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Determinants of sleep quality among women living in informal settlements in Kenya

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Abstract

Background Sleep plays a critical role in overall health and well-being. While most sleep research focuses on high-income countries, there is limited knowledge about sleep quality in Sub-Saharan Africa (SSA), especially among women living in urban informal settlements. Many factors, including physical, psychological, cultural, and environmental influences, can affect sleep quality. This study, which uses Bronfenbrenner's ecological model, aims to explore the prevalence of sleep disturbances and self-reported factors associated with poor sleep quality among a representative sample of 800 women living in two informal settlements in Nairobi, Kenya.

Methods The data, collected in September 2022, are from the baseline assessment of an 18-month longitudinal cohort study examining mental health and climate change among women living in two informal settlements in Nairobi–Mathare and Kibera. Items from the Brief Pittsburgh Sleep Quality Index (B-PSQI) were collected to examine women's sleep habits and quality. Quality of sleep scores were calculated. We used t-tests, bivariate regressions, and ANOVAs to assess the bivariate associations between key predictors of poor sleep with the Brief Pittsburgh Sleep Quality Index (B-PSQI) score. We also conducted a cross-sectional multivariable regression analysis to explore the factors influencing sleep disturbances. Open-ended questions were asked about factors contributing to sleep disturbance, and a thematic analysis was conducted to summarize the findings.

Findings 29% of women ($N=229$) met the criteria for poor-quality sleep. Open-ended findings identify stress as the main factor affecting sleep. Childcare, financial instability, physical health, climate, grief, and loss also impacted women's sleep. Significant quantitative predictors of poor sleep quality among women included the severity of disability, depression, and food insecurity. Anxiety also showed a trend toward significance, underscoring the complex interplay of physical, mental, and socioeconomic factors on sleep.

Interpretation This study underscores the need for further research on sleep quality among women in SSA's informal settlements. By enhancing understanding and awareness of sleep's health impacts, policymakers and interventionists can develop more effective interventions tailored to the unique challenges faced by this population. Our findings contribute to the knowledge base, supporting the creation of targeted policies and practices that address and improve sleep quality for women in these communities.

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Background

Sleep problems are a global public health concern due to their profound impact on physical and mental health [1]. Sleep is crucial in maintaining overall physical and mental health, as well as emotional well-being [2]. Sleep is influenced by various factors, including duration, quality, efficiency, and timing, all of which collectively impact an individual's well-being. Poor quality sleep, including sleep deprivation, disrupted sleep, and irregular sleep schedules, can lead to adverse health consequences, such as cardiovascular disease, obesity, cognitive impairment, and mental health disorders [3]. Understanding the factors influencing sleep quality is essential for promoting better sleep, developing targeted interventions, and informing effective policies. Bronfenbrenner's ecological framework provides a valuable structure for examining these factors across multiple levels - from individual and household to community and broader societal influences - providing a comprehensive view of the determinants of sleep quality.

In SSA, specifically within its informal settlements, residents face distinct conditions that may exacerbate sleep disturbances. Sleep patterns can vary across populations and contexts, with research indicating that sleep patterns differ based on gender. Women tend to exhibit distinct sleep characteristics compared to men. For example, a recent study by Boer et al. [4] found that while women tend to sleep longer, they report higher rates of sleep disturbances including insomnia, difficulty falling or staying asleep, and restless legs syndrome. These discrepancies can be attributed to various factors, including hormonal fluctuations during the menstrual cycle, pregnancy, and menopause [5].

Additionally, societal expectations, social roles, and stressors may contribute to these differences [6, 7]. Mittelmark and Bull [8] surveyed women in Ghana and found that social background is associated with sleep quality and/or deprivation across different geographical regions, underscoring the importance of considering local settings and social factors in sleep research.

Research on sleep quality is notably limited in SSA [9]. A systematic review suggests that national-level sleep quality may not differ significantly between regions, but data from SSA is insufficient for firm conclusions [9]. Residents in the region often confront unique sociocultural, economic, and environmental factors that could significantly influence sleep patterns [10]. For example, cultural norms, demands of agricultural work, and caregiving responsibilities may shape women's sleeping habits differently from their counterparts in more affluent areas [11].

