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Cross-Sectional Study

Syndemic Burdens of Oral Disease, Metabolic Risk, and Women's Health in Rural Tanzania: Findings From Community-Based Screening

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ABSTRACT

This cross-sectional study investigated the linkages between oral health conditions, additional non-communicable diseases (NCDs), and overall health among women in rural areas of Tanzania. By conducting screenings at the community level, the research sought to uncover clustered vulnerabilities consistent with syndemic frameworks and to support the design of comprehensive, coordinated health services. During July 2023, a sample of 224 adult women was assembled through outreach programs in the villages of Burere, Nyambogo, and Roche within Tanzania's Rorya District. Each participant received a standardized clinical examination of the oral cavity, periodontal biomarker testing via the PerioMonitor™ device, and structured questionnaires that included the Oral Health-Related Quality of Life (OHRQoL) measure and the Hologic Global Women's Health Index (HGWI). Furthermore, a subgroup of 45 women was evaluated for blood pressure and random blood glucose concentrations. Merely 18.2% of the women indicated any history of blood pressure monitoring. The average Decayed, Missing, and Filled Teeth (DMFT) value stood at 5.16, while 40% displayed signs of heightened periodontal inflammation. Participants' mean OHRQoL score reached 11.15, suggesting notable impairments in daily functioning and emotional well-being related to oral health. Within the subgroup assessed for cardiometabolic markers, hypertension was detected in 49%, hyperglycemia in 2%, and hypoglycemia in 18%, with the majority of these cases previously unrecognized. The implementation of screenings in community settings was both practical and revealing, highlighting concurrent challenges from unmanaged dental issues, dysregulated metabolism, and limited access to routine prevention. Such patterns illuminate systemic and service-related inequities in oral health and reinforce syndemic perspectives, calling for holistic interventions that are sensitive to gender dynamics and local cultural contexts. Ultimately, these insights lay groundwork for replicable and enduring healthcare frameworks suited to settings with constrained resources.

Keywords: Oral disease, Tanzania, Metabolic risk, Women's health

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Introduction

Non-communicable diseases (NCDs) represent an escalating public health issue in Tanzania, contributing to approximately one-third of total mortality [1, 2]. This challenge is particularly acute in rural regions such as Rorya District, characterized by inadequate healthcare infrastructure, limited preventive services, and substantial obstacles to timely diagnosis and management [3]. Beyond impairing individual functioning and quality of life, these diseases impose significant pressure on overburdened health systems [1].

Among NCDs, oral conditions—including dental caries and periodontal disease—are highly prevalent yet frequently overlooked in rural Tanzanian communities [4]. Despite their potential systemic consequences, oral health issues are seldom prioritized in national policies. Factors such as traditional oral hygiene methods, restricted healthcare access, and practices like shared toothbrush use contribute to elevated levels of untreated disease [5-9].

Concurrently, the increasing incidence of hypertension and diabetes in sub-Saharan Africa has overwhelmed rural diagnostic capabilities, resulting in numerous undetected cases [10, 11]. Such co-existing conditions highlight the need for holistic approaches that simultaneously target oral and general health [12].

Women's health in these contexts remains insufficiently supported. Achievements toward maternal health objectives, including Sustainable Development Goal 3.1, have been uneven [13]. Ongoing barriers—including shortages in healthcare personnel, disjointed service delivery, and economic or geographical limitations—continue to restrict access to fundamental preventive measures [14, 15]. In rural settings, women typically rely on primary care facilities that are poorly equipped to address their comprehensive needs, leading to undetected and unmanaged issues in reproductive health, chronic illnesses, and psychological welfare.

Employing a syndemic lens, this study investigates the interrelated challenges of oral pathology, metabolic risks, and gender-specific inequities among women in rural Tanzania. Syndemic theory emphasizes the synergistic interactions between clustered diseases, exacerbated by social and structural vulnerabilities in disadvantaged groups. Informed by three years of community-engaged work in Rorya District, the research combines clinical oral evaluations, biomarker testing, and established questionnaires to produce context-specific, multifaceted evidence. The findings seek to guide equitable, culturally attuned strategies and advance inclusive policymaking for marginalized communities.

