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Research article

Bicycle ownership and utilization in Tamale Metropolis; influencing factors and impacts to sustainable transport

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ABSTRACT

The study seeks to identify bicycle ownership and ridership and gain insights into how demographics, perceptions and experiences of respondents influenced the status of cycling in Tamale Metropolis. Earlier studies have focused on examining the determinants of utility cycling among adults in the same metropolis, but this study assesses cycling from a broader perspective in terms of demographics, barriers, and promotional strategies. A cross-sectional survey was carried out with 500 semi-structured questionnaires through mainly a face-to-face approach. Five trained survey assistants administered the questionnaires within demarcated zones in the metropolis and tracked participants by geographic information system. Binary logistic regression, chi-squared test and descriptive statistics were employed in the analysis of the data. Out of the 439 valid questionnaires, bicycle ownership and ridership were 56% and 78% respectively. Gender and occupation were significant in owning and riding bicycles, where $p < 0.05$. Males and the non-income earners (i.e., students, apprentices and unemployed) were more likely to ride and own bicycles. Cycling was prevalent among low-income individuals and in households where bicycles were available. The major motivation of bicycle riders was affordability. Age was statistically insignificant to owning or riding bicycles since every age group cycled as much. Despite the existing infrastructure provision for cycling and its associated benefits, there is a latent desire to shift from bicycles by 85% of the riders. A chi-square test conducted revealed that the desire to shift from bicycle use was independent of one's gender, age and occupation, but associated with bicycle ownership. Moreover, speed, fatigue endured in riding and inadequate infrastructure were mentioned as part of the factors that discourage cycling. This study, therefore, recommends government interventions such as a reduction in bicycle cost, and the introduction of electric bicycles to meet the respondents' transport needs of speed and travelling with less fatigue.

1. Introduction

1.1. Background

A common transport challenge in most sub-Saharan African urban cities is reduced mobility and accessibility. Apart from the lack of adequate transport facilities, poor traffic management and planning and the neglect of multimodal transport system contribute immensely to the transport problems. Non-motorized transport (NMT) such as cycling has been noted to be contributing to meeting the Sustainable Development Goals (SDGs) especially in "improving energy efficiency in the transport sector (Goal 7)"; "making cities and human settlements inclusive, safe, resilient and sustainable (Goal 11)"; and "combating climate change impacts on transport (Goal 13)" (World Bicycle Relief, 2018; World Cycling Alliance and European Cyclists' Federation, 2016; UN-Habitat et al., 2015; UNCG Ghana and CSO Platform on SDGs, 2017). Cycling forms an integral part of sustainable transport in developing countries as it plays several roles in the mobility and accessibility of its users, and the environment by being emission-free (Shaheen et al., 2011; Tiwari et al., 2016). Bicycles, as an NMT, have proven to improve mobility, accessibility and the environment in major cities and suburban areas of countries such as the Netherlands, Denmark, and China (Pucher and Buehler, 2010; Shaheen et al., 2011). In Ghana, despite the benefits associated with bicycles as a means of transport, little effort has been made to sustain and increase its patronage in some urban cities. In developing cities, which Ghana's cities are no exception, cycling is

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utilitarian but has low patronage as a transport mode (Acheampong, 2017; Nkurunziza et al., 2012).

Survey data tracked between 1989 to 2012 for 150 countries around the world revealed that the weighted mean percentage of bicycle ownership ranges from 20% to 81% with some nine countries in Northern Europe and one in West Africa (Burkina Faso) having the highest and 62 countries from West, Central and North Africa and Central Asia having the lowest (Oke et al., 2015). Despite the assertion that ownership of bicycles does not translate into use, in Europe and especially countries like the Netherlands and Denmark, ownership and ridership have been extensively discussed to be very high (Pucher and Buehler, 2008, 2010; Buehler and Pucher, 2012; Tiwari, 2008) if not equivalent.

The Tamale Metropolis made up of 50.2% females and 49.8% males, has a population of 233,252 which represents 9.4% of the Northern Regional population (GSS, 2014). The majority of the populace (80.8%) live in urban areas and the rest in rural areas (GSS, 2014). The metropolis makes a good case study for any agenda that seeks to promote bicycles as a sustainable transport mode in Ghana since it is perceived to be probably the most bicycle-friendly urban environment in the country. The metropolis is also known to be the bicycle hub of the country (Damsere-Derry and Bawa, 2018). The study area covers both the Tamale Metropolis and Sagnerigu Municipality which used to be part of the Tamale Metropolis until 2012 when it was carved out of the metropolis (Fuseini and Kemp, 2016). The study area for this study is simply referred to as the Tamale Metropolis.

