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Spatio-Temporal Trend and Geographic Disparity of Infertility Prevalence in Burkina Faso, 2011 to 2020

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Abstract

Background: Infertility affected 10% to 25% of couples globally, and about half of the infertility cases were reported in sub-Saharan Africa. Infertility poses significant social, cultural, and health challenges, particularly for women who often face stigmatization. However, comprehensive and nationally representative data, including prevalence, temporal trends, and risk factors, are lacking, prompting a study in Burkina Faso to address the need for informed policies and programs in infertility care and management. **Objectives:** This study aims to better understand the spatiotemporal trend of infertility prevalence in Burkina Faso. **Methodology:** This is a retrospective population-based study of women infertility from healthcare facilities in Burkina Faso, during January 2011 to December 2020. We calculated the prevalence rates of infertility and two disparity measures, and examined the spatiotemporal trend of infertility. **Results:** Over the 10-year period (2011 to 2020), 143,421 infertility cases were recorded in Burkina Faso healthcare facilities, resulting of a mean prevalence rate of 3.61‰ among childbearing age women and 17.87‰ among women who consulted healthcare facilities for reproductive issues (except contraception). The findings revealed a significant increase of infertility, with the prevalence rate varied from 2.75‰ in 2011 to 4.62‰ in 2020 among childbearing age women and from 13.38‰ in 2011 to 26.28‰ in 2020 among women who consulted healthcare facilities for reproductive issues,

corresponding to an estimate annual percentage change of 8.31% and 9.80% respectively. There were significant temporal and geographic variations in the prevalence of infertility. While relative geographic disparity decreased, absolute geographic disparity showed an increasing trend over time. **Conclusion**: The study highlights an increasing trend of infertility prevalence and significant geographic variation in Burkina Faso, underscoring the urgent necessity for etiologic research on risk factors, psychosocial implications, and economic consequences to inform effective interventions and mitigate the socioeconomic impact of infertility.

Keywords

Infertility, Prevalence, Temporal Trend, Geography, Disparity

1. Introduction

Infertility, characterized by the incapacity of a couple to conceive after 12 months of consistent unprotected sexual intercourse [1]-[4], is one of the emerging public health issues. The prevalence of infertility raises demographic concerns and carries significant economic ramifications. Furthermore, its influence on the social and mental well-being of affected couples is an important concern in sub-Saharan African countries [5]-[8]. It was estimated that infertility globally affects 10% to 25% of couples, highlighting its widespread impact on reproductive health [1] [5] [9]-[12], with half of them situated in sub-Saharan Africa [13]-[16]. Infertility is a complex issue with far-reaching implications across social, cultural, and health dimensions. Its impact is notably pronounced in pronatalist societies, particularly in sub-Saharan Africa, where childlessness is culturally stigmatized and not tolerated [17] [18]. In certain sub-Saharan African societies, infertility is perceived as a curse, subjecting individuals to frequent stigmatization, isolation, marginalization, and exclusion from their communities [18]-[20]. Infertility can be attributed to either male or female health issues, however, women bear the majority of the socioeconomic and sanitary burden due to frequent blame. Men who are unable to have children with their current wives may use infertility as grounds for seeking another wife or divorce [18] [20] [21].

The available estimates of infertility prevalence in sub-Saharan Africa, along with its social impact, often lack comprehensive data and are typically confined to specific population groups or particular areas [22]-[27]. As a result, these data may lack representativeness to accurately reflect actual trends in the general population. Nationally representative data allowing for prevalence estimation, temporal trend analysis, and risk factor assessment are not readily available in low- and middle-income countries. The existing data mainly rely on cross-sectional designs within specific groups or areas, and are outdated (more than 20 years) [13] [25]. It remains under-reported in spatial epidemiologic characteristics of infertility in Burkina Faso.

In this study, we aim to assess the prevalence and spatiotemporal trends, and geographic disparities of infertility in Burkina Faso over the past decade.

2. Methods

2.1. Data Sources

We utilized existing data of hospital activity records related to medical visits for reproductive concerns in Burkina Faso. National Healthcare Statistical Directory of Healthcare Activities data were used, which provides the annual aggregated diagnosis information (both outpatients and inpatients) from both public and private healthcare facilities in Burkina Faso. It also provides the number of childbearing age (14 - 49 years old) women. Due to administrative issues, infertility data were not collected in 2019. Thus, the analysis covers the period from 2011-2018 and 2020, with 2011 chosen as the starting point when infertility information was first recorded in the statistical directory in Burkina Faso.

