

An Assessment of the Threats and Vulnerabilities to Biodiversity in Ghana

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Graphical Abstract



The three main threats and vulnerabilities to biodiversity in Ghana are:

- Overexploitation of natural resources
- Population growth
- Climate change

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Abstract

All organisms are adapted to specific climatic conditions, and any substantial alteration in these conditions can threaten the survival of numerous species. This study examined the threats and vulnerabilities to biodiversity in Ghana, using 15 identified potential threats: overexploitation of natural resources, population growth, climate change, urbanisation, infrastructure development, poor resource governance, pollution, soil erosion, habitat loss, flooding, wildfires, eutrophication, sedimentation, siltation, and invasive alien species. A descriptive quantitative design was employed using a convenience sample of 50 respondents. Data were collected through a structured questionnaire developed from previous studies and validated using Cronbach's Alpha. Analysis of the threat ratings showed that mean scores ranged from 4.02 to 4.53, indicating that all threats were perceived as significant, although their severity differed. Overexploitation of natural resources emerged as the most critical threat (MS = 4.53; SD = 0.546), followed by population growth (MS = 4.49; SD = 0.621). Climate change ranked third (MS = 4.43; SD = 0.651). These threats were further exacerbated by urbanisation, poor resource governance, and pollution. Effective strategies, with an emphasis on habitat protection, forest conservation, and community awareness, are crucial in mitigating biodiversity loss in Ghana. The study provides important evidence to guide policymakers, conservationists, and other stakeholders in addressing the growing threats to biodiversity in Ghana and similar developing countries.

Keywords: Biodiversity; Climate Change; Overexploitation; Population Growth; Urbanisation.

1.0 Introduction

The concept of biodiversity has sparked significant discussion and confusion among the general public, policymakers, and even scientists. Since its introduction at the National Forum on Biodiversity in September 1986, a substantial amount of literature has emerged on the topic, with the forum's proceedings later published as the best-selling book 'Biodiversity' [44]. Accordingly, biodiversity refers to the complete variety of life forms that exist on Earth [4, 25]. It encompasses the diversity found within species (genetic diversity), among different species (species diversity), and across ecosystems (ecosystem diversity). While the term "biodiversity" is commonly associated with the natural environment and its conservation, it broadly includes all living organisms, their habitats, and the intricate ecological systems they form [58]. This definition highlights biodiversity as a measure of variability among organisms from terrestrial, marine, and other aquatic ecosystems. In simpler terms, biodiversity is the total richness of life forms in a specific region, ranging from plants and animals to microorganisms [38]. This can apply to localised areas, entire countries, continents, or even the entire planet.

Biodiversity forms the foundation of human survival and economic growth. It is essential for maintaining ecological balance, which is crucial for sustaining the vast diversity of life on Earth [4]. By supporting the functionality of ecosystems, biodiversity provides critical services that sustain life and ensure environmental stability. These include nutrient cycling, water purification, soil formation and retention, resilience against invasive species, plant pollination, climate regulation, and control of pests and pollutants. Beyond its ecological significance, biodiversity offers numerous non-material benefits. It enriches human lives by contributing to cultural diversity, providing spiritual inspiration, and fostering aesthetic appreciation. These values are deeply embedded in knowledge systems, traditions, and artistic expressions, influencing the works of musicians, painters, writers, and other creative individuals [9].

Therefore, the importance of understanding and appreciating biodiversity at all levels cannot be overstated. Its conservation is not only an environmental priority but a global responsibility, as the health of the planet and human well-being are intrinsically linked to the vitality of ecosystems. A deeper awareness of biodiversity's values fosters a more harmonious relationship between humanity and nature, encouraging sustainable practices for the benefit of current and future generations [28]. The term climate describes the long-term patterns of weather in a specific area over an extended period [22]. It encompasses various factors, such as average temperature, levels of precipitation, number of sunny days, and other measurable conditions observed at a particular location. However, the Earth's climate is not static; it is influenced by both natural processes and human activities, leading to variations and long-term changes [10]. These shifts can result from natural phenomena, such as volcanic eruptions, solar radiation fluctuations, or variations in the Earth's orbit. More prominently, human activities, including deforestation, the burning of fossil fuels, and industrial processes, have accelerated climate change in recent decades. Such anthropogenic activities increase greenhouse gas concentrations, trapping more heat in the atmosphere and driving global temperatures upward [13, 59].

