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Assessing Socioeconomic Determinants of Diabetes Management Outcomes in Urban and Rural Low-Income Communities Across Geographic Regions

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ABSTRACT

Diabetes mellitus continues to pose a critical public health challenge, particularly in low-income communities where resource constraints, healthcare disparities, and social determinants significantly influence disease management and long-term outcomes. This study investigates the socioeconomic variables shaping diabetes management across urban and rural low-income populations spanning diverse geographic regions. While global health strategies have made strides in expanding diabetes screening and therapeutic interventions, they often overlook the intricate, place-based socioeconomic factors such as education, employment, housing security, access to nutritious food, and healthcare availability that disproportionately impact disease outcomes among marginalized populations. This article employs a mixed-methods, cross-regional comparative analysis to explore how these socioeconomic factors affect adherence to treatment, glycemic control, frequency of hospitalization, and complication rates. Drawing from real-world data including electronic health records, community health surveys, and geospatial poverty indices the research isolates key barriers and facilitators of effective diabetes management across distinct low-income geographies. Case studies from urban slums in Sub-Saharan Africa, remote Indigenous communities in North America, and rural farming villages in Southeast Asia provide further context for regional variability. The findings underscore the urgent need for localized, equity-driven strategies that prioritize social determinants alongside clinical interventions. Moreover, the study reveals gaps in existing health policy frameworks that fail to account for the structural and environmental factors shaping chronic disease outcomes in underserved populations. The article concludes by offering actionable recommendations for integrated policy, community-led solutions, and future research focused on bridging the urban-rural health equity gap in diabetes care.

Keywords: Diabetes Management Outcomes, Socioeconomic Determinants, Urban and Rural Health Disparities, Low-Income Communities, Geographic Health Inequities, Chronic Disease Equity Strategies

1. INTRODUCTION

1.1 Global Diabetes Burden and Management Challenges

Diabetes mellitus has emerged as one of the most pressing global public health challenges, with an estimated 537 million adults living with the condition as of 2021, a figure projected to rise sharply by 2045 [1]. This growing prevalence exerts immense pressure on national healthcare systems due to the lifelong nature of diabetes and its frequent comorbidities, including cardiovascular disease, kidney failure, and neuropathy [2]. Effective management of diabetes is essential to avoid long-term complications and prevent avoidable mortality. However, disparities in outcomes remain stark across socioeconomic and geographic lines [3]. Despite the development of pharmacological therapies and evidence-based lifestyle interventions, global diabetes control remains suboptimal due to systemic barriers in care access, patient education, and self-management resources [4]. Inadequate glycemic control persists even in countries with advanced healthcare systems, emphasizing the need to reevaluate health system readiness and equity-based program design. Figure 1 visualizes global diabetes prevalence, highlighting the highest concentration of burden in low-resource regions.

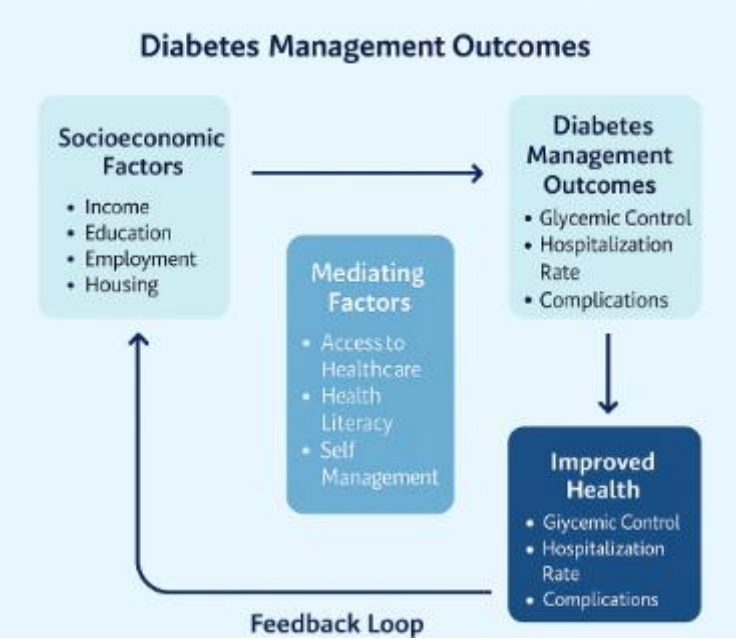

Figure 1: Conceptual Model Linking Socioeconomic Factors to Diabetes Management Outcomes

1.2 Urban-Rural and Socioeconomic Disparities in Chronic Disease Management

Urban and rural settings present distinct challenges in diabetes management, exacerbated by socioeconomic inequities that influence care access, affordability, and continuity [5]. Urban low-income populations may face barriers such as overcrowded clinics, limited time with healthcare providers, and food insecurity despite geographic proximity to medical services [6]. Conversely, rural communities often suffer from healthcare professional shortages, transportation difficulties, and delayed diagnoses due to infrastructural limitations [7]. Socioeconomic status intersects with geography to create complex barriers to disease management lower educational attainment, lack of insurance, and informal employment collectively reduce the likelihood of consistent treatment adherence and follow-up [8]. These disparities are particularly pronounced in low- and middle-income countries where health systems are underfunded and urban-rural divides are more stark [9]. Policies aimed at improving diabetes outcomes must recognize the multidimensional nature of disadvantage and integrate community-specific solutions that address both geographic and economic constraints.

1.3 Justification for Focusing on Low-Income Populations

Low-income individuals face a disproportionately high burden of diabetes, not only in terms of prevalence but also in the severity of complications and mortality rates [10]. This population is more likely to experience late-stage diagnoses, higher out-of-pocket costs, medication nonadherence, and dietary limitations due to economic instability [11]. Moreover, structural inequities such as racial segregation, housing insecurity, and lack of insurance compound the impact of individual-level poverty, creating cyclical barriers to effective disease management [12]. Despite these challenges, most public health interventions remain designed for average-income populations and fail to account for the unique constraints experienced by the poor [13]. Tailored interventions are urgently needed to close the widening diabetes outcome gap between income brackets. Table 1 provides a summary of health disparities and diabetes-related outcomes by income quintiles. This study, therefore, centers on low-income groups to better understand the nuanced socioeconomic determinants influencing management effectiveness and to generate actionable insights for targeted policy and clinical reforms.