2.2. Study Population

The study population includes all women of childbearing age (considering the demographer's point of view of childbearing age: 14 - 49 years old) [4] in Burkina Faso during 2011-2018, and in 2020.

2.3. Definition of Infertility Cases

The infertility case is based on the definitive diagnoses documented in hospitals and reported in the registry, and clinically defined as the inability to conceive as expected in women of childbearing age [4].

2.4. Statistical Analysis

Given the absence of dedicated information on infertility among at-risk populations, we estimated its prevalence using two background populations all women of childbearing age and women seeking reproductive health services. Not all women of childbearing age are at risk of infertility due to factors such as being single, not engaging in regular unprotected sexual activity, or using contraception. However, due to the lack of data necessary to exclude these individuals, we chose to estimate prevalence across the entire population of women of childbearing age. This approach provides an overview of infertility prevalence within society as a whole. While it may underestimate the actual prevalence by including those not actively attempting to conceive, it still offers valuable baseline data for understanding the broader landscape of infertility and informing public health strategies.

Furthermore, to comprehensively assess infertility as a health care need and evaluate its potential impact on clinical activities, we estimated the proportion of women diagnosed with infertility among those seeking healthcare services for reproductive health issues. This approach aims to provide a thorough understanding of pressures related to infertility, enabling informed decision-making for

healthcare policymakers and facilitating organizational strategies for healthcare facilities. Our analysis incorporates data on women seeking healthcare services for pregnancy, abortion, and infertility, while excluding consultations related to contraception. By doing so, we aim to provide a comprehensive perspective on reproductive health challenges. The prevalence calculation involves dividing the number of infertility cases by the respective totals of women of childbearing age-and those seeking reproductive healthcare services.

Then, we examined spatial and temporal trends of infertility prevalence in Burkina Faso, as well as variation across different regions at the provincial level. This involved the utilization of established concepts such as the estimated annual percentage change (EAPC), relative disparity measured by mean log deviation (MLD), and absolute disparity assessed through between-group variance (BGV). These methodologies have been refined through cross-validation in prior studies [28]-[31], ensuring their reliability and effectiveness in our analyses. Using these concepts, we calculated the estimated annual percentage change (EAPC) to discern alterations in infertility rates over time and geographical discrepancies. This was achieved by applying exponential regression to the yearly rates, with the calendar year serving as the regression variable. The model utilized for analysis was structured as follows: the rate (y) was expressed as a function of the calendar year (x), $y = exp(ax) + b$ with a representing the slope coefficient and b the intercept. The estimated annual percentage change (EAPC) was derived from this model using the formula: EAPC = 100 * ($exp(ax) - 1$), where e is the base of the natural logarithm. We conducted Joinpoint regressions to pinpoint notable shifts in rates over time. This method utilizes permutation tests to identify critical points where significant changes occur in the trend's slope, following a previously validated methodology [30] [32]. To quantify geographic disparities, both relative (MLD) and absolute (BGV) disparities were computed at the province level according to the formula proposed by Harper and Lynch [28]. Thus, the MLD was calculated as follow $\mathrm{MLD} = \sum_{i=1}^{I} p_{i(-\ln q_i)}$ in which $q_i = y_i/\mu$, p_i, the province i's population fraction, y_i, the province i's rate, and μ is the rate across all provinces, summarizes the disproportionality between province rates and population size and the yearly absolute disparity of BGV was defined as $\sum_{i=1}^{I} p_i \left(y_i - \mu\right)^2$ accordingly to the Harper and Lynch' formula [28]. The y_i was defined model-based predicted province-year-specific rates, and μ was obtained from a summary after multiplying the province rate by its population fraction. All the prevalence and disparities measures were expressed in per 1000 (‰) and the EAPC in percentage (%). Joinpoint regressions was further performed to identify the significant changes in both absolute and relative disparity measures. Additionally, we calculated the period change in absolute and relative disparity between 2011 and 2020.

All data management and analyses were performed using R software (version 4.3.1) and Joinpoint Trend Analysis Software (Version 5.0.2). Mapping was conducted using ArcGIS Pro (ESRI).

