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ORIGINAL RESEARCH ARTICLE

Spatial Distribution and Environmental Correlates of Cataract and Glaucoma Prevalence in Damaturu LGA, Nigeria

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ABSTRACT

The rising prevalence of blindness and vision impairments, particularly due to cataracts and glaucoma, poses significant challenges in developing countries with limited access to essential healthcare services. This paper delves into the spatial analysis of cataracts and glaucoma in Damaturu Local Government Area of Yobe State, Nigeria, aiming to uncover spatial trends and demographic distributions of these eye conditions within the region. Drawing data from Yobe State University Teaching Hospital, where records of patients with Glaucoma and Cataract diseases were periodically documented, the study included a total of 187 patients. An essential aspect of the analysis focused on mapping the age groups affected by cataracts and glaucoma, providing valuable insights into the vulnerability of different age cohorts to these diseases. The data encompassed age groups ranging from 20 to 80 years, with notable concentrations observed between ages 25 to 60 and 25 to 80 years, indicating the higher susceptibility of middle-aged and older individuals. It's noteworthy to mention that due to the nature of data collection at the hospital, the age group values were recorded as string data types, represented by unique values for each case. This necessitates a detailed understanding of the age demographics affected by cataracts and glaucoma to tailor healthcare interventions effectively. To correct any errors or ambiguities, the data was also evaluated and analyzed using the Arc Map software with variables and the Statistical Product and Service Solutions (SPSS) was also be used for analysis along with the administrative boarders. The study's conclusion underscores the critical need for intensified management and treatment of patients with progressive cataracts and glaucoma cases, emphasizing the importance of optic disc excavation and addressing distorted vision fields. These findings align with previous hospital-based studies, highlighting the ongoing challenges and the imperative for targeted healthcare strategies to address the growing burden of these eye conditions comprehensively. In essence, this research contributes valuable insights into the spatial and demographic aspects of cataracts and glaucoma in Damaturu LGA, advocating for focused healthcare interventions and management protocols to enhance patient outcomes and mitigate the impact of these prevalent eye diseases.

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INTRODUCTION

Blindness and vision impairment are significant public health concerns globally, with cataracts and glaucoma being prominent contributors to these conditions (Prum et al., 2016). Cataracts refer to the clouding of the eye's lens, while glaucoma is characterized by optic nerve damage, often associated with increased intraocular pressure. Despite advancements in medical science, managing these diseases remains challenging in many developing countries, including Nigeria, where access to eye care services and awareness about preventive measures is limited. According to Prum et al. (2016), glaucoma accounts for approximately 8% of global blindness cases, making it a significant public health concern. Further highlights that the prevalence of glaucoma is notably high among individuals aged 40 to 80 years, indicating the age-related nature of the disease. In Nigeria, glaucoma stands as the second leading cause of blindness among adults, following cataracts (Ibrahim & Lawan, 2018). This highlights the urgent need for targeted interventions and a comprehensive understanding of the spatial distribution of these diseases to address their impact effectively.

While there have been several studies examining the clinical aspects and risk factors associated with cataracts and glaucoma in Nigeria (Ahmad et al., 2019; Adio et al., 2020), there is a noticeable gap in research focusing on their spatial distribution and hotspot analysis. Spatial analysis plays a crucial role in identifying geographical patterns, clusters, and potential risk factors associated with

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disease prevalence. By using spatial analytical techniques, researchers can uncover underlying factors contributing to the concentration of disease incidences in specific areas. As such, this paper aims to fill this gap by conducting a spatial analysis of cataract and glaucoma incidences in Damaturu Local Government Area of Yobe State, Nigeria. The choice of Damaturu is strategic, considering its demographic characteristics, healthcare infrastructure, and existing data availability on eye diseases. Through a spatial lens, the study seeks to explore the distributive patterns of these diseases, identify potential spatial clusters or hotspots, and analyze the environmental and socio-economic factors associated with their prevalence.

Spatial analysis techniques such as spatial autocorrelation, kernel density estimation, and hotspot analysis were employed in analyzing the data and generating spatially explicit insights. This approach will not only help in identifying areas with high disease burden but also provide valuable information for targeted intervention strategies and resource allocation in healthcare planning. The significance of this study lies in its potential to contribute to evidence-based decision-making in public health policy and practice. By understanding the spatial distribution of cataracts and glaucoma, health authorities can prioritize areas for intervention, improve access to eye care services, and implement preventive measures effectively. Moreover, the study will enhance knowledge about the geographical determinants of these diseases, facilitating informed strategies for disease management and control.

Glaucoma, a leading cause of irreversible blindness worldwide, has garnered substantial attention from researchers aiming to understand its epidemiology and impact. According to Tham et al. (2014), the global prevalence of glaucoma is estimated to be around 3.54%, with variations across different geographical regions. This condition poses a significant public health challenge, affecting millions of individuals and posing a considerable economic burden on healthcare systems (Tham et al., 2014). Numerous empirical studies have delved into the risk factors associated with glaucoma. Age is a well-established risk factor, with older individuals being more susceptible to developing glaucoma.

Additionally, genetic predisposition plays a crucial role, as evidenced by studies highlighting the familial aggregation of glaucoma cases (Stone et al., 2016; Wiggs, 2015). Genetic variants, particularly those related to intraocular pressure regulation and optic nerve integrity, have been identified as key contributors to glaucoma pathogenesis (Wiggs, 2015; Stone et al., 2016). Advancements in diagnostic modalities have revolutionized the early detection and management of glaucoma. Studies by Weinreb et al. (2014) and Medeiros and Weinreb (2016) have emphasized the importance of optical coherence tomography (OCT) and visual field testing in diagnosing and monitoring glaucoma progression.