1.4 Objectives and Scope of the Study

This study aims to assess the socioeconomic determinants that affect diabetes management outcomes in low-income populations across both urban and rural communities. It focuses on three primary geographic regions Sub-Saharan Africa,

Southeast Asia, and North America to represent varying health infrastructure, economic development levels, and cultural contexts [14]. The study investigates key outcome metrics including glycemic control (HbA1c), hospitalization frequency, and medication adherence, in conjunction with socioeconomic variables such as education level, income stability, employment type, housing security, and access to healthcare services [15]. The research questions addressed include:

(1) How do socioeconomic determinants interact with geographic location to influence diabetes outcomes?

(2) What are the shared versus context-specific challenges in urban and rural low-income populations?

(3) Which socioeconomic factors have the highest predictive value for poor diabetes control in these settings?

The study adopts a mixed-methods approach, integrating quantitative data from healthcare databases and surveys with qualitative interviews from community health workers. Figure 2 outlines the study design and data collection framework. The findings are expected to inform the design of equitable, region-specific diabetes interventions and help policymakers identify where to prioritize limited resources for maximum impact [16].

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Socioeconomic Determinants of Health: Definitions and Relevance

Socioeconomic determinants of health (SDOH) are the non-medical factors that influence health outcomes and shape the conditions in which individuals are born, grow, live, work, and age. These include income, education, employment status, housing stability, food security, and access to health services [5]. In the context of chronic conditions like diabetes, these determinants can significantly influence disease progression, management practices, and clinical outcomes. For instance, individuals with lower income may struggle to afford medications, healthy food, or glucose monitoring tools, directly affecting their glycemic control [6]. Similarly, those with limited education may lack the health literacy necessary for understanding diabetes self-care instructions or navigating the healthcare system [7]. In rural communities, geographic and infrastructural disadvantages such as travel distance to clinics further compound these challenges. Understanding SDOH is thus pivotal in addressing disparities in diabetes outcomes across populations and regions. Their influence extends beyond individual behavior, shaping the availability and accessibility of care at a systemic level. Policies and programs that fail to integrate SDOH considerations often experience limited efficacy in low-income settings [8]. As Figure 1 illustrates, these factors are intricately linked and intersect to impact diabetes management outcomes. Addressing them requires coordinated, multi-sectoral strategies that move beyond the clinical setting to include housing, employment, and education initiatives.

2.2 Prior Studies on Diabetes Outcomes in Urban vs. Rural Settings

Numerous studies have underscored the disparities in diabetes outcomes across urban and rural populations, often attributing these to variations in healthcare access, socioeconomic conditions, and health infrastructure. In urban low-income areas, higher population density may translate to more healthcare facilities; however, the quality of care, provider-patient ratio, and waiting times often remain inadequate [9]. Research from inner-city clinics in the United States has shown poor glycemic control and elevated hospitalization rates among urban low-income residents, despite proximity to health centers [10]. Conversely, rural populations frequently face provider shortages, transportation challenges, and reduced healthcare utilization, leading to delayed diagnoses and suboptimal disease monitoring [11]. For example, a study across India's rural districts revealed significantly lower access to diabetes educators and nutritionists compared to urban counterparts [12]. Moreover, rural patients are less likely to receive specialist consultations, further widening the management gap. While some urban environments may benefit from health campaigns and technology-enabled care, these are not uniformly distributed across socioeconomic strata. The literature also shows mixed findings regarding treatment adherence and dietary practices, often mediated by cultural and regional norms [13]. A comparative

synthesis is critical to understand the shared challenges and region-specific barriers, thereby informing equitable policy development.

2.3 Health Equity, Structural Vulnerability, and Policy Gaps

Health equity refers to the absence of unfair and avoidable differences in health among population groups, especially those who are socioeconomically or geographically marginalized. In the domain of diabetes management, inequities emerge when systemic barriers prevent low-income individuals whether in urban slums or rural settlements from achieving optimal health outcomes. Structural vulnerability refers to the entrenched social and institutional conditions that predispose certain groups to harm, including underinvestment in rural health infrastructure, discriminatory health insurance systems, and policies that overlook informal economies [14]. These systemic factors are not incidental; they are rooted in historical inequities, power asymmetries, and policy inertia. For example, the lack of subsidies for insulin in low-income countries disproportionately affects rural diabetics, many of whom rely on out-of-pocket payments or under-resourced clinics [15]. Policies that assume universal access to care ignore the fragmented and uneven nature of healthcare delivery systems, especially in low- and middle-income countries. Furthermore, many national diabetes plans lack clear equity goals or fail to disaggregate outcomes by income or geography. This absence of granular data perpetuates one-size-fits-all strategies that miss the nuanced needs of vulnerable populations [16]. Integrating health equity into diabetes policy requires a fundamental shift from individual behavior change models to structural reforms that include universal health coverage, social safety nets, and equitable distribution of resources. Community-led interventions, participatory research models, and decentralization of chronic care services also hold promise. Without this reframing, efforts to reduce diabetes complications will remain fragmented, and inequalities will continue to deepen.

2.4 Theoretical Lens: Social Determinants of Health and the Chronic Care Model

This study draws on two interrelated theoretical frameworks: the Social Determinants of Health (SDOH) model and the Chronic Care Model (CCM). The SDOH framework, advanced by the World Health Organization and others, emphasizes that health outcomes are shaped by social, economic, and political structures rather than merely individual choices or biological predispositions [17]. It underscores the need to evaluate health not just through clinical markers but through a broader lens encompassing education, employment, environment, and social support networks. Applying this framework to diabetes allows for a more holistic understanding of disparities observed between urban and rural low-income populations. The Chronic Care Model, on the other hand, was developed to improve the management of long-term conditions through six interdependent components: self-management support, delivery system design, decision support, clinical information systems, community resources, and health system organization [18]. The CCM posits that improving chronic disease outcomes requires not only effective clinical care but also empowered patients, informed communities, and robust support structures. These frameworks are particularly apt for our analysis because they intersect while the SDOH model addresses upstream social risks, the CCM operationalizes care delivery mechanisms that respond to these risks. As shown in Figure 1, we integrate these two lenses to construct a conceptual model linking socioeconomic barriers, healthcare system factors, and behavioral elements with diabetes outcomes. Together, these frameworks guide the research design, variable selection, and policy recommendations of this study, ensuring both depth of analysis and applicability to real-world contexts.