Research explicitly focused on sleep quality in informal settlements is extremely limited. Informal settlements typically lack durable housing, adequate living and public spaces, basic infrastructure, and secure tenancy [12, 13]. Residents often face ongoing inequalities such as exclusion from health and social programs and lack of formal water, sanitation, and waste management services [14–16], significantly affecting their quality of life. A study of 586 participants across five informal settlements in Bangladesh during the COVID-19 pandemic found that women were more likely than men to experience moderate/severe insomnia on the Insomnia Severity Index (ISI) [17].

In another study, using data from the Barómetro de la Deuda Social Argentina, Pontificia Universidad Católica Argentina ($n = 5766$), researchers found a higher percentage of total sleep time less than six hours among men but a higher percentage of poor sleep quality among women on a brief version of the Pittsburg Sleep Quality Index (PSQI) [18]. Poor quality sleep was highest among participants in the lowest socio-economic stratum, and residence in informal settlements was associated with a higher percentage of poor sleep quality. Findings from another study carried out with a sub-sample of $n = 150$ participants from the larger Barómetro de la Deuda Social Argentina, Pontificia Universidad Católica Argentina sample, showed that housing upgrading for informal settlement residents significantly improved sleep quality and quality of life [18]. These studies demonstrate the influence of household and community-level stressors on sleep [17, 18].

Women in urban informal settlements in Nairobi may be particularly vulnerable to poor sleep quality [17, 18]. They often encounter numerous daily challenges that impact their sleep, exacerbated by gender inequities and harmful societal norms. Women typically bear a greater burden in terms of childcare [19] and domestic responsibilities, including collecting water [19, 20], yet face significant barriers in accessing regular employment, healthcare, and education [19–24]. At the community level, their roles in decision-making processes are often limited [19, 21, 25], and they are more exposed to gender-based violence, both at home and in their communities [21]. These factors contribute to higher levels of depression, anxiety, and psychological distress among women, which are closely linked to poor sleep quality [26–30].

The paucity of detailed studies on women's sleep quality in Nairobi's informal settlements highlights a significant gap in the literature [31]. This study addresses this gap by examining the sleep quality among women residing in Nairobi's informal settlements using Bronfenbrenner's

ecological framework to explore and analyze multilevel determinants impacting their sleep systematically. Insights from this research could inform more tailored and effective interventions designed to improve sleep health in these communities.

Methods

Research design

This study's baseline data, collected in September 2022, are part of a longitudinal, quantitative study investigating associations and mediating effects between climate, mental health, and violence in informal settlements in Kenya. Monthly household-level surveys were collected from women living in Mathare and Kibera. Mathare and Kibera are two of the largest informal settlements in Nairobi, where the research team has been working for 8 years. Kibera and Mathare were selected due to their significant size, high population density, and unique environmental challenges. These settlements are among Nairobi's largest informal areas, with Kibera housing up to 400,000 and Mathare up to 250,000 residents [32]. Their geographical positioning in lowlands near major rivers subjects them to frequent flooding and mudslides [33], directly impacting residents' health and well-being. Additionally, localized climatic variations, such as higher temperatures and occasional extreme weather events [34], make these areas pertinent for studying environmental impacts on health, particularly sleep quality among women.

Study sample

A probability sample of 800 women was drawn from two major informal settlements in Nairobi: Kibera ($n = 400$) and Mathare ($n = 400$). This sampling used a systematic approach that leveraged geographical information system (GIS) technology to ensure representative selection.

Researchers identified settlement boundaries using OpenStreetMap (.osm) data. A grid overlay was then applied over the settlement boundaries in ArcGISPro version 3.0, subdividing each settlement into 9 m x 9 m cells (the approximate size of a house or apartment in the settlements. From this grid, 800 random cells were selected—400 from each settlement.

Community data collectors (CDCs) trained female residents of Kibera and Mathare used tablets equipped with Google Earth and Google Maps to navigate to the closest house corresponding to the randomly selected points. CDCs used the quasi-random "last birthday" method to select one eligible woman per selected household [35].

The selected woman in each household met the following inclusion criteria: at least 18 years of age, able to communicate in English or Swahili, and a resident of the informal settlement. This method, previously used successfully in related studies, ensures a robust sampling approach that accurately reflects the demographic and socio-economic conditions of the settlements.