Over two decades ago, 60% of traffic volume in Tamale consisted of bicycles (Salifu, 1993; Damsere-Derry and Bawa, 2018). This traffic composition has however changed over time due to the influx of other faster modes of transport such as the motorcycle. Over 90% of all registered vehicles in Northern Ghana are said to be motorcycles (Driver and Vehicle Licensing Authority, 2014; Damsere-Derry and Bawa, 2018), which was not so previously. Additionally, there is the emergence of tricycles use as public transport in Ghana with high patronage in the northern regions although this is considered illegal (Afukaar and Damsere-Derry, 2019; Darfour, 2020). Roadside observations on major corridors of the city suggests that travel for most daily activities is currently dominated by motorcycles, tricycles and shared taxis. However, evidence suggests that there is a fairly large proportion of bicycles ownership and usage in Northern Ghana (SSATP Ghana, 2018). According to the Ghana Living Standards Survey, Round 6 (2014), bicycle ownership in the northern part of Ghana is about 63%, which is higher than the total national ownership of about 20%, (GSS, 2014). Eighty percent of residents of Tamale Metropolis, in the northern part of Ghana, are reported to own bicycles or motorcycles (ASIRT, 2014). The report, however, does not explicitly state how much of the 80% are bicycle owners and whether or not the owners are also riders. Acheampong and Siiba (2018) pointed out a huge cycling potential in a survey in the Tamale Metropolis. The authors reported 51.92 km dedicated bicycle network along principal streets in the metropolis; bicycle ownership of 39% and ridership of 61% among 455 respondents and average cycling distance of 4.7km which are positive factors for the promotion of cycling. However, the authors asserted that non-captive riders of bicycles are discouraged from using bicycles due to the lack of safe and convenient facilities.

Recommendations on infrastructural provision, enforcement of road and traffic regulation and education have been proposed for the promotion of safe and increased cycling in the metropolis (Damsere-Derry and Bawa, 2018; Acheampong and Siiba, 2018) which failed to solicit the needs or views of residents on promotional measures. This can result in poor policy formulation, poor usage or under-usage of the facilities in the metropolis. This study aims to contribute to the promotion of cycling by exploring the perceptions of users and non-users of bicycles in the Tamale metropolis. In particular, this study attempted to 1) examine the influence of socio-demographic characteristics on bicycle ownership and ridership. 2) assess the associations between socio-demographic characteristics of bicycle users and the desire to shift from cycling. 3) identify the key attitudinal factors that influence an individual's decision to cycle as well as shift from cycling. 4) identify the main challenges of cyclists and key promotional measures of cycling in the metropolis. The results of this study will provide useful information to transport planners and engineers, and policymakers that can form the basis of future policies aligned to promoting cycling in Tamale Metropolis which when achieved, will promote good health among riders and increase the sustainability of the environment.

1.2. Trends of non-motorised transport around the world

Sustainable urban transport and mobility play a key role in progressing the achievement of the 2030 agenda on sustainable development and the 17 Sustainable Development Goals (SDGs) especially Goals 7, 11, and 13 (Global mobility report, 2017). There is strong empirical evidence that increased sustainability of urban passenger transport systems can be achieved by reducing private motorized transport and promoting public transport as well as non-motorized transport modes (walking and bicycling). Non-motorised transport is dominated by cycling and walking with walking being the dominant means of transportation in most cities in developing countries. In some African cities, over 80% of trips are made on foot (FiA Foundation, 2016). Cycling, the focus of this study, also provides the mobility needs of cities in Europe and developing countries, especially those in Asia. However, recent trends have seen a decline in cycling in some Asian cities as a result of rising economic levels and associated motorization, as well as changing social perceptions which tend to view cycling as a means of transport for the poor (Tiwari, 2008). Bicycle ownership and ridership is however high in developed countries, particularly in Western European countries such as the Netherlands, Denmark and Germany due to the transport and land-use policies which favour non-motorized and public transport facilities (United Nations Centre For Regional Development, 2018).