Moreover, community-based screening programs have been instrumental in identifying individuals at risk, particularly in underserved populations where access to eye care services may be limited (Ramulu, 2009; Kim et al., 2015). The management of glaucoma involves a range of treatment modalities aimed at reducing intraocular pressure and preserving optic nerve function. Studies comparing the efficacy of various medications, such as prostaglandin analogs, beta-blockers, and alpha-adrenergic agonists, have provided valuable insights into optimal treatment regimens (Heijl et al., 2002; Nouri-Mahdavi et al., 2004). Furthermore, surgical interventions, including trabeculectomy and minimally invasive glaucoma surgeries (MIGS), have demonstrated favorable clinical outcomes in lowering intraocular pressure and halting disease progression (Saheb & Ahmed, 2012; Gedde et al., 2012).

Beyond clinical outcomes, empirical research has explored the psychosocial impact of glaucoma on patients' quality of life and daily functioning. Studies by Revie (2021) have highlighted the challenges faced by glaucoma patients, including reduced mobility, driving limitations, and emotional distress. Understanding these psychosocial factors is crucial for developing comprehensive patient-centered care approaches and support services (Grover et al., 2022). The landscape of glaucoma research continues to evolve with the emergence of novel technologies and therapeutic targets. Recent studies on neuroprotection strategies, stem cell therapies, and gene editing techniques offer promising avenues for advancing glaucoma management and improving patient outcomes (Lo et al., 2023). Collaborative efforts between researchers, clinicians, and industry stakeholders are essential for translating these advancements into clinical practice and addressing the multifaceted challenges posed by glaucoma on a global scale.

Cataracts are a prevalent cause of visual impairment and blindness globally. A study by Awidi et al., (2023) estimated the prevalence of cataracts among adults in the United States, highlighting its significant impact on vision health. This finding is consistent with the global data on visual impairment reported by Jiang et al., (2023) which emphasized the increasing burden of cataracts worldwide. Conversely, the magnitude and cost implications of global blindness due to cataracts, stressing the need for effective interventions to alleviate this growing problem. Malik et al., (2022) provided insights into the prevalence of cataracts and the coverage of cataract surgical services, emphasizing the importance of access to quality eye care. In regional studies, Khandekar et al., (2015) conducted research in Oman to assess cataract prevalence and surgical coverage, shedding light on barriers to accessing cataract surgical services. Similarly, Sarkar et al., (2023) examined cataract prevalence in rural and urban South India, highlighting regional variations and factors influencing cataract incidence. Understanding risk factors is crucial in addressing cataract burden. Halim et al., (2022) conducted a case-control study to identify risk factors associated with cataracts, providing valuable insights for preventive strategies. National surveys, such as the study by Sethu (2018), contribute to understanding visual acuity

trends and cataract prevalence among specific populations, aiding in public health planning and resource allocation. Overall, empirical studies on cataracts offer critical data on prevalence, risk factors, access to care, and regional variations, essential for developing evidence-based strategies to combat cataract-related visual impairment and blindness globally.

MATERIALS AND METHODS

Study Area

The study was conducted in Damaturu Local Government Area of Yobe State, Nigeria. The area is located in the Sahel region, characterized by semi-arid climatic conditions with limited rainfall and high temperatures, as well as relatively flat terrain typical of the Sudano-Sahelian ecological zone. It is experiencing a typical Sahelian climate, characterized by a long dry season from October to April and a short rainy season from May to September. The vegetation of the area is predominantly Sahelian, consisting of savannah grasslands, scattered shrubs, and acacia trees. The landscape is generally open, with few forests or dense vegetation (Adamu & Taa, 2022).

Data Collection Technique

The study used a retrospective approach in collecting data from Yobe State University Teaching Hospital, where patients with Glaucoma and Cataracts are regularly recorded. The data was imported into ArcGIS as a CSV file, displaying feature points using Longitude and Latitude fields. However, from the achieved database of the patients, 187 were randomly sampled for the study, which helped in capturing a diverse range of cases. An aggregation for the male and female affected population is recorded in a numerical field which allow for numerical data representation of data. The Age group of people affected by both Cataract and Glaucoma is a range of values for different age groups like 20-60, 25-60, amongst others.

Sample Size and Sample Techniques

Specifically, the method of sampling used for this analysis is the non-probability sampling method, random sampling, where a representative population of 187 patients was sampled. The secondary data was obtained from Yobe State University Teaching Hospital Damaturu to reflect the general occurrence of cataracts and glaucoma in Damaturu to determine the sample size for this research work.

Data Analysis

To ensure accuracy and clarity, the data collected was assessed and processed using ArcGIS software, specifically ArcMap. This is because ArcMap is particularly relevant for this study due to its robust capabilities for spatial analysis, data visualization, and cartographic output. It also offers a wide range of tools and functionalities that are essential for analyzing geographic data, creating maps, and conducting various spatial analyses.