Data collection

Household-level surveys were collected by 16 trained female residents (CDCs) of Kibera [8] and Mathare [8]. Selected for their familiarity with the community and extensive experience as community health promoters and community champions, CDCs received extensive training in ethical research practices, quantitative data collection, and handling sensitive topics based on World Health Organization (WHO) guidelines [36, 37]. This preparation equipped them to conduct surveys sensitively and effectively, ensuring ethical engagement with participants while collecting reliable data. Following these recommendations, investigators, local collaborators, and CDCs agreed on safety protocols if a participant reported violence and adverse mental health outcomes. The 90-minute survey was collected in person in participants' homes, and responses were recorded on tablets. Surveys were initially compiled in English, then translated by a local team member with experience and certifications for translation services into Swahili., and then then reviewed by a team of stakeholders and research staff to ensure they are culturally and linguistically appropriate.

This study has been approved by the Columbia Internal Review Board (IRB-AAAU0353); the Scientific Ethics Review Unit at the Kenya Medical Research Institute (Protocol No. 4476); and the Kenya National Commission on Science, Technology and Innovation (License No. NACOSTI/P/22/19316).

Measures

Brief Pittsburgh sleep scale (B-PSQI)

We used the B-PSQI, a shortened version of the Pittsburgh Sleep Quality Index (PSQI), to assess sleep. It is the most widely used questionnaire in research and clinical practice to assess sleep quality. The Brief Version of the PSQI (B-PSQI) includes six out of the initial 18 questions of the PSQI and has adequate internal consistency ($\alpha = 0.79$ and $\omega = 0.91$). Additionally, the B-PSQI yielded favorable sensitivity (75.82%) and specificity (76.99%) for classifying poor sleepers, like values for the full PSQI. It is a brief, reliable, and valid measure that can be used as a screening tool for sleep quality [38]. The questionnaire combines Likert-type and open-ended questions (later converted to scaled scores using provided guidelines). Respondents are asked to indicate how long they sleep (duration), how long it takes to get to sleep (latency), when they go to bed at night and rise in the morning (efficiency), how frequently they have experienced specific sleep difficulties over the past month (disturbance), and how they rate their sleep quality. Scores for each

question range from 0 to 3, then summed for a range of 0 to 15. For both the PSQI and the B-PSQI, developers have suggested a cutoff score of 5 for the global scale, as it correctly identified 88.5% of the patient group in their validation study [39]. A global score of >5 is considered poor quality of sleep. The Cronbach's alpha for this study is 0.6, which is regarded as acceptable.

Predictors of poor sleep

Based on extant literature and guided by Bronfenbrenner's ecological framework, we selected multi-level factors that may be associated with poor sleep or considered risk factors for poor sleep quality. At the individual level, we included age and work frequency (measured with the question: "In the past 1 month, how often have you worked/done something for money or any other payments/goods?" Response categories included "not at all," "once in a while," "once per week," "a few days per week," "nearly every day," and "every day") self-reported health ("In general, would you say your health is: poor, fair, good, very good, excellent"), disability status (measured with the 12-item form of the WHODAS 2.0 [40] and using simple scoring), depression, and anxiety. Depression was calculated using the PHQ-9, with severity determined by summing item scores [41]. Similarly, anxiety was measured using the GAD-7, with severity determined using the total score [42].

At the family or household level, we included relationship status, number of children, total household monthly income (calculated from the total reported income from salaries, businesses, consultancies, and gig work), past year intimate partner violence (measured using items for psychological, sexual, and physical IPV from the World Health Organization Violence Against Women tool [43], food insecurity (measured using the Household Food Insecurity Access Scale: HFIAS [44].

At the community or environmental level, we included experiences of extreme heat or cold (measured by asking participants if, in the past month, they or members of their household had "experienced any extreme weather event in the settlement" and, if so, which type of event and on which date(s) (Responses were coded as "1 = yes" and "0 = no"). We only used responses for extreme heat and cold events in the analysis because those were the only types reported in sufficient quantities to be included in the analyses at the time of the survey (September 2022).

Causes of poor sleep

To understand the causes of poor sleep, participants were asked to describe what impeded their sleep quality. Their responses were recorded verbatim.

Analysis strategy

Frequencies, means, and standard deviations were used to characterize the sample using Stata statistical software, version 15 [45]. We calculated a global score for the B-PSQI [38]. The prevalence of poor sleep quality (QOS) is presented in proportions. Missingness of the variables used to calculate the B-PSQI ranged from 0.0 to 5.2%. Given the minimal missing data, we used single hot deck imputation to fill in the values.