In Africa, particularly sub-Saharan Africa, the challenges of non-motorised transport leave much to be desired. The needs of cyclists and pedestrian are often ignored which puts them at risk. They form a large share of traffic accident victims. In Tanzania's capital Dar es Salaam, for example, more than 50% of the population use non-motorised transport, but there is some level of unwillingness in the use of bicycles in the city because of the fear of road accidents resulting from speeding motorized traffic. A study conducted by Damsere-Derry and Bawa (2018) in three northern cities of Ghana reported that 58% of all cyclists' injuries and fatalities were no apparent fault on the part of the cyclists. The authors further posited that of all the fatal cyclist's accident victims, 64% of the riders was not at fault with regards to their crashes. These findings indicate how vulnerable cyclists are in most developing countries. Although cycling and walking are important means of transport for low-income travellers in Africa, the infrastructure is most often not in existence or poorly designed and constructed if provided. The share of bicycles in the transport modes in Africa is therefore very low compared to other Asian and European countries. While 47% of Nairobi residents walk to their places of work, only about 4% use bicycles. The share of cycling was reported to be only 3% in Dar es Salaam which increased to 5% in 2007 (Pendakur, 2005; Green Africa Foundation and UN Habitat 2014). India however has a high household bicycle ownership rate which reflects in relatively high modal share of cycling in cities such as Delhi (12%) and Ahmedabad (14%) (United Nations Centre For Regional Development, 2018). In recent times, in some European cities such as Copenhagen or Amsterdam, over 60% of all road users are cyclists (Makarova et al., 2017). Contrary to the developed countries, investment in transport facilities and transport policies in most African countries appears to focus on the minority who can afford motorized transport at the neglect of the needs of non-motorised transport users. For instance, only 10% of African countries (e.g., Nigeria, Kenya, Ghana, Uganda and Tanzania) have been able to develop policies for promoting non-motorised transports (cycling and walking) compared with 64% in

Europe (FiA Foundation, 2016; Wold Highways, 2016; Movin'On LAB, 2018). In Ghana, however, although most cities have transport plans they do not have an existing bicycle masterplan (UN HABITAT, 2011). Not only is the lack of adequate infrastructure a challenge to cycling in Africa, but also attitude and culture. In Kenya for instance, there exist some negative attitude among the urban youth towards walking and cycling. These modes are seen as a sign of poverty and low class whilst most of the urban youth want to be associated with a high standard of living (Movin'On LAB, 2020).

Cycling is associated with a wide spectrum of benefits including health and environmental benefits (Tapp et al., 2016; Bardi et al., 2019; Jarret et al., 2012; Rojas-Rueda et al., 2011). Encouraging its use could therefore contribute to achieving the global goals of providing sustainable transport and a green environment. Some efforts and initiatives have been made in promoting cycling in Africa which are not enough. For example, cycling is promoted at the University of Nairobi through a bicycle-sharing scheme (Movin'On LAB, 2020). In Ghana, through the Ghana Bamboo Bikes Initiative, one bicycle is donated to a student in a rural community for every bicycle purchased (Whiting, 2020). In Nigeria, AwaBike, an android based bicycle-sharing application commonly used by university students is used in searching for available bicycles, making payment, unlocking bicycles, and locking them after use (Technext, 2019).

2. Impact of socio-demographics on cycling

2.1. Gender

Earlier studies have suggested that there are large differences among countries with regards to cycling rates between males and females. In Netherland, Germany and Denmark, females cycle as often as males (Pucher et al., 2011; Buehler and Pucher, 2012; Ton et al., 2018). However, in countries where gender is significant to cycling (e.g., USA, Canada, the UK and developing countries), mostly women have been found to withdraw from cycling due to the seeming danger of riding in motorised traffic and in other cases where cultural barriers tend to masculinise women cyclists (Grieco et al., 1994; I-ce, 2008; Buehler and Pucher, 2012; Acheampong and Siiba, 2018). Quarshie (2004) reported in his study conducted in Accra that ownership among men is higher than females. However, he asserted that the females used the bicycles for short distance errands and not for work or school as in the case of the males. Emond et al. (2009) in their study sought to gain an understanding of how gender influences the decision to use a bicycle in the USA by employing a binary logistic regression approach. The authors reported bicycling behaviour to be strongly influenced by gender, along with certain individual, social and environmental factors. The situation is not different in many parts of Africa which include the Tamale metropolis in Ghana. Angie (2017) states that, "In many parts of Africa, such as rural Ghana, it is rare to see a woman cycling. According to a study on Ghana, co-authored by Professor Gina Porter, this is because of male attitudes towards women cycling and the fact that many women simply do not have the time to learn to ride bicycles in addition to their chores." Cycling policies fails due to their inability to address the cultural issues related to women (Grieco et al., 1994). Similarly, Sarrica et al. (2020) asserts that the lack of regard for cultural and social issues regarding especially cycling, hinders its growth and result in related policy failure.