Background

Oral health plays a fundamental role in general health, facilitating essential activities like nutrition, communication, and social interaction without discomfort [16-20]. In rural Tanzania, however, barriers such as scarce availability of modern hygiene products and persistent use of traditional tools like chewing sticks perpetuate poor outcomes [21]. Dental caries and periodontitis are common, leading to ongoing pain, systemic inflammation, and diminished life quality [22]. While interventions like fluoride toothpaste brushing are proven efficacious, socioeconomic and distributional constraints limit their adoption [23].

Building on prior qualitative investigations [22], this research utilizes the PerioMonitor™, a quick, chairside, non-invasive device that quantifies neutrophil levels in salivary rinses to identify early periodontal inflammation [24]. Its ease of transport and low resource requirements render it ideal for resource-constrained, community-based applications. Oral status is further evaluated via clinical exams employing the Decayed, Missing, and Filled Teeth (DMFT) index [25], complemented by assessments of perceived impacts using the Oral Health-Related Quality of Life (OHRQoL) instrument [26]. These methods collectively offer a comprehensive view of oral health challenges in this population.

Beyond oral evaluations, the study incorporates screening for hypertension and diabetes—prevalent NCDs often undiagnosed in sub-Saharan Africa [24]. Prompt identification is vital for enabling education and management in areas with sparse diagnostic resources. To situate these clinical data within women's broader experiences, the preventive care subsection of the Hologic Global Women's Health Index (HGWI) [27]—applied in more than 140 nations to gauge healthcare access, emotional health, security, and essential requirements—is employed. This instrument yields valuable perspectives on the socioeconomic and structural factors influencing women's health in Rorya District.

Materials and Methods

Study Design

This cross-sectional investigation took place in July 2023 in the rural villages of Burere, Nyambogo, and Roche located in Tanzania's Rorya District. Data gathering occurred in partnership with the Village Life Outreach Project (VLOP), alongside local collaborators such as the Roche Health Center and SHED (Supporting Health and Education in the District) facilities. The study received ethical clearance from the University of Cincinnati Institutional Review Board (Protocol No. 2022-0332) and the SHED ethics committee.

Ethical considerations

Special attention was devoted to ethical and cultural sensitivities, particularly in light of the potential identification of previously undetected conditions, including hypertension or glucose irregularities. In such instances, individuals were discreetly notified and directed to appropriate local healthcare services following established guidelines. Consent processes were tailored to the community's context to promote understanding in environments with varying literacy levels. Consent was secured both orally and in written form, delivered in participants' chosen language (Swahili or English) through straightforward explanations and supportive visuals where necessary. Bilingual trained personnel oversaw the process, allowing sufficient time for inquiries. These measures

underscore a dedication to principled, thoughtful research that safeguards participant welfare, self-determination, and respect in settings with limited resources.

Sampling and recruitment

Using purposive sampling, 224 adult women were enrolled during community-based health outreach activities. Inclusion criteria comprised women aged 18 years or older, residing in the designated villages, and capable of communication in Swahili or English. Unique anonymized six-digit identifiers were assigned to each participant to maintain privacy. Owing to logistical limitations at temporary clinic locations—such as time constraints, resource availability, and participant scheduling—a subset of 45 women received supplementary NCD evaluations, encompassing blood pressure and fasting glucose testing. All participants were provided with oral hygiene packages, including toothbrushes, toothpaste, and informational resources consistent with American Dental Association recommendations [28].

Measures

Oral health evaluations integrated clinical assessments, patient-reported outcomes, and PerioMonitor™ biomarker analysis, which detected neutrophil concentrations in salivary rinses as an indicator of early periodontal inflammation. Inflammation was classified as moderate-to-severe at PerioMonitor™ values ≥2. Colorimetric changes on the test strip—from pale pink (minimal activity) to intense purple (elevated activity)—were interpreted visually against validated periodontal markers. Calibrated clinicians performed oral exams with mirrors "mouth mirror and explorer" under ambient or supplemental illumination.