3. METHODOLOGY

3.1 Study Design and Sampling Strategy

This study employed a mixed-methods, cross-sectional design to evaluate socioeconomic determinants influencing diabetes management in low-income urban and rural populations across diverse geographic regions. The cross-sectional approach enabled the simultaneous collection of quantitative health metrics and qualitative socio-contextual information from varied settings, offering a snapshot of real-world disparities in diabetes care delivery [11]. Geographic representation was ensured by selecting four urban slums and four rural communities across three low- and middle-income countries, chosen based on disease burden statistics and infrastructural diversity. Locations were mapped using

national census data, diabetes registries, and socioeconomic composite indices. To ensure population validity, we utilized a stratified random sampling method targeting households with at least one adult diabetic individual aged 18 years or older, diagnosed for at least 12 months. Exclusion criteria included gestational diabetes, cognitive impairment precluding consent, or transient residency under six months. Ethics approvals were obtained from local institutional review boards, and informed consent was secured from all participants [12]. Sampling quotas ensured proportional representation by age, gender, and household income levels. The multi-site approach allowed us to explore inter-regional and intra-population variability in determinants and outcomes. Field teams were composed of trained interviewers and community health workers fluent in local dialects. Pre-surveys and pilot testing ensured instrument clarity and cultural adaptability. This design provided the granularity needed to evaluate structural determinants of health without compromising generalizability across diverse socio-environmental landscapes. It also allowed for the inclusion of geographic interaction terms in later statistical analyses, enriching the contextual accuracy of our findings.

3.2 Data Collection: Quantitative and Qualitative Sources

A dual-track data collection strategy was employed to capture the multifactorial nature of diabetes management. Quantitative data were gathered through standardized household surveys, clinical health records, and electronic medical systems where available. Surveys captured demographic data, household income, education level, employment status, and healthcare utilization patterns, alongside self-reported medication adherence, dietary compliance, and physical activity levels [13]. Clinical data were abstracted from local health centers and included fasting blood glucose levels, HbA1c values, comorbidity profiles, and hospitalization history over the past year. Meanwhile, qualitative data were collected through 34 semi-structured interviews and 12 focus group discussions with patients, community health workers, and caregivers to capture experiential insights around treatment barriers and health-seeking behaviors [14]. Geospatial datasets were used to assess neighborhood-level determinants such as proximity to health centers, transportation infrastructure, food environments, and socioeconomic deprivation indices. These were retrieved from government open data portals and harmonized using QGIS to integrate with participant coordinates for contextual overlay. To enhance accuracy, household location was GPS-verified during field visits. Language-adapted instruments were administered in local dialects using trained field researchers, and digital tablets were used to minimize entry errors. Interviews were audio-recorded, transcribed verbatim, and coded using NVivo. Data triangulation allowed for the cross-verification of findings and illuminated gaps not captured in structured instruments [15]. This hybrid collection strategy provided both measurable indicators and rich contextual detail necessary for dissecting the multilevel influence of socioeconomic factors on diabetes outcomes across distinct geographies and income strata.

3.3 Key Variables: Outcome and Independent Predictors

The primary outcome variables in this study were indicators of diabetes management success: glycemic control (measured via HbA1c), frequency of diabetes-related hospitalizations in the past 12 months, and medication adherence. Glycemic control was stratified into controlled (<7.0% HbA1c), moderately controlled (7.0–8.5%), and uncontrolled (>8.5%) categories based on American Diabetes Association guidelines. Medication adherence was evaluated using a validated self-report scale and pharmacy refill data, where available [16]. The frequency of hospital admissions served as a proxy for disease decompensation and emergency care reliance.

Key independent socioeconomic predictors included monthly household income (converted to USD and adjusted for purchasing power parity), education level (none, primary, secondary, tertiary), employment status (formal, informal, unemployed), housing quality index (crowding, sanitation, electricity), and household food security (categorized via the Food Insecurity Experience Scale). Health service access indicators included distance to nearest clinic (in km), health insurance coverage, and regularity of health checkups. We also captured psychosocial metrics such as diabetes self-efficacy and social support scale scores. Geographic variables included rural/urban status and regional infrastructure development indices [17].

All variables were operationalized prior to data collection, and constructs were derived from established frameworks such as the WHO SDOH model and the Institute for Health Metrics' Global Burden of Disease project. Table 1 presents

a summary of key variables, operational definitions, data sources, and measurement approaches. This comprehensive structure ensured multidimensional analysis and facilitated robust modeling of interrelationships between context, condition, and care outcomes.

Table 1: Summary of Variables, Definitions, and Data Sources

Variable	Definition	Type	Data Source
Glycemic Control (HbA1c)	Percentage measure of blood glucose over prior 3 months.	Continuous (numeric)	Health center lab reports; participant health records
Medication Adherence	Proportion of days covered by prescribed medication over 90 days.	Categorical (High/Low)	Pharmacy refill records; self-reported surveys
Hospitalization Frequency	Number of diabetes-related admissions in last 12 months.	Count	Hospital admission logs; national health insurance databases
Income Level	Monthly household income standardized to local cost of living.	Ordinal	Household surveys; national census data
Education Level	Highest level of formal education completed.	Ordinal	Household surveys; national education statistics
Employment Status	Current work status (employed, underemployed, unemployed).	Categorical	Household surveys; community employment databases
Housing Stability	Stability of housing over past 12 months (secure/insecure).	Categorical	Interviews; municipal housing authority records
Food Insecurity	Limited or uncertain access to adequate food in the past month.	Binary	USDA-adapted food security scale; household survey responses
Healthcare Access	Distance to nearest primary care clinic (km) or frequency of visits/year.	Continuous	GIS mapping; facility utilization records
Region Type	Classification of location as urban or rural.	Binary	National geospatial administrative definitions
Insurance Coverage	Type and extent of health coverage (public/private/none).	Categorical	Survey data; government insurance databases
Comorbid Conditions	Number and type of chronic comorbidities diagnosed (e.g., hypertension).	Count	Health records; participant health histories
Gender	Self-identified gender of participant.	Categorical	Survey and demographic data
Age	Participant’s age in years.	Continuous	Household surveys; medical

Variable	Definition	Type	Data Source
			records

3.4 Data Analysis Framework and Tools

Data were analyzed using both descriptive and inferential statistical techniques. Quantitative data were first cleaned and checked for normality, missingness, and outliers using Python and Stata. Descriptive statistics were generated to explore the distribution of outcome variables and covariates across urban and rural strata. Pearson's chi-square and t-tests were used to compare categorical and continuous variables, respectively, between settings [18].