2.5. Ethics Approval

This study received ethical approval from the Washington University in St. Louis review board (approval no. 202312172) on January 04, 2024. This is an IRB-approved retrospective study, all patient information was de-identified and patient consent was not required. This article does not contain any studies with animal participants.

3. Results

3.1. Prevalence and Temporal Trend over Time

A total of 39,774,645 women of childbearing age were recorded between 2011 to 2018 and 2020 in Burkina Faso. Among them, 7,648,131 consulted health services for reproductive health issues excluding contraception-related consultations and 143,421 were recorded for infertility, corresponding to a mean rate of 3.61‰ and 17.87‰ among childbearing age women and among women seeking healthcare facilities for reproductive issues such as pregnancy, abortion, and infertility respectively (Table 1). Throughout the study period, there was a doubling of infertility prevalence, with the prevalence escalating from 2.75‰ in 2011 to 4.62‰ in 2020 and from 13.38‰ to 26.28‰ respectively among childbearing aged women and among women seeking healthcare facilities for reproductive issues such as pregnancy, abortion, and infertility, excluding contraception-related consultations (Table 1 and Figure 1). The distribution of infertility cases exhibits a skewed pattern, leading to variations in both the median and mean numbers of these indicators across provinces and years. This skewness underscores the presence of a substantial number of infertility cases in several provinces, contributing to the overall diversity in the data. Notably, the median and mean values for infertility cases per province per year reflect the dynamic nature of the study's findings. These changes translate to significant annual increases of 8.31% ($p < 0.001$) and 9.80% ($p = 0.006$) within both the population of all women of childbearing age and among those seeking healthcare facilities for reproductive issues such as pregnancy, abortion, and infertility respectively (Table 2).

3.2. Geographic Disparities

Figure 2 illustrates the disparities and variations in infertility prevalence across provinces, highlighting hotspots notably in the central-north and northern regions, as well as in provinces housing the capital, Ouagadougou, and Bobo-Dioulasso, the country's second most significant city. The relative geographic disparity tends to decrease over time (EAPC = −5.40%, $p = 0.073$; EAPC = −0.37%, $p = 0.085$ respectively among all women of childbearing age and among those seeking healthcare facilities for reproductive issues such as pregnancy, abortion, and infertility. While the absolute geographic disparity in contrast showed an increasing trend over time (EAPC = 5.15%, $p = 0.026$, among all women of childbearing age and EAPC = 13.16%, $p = 0.016$ among those seeking

healthcare facilities for reproductive issues such as pregnancy, abortion, and infertility (Figure 1(B), Figure 1(C), and Figure 2).

Table 1. The prevalence of infertility in Burkina Faso, over time, 2011 to 2020.

	Overall study period (2011-2020)					2011	2020
	Total	Min	Median	Mean	Max	Total	Total
Crude numbers	143,421	9.49	13.34	15.94	23.90	10,474	23,895
Prevalence in all childbearing age women*, (‰)	3.61	2.31	3.04	3.52	4.71	2.75	4.62
Proportion of infertility case within reproductive healthcare seeker**, (‰)	17.87	11.83	15.79	18.47	26.28	13.38	26.28

*All childbearing age women (14 - 49 year-old). ** Include women who consulted healthcare facilities for reproductive health issues (pregnancy, abortion, or infertility).