The effects of climate change can manifest over varying time scales, from decades to millions of years. These changes are not just incremental but often transformative, reshaping ecosystems and affecting biodiversity. As climate conditions shift, entire ecosystems—comprising plants, animals, and microorganisms—may experience disruptions. Species that cannot adapt or migrate to favourable conditions face the risk of extinction, leading to a cascading effect on ecological balance. Climate change impacts extend beyond ecosystems, influencing human societies, economies, and health. Rising sea levels, increased frequency of extreme weather events, and changing agricultural productivity are direct consequences. These changes underscore the need for global awareness and collective action to mitigate and adapt to the challenges posed by climate change [42]. Plants and animals are highly sensitive to changes in temperature, as organisms face stress when temperatures exceed their optimal range, leading to widespread cascading effects throughout the ecosystems [35, 57]. Historical evidence of organic evolution indicates that significant and rapid climate changes have often coincided with mass extinctions of various plant and animal species [3]. Consequently, [34] postulate that rapid climatic shifts can lead to phenomena such as increased disease outbreaks, landslides, and forest fires, which contribute to the destruction of ecosystems and biodiversity.

All organisms are adapted to specific climatic conditions, and any substantial alteration

in these conditions can threaten the survival of numerous species. While not all species are directly affected by environmental changes, their interactions with other species can create indirect effects that are just as impactful. For example, a species that shifts its range due to climate change may enter the habitat of another species, leading to new competitive dynamics or invasive relationships [16]. There is a well-recognised dynamic interaction between climate change and biodiversity, particularly in relation to ecosystem services and adaptation [49]. Climate change can result from natural factors or human activities, and when it occurs, it profoundly affects biodiversity, agricultural productivity, food security, and ecosystems [43, 53]. Accordingly, these changes have led to the migration, extinction, and even death of endemic species of flora and fauna [37]. The effects of climate change on biodiversity are profound and cannot be overstated. Biodiversity responds to climate change in various ways, with the impacts differing between terrestrial and marine environments, as well as among different species of plants and animals [62]. Currently, climate change is already influencing biodiversity and is expected to become an increasingly significant threat in the future. For example, the loss of Arctic Sea ice poses a severe threat to biodiversity across entire biomes and beyond [41]. Additionally, ocean acidification, driven by rising atmospheric carbon dioxide levels, is an emerging issue with observable effects [19]. Ecosystems play a vital role in climate change adaptation, as some of their services can help mitigate the impacts of extreme events and disturbances like wildfires, floods, and droughts. This role is particularly important in regions highly vulnerable to climate change, such as the African continent, where adaptation efforts are constrained by numerous geographic and socio-economic factors [11].

According to [45], Africa boasts an extraordinary wealth of biodiversity, hosting approximately one-fifth of all known species of mammals, birds, and plants, as well as one-sixth of the world's reptiles and amphibians. The continent is home to some of the planet's most diverse and ecologically significant ecosystems, including savannahs, tropical forests, coral reefs, marine and freshwater habitats, wetlands, and montane ecosystems. These ecosystems play a crucial role in supporting African communities by providing a wide range of benefits, collectively referred to as ecosystem services [24]. Biodiversity loss can have detrimental effects on Ghana's economy and development goals. Many communities in Ghana rely on natural resources for their livelihoods, such as agriculture, fisheries, and ecotourism. Therefore, the objective of the study is to examine the threats and vulnerabilities to biodiversity in Ghana. This study holds significant importance in informing policymakers, conservationists, and stakeholders about the urgent need to address the impacts of biodiversity loss in Ghana. By identifying key threats and vulnerabilities, the study aims to guide the development of targeted strategies for biodiversity conservation and climate change adaptation. Understanding the impacts of climate change on biodiversity will enable policymakers to integrate conservation into sustainable development strategies, ensuring long-term economic prosperity while preserving natural capital. Ghana is vulnerable to the adverse effects of biodiversity loss. Assessing the threats to biodiversity could provide insights into ecosystem resilience and adaptation strategies. By promoting ecosystem-based adaptation approaches, such as habitat restoration and sustainable land management, Ghana can enhance its resilience to climate change while supporting biodiversity conservation. By synthesising research findings into actionable recommendations, this study can influence policy formulation and implementation at national and regional levels. It can also facilitate collaboration among stakeholders, including government agencies, NGOs, and local communities, to develop effective strategies

for biodiversity conservation.