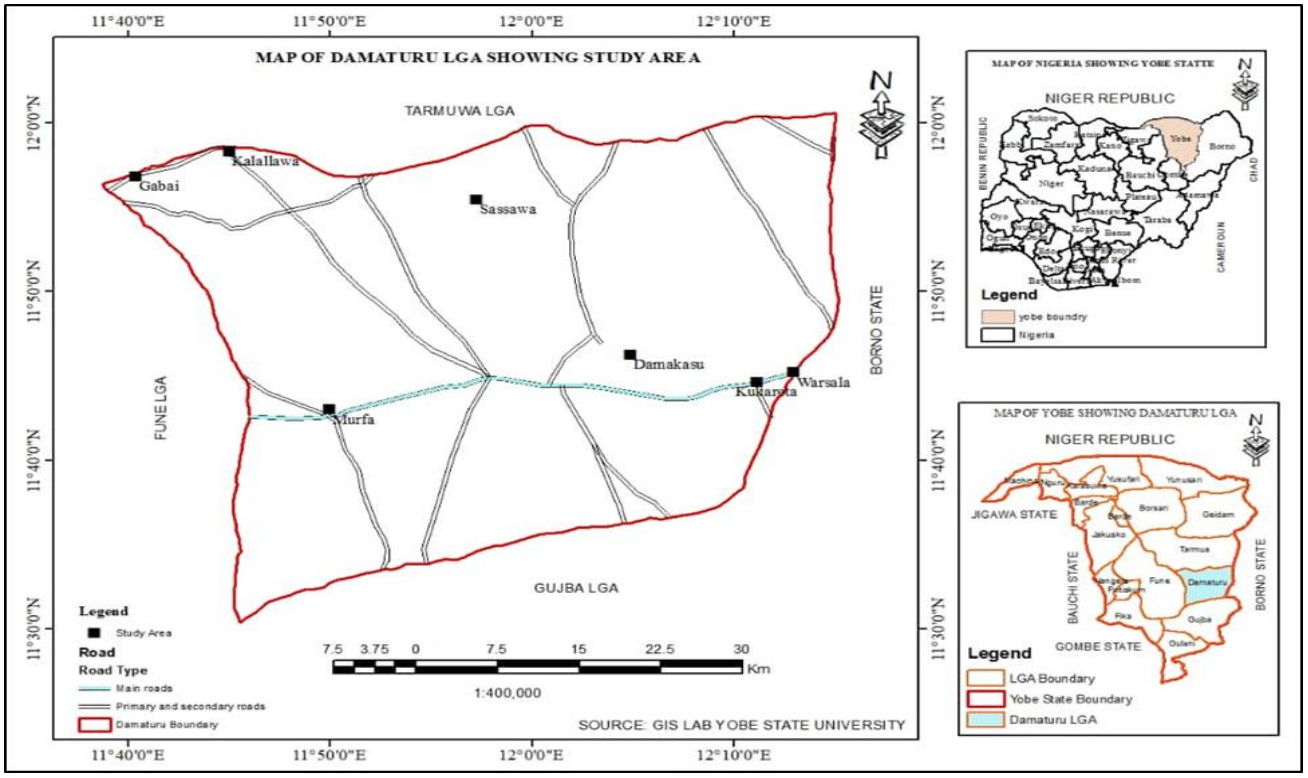

Figure 1: Study Area

RESULTS AND DISCUSSIONS

The analysis of Figure 2 indeed brings to light a significant clustering of Cataract cases within the central region, drawing attention to it as a key area of concern regarding this specific health issue. However, the intriguing observation in Maisandari Ward, slightly removed from the central zone yet demonstrating a notable number of Cataract cases, hints at a localized influence or factor contributing to the prevalence of Cataracts in this particular area. This anomaly underscores the need for further investigation into the unique circumstances driving Cataract prevalence in Maisandari Ward. Additionally, the emergence of Kukareta-Warsala as another notable hotspot with a substantial concentration of Cataract cases indicates a specific micro-environmental concern within the broader region of Damaturu. Conversely, the relatively lower incidence of Cataract cases in the remaining five areas, each reporting fewer than or equal to four cases, suggests varying degrees of Cataract prevalence across different geographical locations within Damaturu. Moreover, the statistical analysis depicted in the figure elucidates the distribution of Cataract cases across a 6-bin range, with a standard deviation of approximately 4, positioning it 2 counts below the mean value of 6. The maximum recorded value of 12 Cataract cases in Damaturu, along with a total of 71 cases documented across all settlements, provides a comprehensive overview of the magnitude of the issue.