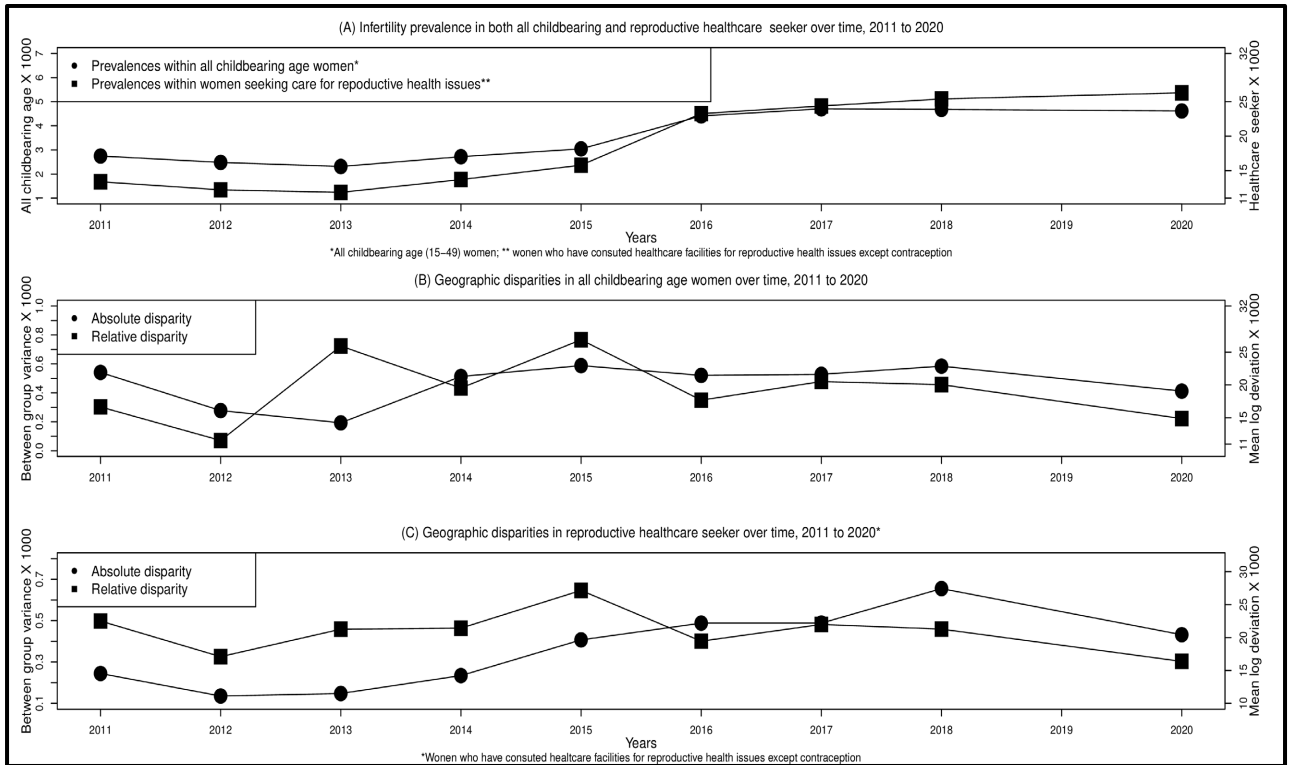

Figure 1. Women infertility prevalence (A), Geographic disparities in all childbearing age women (B), Geographic disparities in reproductive healthcare seeker (C) over time in Burkina Faso, 2011-2020.

4. Discussion

This is the first study to assess the prevalence of infertility and its spatiotemporal trend in Burkina Faso. Our analysis revealed a significant increasing trend and important geographic disparities of infertility prevalence over the past decade.

Our findings, derived from infertility cases records in hospital, contrast with decreasing trends reported in population-based surveys in several low and middle-income countries [26] [27] [33]. This contrast may be attributed, in part to differences in the infertility case definition, as previous studies often used childlessness or time-to-pregnancy as a surrogate for infertility [18] [25] [34] [35].

Both childlessness and time-to-pregnancy definitions may differ from infertility definition or may not directly align with the concept of infertility [3] [4] [36]-[39].

Table 2. Trends of the prevalence, absolute disparity, and relative disparity of infertility prevalence in Burkina Faso, 2011-2020.

Prevalence and disparity measures	Trend 1			Trend 2			EAPC over time, 2011 to 2020	P value
	Years	EAPC	P value	Years	EAPC	P value		
In all childbearing age women*								
Prevalence	2011-2016	11,62	0.016	2016-2020	4.75	0.127	8.31	<.001
MLD	2011-2013	81.79	<0.001	2013-2020	−13.51	0.004	−5.40	0.073
BGV	2011-2013	476.94	<0.001	2013-2020	−24.90	<0.001	5.15	0.026
Reproductive healthcare seeker**								
Prevalence	2011-2017	13.19	0.005	2017-2020	3.32	0.700	9.80	0.006
MLD	2011-2015	6.09	0.021	2015-2020	−5.87	0.015	−0.37	0.085
BGV	2011-2017	23.75	<0.001	2017-2020	−5.37	0.293	13.16	0.015

*Include all childbearing age (14 - 49 year-old) women. **Include women who consulted healthcare facilities for reproductive health issues (pregnancy, abortion, or infertility). EAPC: estimate annual percentage change. MLD: mean log deviation. BGV: between group variance.