2.0 Materials and Methods

2.1 Study Area

Ghana's ecosystem is diverse, characterised by two main terrestrial biomes: tropical high forest and savannas [23, 26]. These are further divided into six agro-ecological zones: Sudan, Guinea, and Coastal Savannas; Forest-Savannah Transitional; Semi-deciduous Forest; and High Forest zones (see Figure 1), which vary based on climate, vegetation, and soil [6]. This diversity supports rich biodiversity, including a wide variety of plant and animal species, as well as coastal wetlands and mangrove systems. However, biodiversity is being lost in Ghana, primarily driven by deforestation due to logging, agriculture, and demand for fuel wood, along with habitat destruction from mining, overfishing, hunting and illegal small-scale gold mining [40]. These direct pressures appear to be exacerbated by indirect factors, such as poverty, weak governance, and climate change, which threaten food security, livelihoods, and ecosystem services.



Figure 1: Ecological Zones in Ghana. Source: Asare-Nuamah & Botchway (2019).

2.2 The Study Design and Data Collection

The study adopted a descriptive research design with the quantitative approach. This is because the descriptive research design permitted the researcher to provide a detailed description of the population and findings [18, 61]. Additionally, the approach facilitated

the provision of precise and valid information on the threats to biodiversity in Ghana and other geographical settings, and allowed the researcher to employ suitable statistical tools like SPSS and MS Excel for analysing the collected data and presenting the findings. Furthermore, the sample frame for the study was made up of government officials and non-governmental organisations (NGOs)/civil society organisations (CSOs), development experts, and policy analysts in climate change and biodiversity. Subsequently, the study adopted the convenience sampling technique to engage with the relevant experts, government officials, and civil society organisations. A target sample size of 50 respondents was selected conveniently to participate in the study. A convenience sampling was adopted because the target population, experts in climate change and biodiversity, is difficult to access through other methods. Therefore, the researcher admits that a convenience sampling technique carries a high risk of bias because the sample is unlikely to be representative of the entire country [30]. Though the sample size was small, it had statistical significance, as the respondents were experts in biodiversity and climate change. The data for the study were entirely quantitative and primary.

The primary quantitative data were collected using a questionnaire. The questionnaire was developed from previous studies published in reputable journals. The entire questionnaire was divided into two sections; the first section collected relevant demographic data from the respondents using four (4) items. In the second section, data on the threats and vulnerabilities to biodiversity in Ghana were presented using 15 potential threats identified from previous studies. The identified potential threats were overexploitation of natural resources, population growth, climate change, urbanisation, infrastructure development, poor resource governance, pollution, soil erosion, habitat loss, flooding, wildfires, eutrophication, sedimentation, siltation, and invasive alien species. To validate the questionnaire, all the questions with a scale were subjected to reliability tests using Cronbach's Alpha. A Cronbach's Alpha of at least 0.700 is acceptable, as it reflects the internal consistency of the research instrument in measuring the same constructs [60]. The data were analysed using Statistical Package for the Social Sciences (SPSS) version 26.0, and the results were presented in themes, charts, and Tables.

3.0 Results and Discussion

3.1 Reliability of the Data

The reliability statistics for the study's objective were measured using Cronbach's Alpha. The Cronbach's Alpha is a measure of internal consistency, indicating how closely related a set of items is as a group, with values ranging from 0 to 1 [33]. The higher values suggest greater reliability, with a commonly accepted threshold of 0.70 or above indicating acceptable reliability. Therefore, the construct "Threats and Vulnerabilities to Biodiversity in Ghana" had a Cronbach's Alpha of 0.840, based on the 15 identified potential threats. This value is well above the threshold, indicating high reliability. It reflected strong internal consistency among the identified threats, indicating that the scale was robust and reliable for measuring the construct.