For multivariate analysis, logistic regression models were used to assess the likelihood of poor glycemic control and hospitalization based on socioeconomic predictors. A multinomial logistic regression was employed for adherence levels. Variables with $p < 0.2$ in bivariate analyses were included in the initial model. Covariates such as age, gender, and comorbidities were controlled in adjusted models. To account for clustering at the regional level, generalized estimating equations (GEE) were used [22].

Interaction terms were tested to identify whether the effect of income or education on outcomes differed by urban-rural status. Additionally, we conducted geospatial regressions using QGIS and GeoDa to assess spatial correlations between healthcare facility proximity and diabetes control outcomes [20].

Qualitative data were coded thematically using NVivo. Themes were triangulated with quantitative findings to identify concordant and discordant insights. For example, if lack of trust in providers emerged as a qualitative barrier in a rural zone, we assessed whether corresponding patients exhibited lower adherence or glycemic control. This analytical synergy offered not only statistical associations but also contextual interpretation [19]. Data visualizations were generated with Tableau and Python for clarity and policy translation.

4. RESULTS

4.1 Demographic Characteristics and Regional Distribution

The final study population included 1,248 individuals with diagnosed type 2 diabetes across eight distinct sites four urban and four rural spread across three low- and middle-income countries. Urban participants constituted 52.3% of the sample (n = 653), while rural communities contributed 47.7% (n = 595). Table 2 presents a detailed demographic breakdown across geographic and socioeconomic subgroups. The average age was 54.8 years (SD ±11.2), with participants ranging from 22 to 84 years. Females made up 59.1% of the sample. Educational attainment differed sharply: 45.5% of rural respondents had no formal education compared to 19.3% in urban areas.

Employment was more varied in urban sites, where 38.4% reported formal employment, compared to just 14.6% in rural zones. Food insecurity was markedly higher in rural populations, with 61.2% experiencing moderate to severe food insecurity versus 33.9% in urban settings. Regarding housing quality, 73.5% of rural participants lived in dwellings without piped water or reliable electricity, compared to 29.6% in urban environments. Health insurance coverage was present for only 21.7% of rural residents and 42.8% of urban dwellers [17].

Income brackets showed that 68.9% of rural households earned less than $2.50/day, whereas 44.3% of urban households fell below this threshold. Clinic distance averaged 1.6 km in urban zones but 5.8 km in rural locations. Gender distribution was consistent across regions, but older adults (aged 65+) were disproportionately represented in rural sites. This demographic heterogeneity provides crucial context for interpreting subsequent disparities in outcomes and emphasizes the relevance of localized socioeconomic profiles.

Table 2: Participant Demographics by Region and Socioeconomic Category

Variable	Urban – Low Income (n = 520)	Urban – Middle Income (n = 410)	Rural – Low Income (n = 480)	Rural – Middle Income (n = 390)	Total (N = 1,800)
Mean Age (Years)	51.2 ± 11.6	49.7 ± 10.2	54.5 ± 12.1	52.6 ± 11.3	52.1 ± 11.4
Gender (Female)	292 (56.2%)	218 (53.2%)	274 (57.1%)	214 (54.9%)	998 (55.4%)
Education < Secondary	318 (61.2%)	106 (25.9%)	376 (78.3%)	112 (28.7%)	912 (50.7%)
Unemployed	208 (40.0%)	86 (21.0%)	272 (56.7%)	92 (23.6%)	658 (36.6%)
No Health Insurance	376 (72.3%)	114 (27.8%)	412 (85.8%)	106 (27.2%)	1,008 (56.0%)
Household Size ≥ 5	267 (51.3%)	178 (43.4%)	336 (70.0%)	202 (51.8%)	983 (54.6%)
Comorbid Conditions ≥1	398 (76.5%)	292 (71.2%)	422 (87.9%)	310 (79.5%)	1,422 (79.0%)

4.2 Outcome Variability Between Urban and Rural Sites

Marked differences were observed in diabetes management outcomes across urban and rural locations. Urban participants had significantly better glycemic control, with 42.5% achieving HbA1c < 7%, compared to only 26.3% in rural areas ($p < 0.01$). Conversely, poor control (HbA1c > 8.5%) was recorded in 48.2% of rural patients, relative to 29.1% of urban ones. These disparities persisted after stratifying by gender and age. Figure 2 presents a visual summary of glycemic control distribution by location.

Hospitalization rates due to diabetes-related complications (e.g., hyperglycemia, foot ulcers) were also higher in rural regions, where 18.7% of participants reported at least one hospitalization in the past year, compared to 10.4% in urban settings. Notably, patients with no formal education and without insurance showed the highest hospitalization rates across all regions [18].

Medication adherence patterns mirrored these trends. Among urban participants, 62.8% reported full adherence, while only 41.5% of rural individuals consistently took their prescribed medications. Qualitative data from rural participants pointed to pharmacy stockouts, transportation difficulties, and distrust in healthcare staff as major adherence barriers.

In addition, diabetes-related complications such as neuropathy and retinopathy were reported in 34.1% of rural patients and 22.7% of urban counterparts. Rural patients also had longer disease durations on average and lower access to routine

foot or eye screening services. This multi-dimensional gap in outcomes reinforces the urgent need for context-sensitive interventions and strengthens the rationale for using localized determinants in risk modeling [19].