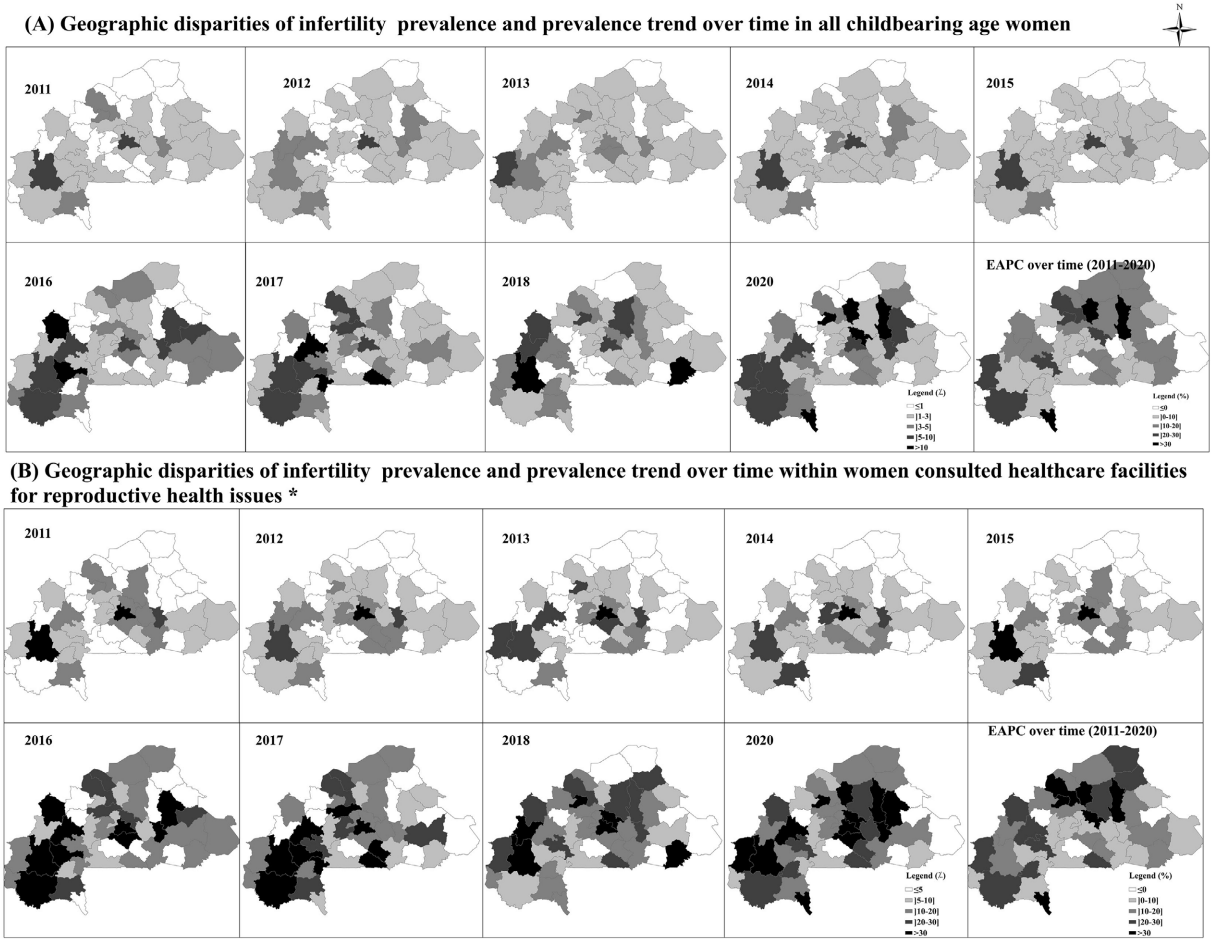

Figure 2. Geographic disparity of women infertility and estimated annual percentage based on joinpoint analysis: Geographic disparities in all childbearing age women (A), Geographic disparities in reproductive healthcare seeker (B) across Provinces in Burkina Faso, change over time 2011-2020.