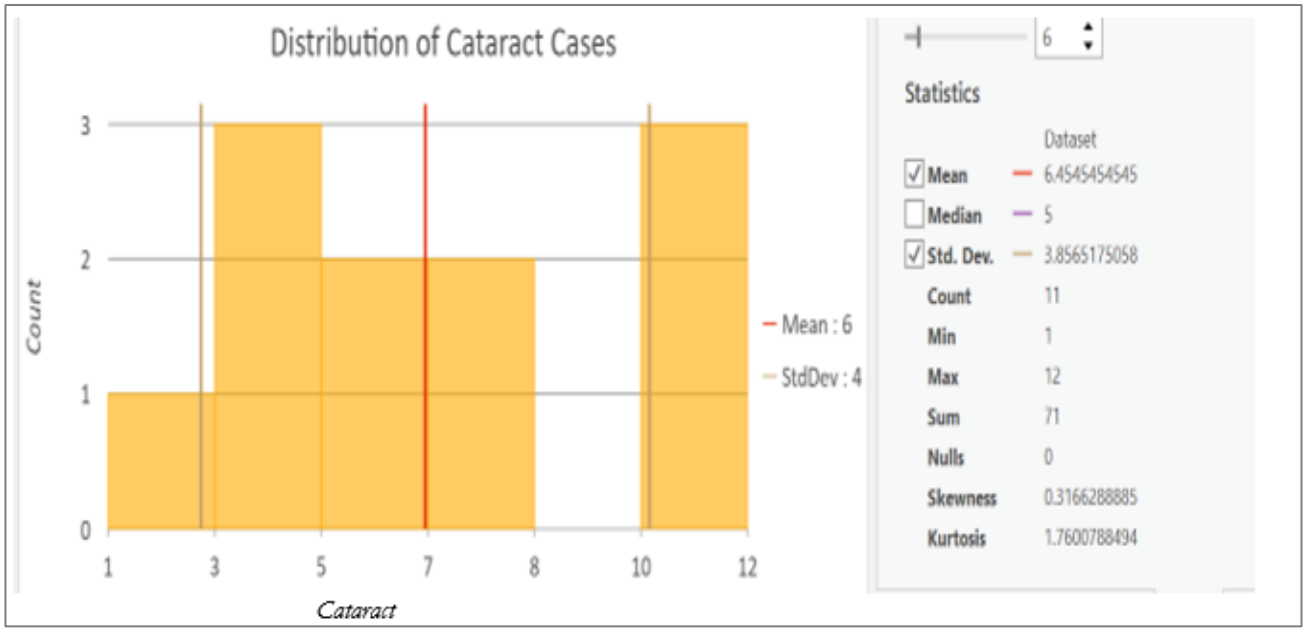

Figure 2: Statistics of Cataract cases

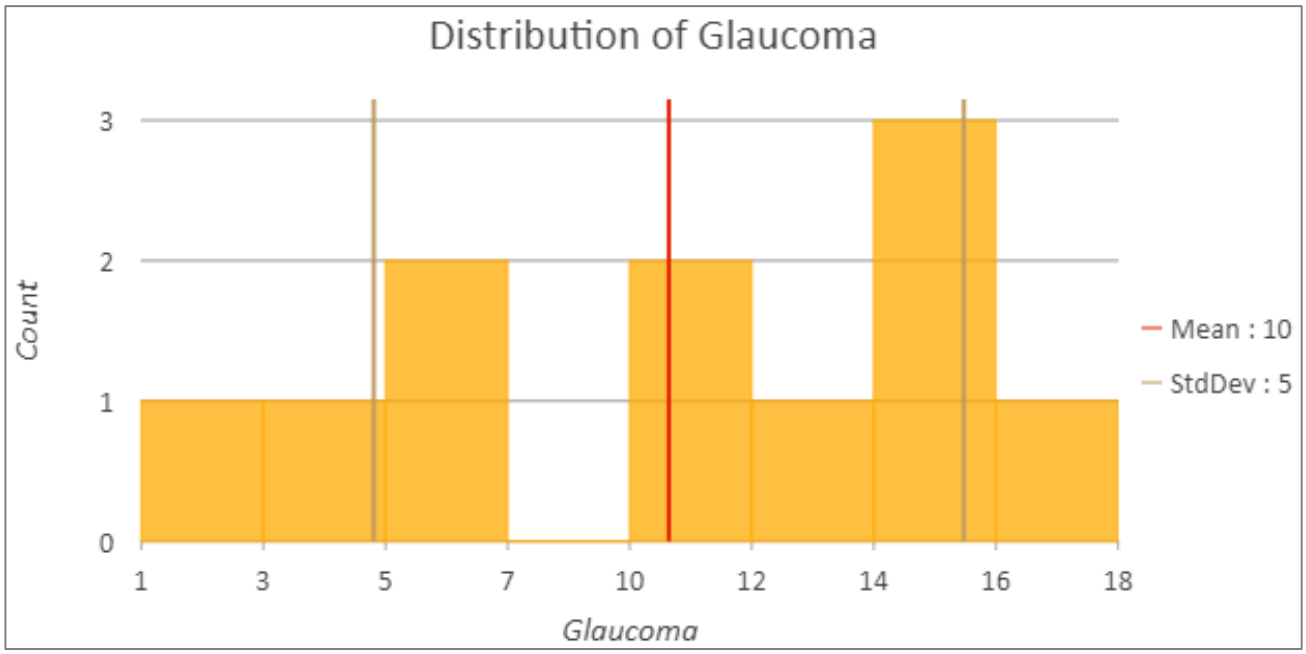

Figure 3: Distribution of Glaucoma Cases

Conversely, the analysis transitions to the prevalence of Glaucoma instances in Damaturu, which stands out significantly compared to Cataract cases. With a total of 112 Glaucoma cases, translating to a mean value of 10 as illustrated in the accompanying chart, the distribution pattern of Glaucoma showcases notable variations across different areas. A visual examination of the Glaucoma distribution map emphasizes Maisandari Ward as the location with the highest number of cases, reaching up to 18 cases across both male and female populations. The variability in Glaucoma distribution is further highlighted by the standard deviation of 5, diverging notably from the mean value of 10, indicating considerable diversity in the prevalence of Glaucoma across Damaturu. This underscores the complexity of Glaucoma distribution and the need for targeted interventions and healthcare strategies to address this significant health challenge effectively.

The analysis of Glaucoma cases in Damaturu reveals intriguing insights into the spatial distribution and environmental factors influencing the prevalence of this eye condition. Notably, Damakasu, Gambir Moduri, Kukareta Warsala, and Sasawa Kabaru demonstrate identical values for recorded cases, indicating a consistent pattern of Glaucoma prevalence across these areas. On the other hand, Damaturu Central stands out with the lowest count of 1 recorded case, suggesting a relatively lower incidence of Glaucoma in this particular locality. A compelling trend observed from Figure 3 is the correlation between settlement environments and Glaucoma case numbers. Settlements situated in predominantly sandy environments tend to report higher case numbers of Glaucoma. This phenomenon can be attributed to environmental factors such as dust exposure, wind strength, and infrastructure development. Upon closer examination, it becomes apparent that Damaturu Central, despite its limited visibility on the map, boasts significant development characterized by ample trees and infrastructure. This unique characteristic likely mitigates wind strength and reduces the circulation of dust and impurities in these regions. As a result, individuals residing in Damaturu Central are less exposed to environmental factors that contribute to Glaucoma development. Conversely, other areas with relatively low settlement densities lack significant tree cover and infrastructure, leading to stronger winds and increased dust exposure. This environmental condition, particularly affecting middle-aged and elderly individuals who often spend prolonged periods outdoors, contributes to the higher incidence of Glaucoma cases observed in these age groups across these regions.

However, the spatial analysis of Glaucoma cases in Damaturu underscores the intricate relationship between environmental factors, settlement characteristics, and Glaucoma prevalence. It emphasizes the importance of considering environmental conditions and urban planning strategies in addressing eye health issues, particularly Glaucoma, among vulnerable populations residing in diverse geographical areas.

The age distribution analysis of individuals affected by Cataract and Glaucoma in Damaturu, Yobe State, provides valuable insights into the demographic patterns of these eye diseases and their impact on different age groups within the community. Understanding the age distribution is crucial for identifying vulnerable populations, designing targeted interventions, and allocating resources effectively to address these health challenges. The data reveals a range of age groups affected by Cataracts and Glaucoma, spanning from 20 to 60, 70, and 80 years. This broad age range underscores the prevalence of these eye conditions across various stages of adulthood and older age. Interestingly, there are notable concentrations of cases observed between ages 25 to 60 and 25 to 80 years, indicating a higher susceptibility to Cataracts and Glaucoma among middle-aged and older individuals in Damaturu. The absence of cases among individuals below the age of 20 suggests that these eye diseases are less prevalent among younger age groups in the community. This finding aligns with epidemiological trends showing that Cataracts and Glaucoma are more commonly associated with aging and factors such as prolonged exposure to environmental stressors, genetic predisposition, and lifestyle habits. Analyzing the spatial distribution of cases across different age groups highlights specific areas within Damaturu where Cataract and Glaucoma prevalence is notably higher. Areas like Kalallawa Gabai, Murfakalam, and Damakasu emerge as hotspots with a concentration of affected individuals, particularly in the middle-aged and older age brackets. This spatial pattern indicates potential environmental or socio-economic factors contributing to the higher incidence of Cataracts and Glaucoma in these localities. However, the age distribution analysis underscores the importance of age as a determinant of Cataract and Glaucoma prevalence. It emphasizes the need for tailored healthcare services, awareness campaigns, and preventive measures targeting middle-aged and older populations to mitigate the burden of these eye diseases and promote eye health and well-being in Damaturu and similar communities.