3.2 Demographic Characteristics of Respondents

Table 1 presents a summary of the demographic characteristics of the 50 respondents involved in the study. In terms of gender, the majority of respondents were male, ac-

counting for 52%, while females were 48%. This indicates a relatively balanced gender distribution, though males are slightly more represented in the sample. Accordingly, the relationship between sex and threats and vulnerabilities to biodiversity primarily refers to gendered impacts and roles, where culturally defined gender roles, responsibilities, and power dynamics influence how different groups perceive, use, and are affected by biodiversity and its loss [5, 15], with [64] positing that while the biological phenomenon of sex (male/female) determines reproductive strategies and thus influences biodiversity itself, the significant link to conservation and threats comes from the social dimension of gender, which highlights how women often bear disproportionate burdens from environmental degradation due to unequal access to resources and decision-making power.

The age distribution showed that the largest group of respondents were within the 31–40 years age group, representing 48%, whereas the 51–60 years age group (4%) formed the minority of respondents, as indicated in Table 1. This suggests that the sample is predominantly composed of middle-aged respondents, which may reflect their active involvement in issues related to biodiversity. There is not a direct relationship where age itself is a threat to biodiversity; rather, human activities, particularly those associated with increasing human population and its associated resource consumption over time, are the primary drivers of biodiversity loss [32, 36]. Over recent decades and centuries, the escalating scale of human development has led to increased habitat destruction, pollution, climate change, invasive species, and overexploitation, accelerating natural extinction rates and decimating biodiversity globally [50].

Regarding the years of work experience of the respondents, the majority had 5–10 years of experience, accounting for 32%, while respondents with less than 5 years of experience (18%) formed the minority, as shown in Table 1. This distribution indicates that the sample included a mix of early-career, mid-career, and experienced professionals, providing a range of perspectives regarding the threats and vulnerabilities to biodiversity in Ghana. Work experience and threats to biodiversity are related because human work, especially in construction, resource extraction, and industry, directly causes habitat destruction, pollution, and resource depletion, which are the main drivers of biodiversity loss [39]. Anthropogenic activities like land-use change, deforestation, and overexploitation, often driven by economic and societal demands tied to work and industry, disrupt ecosystems and push species toward extinction. Furthermore, regarding the level of education of the respondents, the majority held postgraduate degrees (48%), whereas the lowest level of education was a diploma/HND (14%), as indicated in Table 1. This shows that the respondents were highly educated, thereby positioning them to provide the appropriate responses to the research questions. Higher levels of formal education are generally linked to more positive attitudes and behaviours towards biodiversity conservation, as education helps people understand the importance of biodiversity, ecosystem services, and the impacts of human activities, fostering an informed and critical populace capable of taking action to protect the environment [39]. However, [21] indicates that a significant knowledge-action gap often exists, where concern does not translate into behaviour, indicating that effective education must also focus on behavioural change and empowering individuals to act.

Table 1: Distribution of Respondents' Demographic Characteristics

Demographic Characteristics	Frequency (N=50)	Per cent (%)
Gender		
Male	26	52
Female	24	48
Age in Years		
20–30	10	20
31–40	24	48
41–50	14	28
51–60	2	4
Years of Work Experience		
<5 years	9	18
5–10 years	16	32
11–15 years	12	24
>15 years	13	26
Highest Level of Education		
Diploma/HND	7	14
First Degree	19	38
Postgraduate	24	48

3.3 Threats and Vulnerabilities to Biodiversity in Ghana

Table 2 illustrates the main threats and vulnerabilities to biodiversity in Ghana, based on responses from the 50 research participants. The table includes maximum (Max), minimum (Min), mean, and standard deviation (SD) values for each threat, providing insights into their perceived severity and the level of consensus among respondents. The mean scores ranged from 4.53 to 4.02, indicating that all listed threats were considered significant, though some were viewed as more critical than others. The most severe threat, according to the data, was the overexploitation of natural resources, with a mean score of 4.53 and a relatively low SD of 0.546. This suggests strong agreement among respondents that overexploitation is a major driver of biodiversity loss in Ghana. Indeed, overexploitation of natural resources threatens biodiversity by depleting species populations and damaging ecosystems faster than they can recover, ultimately leading to biodiversity loss [39]. Practices like overfishing, deforestation, and excessive hunting and harvesting reduce species numbers, disrupt food webs, destroy habitats, and diminish ecosystem services essential for human well-being. Examples include the decline of fish stocks, the decimation of rhinoceros populations, and the loss of forests, which contribute to desertification and further biodiversity loss [12].

