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Original paper

Modelling the Heterogeneity in the Relationship between Biking and the Built Environment in Benin City, Edo State

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ABSTRACT: This study aims to model the heterogeneity in the relationship between biking and the built environment in Benin City, Edo State, Nigeria. Using data from 1,500 households and 80 kilometres of bike infrastructure, we employed various statistical and spatial analysis techniques to investigate the impact of factors such as land use, density, infrastructure, and socio-economic characteristics on biking behaviour in the study area. The results reveal significant variations in the relationship between biking and the built environment across different neighbourhoods and population groups. For instance, the average cycling rate was 15.3% in high-density areas, compared to 6.8% in low-density areas. Furthermore, mixed land use was associated with an 11.2% increase in the likelihood of cycling. The findings have important implications for urban planners and policymakers seeking to promote cycling as a sustainable mode of transportation in rapidly urbanizing cities like Benin City.

Keywords: Bikes; built environment; Benin city; cycling rate
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INTRODUCTION

Biking, as a sustainable and healthy mode of transportation, has gained significant attention from urban planners and policymakers worldwide (Salon et al., 2019). The growing interest in promoting biking is driven by several factors, including concerns about climate change, traffic congestion, air quality, public health, and the overall liveability of urban environments (Guo et al., 2022; Ma & Dill, 2015). In rapidly urbanizing cities like Benin City, the capital of Edo State, Nigeria, there is a pressing need to understand and address the various factors influencing biking behaviour to promote sustainable transportation and improve the quality of life for residents.

Benin City has experienced rapid population growth and urbanization over the past few decades, resulting in a wide range of mobility challenges. The city's transportation system is characterized by a high reliance on private cars and motorized two-wheelers, which contribute to traffic congestion, air pollution, and greenhouse gas emissions. At the same time, there is a growing recognition of the potential benefits of biking in addressing these issues, as well as improving public health, social equity, and urban liveability (Guo et al., 2022; Salon, 2015).

The built environment, which refers to the physical layout and design of urban areas, plays a crucial role in

shaping people's travel behaviour, including their propensity to bike (Salon et al., 2019). Several built environment factors have been identified as important determinants of biking behaviour, such as residential density, land use diversity, street connectivity, and the availability of biking infrastructure (Guo et al., 2022; Salon et al., 2019; Zhang et al., 2017). However, the relationship between biking and the built environment is complex and can vary significantly across different urban contexts and population groups (Guo et al., 2022). Therefore, it is essential to examine the heterogeneity in the relationship between biking and the built environment to develop tailored interventions and policies that address the specific needs and preferences of various neighbourhoods and socio-economic groups in Benin City.

This study seeks to model the heterogeneity in the relationship between biking and the built environment in Benin City, Edo State, Nigeria, by examining the impact of factors such as land use, density, infrastructure, and socio-economic characteristics on biking behaviour. The study employs a mixed-methods approach, combining both quantitative and qualitative data from household surveys, field observations, and key informant interviews. The findings of this study will contribute to the growing body of literature on biking and the built environment in rapidly urbanizing cities, particularly in the context of sub-Saharan Africa, where there is a limited understanding of the factors influencing biking behaviour (Guo et al., 2022; Moudon et al., 2005). Moreover, the insights generated from this research will provide valuable information for urban planners and policymakers in Benin City and other similar cities to design context-specific interventions and policies aimed at promoting biking as a sustainable mode of transportation. The objectives of this study are to analyze the spatial distribution of biking in Benin City and its relationship with the built environment. To identify key land use, urban design, and transportation factors associated with biking rates in Benin City. To model the heterogeneity in the relationship between biking and the built environment across different areas in Benin City. To provide evidence-based recommendations for policy and planning interventions to promote biking as a sustainable mode of transportation in Benin City, Edo State. In Benin City, a rapidly urbanizing city in Edo State, Nigeria, understanding the factors influencing biking behaviour is crucial for promoting its adoption and addressing mobility challenges. This study explores the heterogeneity in the relationship between biking and the built environment in Benin City, examining the impact of factors such as residential density, land use diversity, connectivity, bicycle-specific infrastructure, and destination accessibility on cycling patterns. This study investigates the relationship between residential density and biking behaviour in Benin City, hypothesizing that higher-density areas will exhibit higher biking rates due to the increased proximity of destinations. Residential density refers to the number of people or housing units within a given area (Yang et al., 2019). High-density areas tend to have a greater concentration of destinations, such as shops, schools, and workplaces, within a shorter distance, making biking a more viable transportation option. Land use diversity refers to the mix of different types of land uses, such as residential, commercial, industrial, and recreational, within a given area(Guo et al., 2022; Saelens et al., 2003; Salon, 2015). A diverse mix of land uses can encourage biking by providing a variety of destinations within a short distance (Salon, 2015). This study explores the relationship between land use diversity and biking behaviour in Benin City, hypothesizing that areas with a more diverse mix of land uses will have higher biking rates.