The distribution of females affected by Glaucoma and Cataract diseases reveals notable concentrations in Gambir Moduri, Kukareta Warsala, and Nayinawa areas, each registering a value of 12 in the graduated symbology depicting distribution patterns. Conversely, areas on the outskirts exhibit lower numbers of affected females, potentially attributed to reduced outdoor exposure, particularly prevalent among females in Northern Nigeria. However, in regions with higher female prevalence, it's worth noting that rural females may undertake extensive journeys to access water or gather local fuel, like firewood, for household needs. In Figure 06's map, Damakasu stands out as the sole area with an approximately equal ratio of 50% for both males and females affected by Cataract and Glaucoma diseases.

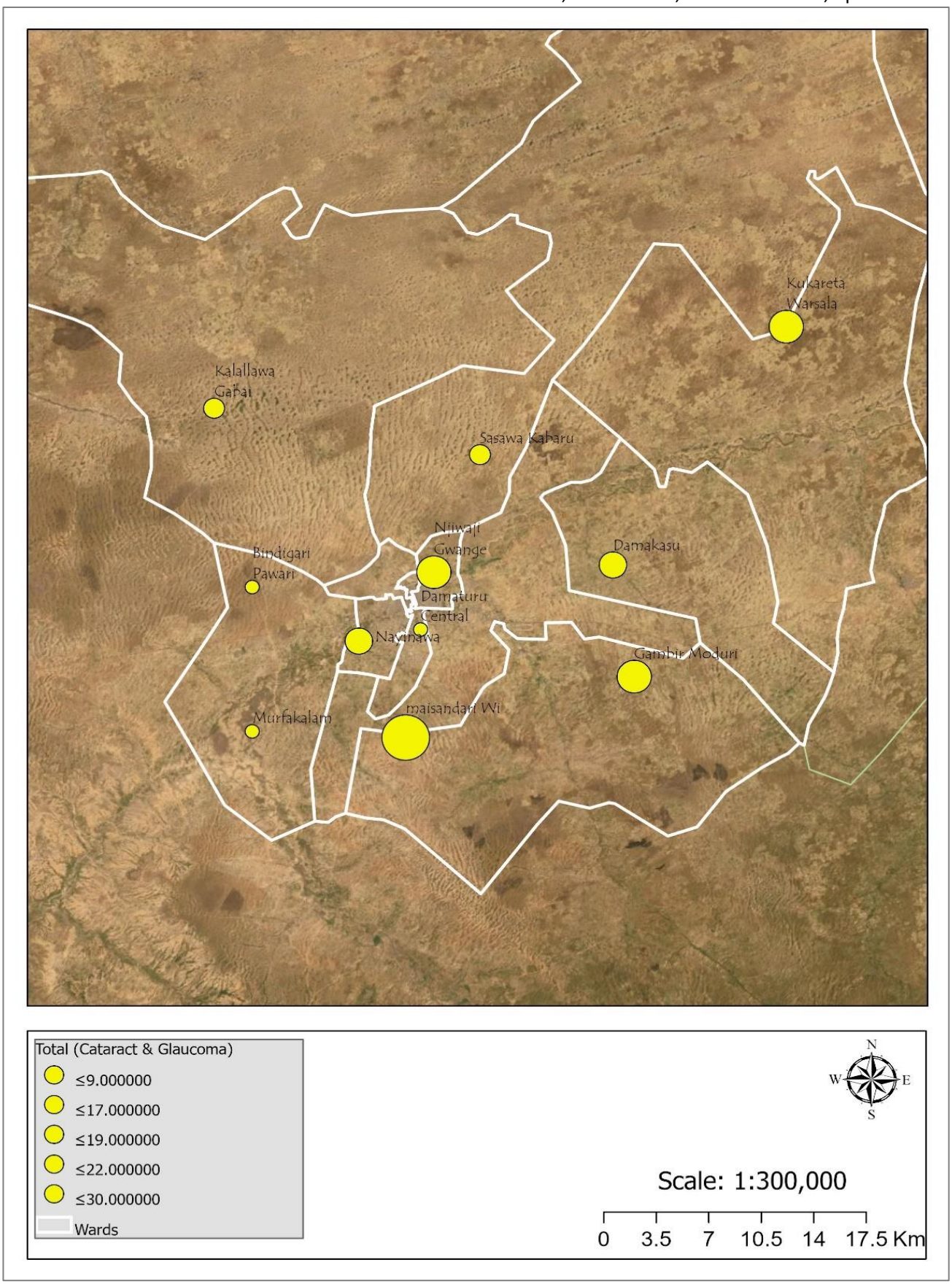