Additionally, several studies in sub-Saharan Africa are based on selected population, areas, or cross-sectional designs [22]-[27], raising concerns about their representativeness. The observed trend in our study might be a surrogate of progress in accessing and utilizing reproductive health services in sub-Saharan Africa [40] particularly in Burkina Faso rather than a real increase in the infertility prevalence. Urbanization, improving living conditions, educational advancements [41], and the collaborative efforts of local authorities and technical partners [42] in reproductive health might contribute to increased trust in conventional medicine over alternative methods such as traditional medicine and prayers which contributed to increase in infertility prevalence in our study. However, it's important to note that we might have overestimated infertility indicators, considering that, the same individual might be counted multiple times for consulting in different hospitals. In contrast, using medical recorded data may underestimate infertility cases by not accounting for women seeking alternative medicine or religious guidance. A future community-based longitudinal study is necessary to accurately estimate the prevalence of infertility and to identify both the at-risk population and associated risk factors.

In this study, we utilized both prevalence rates within all women of childbearing age and specifically within those seeking care for reproductive issues (pregnancy, abortion, and infertility). Relying solely on prevalence within the general childbearing age population may introduce bias by including contraceptive users [43] or couples not actively seeking pregnancy or even avoiding it. Additionally, prevalence within the general population may offer less informative insights for resources planning and might not accurately reflect the expressed or latent needs in reproductive services. Our infertility indicator within women seeking care for reproductive issues offers more relevant and informative insights. By considering the actual population actively seeking pregnancy, this approach better informs service use or need.

We also conducted an analysis of the geographic disparities and trend in infertility prevalence over time using the absolute (BGV) and relative disparity (MLD) measures [28]. Additionally, we estimated annual percentage change (EAPC) [44] over time both at the province level. The analysis revealed a significant and increasing absolute geographic disparities in both infertility prevalence and prevalence trend across Burkina Faso's provinces particularly when considering women seeking care for reproductive issues. Furthermore, the provinces in the northern and central-northern regions, which correspond to the primary areas of mining exploitation activities in the country, overall demonstrate notably high prevalence rates and the most rapid growth trends. The disparities found in this study may be partly attributed to socioeconomic, environmental, and healthcare services variations across the provinces. Ecological studies indicate that, overall health, including reproductive health, is deeply rooted in social inequalities, including neighborhood context [45]-[47]. The underlying causes linking neighborhoods to health disparities, including reproductive health, may involve individual characteristics, social, economic and political organization, as

well as healthcare service availability and accessibility [45]-[47]. Economic and/or geographic accessibility might partly explain the higher prevalence and faster-growth trend of the economically viable provinces of the mining basin in Burkina Faso [48], and the provinces housing the two most important cities, Ouagadougou and Bobo-Dioulasso, which are considered the economic hubs of the country and equipped with a significant number of healthcare facilities, including the major ones. The depiction of hotspots and rapid trends in infertility prevalence in this study, particularly concentrated around gold miner exploitation (including artisanal exploitation) areas [48], indicates a potential correlation between gold mining activities and increased infertility rates in these regions. Mining activities can have a positive impact on the socioeconomic conditions of households, making them better able to access healthcare services including the reproductive health demand. This financial empowerment may mask previously underestimated reproductive health needs due to financial constraints. Neighborhood and residential areas may also contribute to reproductive health disparities through exposure to risk factors such as unhealthy environments (exposure to toxics, air pollution, water quality, housing conditions, and public spaces), and influencing behaviors and diet [45] [47] [49]-[51]. While mining may potentially contribute to income enhancement and improved access to healthcare services, it can also have adverse health consequences, particularly concerning reproductive health., While socioeconomic activities such as mining hold the promise of economic empowerment and potential improvements in healthcare access, they can also have detrimental effects on the health of the local residents. Environmental pollution resulting from mining activities may lead to the deterioration of public health, including impacts on reproductive health. Unfortunately, access to Burkina Faso's mining cadaster files is currently restricted due to security and geostrategic constraints. This limitation hampers further and deeper analysis of the relationship between the location of mining operations and the prevalence of infertility.