2.2. Age

Age has been seen as a determinant of the rate and the choice to cycle. Although children and adolescents have the highest rates of cycling in almost every country, the Dutch, Danish and German elderly cycle almost as much (Pucher and Buehler, 2008; Buehler and Pucher, 2012). Acheampong and Siiba (2018) mentioned that, in the Tamale Metropolis, people shifted to motorised modes like motorcycles in the later stages of their lives to show elevated living condition or due to weakness to ride. According to a World Bank urban transport strategy review: cities on the move, nearly all secondary-level school children in Vietnam go to school by bicycle, while motorcycles are rapidly taking the place of the bicycle as a means of transport for the age group, 25 to 35. Also, Rahul and Verma (2013), based on a logistic regression model, reported that old people (age greater than 50) had a 92% less chance of using a bicycle in Bangalore city.

2.3. Income

Cycling rate is said to be not different among the various income classes in developed countries like Denmark and the Netherlands (Pucher and Buehler, 2008; Fishman et al., 2015). The case is however different for most developing countries where income is said to play a vital role in peoples' choice to cycle (I-ce, 2008; Tiwari, 2008; Acheampong, 2017). For some poor countries and towns that depend solely on foot for transport, bicycles are luxuries that are unaffordable to the middle-income earners whilst for other developing countries, bicycle users develop out of cycling due to its association with poverty, low-tech and lack of innovation (Tiwari, 2008).

Engagement of citizenries and determination of demographic impacts on cycling have formed the basis for good policy decisions which have seen the growth of cycling and non-abandonment of bicycle infrastructure. Such good policies like the reduction of cost of bicycles, incorporation of cycle infrastructure into town planning, motorised vehicle restrictive measures (I-ce, 2008; European Union, 2015) have led to the declaration of a country like Denmark as one of the safest and most pleasant countries to walk or cycle in (UN Environment, 2016). Dar-es-Salaam, a developing city in Tanzania, is said to have increased bicycle mode share from 3% in 2002 to 5% in 2007 (Nkurunziza et al., 2012; Green Africa Foundation and UN-Habitat, 2014) mainly by creating public awareness through educational programmes that highlight the importance and benefits of cycling. This substantiates the suggestion of using education as one way of dealing with poverty tagging of bicycles in developing countries by Verma et al. (2016).

3. Materials and methods

3.1. Questionnaire design

The study adopted a cross-sectional questionnaire survey to examine bicycle ownership and utilization, and the socio-demographics of participants. The target respondents were individuals in the Tamale Metropolis comprising of both cyclists and non-cyclists of all ages and gender. Individuals were expected to affirm or deny personal ownership of bicycles and declare whether they currently ride or not. Those who affirmed riding were expected to be daily bicycle users for all trips or seldom users of bicycles within the week, whilst those who denied usage were expected to be individuals who do not use bicycles for any purpose currently. Four basic social demographics: age, gender, occupation and income, which have been widely discussed in some jurisdiction were considered. Individuals were expected to choose one major option under each demographic with anticipation of multi-occupational individuals. All demographics were made to be self-explanatory, however, the survey assistants were trained to understand each question on the questionnaire to enable them to translate the questions to the local language to some of the respondents. Concerning the variable, "occupation", students represented respondents who are schooling and are at an educational level between kindergarten and higher learning. Unemployed referred to people with no form of work or apprenticeship whilst apprentice referred to anyone under informal skill-training. Government workers referred to those employed in government institutions whilst private businessmen referred to all types of entrepreneurs and finally, labourers referred to free-lance labourers.

Questions that sought for respondents attitudes – opinions, perceptions and experiences – were semi-structured to allow participants to

express their views outside the provided options. Further, cyclists answered questions mainly on challenges, motivation, trip origins, destinations, frequencies and views on bicycle mode shift. Non-cyclists, however, answered questions mainly on barriers that prevented them from cycling and measures that can promote their interest in cycling. Concerning bicycle mode shift, users were asked the question, "*Do you desire to shift mode from cycling to other modes?*". The response options were either "*Yes*" or "*No*".