Figure 4: Total Cataract and Glaucoma cases

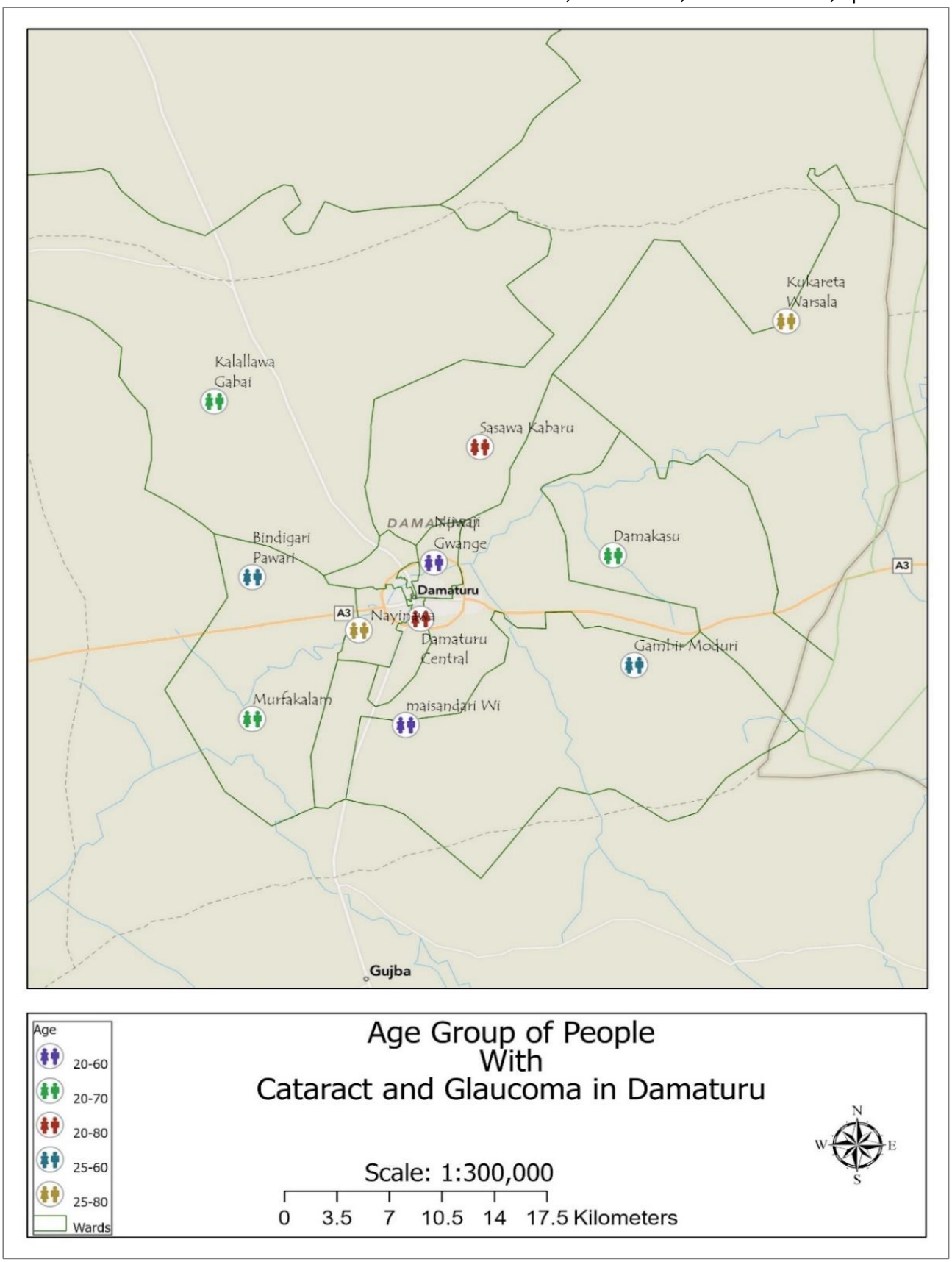

Figure 5: Age group of Cataract and Glaucoma

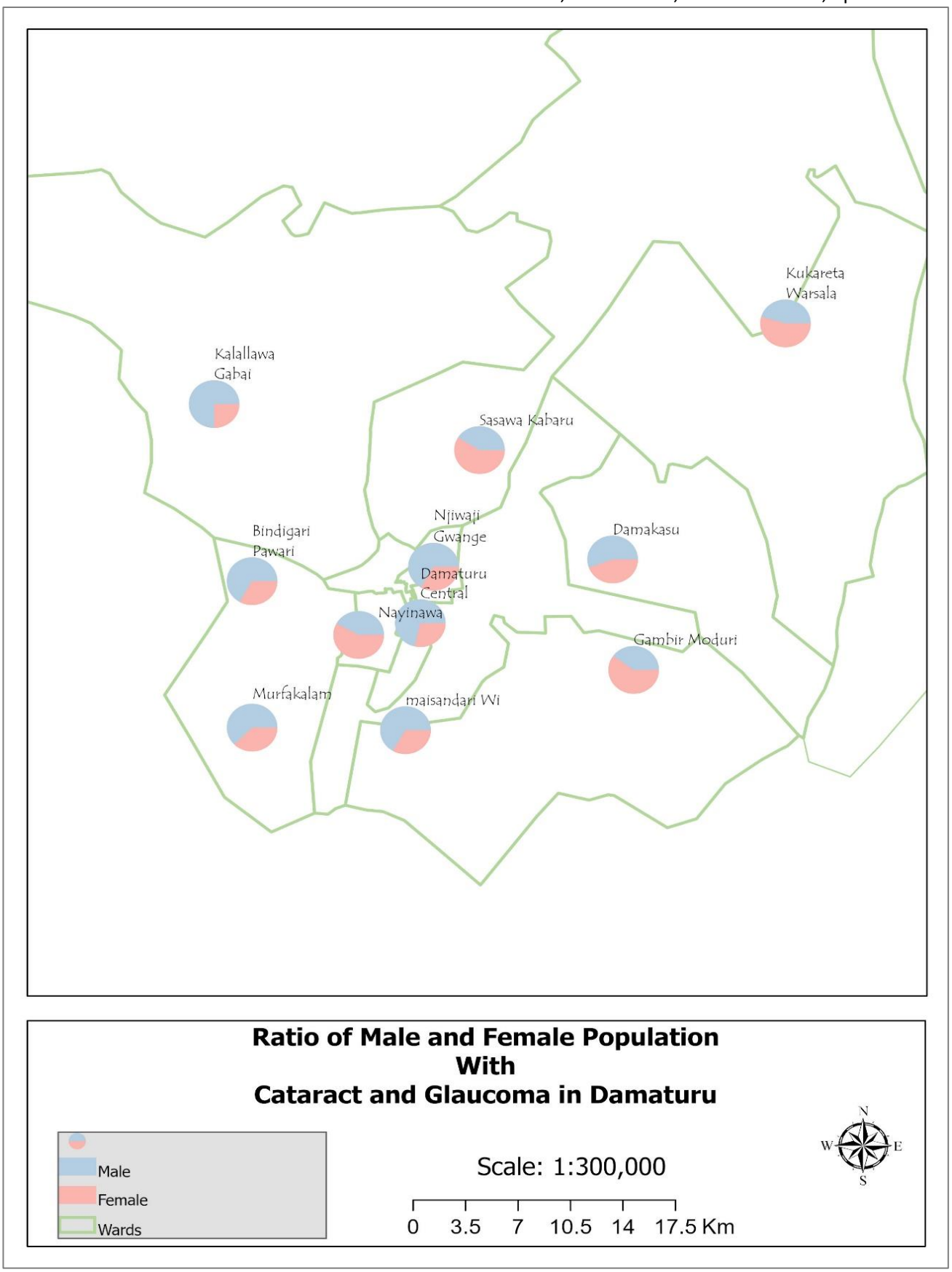

Figure 6: Ratio of male and female population with Cataract and Glaucoma

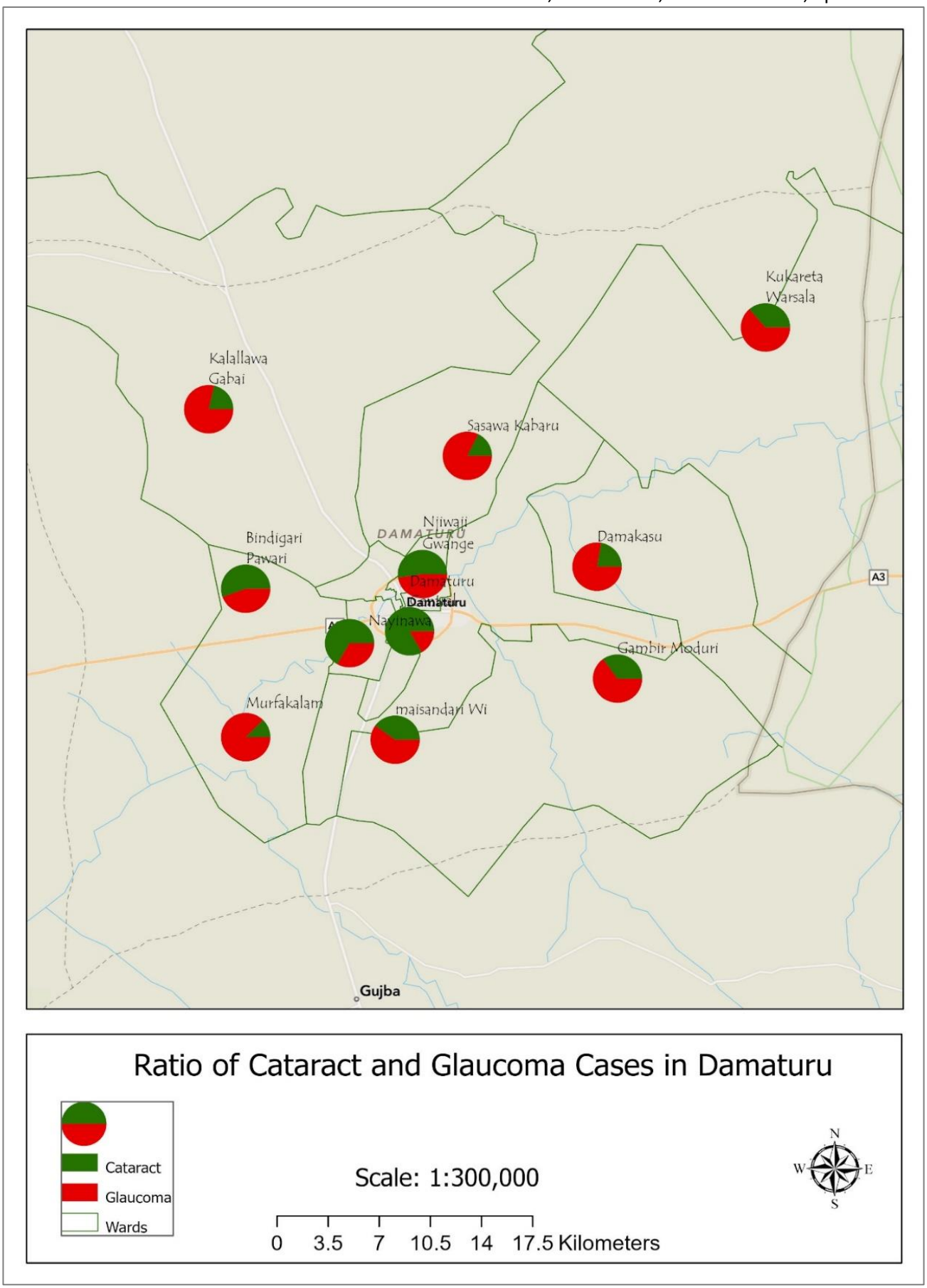

Figure 7: Ratio of Cataract and Glaucoma cases

Upon closer examination of the chart distribution, it's evident that blue-colored sections representing males cover larger areas compared to the female population, which typically ranges from 2 to 12. In contrast, the male population affected by both Cataract and Glaucoma exhibits a wider range, spanning values from 5 to 20. Figure 4 illustrates this distribution, with higher concentrations of cases observed in Maisandari Wi, Gwange, and Kalallawa Gabai, while the central area and Murfakalan record the lowest number of males affected by these diseases in Damaturu. The disparity in numbers can be attributed to the outdoor nature of many male occupations, particularly in Northern Nigeria. Young men from lower-income backgrounds often engage in motorcycle taxi businesses, locally known as Okada or Machine. These activities require prolonged periods of riding, exposing riders to intense dust and air pressure, especially during dry, windy harmattan seasons. While some may wear sunglasses for minimal eye protection, others engage in activities like selling food items or essentials using wheelbarrows or pushing water trucks, involving extensive walking distances. These environmental factors significantly contribute to eye strain and exposure to dust and dirt, exacerbating eye health issues, particularly during harsh weather conditions prevalent in the region.