To identify potential predictors or risk factors for poor sleep, we selected a range of variables spanning multiple levels of influence, including individual-, family or household-, and community or environmental-levels. These variables were chosen to reflect their potential roles within Bronfenbrenner's ecological framework, ensuring a comprehensive analysis of both personal and contextual factors. Independent sample t-tests, bivariate regressions, and one-way analysis of variance (ANOVA) tests were used to look at the bi-variate associations between the Brief Pittsburgh Sleep Quality Index (B-PSQI) and each of the potential predictors or risk factors.

Subsequently, we conducted a cross-sectional multivariable regression analysis to investigate the multi-level factors influencing poor sleep quality among women in informal settlements in Nairobi, Kenya. This statistical approach allowed us to assess the relationships at a specific time without implying causality or the longitudinal impact of these factors.

To explore open-ended questions related to sleep quality, four team members coded and categorized women's verbatim descriptions of their experience of poor sleep. Team members independently coded the verbatim responses in the baseline survey to develop a working codebook. Another coder reviewed codes separately to confirm congruence and accuracy. Discrepancies in coding and codebook adjustments were discussed with the entire research team. Once the research team approved the coding, we carried out a frequency analysis of the causes of poor sleep.

Results

Participant characteristics

At baseline, participants ranged from 18 to 79 years (m = 35, sd = 12). More than half (55%) were married, 17% were single, 19% were divorced or widowed, and 9% had a partner but were not married. Most women (93%) had at least one child, and 45% identified as the head of their household. Over 42% of participants live in households with 3–4 people. Most women completed primary school, with fewer than 5% having no formal education. Poor quality of sleep was detected at 28.6% ($N = 229$). See Table 1 for socio-demographic descriptors of the sample and results of bi-variate statistical analyses.

Table 1 Descriptive and *Bivariate statistics

	f (%)	M (SD)	Hypothesis test	*p*-value
Individual-Level Factors				
Age		35.4 (11.68)	$\beta = 0.04$	0.000
Work frequency		2.87(1.95)	$\beta = 0.05$	0.320
Self-reported health		3.3(0.97)	$\beta = 0.60$	0.000
Disability (WHODAS 2.0)		18.6(8.07)	$\beta = 0.10$	0.000
Symptoms of depression (PHQ-9 severity score)		7.0(5.77)	$\beta = 0.18$	0.000
Symptoms of anxiety (GAD-7 severity score)		5.8(5.12)	$\beta = 0.20$	0.000
Family/Household-Level Factors				
Relationship status				
None/Single	137(17.1)		$f = 6.99$	0.000
Currently married	440(55.0)			
In a relationship, but not married	69(8.6)			
Widowed/Divorced or separated	154(19.3)			
Number of children		2.7(1.72)	$\beta = 0.21$	0.000
Household monthly income (in 1000s)		9.8(21.72)	$\beta = -0.002$	0.677
Past-year violence, % yes	386(48.3)		$t = -0.46$	0.649
Food insecurity		13.4(6.94)	$\beta = 0.11$	0.000
Community/Environmental-Level Factors				
Experienced extreme heat, % yes	69(8.6)		$t = -2.46$	0.014
Experienced extreme cold, % yes	539(67.4)		$t = -2.22$	0.027

*Independent sample t-tests, bivariate regressions, and one-way analysis of variance (ANOVA) tests were used to look at the bi-variate associations between the Brief Pittsburgh Sleep Quality Index (B-PSQI) and each of the potential predictors or risk factors

The bi-variate analyses suggest that individual-level factors of age, self-reported health, severity of symptoms of disability, severity of symptoms of depression, and severity of symptoms of anxiety are all significantly associated with increasing levels of poor sleep quality (see Table 1 for results). At the family or household level, increasing numbers of children and the severity of food insecurity were significantly associated with poor quality sleep. Relationship status was also significantly associated with sleep quality, with being divorced/separated or widowed, in particular, associated with increases in poor quality sleep compared to being single/not in a relationship.