The extent of oral pathology was quantified via the Decayed, Missing, and Filled Teeth (DMFT) index, with scores ≥5 signifying compromised oral health [29]. Impaired oral health-related quality of life was indicated by OHRQoL scores ≥10, reflecting significant effects on physical, emotional, and social domains [30]. Engagement with preventive services over the preceding year was evaluated for all participants using the preventive care section of the Hologic Global Women's Health Index (HGWI). Instruments were administered verbally in Swahili by culturally competent bilingual staff, with data captured on paper questionnaires.

Blood pressure readings were obtained after a five-minute resting period in a seated position, employing a manual sphygmomanometer and stethoscope; hypertension was identified per American Heart Association criteria (≥130/80 mmHg or ongoing medication use) [31]. Capillary fasting glucose was sampled through fingerstick and analyzed with a flash glucose monitoring device, categorized according to American Diabetes Association standards: normal (70–100 mg/dL), hyperglycemic (≥126 mg/dL), or hypoglycemic (<70 mg/dL) [32].

Data analysis and management

Participant data were anonymized and handled securely to uphold confidentiality. Handwritten forms containing survey and clinical records were transcribed into Microsoft Excel [33] by study personnel, with independent verification by the principal investigator to confirm accuracy prior to analytical processing. Digital records were maintained on secured, password-protected devices and replicated on encrypted storage limited to approved team members.

Descriptive analyses characterized demographics, clinical parameters, and questionnaire results. Categorical data were presented as frequencies and percentages, whereas continuous measures—such as DMFT scores, blood pressure, glucose values, and OHRQoL—were summarized with means and standard deviations. Associations between oral health indicators, NCD markers, and women's health variables were examined through inferential tests, including t-tests. Overall risk accumulation was evaluated by classifying individuals exhibiting at least two of the specified thresholds: DMFT ≥5, PerioMonitor™ ≥2, or metabolic abnormality (glucose ≥126 mg/dL or <70 mg/dL, or blood pressure ≥130/80 mmHg/antihypertensive therapy). Those fulfilling multiple criteria were designated as high-risk for comparative analyses. Statistical procedures were executed in Python 3.12, leveraging NumPy 2.1.3, Pandas 2.2.3, Seaborn 0.13.2, and Matplotlib 3.10.0 libraries [34] via the JupyterLab platform [35].

Results and Discussion

Sample demographics

The cohort consisted of 224 women with a mean age of 43.75 years (SD ± 17.62), drawn from three rural communities in Tanzania: Burere (n = 51), Nyambogo (n = 95), and Roche (n = 78) **(Table 1)**. Formal education levels were limited across the group, with 52% (n = 117) reporting primary schooling as their highest attainment, 32% (n = 72) having advanced to secondary education or further, and 16% (n = 35) indicating no schooling whatsoever. Comprehensive oral health evaluations involving clinical inspections were carried out for 82% of the women (n = 183). A smaller group representing 20% of the total (n = 45) received further assessments for blood pressure and

glucose levels. The preventive care component of the Hologic Global Women's Health Index (HGWI) was applied to the full sample (n = 224).

Table 1. The cohort consisted of 224 women with a mean age of 43.75 years (SD ± 17.62), drawn from three rural communities in Tanzania: Burere (n = 51), Nyambogo (n = 95), and Roche (n = 78).