Respondents were presented with five different multiple response questions. The first one which concentrated on influential factors of bicycle mode shift was presented as, "*what will make you shift from bicycle to other modes?*" and its response options are listed below:

i. *Ability to afford other modes like motorbikes*
ii. *Ability of other modes to travel long distance without getting tired*
iii. *Ability of other modes to travel faster*
iv. *Ability of other modes to carry luggage or entire household for trips*
v. *The safety of other modes*
vi. *Others*

On measures of promoting cycling, respondents were asked the question, "*what will promote the use of bicycles in Tamale Metropolis?*" and the response options were:

i. *Provision of more, continuous and dedicated lanes for cyclist*
ii. *Provision of streetlights along cycle routes*
iii. *Creation of public awareness on cycling relevance and the need for giving them priority*
iv. *Provision of adequate and secured parking facilities*
v. *Reduction in the cost of bicycles*
vi. *Provision of electric bicycles (faster bicycles)*
vii. *Others*

Another question – "*why do you choose bicycles over other modes?*" – was asked to obtain information on their choice of bicycles over other modes. Respondents were presented with these response options:

i. *It is affordable*
ii. *It is the only available means of transport*
iii. *It is a convenient mode in avoiding congestion*
iv. *It is a means of exercise to keep me healthy and fit*
v. *It does not pollute the environment*
vi. *Others*

Questions on challenges of cyclists and non-cyclists views were formulated with their respective response options like:

"What are your challenges as a cyclist?"

i. *Poor road surface condition*
ii. *Poor or inadequate connectivity in the bicycle network*
iii. *Careless behaviour and lack of regards of drivers for cyclist*
iv. *Negative or poor image of the community for cyclist*
v. *Others*

"What is your reason for not cycling? (Non-cyclist views)"

i. *I prefer a faster mode*
ii. *I can afford other modes*
iii. *There is too much risk of injury and collisions in cycling*
iv. *Adverse weather conditions*
v. *There are no dedicated lanes for cyclist*
vi. *Bicycles cannot carry my household/luggage for journeys*
vii. *Others*

3.2. Sampling and administration of questionnaires

Using Maccor, 2020 sample size method (i.e., Eqs. (1) and (2)), five hundred (500) questionnaires were administered to respondents in the Tamale Metropolis at a 95% confidence level. Five trained survey assistants who are inhabitants and are fluent in the local dialects and English were engaged to administer a hundred questionnaires each randomly. The survey assistants queried individuals both at home and en-route mainly by a face-to-face approach. Respondents from the en-route surveys included people who were riding bicycles, walking, and alighting or boarding tricycle/motorcycle at bus stops. The four major radial arterials and the ring roads (with some cycle lanes provided at some parts of the network) in the city serve as the main accesses to the CBD, schools and many administrative services. The survey assistants, therefore, intercepted users of these roads at various locations including bus stops and school zones. Most of the people travel at the peak periods (i.e., morning and evening). The en-route surveys were therefore conducted at these times. However, some school children were intercepted and interviewed