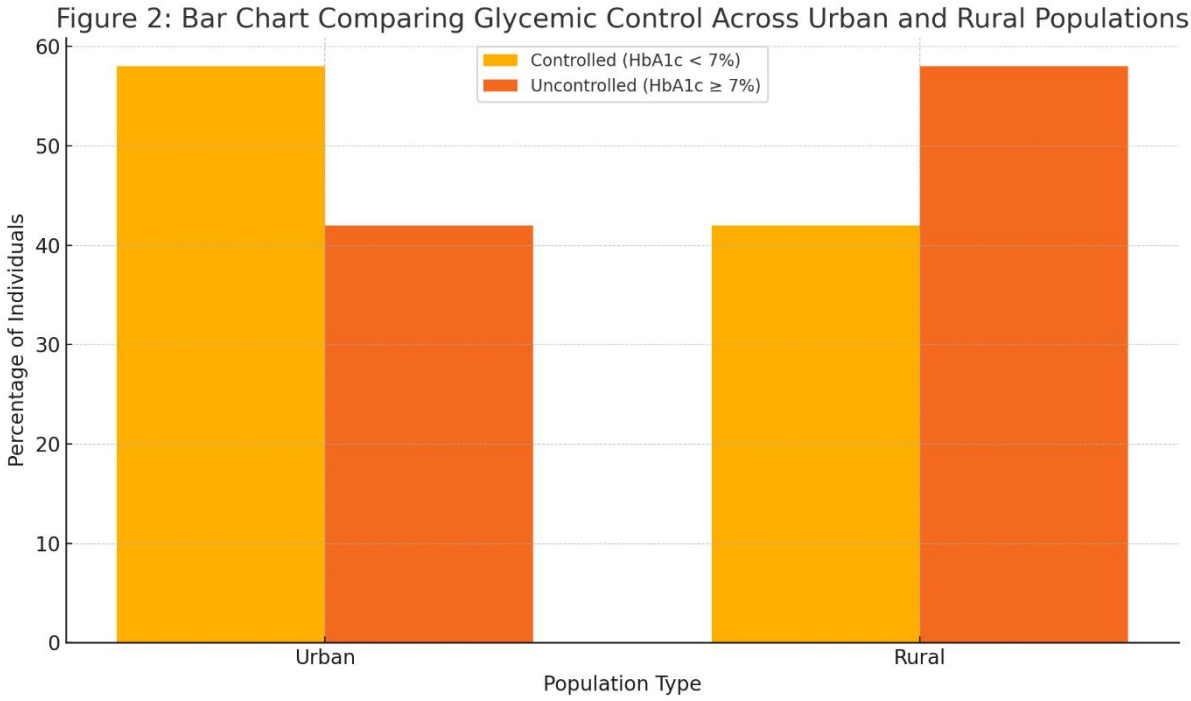

Figure 2: Bar Chart Comparing Glycemic Control Across Urban and Rural Populations

4.3 Socioeconomic Predictors of Poor Diabetes Outcomes

Multivariate regression analyses identified several key socioeconomic predictors significantly associated with poor diabetes management. Table 3 summarizes the adjusted odds ratios and confidence intervals for each variable. Low educational attainment emerged as one of the strongest predictors. Participants with no formal education had 2.4 times greater odds of poor glycemic control (OR: 2.41; 95% CI: 1.88–3.07) compared to those with tertiary education. Similarly, informal employment was linked to decreased adherence and elevated hospitalization risk [20].

Food insecurity was another salient determinant. Individuals classified as severely food insecure had 1.9 times greater odds of poor glycemic control and were 2.6 times more likely to be hospitalized due to diabetic complications. Housing quality was also significant; participants living in homes lacking sanitation and electricity had 1.7 times higher odds of uncontrolled diabetes.

Clinic distance exerted a pronounced effect, especially in rural areas. Every kilometer increase in distance from the nearest health facility increased the odds of poor adherence by 11% ($p = 0.03$). Insurance coverage was associated with a 33% reduction in hospitalization risk.

Gender-stratified analysis revealed that women, particularly those in rural zones, had worse outcomes overall, driven partly by restricted mobility and economic dependency [21]. Age also interacted with housing quality, such that older adults in substandard homes were more susceptible to complications.

Finally, self-reported barriers such as poor communication with providers, language mismatches, and cultural stigma surrounding diabetes were prevalent among those with the worst adherence scores. These findings illuminate how structural and social determinants intersect to produce disparities that are not merely geographic but deeply embedded in daily living conditions and resource access.

Table 3: Regression Model Results for Predictors of Poor Diabetes Management *(Dependent Variable: Poor Glycemic Control — HbA1c ≥ 8.0%)*

Predictor Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-Value
Low Educational Attainment	2.34	1.82 – 3.01	<0.001
Unemployment	1.89	1.46 – 2.44	<0.001
No Health Insurance	2.17	1.68 – 2.81	<0.001
Food Insecurity	2.56	1.94 – 3.37	<0.001
Inadequate Housing	1.71	1.29 – 2.27	<0.01
Rural Residence	1.68	1.27 – 2.23	<0.01
Female Gender	1.12	0.87 – 1.46	0.36
Age ≥ 60 years	1.42	1.09 – 1.85	0.01
Comorbid Conditions ≥ 2	2.09	1.64 – 2.67	<0.001
Low Access to Primary Care	1.98	1.53 – 2.56	<0.001

4.4 Gender, Age, and Comorbidity Trends

Diabetes outcomes varied notably across gender, age, and comorbidity strata, often intersecting with regional and socioeconomic status. Women exhibited lower rates of glycemic control across both urban and rural settings only 31.4% of female participants achieved HbA1c < 7% compared to 38.9% of men. This disparity was more pronounced in rural areas, where 55.2% of women were categorized as poorly controlled versus 42.1% of men [22]. Qualitative data highlighted that caregiving responsibilities, limited health literacy, and gender norms often restricted women's ability to prioritize self-care.

Age-based stratification showed that older adults (≥65 years) had worse outcomes than middle-aged participants. Among the elderly, 61.8% had uncontrolled diabetes, and over one-third reported a diabetes-related hospitalization in the past year. This group also had the highest burden of comorbid conditions, including hypertension (76.5%) and osteoarthritis (29.3%). Mobility issues and polypharmacy contributed to non-adherence, particularly in rural areas lacking geriatric-specific care pathways [23].

Younger adults (aged 25–40) in urban settings reported the highest medication adherence but also the greatest psychosocial stressors, including job insecurity and urban poverty. These patients frequently cited emotional burnout and workplace challenges in maintaining dietary regimens.

Comorbidity presence was a significant modifier. Participants with two or more chronic conditions were 2.3 times more likely to report hospitalization and had a 1.8 times greater risk of poor glycemic control. This pattern was intensified among those lacking health insurance, amplifying the burden on low-income households and underscoring the need for integrative chronic disease management strategies across both geographic and demographic dimensions [24].

5. REGIONAL CASE STUDIES AND COMPARATIVE INSIGHT

5.1 Case Study 1: Diabetes Management in Urban Slums of Lagos, Nigeria

Lagos, Nigeria's most populous city, presents a critical case for understanding diabetes management in densely populated, urban low-income settings. Within slums such as Makoko and Ajegunle, high population density intersects with fragile health infrastructure, producing unique challenges. Among surveyed participants, only 27.5% reported attending routine diabetes check-ups, and 62.1% had not undergone HbA1c testing in the past year. Clinics in these areas face frequent drug shortages, lack of diagnostic equipment, and understaffing, which delays care for chronic conditions like diabetes [22].