Category	Subgroup	n (Blood Pressure/Glucose)	Mean Systolic BP (mmHg)	Mean Diastolic BP (mmHg)	n (Age)	Mean Age (years)	n (DMFT)	Mean DMFT Score^a	n (OHRQoL)	Mean OHRQoL Score^b
Total		45	128.44	85.09	224	43.75	183	5.16	183	11.15
Village										
	Burere	20	130.25	83.40	51	41.92	51	5.88	51	11.00
	Nyambogo	2	127.50	94.00	95	50.11	54	5.07	54	13.57
	Roche	23	126.96	85.78	78	37.22	78	4.76	78	9.58
Age Group										
	15–50 years	27	123.15	83.74	141	32.17	117	5.11	117	10.28
	51–75 years	16	131.88	86.50	71	60.66	61	5.08	61	12.59
	76+ years	2	172.50	92.00	12	79.83	5	7.40	5	14.00
Income Quintile										
	Lowest 20%	11	125.45	79.91	43	40.35	35	3.77	35	10.60
	Second 20%	10	125.00	86.20	45	44.36	38	5.50	38	11.71
	Middle 20%	2	142.50	59.50	17	49.65	14	5.93	14	11.71
	Fourth 20%	6	133.33	74.33	38	45.39	30	5.40	30	11.10
	Highest 20%	6	124.17	86.00	29	47.14	23	4.39	23	11.74
	Unknown	10	132.00	100.70	52	41.04	43	6.00	43	10.65

Oral health burden

The average Decayed, Missing, and Filled Teeth (DMFT) index for the cohort was 5.16 (SD ± 4.56), predominantly driven by untreated decay (mean = 3.4) **(Table 1)**. Participants exhibited a mean of 1.75 missing teeth, whereas restorations were uncommon (mean = 0.03), underscoring restricted availability of professional dental services. Variations in DMFT scores were noted by village **(Figure 1)**, with Burere recording the highest mean (5.88), followed by Nyambogo (5.07) and Roche (4.76); however, these differences did not reach statistical significance ($p > 0.05$). A one-way analysis of variance similarly indicated no meaningful disparities in DMFT across key demographic categories [$F(2, 180) = 1.39$, $p > 0.05$, $\eta^2 = 0.015$].

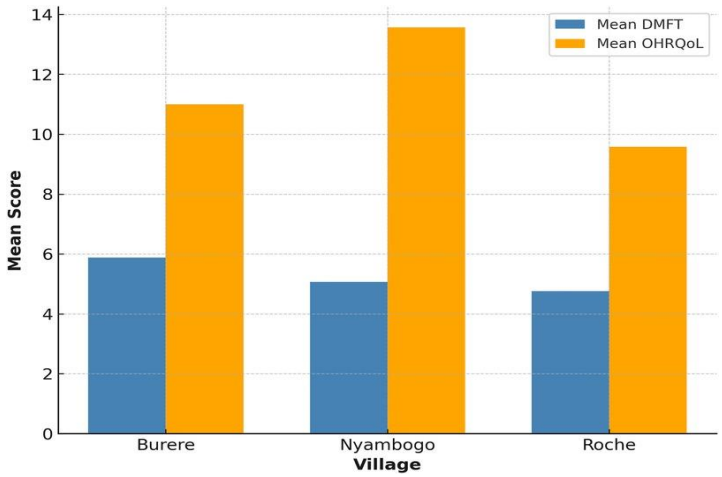

Figure 1. Mean DMFT and OHRQoL by village.

Oral health-related quality of life

Evaluations using the OHRQoL instrument produced an average score of 11.15 (median = 12, SD ± 4.62), suggestive of widespread impairment in oral health-related quality of life within the cohort **(Table 1)**. Village-specific means were highest in Nyambogo (mean = 13.57), intermediate in Burere (mean = 11.00), and lowest in Roche (mean = 9.58) **(Figure 1)**. Analysis of individual items highlighted physical pain (such as toothaches and eating discomfort) and psychological distress (including self-consciousness and embarrassment) as the domains most commonly impacted. Neither one-way ANOVA [$F(2, 180) = 0.19$, $p > 0.05$, $\eta^2 = 0.002$] nor the non-parametric Kruskal–Wallis test ($H = 1.85$, $p > 0.05$) detected significant variations in OHRQoL scores across examined demographic variables.