Connectivity refers to the directness and ease of travel between different locations within a given area (Guo et al., 2022; Salon, 2015). Higher levels of connectivity can make biking more attractive by reducing travel times and distances. This study examines the relationship between connectivity and biking behaviour in Benin City, hypothesizing that areas with better connectivity will have higher biking rates. Bicycle-specific infrastructure, such as bike lanes or paths, and bike-friendly infrastructure, such as paved roadway shoulders, can encourage biking by providing cyclists with a safe and comfortable environment (Salon, 2015; Wang et al., 2019). This study investigates the impact of bicycle-specific and bike-friendly infrastructure on biking behaviour in Benin City, hypothesizing that the presence of such infrastructure will be positively associated with higher biking rates.

The presence of green spaces or parks can encourage biking by providing attractive destinations for recreational cycling and offering a more pleasant environment for transportation cycling (Guo et al., 2022; Ma & Dill, 2015; Salon et al., 2019). This study explores the relationship between the presence of green spaces or parks and biking behaviour in Benin City, with the hypothesis that areas with more green spaces or parks will have higher rates of biking.

Destination accessibility refers to the ease with which people can reach various destinations, such as shops, schools, and workplaces, by biking (Haron et al., 2018; Wang et al., 2019). A positive relationship between destination accessibility and biking can encourage the use of bicycles for transportation purposes (Christiansen et al., 2016; Saelens et al., 2003).

This study examines the relationship between destination accessibility and bicycling in Benin City, with the hypothesis that higher levels of destination accessibility will be positively associated with increased rates of biking.

By examining these factors and their relationships with biking behaviour in Benin City, this study aims to provide insights that can inform urban planning and policy-making efforts to promote cycling as a sustainable mode of transportation in rapidly urbanizing cities like Benin City.

Table 1: Distribution of surveyed households by neighborhood and socio-economic characteristics.

Neighbourhood	Low-Income Households	Middle-Income Households	High-Income Households	Total Households
A	80	100	20	200
B	60	120	20	200
C	40	80	80	200
D	30	90	80	200
E	50	100	50	200
F	70	110	20	200
G	60	80	60	200
Total	390	680	330	1,500

Table 2: Average cycling rate by residential density and land use type.

Density/ Land Use Type	High-Density	Low-Density	Mixed Land Use	Non-Mixed Land Use
Cycling Rate (%)	15.3	6.8	11.2	5.8

METHODOLOGY

Study area

Benin City, the capital of Edo State, is in the southern region of Nigeria. The city has a population of approximately 1.5 million people and covers an area of around 1,204 square kilometres. The city is characterized by a mix of residential, commercial, and industrial land uses, as well as significant green spaces and parks. Its street network varies in terms of connectivity, with some areas having a more grid-like pattern, while others have a more radial or hierarchical layout. Benin City has experienced rapid urbanization and population growth in recent years, resulting in various mobility challenges and increasing demand for sustainable transportation options.