The analysis of disease distribution patterns in Damaturu, specifically focusing on Cataract and Glaucoma cases across different areas, reveals intriguing insights into the epidemiology of these eye diseases within the community. Out of the 11 areas where both diseases are recorded, there is a notable discrepancy in the incidence rates of Cataract and Glaucoma, with Glaucoma cases prevailing in the majority of locations. Interestingly, only two locations stand out with a higher incidence of Cataract cases compared to Glaucoma disease. These areas are Nayinawa and Damaturu Central, as illustrated in Figure 7. The higher prevalence of cataracts in these regions may be attributed to various factors such as age, demographics, genetic predisposition, and environmental influences. Further investigation into the specific characteristics of these areas could provide valuable insights into the drivers of Cataract prevalence.

Conversely, two other areas, Bindigari Pawari, and Njiwaji Gwange, exhibit an almost equal distribution of Cataract and Glaucoma cases, with approximately a 50-50 share for both diseases. This balanced distribution suggests a more uniform impact of both Cataract and Glaucoma within these localities, indicating a potential correlation between disease prevalence and certain community factors or health determinants. The remaining seven areas in the analysis demonstrate a higher prevalence of Glaucoma disease compared to Cataract cases. Among these areas, Sasawa Kabaru and Murfakalan emerge as hotspots with the highest concentrations of Glaucoma cases, particularly noticeable on the outskirts of Damaturu. These areas are characterized by smaller settlements and larger expanses of bare land, contributing to a dusty and potentially more polluted environment. The dusty surroundings in these peripheral areas may play a role in the higher prevalence of Glaucoma, as environmental factors like dust particles can impact eye health and contribute to eye diseases.

In essence, the disparity in disease distribution between Cataract and Glaucoma cases underscores the varying epidemiological patterns and potential environmental influences on eye health within Damaturu. The higher prevalence of Glaucoma in areas with smaller populations and dusty surroundings suggests a need for targeted interventions and public health initiatives focusing on eye care and environmental health in these specific locations. Further research and data analysis could delve deeper into the underlying factors driving disease distribution and inform strategies for disease prevention and management in the community.

The integration of road network data into the analysis provides a comprehensive perspective on the distribution of Glaucoma and Cataract cases in Damaturu, offering insights into the environmental and infrastructural factors influencing disease prevalence. One notable observation is the dense distribution of residential routes around the central area, indicating a higher population density in these regions compared to other areas. This higher density corresponds with the elevated incidence of both Glaucoma and Cataract cases, highlighting the potential impact of population density on disease prevalence. Moreover, these densely populated regions are not only characterized by a dusty environment and strong winds but also by increased exposure to harmful fumes from vehicular emissions and other activities that release smoke particles into the air. The combination of these environmental factors contributes significantly to the elevated prevalence of Glaucoma and Cataract cases observed in these areas. The presence of these risk factors underscores the importance of addressing environmental pollution and promoting clean air initiatives to reduce the burden of eye diseases in densely populated urban areas like the central region of Damaturu.

Conversely, areas such as Kukareta Warsala, which are characterized by unclassified road networks primarily serving as local routes connecting communities, exhibit lower population densities and fewer settlements. These regions are surrounded by large expanses of dry environments, which further exacerbates the conditions conducive to the development of Glaucoma and Cataracts. The combination of dusty surroundings, limited vegetation cover, and fewer human settlements creates an environment where environmental stressors are more pronounced, contributing to the higher prevalence of eye diseases in these peripheral areas.

However, the integration of road network data highlights the complex interplay between population density, environmental factors, and disease prevalence in Damaturu. Addressing these factors requires a multifaceted approach that includes environmental conservation, urban planning strategies, and public health interventions aimed at reducing exposure to harmful

pollutants and promoting eye health awareness. Such initiatives can contribute to mitigating the impact of Glaucoma and Cataracts in both densely populated urban centers and peripheral regions with distinct environmental challenges.

CONCLUSION

A notable prevalence of both cataract and glaucoma cases was found among the patient population under research, according to the findings of the examination of the spatial distributive patterns of cataract and glaucoma cases. 75 cataracts and 112 glaucomas were identified in the 187 participants that took part in the study. This distribution underscores the significant burden of these eye conditions within the community and emphasizes the importance of addressing them effectively. The analysis also identified specific areas within Damaturu LGA that exhibit high prevalence rates of cataract cases. Through interpolation and hotspot analysis techniques in ArcGIS, these hotspot areas were pinpointed, providing valuable information for targeted intervention strategies. The spatial analysis of the spatial distribution of these eye conditions is crucial for healthcare planning and resource allocation, particularly in areas with higher disease burdens.

Furthermore, the study highlights the critical role of early diagnosis and intervention in managing cataracts and glaucoma effectively. Timely referral of at-risk patients to eye specialists for consultation and comprehensive eye tests is essential for early detection and appropriate treatment. This emphasizes the importance of strengthening primary healthcare services and improving the referral system to ensure that patients receive timely and adequate care. As such, it recommends advocacy about eye health and the importance of regular eye check-ups, particularly among at-risk populations. Establishing healthcare centers equipped to handle eye conditions and providing proper follow-up care for patients are also essential strategies to reduce the prevalence and control these eye conditions effectively. However, this study contributes valuable insights into the spatial epidemiology of cataracts and glaucoma in Damaturu LGA, highlighting areas of high prevalence and emphasizing the importance of early detection, intervention, and comprehensive healthcare strategies to address these eye conditions comprehensively. The integration of GIS mapping with epidemiological data offers a robust model for future studies on spatial health disparities. The study equally highlights the significant role of environmental factors in eye health, emphasizing the need for environmental health policies.

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