Periodontal inflammation (PerioMonitor™)

PerioMonitor™ testing was performed on 223 women. Elevated neutrophil activity indicative of periodontal inflammation was observed in a substantial proportion: 40% (n = 89) exhibited high levels (score ≥3), 29% (n = 65) moderate levels (score ≥2 but <3), and 27% (n = 61) low levels (score <2). A small fraction (3%; n = 8) yielded invalid or incomplete results. The colorimetric progression on the test strips—from pale pink to intense purple—aligned with validated indicators of periodontal pathology.

Blood pressure and glucose assessments

In the subsample of 45 participants screened for blood pressure, 49% (n = 22) met criteria for hypertension **(Table 1)**. Of these, 77% (n = 17) were unaware of their condition prior to the study. Mean systolic blood pressure was 128 mmHg (SD ± 19.48), and mean diastolic was 78 mmHg (SD ± 10.36). Village-level averages showed minimal variation: Burere (130/78 mmHg), Nyambogo (128/75 mmHg), and Roche (127/79 mmHg).

When grouped by cumulative risk profile, women classified as high-risk displayed higher mean systolic blood pressure (134 mmHg) and DMFT scores (6.4) compared to their lower-risk counterparts (122 mmHg and 4.7, respectively). Welch's t-tests examining differences in DMFT ($t = -0.23$, $p = 0.82$) and OHRQoL ($t = -0.14$, $p = 0.89$) between hypertensive and normotensive participants revealed no significant associations.

Glucose screening in the same subsample indicated that 80% (n = 36) had normal levels (70–99 mg/dL), 18% (n = 8) were hypoglycemic (<70 mg/dL), and 2% (n = 1) hyperglycemic (≥126 mg/dL). The overall mean fasting glucose was 85 mg/dL (SD ± 20.89). Village averages were highest in Nyambogo (94 mg/dL), followed by Roche (86 mg/dL) and Burere (83 mg/dL). Due to the limited number of hyperglycemic cases (n = 1), ANOVA comparing DMFT across glucose categories was confined to normoglycemic and hypoglycemic groups, yielding no significant difference ($F(1, 42) = 0.21$, $p = 0.65$).

Women's preventive health engagement

Responses to the HGWI preventive care domain from all 224 participants indicated low utilization of routine screenings in the preceding year, with rates falling short of national Tanzanian and international standards **(Figure 2)**. Only 18.8% (n = 42) reported blood pressure monitoring, and 9.4% (n = 21) had undergone diabetes or cancer screening. In comparison, 34.4% (n = 77) had been tested for sexually transmitted diseases. Older age groups (51–75 years and 76+ years) demonstrated somewhat greater engagement with routine health checks, blood pressure, and glucose screening relative to younger participants **(Table 2).**

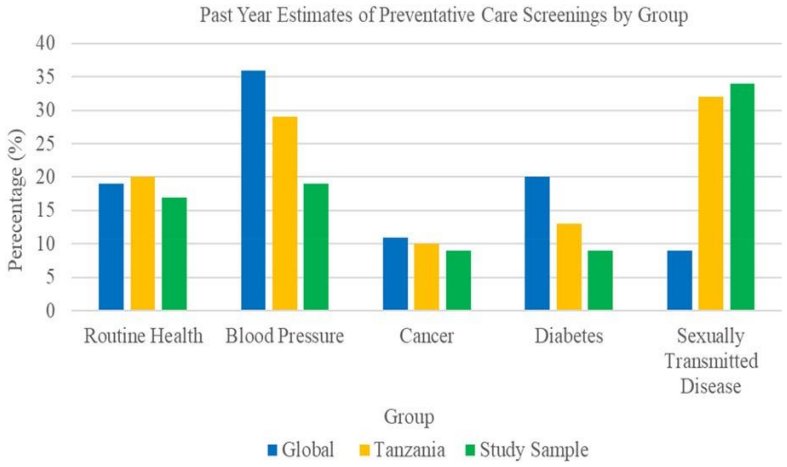

Figure 2. Comparative estimates of past year preventative care engagement*. *Data based on the 2024 three-year executive summary report from the Hologic Global Women's Health Index.

Table 2. Percentage of past year health screenings reported in the study sample.