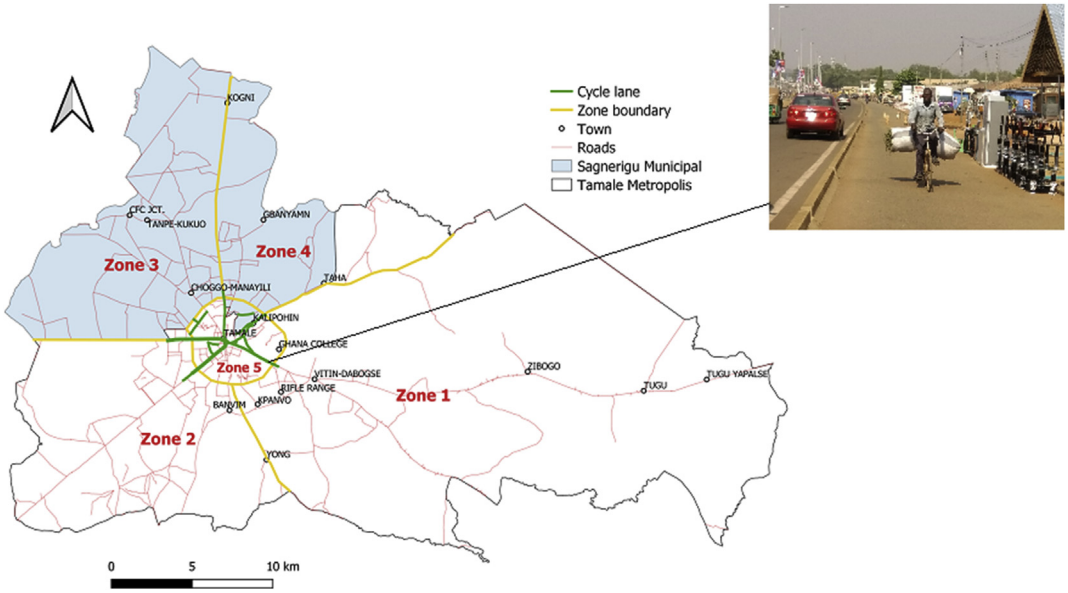

Figure 1. Map showing the five (5) zones and cycling network of the study area (Source: Created by the authors from ArcGIS and researchers' field photography).

in the afternoon after they have closed from school. The home surveys were however conducted at the off-peak periods and on weekends when most people are in their houses. A hundred and fifty (150) of the completed questionnaires were obtained from home surveys and the rest from the intercept surveys. The survey assistants allowed participants to self-complete paper questionnaires where the latter were literate and willing. To ensure that responses are fairly distributed within the metropolis for sample representativeness, the metropolis was delineated into five (5) zones based on the familiarity of assistants with suburbs (Figure 1). Geographical locations of the respondents in Zones 1 to 5 in Figure 2 were tracked by the assistants with the "Mytracks" app, an android GPS-based app, which was used to monitor and ensure adequate coverage within the zones. The extent of coverage was limited to 15km from the Central Business District (CBD). As mentioned by Fuseini et al. (2017), the CBD renders higher-order services – it remains the transport hub and the busiest economic and social interaction point in the city. It was therefore anticipated that people who live on the outskirts of the metropolis will visit the CBD and may be intercepted within the week that the survey spanned. This was confirmed as some participants' gave their origins towns as Yong and Tugu Yapalsu among others (Figure 1).

Equation 1- sample space equation:

$$ss = \frac{Z^2 * p * (1-p)}{C^2} \quad (1)$$

Equation 2- Correction for finite population:

$$new\ ss = \frac{ss}{1 + \frac{ss-1}{Pop}} \quad (2)$$

Where: Z or z-value = 1.96 for 95% confidence level
p = percentage picking a choice, = 0.5
C = Confidence interval = 0.04
Pop = Population = 233,252

3.3. Modelling approach and analysis

Spreadsheet data was developed from the questionnaires and analysed using Statistical Package for Social sciences (SPSS). SPSS is an IBM statistical platform for editing and analyzing a wide range of data (IBM, 2021). Out of 500 questionnaires, 439 were considered for the analysis. Sixty-one (61) questionnaires had more than 50% missing data which included ridership and ownership status and therefore was not considered in the analysis. Also, questions on income were the least answered. Only

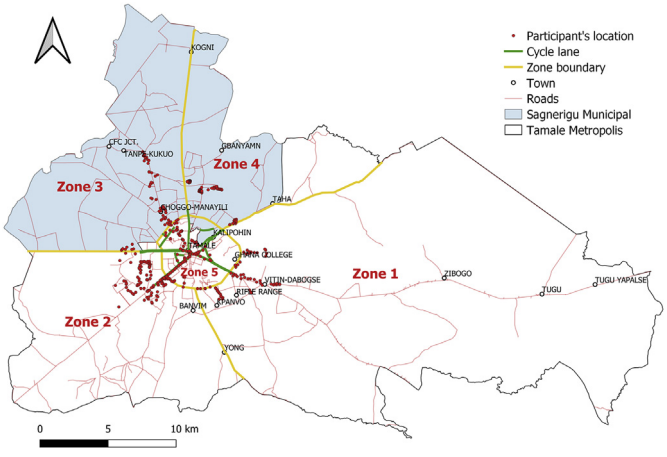

Figure 2. Map showing respondents' location in the study area (Source: Created by the authors from ArcGIS).