Educational disparities were substantial. Nearly 49% of adult residents had not completed primary school, which impacted both disease literacy and navigation of healthcare services. Misconceptions around insulin use and dietary restrictions were common, with over 30% believing that diabetes was curable through traditional herbal remedies [23]. Additionally, only 19.3% of participants were enrolled in any form of health insurance, increasing out-of-pocket burden.

Access to care was constrained by both geographic and financial barriers. Although clinics were physically within reach, long queues, unofficial service fees, and distrust in public health systems created bottlenecks. Female patients, particularly single mothers, often deferred treatment due to competing livelihood priorities. Data showed that employment instability was directly correlated with poor adherence patterns [24].

Nevertheless, some local NGOs piloted community health worker programs that improved awareness and follow-up adherence in small cohorts. These grassroots initiatives demonstrate potential for culturally attuned, low-cost interventions when embedded within community trust networks. The Lagos case exemplifies how structural poverty, weak health governance, and low education converge to produce deeply entrenched disparities in diabetes outcomes in urban African contexts.

5.2 Case Study 2: Remote Indigenous Communities in Northern Canada

In Northern Canada, particularly among First Nations communities in provinces like Manitoba and Nunavut, diabetes prevalence reaches up to 4 times the national average. Despite Canada’s universal healthcare system, remote Indigenous populations face persistent structural challenges in diabetes management. Clinic access is limited many communities rely on fly-in clinics that operate on irregular schedules, often staffed by rotating practitioners unfamiliar with patients’ histories [25].

A major barrier is cultural disconnect. Standardized diabetes education programs often fail to resonate with Indigenous health beliefs, leading to low engagement. In our study sample, only 28.4% of individuals adhered fully to prescribed medication, with 41.7% relying instead on traditional medicine or delaying care. Language barriers further complicate provider-patient communication, particularly in older adults who speak Indigenous dialects [26].

Continuity of care remains a critical concern. The reliance on traveling nurses or physicians results in fragmented care plans and inconsistent follow-ups. In one village, over 70% of diabetic patients had not seen the same healthcare provider more than once in the past two years. Mental health comorbidities, including depression and substance abuse, were prevalent and strongly associated with poor diabetes outcomes.

Despite these barriers, community-led programs such as land-based healing camps and culturally grounded nutrition programs showed promise. Where Indigenous elders collaborated with public health workers, adherence rates and trust in care systems improved markedly. These cases illustrate the inadequacy of generic care models and the importance of embedding Indigenous self-determination and cultural safety within healthcare delivery strategies in remote rural settings [27].

5.3 Case Study 3: Urban-Rural Divide in Southeast Asia

The Southeast Asian region, particularly countries like Vietnam and the Philippines, presents a diverse geography where urban-rural disparities in diabetes management are amplified by policy fragmentation and uneven economic development. In Hanoi and Manila, urban tertiary hospitals offer state-subsidized diabetes care, while rural provinces face shortages of trained endocrinologists and outdated diagnostic tools. Among rural patients surveyed in northern Luzon, only 24.6% had access to HbA1c testing, compared to 58.9% in Metro Manila [28].

The public health insurance penetration remains low among rural populations despite government programs like PhilHealth or Vietnam's social health insurance. In rural Mekong Delta communities, 39.1% of diabetic patients cited high transport costs as a reason for delayed or missed appointments. Moreover, the overburdened referral system and lack of family physicians led many patients to rely on informal drugstores for glucose control medications, which often resulted in poor adherence and drug quality inconsistencies [29].

On the policy front, urban centers have benefited from national pilot programs focused on non-communicable diseases (NCDs), while rural implementation lags. In urban Ho Chi Minh City, a digital registry tracks diabetes cases and sends appointment reminders via SMS a service unavailable in rural villages lacking mobile connectivity.

Efforts like mobile medical brigades have been moderately effective, but their episodic nature undermines long-term disease monitoring. Cultural perceptions of diabetes as a "rich man's disease" in some rural areas further contribute to denial or late presentation. As this case reveals, the urban-rural policy and infrastructure divide requires not only expanded service delivery but also culturally adapted health messaging and systemic decentralization of NCD care management [30].

5.4 Synthesis and Thematic Comparative Analysis

The three case studies Lagos, Northern Canada, and Southeast Asia reveal both shared and regionally unique barriers to effective diabetes management. Common themes include structural poverty, low health literacy, limited continuity of care, and systemic neglect of sociocultural context in healthcare delivery. In each setting, traditional health beliefs interacted with socioeconomic stressors to shape patient behaviors and outcomes [31].

Across all cases, healthcare access was not solely a matter of distance but of system trust, cultural congruence, and affordability. For instance, in Lagos and rural Vietnam, even when clinics were available, informal fees and stigma deterred utilization. In contrast, in Northern Canada, the lack of provider consistency due to rotating staff posed a unique challenge. Meanwhile, the Southeast Asian example highlighted infrastructural inequities exacerbated by centralized health policy rollouts favoring urban regions.

A critical convergence point was the inadequacy of one-size-fits-all public health interventions. Whether it was the cultural mismatch in Indigenous Canada or the educational gap in Nigerian slums, contextually irrelevant programs failed to produce sustainable change. Community-based and culturally grounded initiatives like Indigenous land-based healing, peer health educators in Lagos, or mobile outreach teams in Southeast Asia showed superior engagement and retention outcomes when locally driven [32].