Past year health screenings			Health screenings by type				
		n	**Routine health (%)**	**Blood pressure (%)**	**Cancer (%)**	**Diabetes (%)**	**Sexually transmitted disease (%)**
	Total	224	17.97	18.75	9.38	9.38	34.38
Age	15–50	141	16.84	17.02	8.51	8.51	33.33
	51–75	71	19.72	22.54	9.86	9.86	36.62
	76+	12	20.83	16.67	16.67	16.67	33.33
Age at first pregnancy	No children	10	*0*	*0*	*0*	*0*	*0*
	< 18	104	8.65	2.88	*0*	*0*	31.73
	19–24	108	28.94	36.11	19.44	19.44	40.74
	25+	2	*0*	*0*	*0*	*0*	*0*
Income	Lowest 20%	43	19.19	18.6	13.95	13.95	30.23
	Second 20%	45	12.78	6.67	2.22	2.22	40.00
	Middle 20%	17	14.71	17.65	*0*	*0*	41.18
	Fourth 20%	38	22.37	28.95	15.79	15.79	28.95
	Highest 20%	29	24.14	24.14	17.24	17.24	37.93
	Unknown	52	15.87	19.23	5.77	5.77	32.69

Italicized values represent subgroup percentages within each demographic category (e.g., age group, age at first pregnancy, or income level).

This investigation offers fresh perspectives on the interconnections between oral health, non-communicable diseases (NCDs), and women's health in a rural East African setting. A clear pattern of co-occurring vulnerabilities was evident, with more than 80% of the sample exceeding clinical cutoffs for substantial oral disease burden. Among these, a portion also displayed hypertension and glucose dysregulation, suggesting heightened susceptibility to adverse health trajectories over time. Despite employing suitable statistical techniques—incorporating both parametric and non-parametric tests to account for data characteristics—no significant relationships emerged between demographic factors and oral health indicators in this cohort.

Elevated OHRQoL scores, nonetheless, underscore the considerable impact of oral conditions on daily functioning and emotional well-being. Coupled with widespread high neutrophil activity, these results suggest common inflammatory mechanisms that may connect periodontal disease to broader systemic issues, including cardiovascular and metabolic pathologies. The clustering of these challenges, exacerbated by socioeconomic marginalization, aligns with syndemic conceptualizations, where interrelated conditions amplify each other's detrimental effects.

In line with established patterns in sub-Saharan Africa, utilization of preventive services remained strikingly limited. Less than 20% of participants had undergone blood pressure checks in the previous year, even though nearly half of those tested met hypertension criteria. Additionally, one-fifth showed glucose abnormalities—predominantly undiagnosed—potentially indicative of nutritional deficits or latent metabolic vulnerabilities. Women lacking recent preventive encounters tended to exhibit worse oral health markers, such as higher DMFT values, increased periodontal inflammation, and raised systolic pressures.

Data from the HGWI further exposed ongoing deficiencies in women's preventive health, especially regarding screening access. Obstacles to dental services, including scarce facilities and continued dependence on conventional hygiene methods, echo wider systemic issues driven by rapid urbanization and inadequate diagnostic capabilities. These inequalities highlight persistent gender-based disparities in resource-constrained environments, where delayed

detection perpetuates cycles of avoidable illness and unaddressed needs.

Building upon earlier qualitative work [22] that employed interviews and focus groups to capture women's views on oral and general health, future research should expand this exploratory base. Further qualitative efforts are warranted to better elucidate the everyday experiences, preferences, and requirements of women in comparable contexts. Detailed examination of personal accounts could uncover the interplay of cultural expectations, domestic obligations, stigma, economic barriers, and information access in shaping health-seeking patterns. Such understandings are vital for crafting interventions that are clinically sound, culturally appropriate, and socially attuned, thereby improving the inclusivity and resilience of community health initiatives in underserved areas.