The intricated relationship between neighborhood context and socioeconomic activities underscores the importance of a holistic analysis when evaluating the effects socioeconomic and neighborhood effect on health. Therefore, it is crucial to adopt a balanced approach, considering both socioeconomic aspects and health impacts, to formulate appropriate policies and interventions aimed at maximizing benefits while minimizing health risks in communities affected by several socioeconomic activities. The study results are crucial for local public health stakeholders as they can inform the organization and planning of reproductive health services. By highlighting these disparities, the findings underscore the necessity for a deeper exploration of the intricate relationship between neighborhood context, environmental factors, and socioeconomic factors, and public health outcomes, particularly in reproductive health. This insight is invaluable for guiding policymakers, public health officials, and researchers in crafting targeted interventions and spearheading further research initiatives. By addressing these factors, we can effectively mitigate the adverse impacts of

neighborhood context, environmental conditions, and socioeconomic activities on reproductive health, thereby promoting a sustainable model of development that prioritizes health and well-being. Future studies are warranted to collect and analyze these types of data to enhance our understanding and develop preventive strategies.

Our study has some limitations. Firstly, relying on national medical record data makes our results more representative of women who consulted healthcare facilities for reproductive issues rather than the entire childbearing age population aligning with the infertility definition [1]-[4]. Considering that not all women of childbearing age are at risk of infertility based on the infertility definition intercourse [1]-[4], due to various factors such as not being in a relationship with regular sexual intercourse, not engaging in regular unprotected sexual activity, or actively using contraception to prevent pregnancy, estimating the prevalence of infertility among the entire population of childbearing age women might lead to biased results. Furthermore, some women may resort to methods outside the conventional healthcare system, such as traditional medicine or spiritual practices, to address their infertility issues, which could underestimate our prevalence rates. By using the infertility definition based on cases recorded in medical facilities rather than childlessness and time-to-pregnancy as in several studies may also overestimate the infertility prevalence as both childlessness and time-to-pregnancy definitions may differ from infertility [3] [4] [36]-[39]. Moreover, it is crucial to acknowledge that individuals may cross administrative boundaries to seek care, potentially consulting multiple hospitals, and being included multiple times in our sample. Secondly, the lack of individual-level data, including demographic, professional exposomes, clinical characteristics, treatment, and survival information, neighborhood contextual, and behavioral data, presents a challenge. Obtaining such data is hindered by archiving issues in health institutions and its limited availability elsewhere. Consequently, detailed patient characteristics and analysis of associated risk factors could not be provided due to the aggregated nature of the data from our source. Finally, the lack of access to mining cadaster files poses a significant obstacle to conducting a comprehensive analysis of the relationship between mining activities and the prevalence of infertility, despite the evident overlap between areas of high infertility rates and zones of active mining in Burkina Faso. Finally, since the registry lacked comprehensive data regarding the reproductive history, we were unable to ascertain whether participants never had a biological child and were encountering challenges in conceiving or they might have previously had biological child(ren) but faced difficulties in achieving subsequent pregnancies [4]. Consequently, in this study, we were not able to estimate the prevalence of primary infertility separately.

Our study also has several strengths that enhance its relevant and utility. First, it represents the first effort to delineate spatiotemporal trends and geographic disparities of infertility at the country level within the sub-Saharan region. Second, we applied valid and informative indicators to depict the infertility preva-

lence in both all childbearing age women population and within those consulting healthcare facilities for reproductive issues. Third, our findings not only serve as a crucial baseline of evidence but also as a significant reference point for the sustainable development goal era. The results are relevant as they draw attention to infertility, as often overlooked reproductive health issues in sub-Saharan Africa, and can aid policymakers in organizing and planning health services.

5. Conclusion

Our study reveals a notable upward trend in infertility prevalence and absolute geographic disparity over time in Burkina Faso. These findings suggest the critical need for additional research to pinpoint specific areas requiring concentrated efforts. This research should not only delve into the risk factors associated with infertility but also explore its psychosocial and economic implications. Identifying and addressing these aspects is crucial for mitigating the broader socioeconomic impact of infertility.

Author Contributions to the Manuscript

Study concept and design: Oumarou Nabi;

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Statistical analysis: Oumarou Nabi;

Interpretation of data: Oumarou Nabi, Min Lian;

Drafting of the manuscript: Oumarou Nabi, Pratibha Shrestha, Min Lian;

Critical revision of the manuscript for important intellectual content: All Authors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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