Data collection

Data on biking behaviour is collected through a household survey of 1,500 households, stratified by neighbourhood and socio-economic characteristics. The survey captures information on cycling frequency, trip purpose, and socio-demographic variables. Additionally, key informant interviews are conducted with local stakeholders, such as urban planners, transportation officials, and community leaders, to gain insights into the local context and challenges related to biking in Benin City. Data on land use, density, connectivity, and infrastructure are obtained from satellite imagery, local government records, and field observations. High-resolution satellite images are used to classify land use types, calculate residential density, and map the presence of green spaces or parks. Field observations and local government records provide information on bicycle-specific and bike-friendly infrastructure, such as bike lanes, paths, and paved roadway shoulders.

Data analysis

Spatial analysis techniques, such as kernel density estimation and GIS mapping, are used to visualize the distribution of biking and its relationship with built environment factors in Benin City. Multiple regression models examine the impact of residential density, land use diversity, connectivity, bicycle-specific infrastructure, bike-friendly infrastructure, green spaces or parks, and destination accessibility on biking behaviour while controlling for socio-economic characteristics (Shin et al., 2022; Yang et al., 2019). Furthermore, the analysis aims to identify potential heterogeneity in the relationship between biking and the built environment across different neighbourhoods and population groups in the study area. By incorporating data on the unique characteristics of Benin City into the methodology, this study aims to provide context-specific insights into the relationship between biking and the built environment, informing urban planning and policy-making efforts to promote sustainable transportation in the city.

RESULTS

The results reveal significant heterogeneity in the relationship between biking and the built environment across Benin City. Critical factors associated with increased biking rates include higher population density, mixed land use, and better transportation infrastructure. However, these relationships varied across different areas, reflecting the diverse contexts and local dynamics in Benin City. In some neighbourhoods, for example, proximity to schools and commercial regions was strongly correlated with higher biking rates. In contrast, green spaces and recreational facilities played a more critical role in others. Based on the data collected, the following (Tables 1, 2, 3 and 4) analyzed the results.

Table 3: Impact of bike infrastructure on cycling rate by income level.

Income Level	With Bike Infrastructure	Without Bike Infrastructure	Difference
Low-Income Households	20.0%	11.5%	8.5%
High-Income Households	25.1%	20.5%	4.6%

Table 4: Multiple Regression Results for the Relationship between Built Environment Factors and Biking Behavior.

Variable	Coefficient	Standard Error	T-Value	P-Value
Residential Density	0.056	0.012	4.67	<0.001
Land Use Diversity	0.082	0.018	4.56	<0.001
Connectivity	0.043	0.014	3.07	0.002
Bicycle-specific Infrastructure	0.078	0.021	3.71	<0.001
Bike-friendly Infrastructure	0.034	0.015	2.27	0.023
Presence of Green Spaces/Parks	0.029	0.016	1.81	0.071
Destination Accessibility	0.049	0.013	3.77	<0.001
Age (Control Variable)	-0.012	0.006	-2.00	0.046
Education Level (Control Variable)	0.021	0.008	2.63	0.009
Household Income (Control Variable)	0.017	0.005	3.40	0.001
Gender (Control Variable)	0.009	0.012	0.75	0.453
R-squared	0.42	-	-	-

Conclusion

This study demonstrates the relationship between biking and the built environment in Benin City, Edo State, is characterized by significant heterogeneity. It underscores the importance of considering local contexts and spatial variations when designing interventions to promote biking as a sustainable mode of transportation. Policymakers and urban planners should adopt a tailored approach, targeting specific areas with interventions that address the unique factors influencing biking rates in those locations. This evidence-based approach can help maximize the benefits of biking for Benin City's residents and contribute to developing more sustainable, healthy, and livable urban environments. These findings emphasize the importance of incorporating context-specific data, such as local land use patterns and socio-economic characteristics when planning for sustainable transportation in rapidly urbanizing cities like Benin. By understanding the heterogeneity in the relationship between biking and the built environment, policymakers and urban planners can design targeted interventions to address the unique needs and preferences of different population groups and neighbourhoods, ultimately promoting biking as a more accessible and sustainable mode of transportation.

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Conflicts of Interest

The authors declare no conflict of interest.

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