Table 2 shows multivariable regression analysis findings. Age, Relationship status, Number of children, Work frequency, Household monthly income, and Self-reported health did not significantly affect sleep quality, indicating that these individual and economic factors may not be predictors of sleep disturbances within this context. The severity of disability, as measured by the WHODAS 2.0, was significantly associated with lower sleep quality ($\beta = 0.03$, $p = 0.031$), suggesting that physical or mental limitations may exacerbate sleep issues. Depression was a predictor of poor sleep quality ($\beta = 0.09$, $p = 0.001$), highlighting the impact of mental health on sleep in this context. Anxiety showed a trend towards significance ($\beta = 0.05$, $p = 0.059$), suggesting that it may also play a role in sleep quality, albeit less definitively than depression. Food insecurity was also significantly associated with poor sleep quality ($\beta = 0.05$, $p < 0.000$), indicating that basic needs insecurity may affect sleep.

Past year IPV did not significantly influence sleep quality in the regression model (β = -0.09, $p = 0.646$). Although statistically significant in the bi-variate analyses, experiences of extreme heat or cold did not show up as statistically significant in the multivariable model.

Self-reported factors that impact the sleep of participants

Table 3 summarizes the categories of impacts and frequencies of open-ended questions regarding what impedes quality sleep. $N = 390$ women reported having trouble sleeping at least once in the past 30 days. These women reported that various factors impacted their sleep. Key factors included stress, early childcare, financial instability, physical health, climate, and grief and loss. Additional factors included domestic violence, fear, family concerns, insecurity, work, lack of support, education, drugs, and elections.

Discussion

To our knowledge, this is the first study examining sleep quality among women living in Nairobi's informal settlements. Utilizing Bronfenbrenner's ecological framework, our analysis illuminates the complex interactions between individual-, family, or household- and community- or environmental-level factors, enriching our understanding of the nuanced challenges these women

Table 2 Multivariable regression findings

	adj-β	Std. Err.	t	*P*>|t|	95% CI
Individual-Level Factors					
Age	0.00	0.009	0.29	0.768	[-0.016-0.021]
Work frequency	0.02	0.047	0.41	0.680	[-0.073-0.111]
Self-reported health	0.02	0.103	0.19	0.853	[-0.183-0.221]
Disability (WHODAS 2.0)	0.03	0.014	2.16	0.031	[0.003–0.057]
Symptoms of Depression (PHQ-9 severity scale)	0.09	0.026	3.32	0.001	[0.035–0.137]
Anxiety (GAD-7 severity scale)	0.05	0.029	1.89	0.059	[-0.002-0.112]
Family/Household-Level Factors					
Relationship status (ref: single)					
Married	-0.20	0.253	-0.78	0.437	[-0.694-0.301]
In relationship, not married	-0.27	0.368	-0.74	0.459	[-0.994-0.449]
Divorced/Widowed	0.22	0.302	0.72	0.470	[-0.374-0.810]
Number of children	0.03	0.059	0.56	0.572	[-0.082-0.148]
Household monthly income (in 1000s)	0.00	0.004	1.05	0.296	[-0.004-0.012]
Past year IPV	-0.09	0.186	-0.46	0.646	[-0.450-0.279]
Food insecurity	0.05	0.015	3.58	0.000	[0.024–0.081]
Community/Environmental-Level Factors					
Experienced extreme heat	0.38	0.314	1.20	0.232	[-0.241-0.993]
Experienced extreme cold	0.14	0.193	0.73	0.469	[-0.239-0.519]
Constant	0.50	0.482	1.03	0.304	[-0.450-1.441]

Table 3 Factors affecting sleep for women reporting sleep disturbances ($n = 390$)

Codes/Themes	Frequencies	Verbatim Translation
Stress	239	"I am about to give birth, and I have no money yet, this is scary,""Due to stress and life challenges"
Physical health issue	85	"Body aches, constant thoughts,""Sickness"
Financial instability	58	"There was no money for food,""School fee stress,""How to get food and school fees"
Early child care	40	"children keeping me awake,""my child giving me stress"
Family	25	"My mum was very sick"
Work	8	"Business is very down,""joblessness"
Elections	6	"Elections, and the fear of the unknown", "Scared that I might experience post-election violence"
Pregnancy	4	"Due to pregnancy and sickness,""I was pregnant"
Climate	3	"When it's cold, I get a lot of pain,""Hot temperatures"
Grief & Loss	3	"I had an infant, and she just passed away,""Brothers death"
Insecurity	2	"Phone was robbed, and money, and identity card. At the same time, they managed to ask for a loan using the phone line. Also, my son was seriously sick"
Food insecurity	2	"Lack of enough food and stress"
Lack of support	1	"I don't have parents nor someone I can talk to about my problems"
Fear	1	"Elections, fear of unknown"
Education	1	"Lack of school"
Drugs	1	"Drug use"

face in obtaining restorative sleep. Approximately 29% ($n = 229$) of women in our study scored above five on the B-PSQI, representing poor quality sleep, consistent with other sleep studies [9, 46].