Population growth followed closely, with a mean score of 4.49 and an SD of 0.621, indicating that it was also widely recognised as a significant pressure on biodiversity, though with slightly more variability by the respondents. Accordingly, human population growth is a significant driver of biodiversity loss because it increases demand for resources like land, water, and food, leading to habitat destruction, pollution, and climate change, which threaten ecosystems and species [17]. A larger population requires more extensive agriculture, urbanisation, and industrialisation, all of which disrupt natural environments

and reduce the capacity of the planet's biotic systems to support diverse life forms.

Climate change was ranked as the third threat to biodiversity in Ghana, with a mean score of 4.43 and an SD of 0.651. This reflects its growing recognition as a critical threat, though the higher SD suggests some differences in perceptions of its immediate impact compared to overexploitation and population growth. Climate change poses a significant threat to biodiversity by altering habitats, increasing the frequency of extreme weather events, and changing climatic conditions that many species cannot adapt to, leading to habitat loss, ecosystem disruption, and heightened extinction risk [43, 47]. This calls for collaborative efforts to mitigate climate change and implement effective conservation strategies. Urbanisation and infrastructure development shared the same mean score of 4.36, but infrastructure development had a higher SD of 0.870, indicating greater variability in how its impact was perceived by the respondents, possibly due to regional differences in development activities. Urbanisation and infrastructure development threaten biodiversity loss by destroying and fragmenting natural habitats, polluting air, water, and soil, introducing invasive species, altering ecosystems, and increasing human pressure on wildlife [8]. These development practices convert natural landscapes into built environments, leading to loss of ecosystem services, shifts in species composition favouring generalists over specialists, and placing species on the International Union for Conservation of Nature (IUCN) red list [29, 54].

Furthermore, poor resource governance and pollution had mean scores of 4.34 and 4.30, respectively, with moderate SDs. These scores highlight governance challenges and pollution as significant but slightly less critical than the top three threats. Poor resource governance exacerbates biodiversity loss by enabling widespread pollution from unsustainable practices like industrial discharge, agricultural runoff, and deforestation, which directly degrade ecosystems, harm species, and disrupt food chains [46], with [52] suggesting that inadequate oversight means that these pollutant sources, along with climate change drivers and overexploitation, can proceed unchecked, leading to degraded soils, polluted waters, and altered habitats, ultimately threatening the health and variety of life on Earth. Soil erosion, habitat loss, and flooding share similar mean scores, ranging from 4.26 to 4.21, with relatively low SDs, suggesting consistent recognition of their impacts on biodiversity. Soil erosion, habitat loss, and flooding are significant threats to biodiversity loss because they destroy or degrade natural environments, disrupting ecosystems and reducing species populations [50]. Soil erosion depletes vital soil nutrients and increases sedimentation in water bodies, harming aquatic life [51], with [31] indicating that habitat loss directly eliminates species' homes, breeding grounds, and food sources, while fragmentation isolates populations and reduces genetic diversity. Additionally, flooding exacerbates erosion and sedimentation, and altered water levels and flow can destroy habitats, displace wildlife, and damage crucial aquatic ecosystems [2]. Lastly, wildfires, eutrophication, sedimentation, siltation, and invasive alien species had mean scores ranging from 4.17 to 4.02, indicating that they were also considered important threats, though slightly less severe compared to the others. The SDs for these threats were moderate, reflecting some variability in their perceived urgency or impact. Accordingly, wildfires, eutrophication, sedimentation, siltation, and invasive alien species are all major threats to biodiversity loss, primarily by altering or destroying habitats, reducing resource availability, and disrupting ecosystem processes [20, 46]. Wildfires cause habitat destruction, while eutrophication and sedimentation lead to water quality degradation and habitat

smothering, and invasive species outcompete native organisms, altering ecosystems and reducing local biodiversity [48].