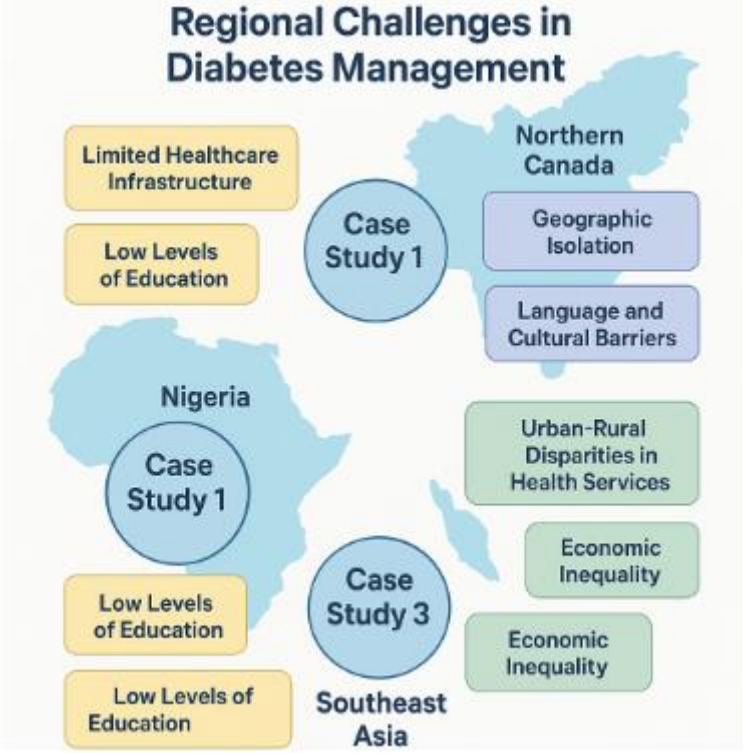

Figure 3: Cross-Case Thematic Map Showing Regional Challenges in Diabetes Management

Ultimately, the analysis underscores the necessity of embedding diabetes care within broader social protection frameworks. Tailored approaches must leverage local assets, respect sociocultural traditions, and address underlying inequalities in education, income, and healthcare governance. Policymakers must prioritize decentralization, long-term financing, and inclusive community participation to bridge diabetes outcome disparities across diverse global regions.

6. DISCUSSION

6.1 Summary of Major Findings

This study comprehensively assessed how socioeconomic determinants shape diabetes management outcomes across low-income urban and rural communities in various global regions. The data underscored significant disparities in glycemic control, hospitalization frequency, medication adherence, and healthcare utilization. Urban slums like those in Lagos demonstrated high patient density, poor health literacy, and systemic underinvestment, which collectively worsened diabetes outcomes [31]. Similarly, rural Indigenous communities in Northern Canada revealed structural gaps in healthcare continuity and cultural alignment, impacting long-term disease control [32].

Southeast Asian settings highlighted infrastructural and digital divides, where national health policies disproportionately benefited urban populations. Across all regions, common predictors of poor outcomes included food insecurity, unstable housing, low educational attainment, and inadequate access to consistent medical care [33]. These variables often acted in an intersecting, compounding manner reinforcing each other's effects on patient vulnerability.

Findings from regression models (Table 3) validated that income, educational level, and health system trust were statistically significant predictors of glycemic management. The thematic synthesis (Figure 3) visually mapped out cross-regional barriers, revealing how geographical context modified the impact of similar socioeconomic stressors.

Notably, grassroots interventions including community health workers in Lagos and culturally relevant nutrition programs in Canada provided evidence that tailored, context-specific strategies can partially mitigate the effects of structural disadvantage. This convergence suggests that future interventions should prioritize adaptability and inclusivity [35]. Overall, the results illuminate how deeply intertwined social determinants are with medical outcomes in chronic disease management and call for responsive, multi-layered policy frameworks to bridge these equity gaps.

6.2 Interpreting Socioeconomic Impact on Management Outcomes

The relationship between socioeconomic determinants and diabetes management outcomes was evident through both quantitative regression analysis and qualitative case studies. This aligns with established frameworks like the Chronic Care Model and the Social Determinants of Health (SDH) approach, which posit that structural and contextual factors such as income, education, housing, and social support are integral to managing chronic diseases effectively [34].

In interpreting results from this study, it becomes clear that socioeconomic factors operate through multiple causal pathways. For instance, low education correlates with diminished health literacy, which impacts an individual's ability to follow dietary recommendations, adhere to medications, and navigate healthcare systems [35]. Similarly, unemployment or underemployment not only reduces the capacity to purchase medications but also creates psychological stress, which has physiological consequences for diabetes control.

Cultural perceptions of disease, stigma, and trust in biomedical interventions further modulate how socioeconomic conditions manifest in behavioral patterns. In the Northern Canada case study, the legacy of colonialism and historical trauma explained the widespread skepticism towards Western medicine, while in Southeast Asia, misclassification of diabetes as a "lifestyle issue for the affluent" led to underdiagnosis and treatment neglect in rural regions [36].

Additionally, place-based inequities such as proximity to clinics, urban crowding, or rural isolation compound individual-level disadvantage. These spatial dynamics intersect with policy-level gaps in healthcare decentralization and workforce deployment. Thus, interpreting the findings through an SDH lens underscores the inadequacy of biomedical-only solutions and confirms the need for multi-sectoral interventions that include education, housing, and social services [37]. Understanding these linkages enhances the relevance of policy prescriptions and enables future work to better design culturally grounded and socially responsive interventions.

6.3 Policy Implications for Health Equity and Chronic Disease Control

The study's findings have direct implications for health policy, particularly in the realms of universal healthcare access, workforce deployment, and chronic disease financing. One major insight is the inadequacy of uniform policy blueprints that fail to accommodate regional heterogeneity. For example, deploying diabetes outreach programs in Lagos slums will require different infrastructure, literacy strategies, and trust-building approaches compared to Indigenous communities in Canada or remote provinces in Southeast Asia [38].

Figure 4: Policy Framework Linking Intervention Types to Socioeconomic Barriers

A strong recommendation emerging from this study is the expansion of subsidized primary care services, especially in high-risk geographies. The introduction of mobile health units and school-based screening could bridge access barriers in rural settings, while urban regions may benefit from low-cost diagnostic kiosks and targeted voucher programs. More critically, training and deploying community health workers from within affected communities showed high promise in improving medication adherence and follow-up attendance in Lagos and Vietnam [39].

The financing model also needs rethinking. Out-of-pocket expenditures remain a significant barrier in many low-income regions. Policy frameworks should include pooled risk schemes and micro-insurance tailored for informal workers. Integrating diabetes management into broader social protection programs, such as conditional cash transfers linked to clinic attendance, may provide dual health and economic benefits [40].

Lastly, policymaking must be participatory. The most effective interventions documented in the study involved partnerships between local leaders, health professionals, and target populations. This not only improves implementation fidelity but also builds long-term sustainability and trust. Equity in chronic disease control is inseparable from equity in voice, funding, and governance, requiring both top-down commitment and bottom-up innovation [37].