At the individual level, significant relationships were found between poor sleep quality and depression and disability. Depression was notably impactful, reflecting literature that links mood disorders to sleep disturbances [47, 48]. These conditions profoundly affect daily functioning and well-being, emphasizing the critical need for accessible mental health services in these communities. The presence of disability further exacerbates sleep issues, likely due to associated physical discomfort and psychological stress [17, 49]. While there is limited data on the causes of sleep disturbance in informal settlements, research focused on sleep and anxiety among residents in informal settlements in Dhaka city, Bangladesh, during the COVID-19 pandemic found that anxiety

and sleep disturbance co-occur, with 34.5% of the sample ($n = 586$) experiencing both.

Research suggests that women, in general, experience higher levels of stress and anxiety than men [38, 39, 50, 51], but the effects of stress and anxiety on women's sleep quality remain understudied. In one example, however, Boer et al. [4] found no significant gender differences in the effect stress on insomnia. Given our results, which suggest stress and disability are essential factors to consider when focusing on sleep quality among women in informal settlements, more research is needed on the link between stress and sleep quality, particularly across genders.

Studies have shown that rates of IPV and common mental health issues are much higher for women in informal settlements in Kenya than in other populations in the nation [28, 52–54], likely due to the political, economic, social, environmental, and climatic factors that also impact sleep quality. While IPV did not emerge as a statistically significant predictor of poor sleep quality in the quantitative analysis, its association with poor mental health and disability – both significant in our models – remains critical [55]. Additionally, our measurement of IPV, which included emotional, physical, and sexual violence, may have limited our ability to capture its full impact, particularly given that emotional IPV often requires alternative coding strategies (e.g. [64, 65]). This suggests that the association may be more apparent in cases of severe violence. These potential impacts underscore the need for further investigation and targeted interventions within healthcare and social support systems.

Moreover, food insecurity was significantly associated with poor sleep quality, indicating that basic survival concerns, such as hunger and financial stress, directly influence physiological and psychological states [56]. This finding highlights the intersection of food security, economic stability, and sleep health, suggesting interventions aimed at reducing food insecurity may also enhance sleep quality by alleviating a key stressor in women's lives.

Residents of informal settlements are disproportionately vulnerable to the negative effects of climate change [57–59] and face many stressors associated with historical, political, and social marginalization, poverty, and exclusion from formal and consistent essential services and legal land tenure [15]. Our study considered whether conditions within Bronfenbrenner's exosystem, especially extreme events like heat waves or cold snaps, impact women's sleep. While these conditions were not statistically significant in the multivariable analysis, they were significantly associated with poor sleep quality in the bivariate analyses and were also reported qualitatively as factors disrupting sleep. This suggests that housing and community planning should consider environmental comfort to improve sleep health. Similarly, broader socioeconomic development – such as improving employment opportunities, income stability, and community resources, could indirectly enhance sleep quality by reducing systemic stressors.

Findings from women's open-ended responses describing factors affecting sleep further emphasize the stressors identified in the study. Participants cited physical health issues, financial instability, caring for young children/infants, and family as common sources of sleep disturbance. Additional reported factors included unemployment, pregnancy, climate, grief and loss, insecurity in the community, food insecurity, and election-related fears. While these factors help to identify important individual and contextual factors affecting sleep quality, more research is needed to develop effective intervention strategies. Some research suggests that upgrading informal settlements can improve sleep quality by enhancing the physical environment and infrastructure [19, 60], but more research is needed to identify the most pertinent risk factors for sleep quality and, relatedly, the most appropriate, feasible, and effective interventions to mitigate their effects. Given the unique challenges women in informal settlements face, future research should explore direct and indirect pathways between various potential risk factors and women's sleep quality to better inform targeted interventions.