Taken together, the present findings and related studies [22] emphasize the pressing demand for participatory, locally informed strategies that target both biomedical and socioeconomic contributors to ill health. They also affirm the merits of unified care frameworks, like the Common Risk Factor Approach, in tackling shared biological, behavioral, and environmental influences. Merging oral health initiatives with NCD management and women's health programs—while respecting regional traditions and constraints—will be crucial. These consolidated approaches promise more effective resource allocation and bolster local systems' ability to identify, treat, and avert interrelated conditions. Ultimately, prioritizing comprehensive, equity-focused care models represents a key opportunity to interrupt cycles of disadvantage and promote enduring health improvements in marginalized rural populations.

Limitations

While this investigation revealed patterns indicative of overlapping oral pathology, inflammatory markers, and metabolic disturbances among women facing socioeconomic and educational disadvantages, several constraints temper the interpretability of the results. The overall sample was relatively small (n = 224), with cardiometabolic evaluations limited to a subset (n = 45), which reduced statistical power and prevented the use of multivariate modeling or adjustment for potential confounders. Consequently, the analyses were confined to descriptive statistics and bivariate tests, consistent with the exploratory aims of the study. The cross-sectional design precludes any inferences about causality, and the reliance on purposive, convenience-based recruitment at outreach events raises concerns regarding selection bias. As a result, the documented prevalence of untreated caries and undetected hypertension may not be generalizable to the wider Rorya District or comparable rural areas. Furthermore, deploying the PerioMonitor™ under field conditions introduced potential variability related to factors such as ambient lighting, humidity, and storage conditions, which could influence test strip performance and colorimetric readings. These issues emphasize the importance of rigorous standardization and calibration in future field applications. Overall, these constraints underscore the necessity for more robust, population-representative research to corroborate and build upon these initial observations, thereby better guiding tailored, integrated health interventions in resource-constrained contexts.

Conclusion

In environments with restricted resources, untreated dental caries and periodontal disease continue to impose a substantial burden, compounded by inadequate access to oral healthcare services. This research illustrates the practicality and benefits of incorporating biomarker-driven tools and comprehensive assessment instruments into community-level health initiatives. Notably, the innovative use of the PerioMonitor™ facilitated the identification of subclinical inflammation through heightened neutrophil activity, including in participants without overt symptoms. Such outcomes reinforce the critical role of timely preventive measures and highlight the pressing demand for cohesive, community-oriented oral health programs in rural Tanzanian communities.

Data derived from instruments like the OHRQoL and HGWI indicate that impairments in one health area frequently coincide with difficulties in others among women, pointing to interrelated vulnerabilities influenced by gender-specific dynamics. The co-occurrence of scarce preventive service utilization, elevated undiagnosed hypertension, glucose irregularities, and pronounced oral pathology exemplifies a syndemic interplay of clinical and systemic challenges. These interconnected issues call for comprehensive, gender-attuned healthcare frameworks that are sensitive to the real-world circumstances of women in rural, low-income regions. This work confirms the viability and effectiveness of community-based screening in marginalized areas, while providing a platform for creating expandable and enduring care systems that blend clinical delivery with authentic community involvement. Broadening such unified screening efforts in similar settings could help mitigate inequities, facilitate earlier disease

identification, and advance oral health justice. Subsequent investigations should focus on larger, more inclusive cohorts to enable advanced multivariate and longitudinal examinations. Concurrently, policymakers and programs ought to pursue decentralization of diagnostics and the adoption of culturally aligned approaches incorporating gender-focused communication.

To foster sustainable, integrated service provision, preventive efforts should incorporate standard oral and NCD evaluations—including blood pressure, glucose, and periodontal biomarker testing—within established primary care and community networks. This might involve capacitating community health workers with fundamental screening skills, outfitting outreach units with affordable devices such as the PerioMonitor™, and synchronizing activities with maternal and child health programs. Non-governmental organizations and health ministries can contribute significantly through investments in training, infrastructural enhancements, and contextually appropriate sensitive education. Emphasizing these synergies would enhance early intervention, streamline care pathways, and establish robust, equity-centered primary healthcare infrastructures in underserved populations.

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Ethics Statement: The studies involving humans were approved by the University of Cincinnati Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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