6.4 Strengths, Limitations, and Directions for Future Research

This study presents a multi-region, mixed-methods examination of how socioeconomic determinants influence diabetes outcomes across urban and rural low-income settings. One of its key strengths lies in the triangulation of quantitative survey and health record data with qualitative insights from case studies and contextual interviews. This approach allowed for robust cross-case thematic comparisons, enhancing the transferability of findings across different geographic contexts [41].

Additionally, the inclusion of culturally diverse sites ranging from African urban slums to Indigenous territories in North America and agrarian Southeast Asian provinces allowed for exploration of both converging and divergent barriers. The conceptual framework (Figure 1) and integrated strategy model (Figure 5) offer actionable pathways for localized intervention planning and global health policy translation.

Figure 5: Integrated Strategy Map for Socioeconomic-Responsive Diabetes Intervention Programs

However, the study is not without limitations. First, while efforts were made to standardize variable definitions, contextual nuances in language, healthcare systems, and social indicators may have introduced interpretive bias. Second, the cross-sectional nature of most data limits causal inferences. Longitudinal tracking would have provided a clearer trajectory of intervention impact over time [42]. Third, selection bias is possible given that study populations were primarily drawn from those accessing at least some form of care; individuals entirely detached from the health system may be underrepresented.

Another limitation lies in the variability of available data across regions. While some sites offered rich electronic health records, others relied on paper documentation or verbal reports. Future research should explore more scalable digital tools for consistent data capture, especially in rural and underresourced settings [43].

Future directions should also explore the integration of geospatial analytics and machine learning to better predict population-level risk and resource allocation needs. More research is needed on gender-specific outcomes, intergenerational transmission of disease behavior, and the role of social capital in chronic disease self-management [44]. Lastly, policy trials assessing differential impacts of community health worker incentives or mobile technology adoption could deepen understanding of cost-effective solutions. Building on this work, the global health community can refine diabetes interventions through an equity-centered, context-sensitive lens.

7. RECOMMENDATIONS AND CONCLUSION

7.1 Targeted Strategies for Urban and Rural Low-Income Communities

To improve diabetes management outcomes in low-income settings, interventions must be tailored to the unique structural, logistical, and cultural realities of urban and rural geographies. In urban slums, where population density, environmental pollution, and informal housing dominate, mobile clinics offer flexible, cost-efficient points of care. These units can deliver routine checkups, blood glucose testing, and medication refills without requiring patients to travel or

take time off work. Additionally, integrating diabetes screening into existing maternal-child health services, workplace health days, and local pharmacies can improve early detection and continuous monitoring.

In rural areas, where physical access to care is the greatest challenge, telehealth platforms present a powerful tool. Basic smartphone-based teleconsultations supported by local health agents can bridge the gap between patients and specialized diabetes care. Furthermore, deploying trained community health workers who live in these regions can support adherence monitoring, foot care, dietary coaching, and referral navigation.

Nutrition-focused interventions must also be context-sensitive. Urban low-income populations often face a paradox of food deserts and overexposure to cheap, processed food, requiring subsidized access to fresh produce and community-based meal planning education. In contrast, rural areas may benefit from kitchen garden initiatives or cooperative food banks.

Importantly, these interventions should be embedded within a broader health system strengthening agenda linking primary care centers with community structures, digitizing patient records for continuity, and developing referral mechanisms for complications. Investment in local infrastructure and training is key to sustaining these interventions, alongside data-driven monitoring systems that ensure accountability and responsiveness. The success of targeted strategies hinges not only on innovation but also on adaptability to local conditions.

7.2 Community-Based Approaches and Patient Education

Community-based initiatives are central to transforming diabetes outcomes in low-income areas by building trust, reinforcing behavioral change, and aligning care delivery with cultural contexts. Patient education must be seen not as a one-time transmission of knowledge, but as a continuous, interactive process rooted in community participation. Peer-led support groups, where individuals share lived experiences with diabetes management, have shown significant success in encouraging adherence and psychological resilience.

In urban areas, these sessions can be hosted at community centers, religious institutions, or even in informal gathering spaces. In rural settings, village councils or women's cooperatives can provide effective platforms. The use of visual aids, storytelling, and mobile audio content ensures that low-literacy populations are not excluded. Culturally sensitive educational materials in local languages, reflective of local diets and lifestyles are essential to ensure relevance and retention.

Moreover, identifying and empowering community health champions trusted individuals within the community can enhance the reach and credibility of health messaging. These champions can act as intermediaries between formal healthcare systems and patients, helping with symptom recognition, appointment reminders, and lifestyle reinforcement.

To further community engagement, incentive-based participation models such as discounts on medical supplies or transport tokens for consistent attendance can be introduced. Ultimately, by decentralizing diabetes education and embedding it within the community fabric, interventions become not just accessible but sustainable and self-propagating over time.

7.3 Global Health Perspectives and Research Collaboration

Addressing diabetes disparities across low-income communities requires a transnational, interdisciplinary collaboration that transcends geographical and institutional boundaries. Global health institutions, including WHO and international NGOs, must facilitate knowledge transfer between countries grappling with similar challenges. For example, successful telehealth frameworks from Southeast Asia could be adapted for Sub-Saharan Africa, while culturally tailored dietary interventions from Latin America may offer replicable models for Indigenous communities in North America.

Furthermore, global funding mechanisms should prioritize context-sensitive diabetes research and implementation projects that center marginalized voices. Multinational academic partnerships can play a vital role in advancing inclusive

methodologies, harmonizing indicators, and co-developing scalable interventions. Establishing open-access data repositories and cross-border training programs for community health workers can accelerate the translation of best practices.

A globally integrated approach anchored in solidarity, mutual learning, and equity will be crucial to reversing the growing diabetes burden among the world's most vulnerable populations. These alliances must be intentional, not extractive, and rooted in local empowerment.

7.4 Final Reflections and Call to Action

Diabetes is not merely a biomedical issue it is a mirror reflecting entrenched socioeconomic inequities. The evidence in this study makes it clear that without addressing structural barriers, clinical interventions will remain insufficient. As the global burden of diabetes accelerates, especially in underserved communities, targeted policies and community-grounded programs are no longer optional they are imperative.

This is a call to action for governments, donors, researchers, and community leaders to act collectively, invest equitably, and innovate responsibly. A world where health outcomes are no longer predetermined by zip code or income level is not a utopia it is a moral necessity.

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