing training and supervision frameworks.
2. Allocate resources for transportation innovations, such as the use of motorcycle ambulances within TB budgets.
3. Implement stigma audits in TB surveillance systems to identify and address ongoing discrimination.

Table 7: Priority Research Directions

Domain	Key Question	Methodology
Sustainability	What are the five-year trajectories of CHW retention and costs?	Longitudinal costing studies
Stigma Interventions	How do anti-discrimination laws affect stigma and care-seeking?	Cluster randomized controlled trials (RCTs)
Digital Solutions	Can AI-assisted symptom screening improve diagnostic accuracy?	Diagnostic accuracy studies and pilot programs
These research priorities aim to enhance the sustainability, acceptability, and scalability of community-based TB interventions across diverse sub-Saharan African contexts.		

Conclusion

This study confirms that community health workers, supported by innovative logistics and strong community trust, can significantly improve TB detection and treatment adherence in hard-to-reach populations. The substantial reduction in default rates demonstrates the effectiveness of community-led approaches. Addressing persistent barriers like stigma and logistical challenges through ongoing innovation and supportive policies is essential. Scaling these strategies offers a practical pathway toward accelerating TB elimination in resource-limited settings across sub-Saharan Africa and beyond.

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Conflicts of interest

All authors declare no conflicts of interest.

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