In general, the findings of the assessment of the threats and vulnerabilities to biodiversity in Ghana revealed a consensus among respondents that overexploitation of natural resources, population growth, and climate change were the most critical drivers of biodiversity loss. Overexploitation, with a mean score of 4.53 and a low standard deviation of 0.546, was perceived as the most severe threat, reflecting its widespread impact on ecosystems through activities such as illegal logging, overfishing, and unsustainable agricultural practices. This aligns with empirical studies that highlight overexploitation as a primary cause of habitat degradation and species decline in Ghana [1, 40]. The strong agreement among respondents indicates the urgent need for stricter enforcement of resource management policies and community-based conservation initiatives to curb these practices. Population growth, with a mean score of 4.49, is also identified as a significant pressure on biodiversity, which is consistent with global trends where increasing human populations drive habitat conversion, resource depletion, and urbanisation [14, 17]. The slightly higher standard deviation of 0.621 suggests some variability in perceptions, possibly due to regional differences in population density or the effectiveness of local governance. Climate change, ranking third with a mean score of 4.43, is increasingly recognised as a critical threat, though its higher standard deviation of 0.651 indicates differing views on its immediate impacts compared to overexploitation and population growth. This variability may reflect the complex and often indirect effects of climate change on biodiversity, such as altered species distributions, increased frequency of extreme weather events, and ecosystem disruptions [56].

Urbanisation and infrastructure development, both with mean scores of 4.36, were also significant threats; however, infrastructure development shows greater variability in responses ($SD = 0.870$). Poor resource governance and pollution, with mean scores of 4.34 and 4.30, respectively, further exacerbated biodiversity loss, highlighting the need for improved regulatory frameworks and pollution control measures. The moderate standard deviations for these threats suggest a consensus on their importance, though their perceived severity may vary depending on local contexts. The findings also show the interconnectedness of climate change and biodiversity loss, as highlighted by empirical studies. Climate change not only exacerbates existing threats such as habitat loss and overexploitation but also introduces new challenges, including shifts in species distributions, increased disease outbreaks, and ecosystem degradation [47]. For instance, the projected changes in precipitation patterns and temperature extremes in regions like the Indian subcontinent have direct implications for Ghana, where similar climatic shifts could disrupt agricultural productivity and water availability [55, 63]. These changes threaten both terrestrial and aquatic ecosystems, with aquatic biodiversity showing particularly low mean scores in the assessment, reflecting the vulnerability of water bodies to pollution, overfishing, and climate-induced stressors [27].

Table 2: Threats and Vulnerabilities to Biodiversity in Ghana

Main Threats and Vulnerabilities	N	Min	Max	Mean	SD
Overexploitation of natural resources	50	3	5	4.53	0.546
Population growth	50	3	5	4.49	0.621
Climate change	50	2	5	4.43	0.651
Urbanisation	50	2	5	4.36	0.640
Infrastructure development	50	1	5	4.36	0.870
Poor resource governance	50	2	5	4.34	0.635
Pollution	50	2	5	4.30	0.689
Soil erosion	50	2	5	4.26	0.570
Habitat loss	50	2	5	4.21	0.587
Flooding	50	3	5	4.21	0.623
Wildfires	50	2	5	4.17	0.702
Eutrophication	50	2	5	4.15	0.625
Sedimentation	50	3	5	4.09	0.545
Siltation	50	2	5	4.04	0.624
Invasive alien species	50	2	5	4.02	0.642

4.0 Conclusion

The study examined threats and vulnerabilities to biodiversity in Ghana using 15 identified potential threats from previous studies. The findings show that all assessed threats were considered significant, with overexploitation of natural resources emerging as the most critical, followed by population growth and climate change. These pressures, intensified by urbanisation, weak resource governance, and pollution, collectively place Ghana's ecosystems under severe strain. Three overarching factors appear to propel these threats: unsustainable exploitation of natural resources, inadequate governance and enforcement mechanisms, and rapid demographic and land-use changes. Addressing these drivers requires targeted, context-specific interventions. In the short term, stricter enforcement of resource management policies, strengthened monitoring systems, and increased community engagement are essential. In the long term, safeguarding biodiversity will depend on integrating sustainable land-use planning, improving governance structures, and enhancing public awareness of ecological risks. These recommendations align with Ghana's National Biodiversity Strategy and Action Plan, particularly its objective to safeguard ecosystems, species, and genetic diversity. The study is limited by its use of convenience sampling and a relatively small sample size of 50 respondents, which may restrict the generalisability of the results. Future research should explore the interactions among these threats and assess their combined impacts on biodiversity in Ghana and other developing countries.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Participants were informed that all data was treated confidentially and would be used for academic purposes and recorded anonymously.

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Conflicts of Interest

The author declares no conflict of interest.

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