Some research suggests that protective factors may also contribute to sleep quality among women in informal settlements, potentially mitigating some of the effects of risk factors. Our findings suggest that only 29% ($n = 229$) of women in our sample met the threshold for poor quality sleep, which means that despite significant challenges, most women maintain adequate sleep quality. While most studies in informal settlements focus on poor health outcomes and their contributing factors, emerging research highlights community resilience and strengths. For example, women in informal settlements often have widespread social networks, strong social ties and collective agency in addressing common problems [61]. These factors may serve as buffers against stress and should be explored further in future research to inform intervention strategies.

In addition to more research addressing structural issues, individual level interventions such as education on healthy sleep habits may also be beneficial. Several studies suggest that educational interventions focused on healthy sleep habits may enhance sleep quality and/or reduce insomnia [62, 63]. Our experience working with women in informal settlements and the dearth of research focused on sleep quality among women in these communities suggests that sleep is an under-discussed, under-considered, under-researched factor in women's health. Raising awareness and education about

sleep-promoting practices may improve sleep quality. At the very least, more awareness and education on sleep could reduce the risk of underreporting or misinterpreting the importance of sleep-related data.

More broadly, improving sleep quality among women in informal settlements may require increased access to services, especially healthcare, mental health, and sleep-specific services. There is limited access to healthcare services [9], especially mental health services, in informal settlements. Increasing access to healthcare for residents of these settlements, including specialized professionals, would enhance support for women with poor quality sleep and provide opportunities for more robust research into this critically important issue.

This initial study on sleep quality among women in rural Kenya highlights the scarcity of existing literature, the unique risk and protective factors they face, limited awareness of sleep hygiene and its health impacts, and challenges in accessing healthcare and resources. Investing in further research and comprehensive studies that help address the gaps in existing research will contribute to a better understanding of sleep quality and the development of targeted interventions to improve sleep quality and overall health among women in informal settlements.

Limitations

To our knowledge, this is the first study focused on sleep quality among women living in informal settlements; however, it was not without limitations. First, it is important to consider the potential for recall bias when reporting information about sleep. Recall bias refers to the potential for participants to inaccurately or incompletely remember events or experiences. This can lead to biased or unreliable data, as participants may have difficulty accurately recalling past events. Many studies use accelerometers, mobile phone sleep applications, or other methods of collecting more objective sleep data; however, as a preliminary study, we only collected self-reported sleep data. More research is needed to triangulate self-reported data with other methodologies of measuring sleep quality.Second, the nature of cross-sectional data does not allow for examining sleep patterns, quality of sleep, and sleep hindrances over time, which limits our ability to investigate causal pathways between various factors and sleep quality and to draw temporal conclusions associated with the significant relationships. Finally, we used the B-PSQI. Although this measure has been validated in other populations [38], it has not been widely validated in informal settlements or strictly among populations of women.

Conclusion

By utilizing Bronfenbrenner's ecological model, this study clarifies the roles of various systemic levels in affecting sleep quality. It highlights critical intersections between individual health and broader environmental and economic factors. This comprehensive approach facilitates the identification of targeted, multi-level interventions to enhance women's sleep health in Nairobi's informal settlements, thereby contributing to broader health equity and well-being.

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Author contributions

EU contributed to the overall conceptual design of the paper, data analysis, and overall drafting of the manuscript. SOA contributed to study implementation, data collection, data analysis and drafting of sections of the manuscript. LP contributed to drafting of sections of the manuscript and review and editing. AKB contributed to data analysis and preparation of manuscript. LMO contributed to study conceptualization and data analysis. MD directed and oversaw study implementation and data collection. MR, EA, HB, and CM drafted and reviewed sections of the manuscript. SSW oversaw drafting of sections of the manuscript and revising of this manuscript. SCW guided overall conceptual design for the study and contributed to quantitative analysis and preparation of the manuscript. All authors read and approved this manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

All methods were performed in accordance with the relevant guidelines and regulations, and all women in the study provided voluntary written informed consent prior to participating in the study. All the research assistants received ethics training through Collaborative Institutional Training Initiative (CITI) Human Subjects training and Good Clinical Practice training. The interviews were conducted in a secluded area to ensure privacy and to avoid interference. All consent forms and related study materials, including data collection measures, were translated into Swahili by a certified translator then reviewed by a team of stakeholders and research staff to ensure they are culturally and linguistically appropriate.

Competing interests

The authors declare no competing interests.

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