125 out of the 233 employed respondents were willing to disclose their income or its range. In all, 331 individuals, of which 206 were non-income earners who were students, apprentices and unemployed persons were considered for analysis on income. Descriptive analysis, chi-square test and binary logistic regression modelling were employed in this study.

Regression is one of the most widely used techniques for establishing the relationships between two or more explanatory variables and a response variable. The regression method could be simple linear regression or multiple linear regression if the response variable is continuous. If on the other hand, the response variable is categorical (binary or polytomous), logistic regression is one method that is widely employed instead of linear regression models. This is because logistic regression models the probabilities for discrete events (classification). On the other hand, the linear regression models do not output probabilities, but treat the classes of the response variable as numbers (0 and 1) and fits the best hyperlane by simply interpolating between the points. There is therefore no meaningful threshold for distinguishing one class from the other in linear models Molnar (2021). Further, ordinary least square regression models (e.g., linear regression) are not preferred when modelling categorical outcomes because such models have a number of shortcomings such as heteroscedasticity, violation of assumption of independence, and predicted probabilities outside the unit interval. Also, student t-test and analysis of variance (ANOVA) are not reliable for categorical variables because the key assumptions of these models are that the response or dependent variables must be continuous, with normally or roughly normally distributed residuals (Bardi et al., 2019). The binary logistic regression modelling technique was therefore employed to investigate the relationship between individual social demographics (i.e., age, income, gender, income and occupation) and bicycle ownership, and ridership. The logit models are usually estimated via maximum likelihood estimation. The idea behind the logit regression modelling is as shown in Eqs. (3), (4), and (5).

Let y_i denote the response of an individual i with respect to the outcome of the explanatory variables $x_{1i,\ldots,}x_{ki}$. For this study, the response variable y_i is a binary categorical variable expressed by numeric values of 1 and 0, where 1 denote the occurrence of an event; and 0 otherwise. The logistic regression provides information about a "transformation" of the dependent variable, logit(p):

$$\text{logit}(p) = \log\left(\frac{p}{1-p}\right) = \log(\text{odds ratio}) \quad (3)$$

where p is the probability to be a bicycle rider, and $1-p$, the probability of not being a bicycle rider.

With k explanatory variables, the general regression model can be rewritten as shown in Eq. (4).

$$\text{logit}\left(P(Y=1|x_1,\ldots,x_k)\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_k \quad (4)$$

Where $P(Y=1|x_1,\ldots,x_k))$ represents the probability of an individual to be a bicycle rider based on the values of the explanatory variables x_1, x_2, x_3,…., x_k, with logistic regression coefficients β_0, β_1 ,β_2,…, β_k. The model can also be rewritten as shown in Eq. (5) below and the output assumes values that lie between 0 and 1.

$$P(Y=1|x_1,\ldots,x_k) = \frac{\exp(\beta_o + \beta_1 x_1 + \ldots + \beta_n x_k)}{1 + \exp(\beta_o + \beta_1 x_1 + \ldots + \beta_n x_k)} \quad (5)$$

Further, the chi-square test was employed to test for a possible association between the socio-demographics of respondents and the respondents' desire to shift from bicycle mode. For ease and clarity of interpretation of variables in SPSS, codes were used to define both dependent and independent variable partitions (Table 1). Students and apprentices were added to the unemployed category whilst government workers, private businessmen and labourers were put under the employed category.

Table 1. Description of variables in the model.

Variable Name	Code [Range]	Code Description
Dependent variable		
Bicycle Ownership	[0,1]	0 = Does not own bicycle; 1 = Owns bicycle
Bicycle Ridership	[0,1]	0 = Does not ride bicycle; 1 = Rides bicycle
Independent variables: Social demographics		
Gender	[0,1]	0 = Female; 1 = Male
Age	[1,5]	1 = Less than 13 years (children); 2 = Between 13 and 19 years (teenager); 3 = Between 20 and 39 years; 4 = Between 40 and 59 years and 5 = More than 60 years
Occupation	[1,2]	1 = Employed, 2 = Unemployed
Income/month	[1,6]	1 = 9-37 USD; 2 = 37-93 USD, 3 = 93-185 USD; 4 = 185-370 USD; 5 = greater than 370 USD and 6 = no income

4. Results and discussions

4.1. Characteristics of respondents

Respondents were mainly Ghanaians. The majority of the sample were males; people between 20 and 39 years; private workers or businessmen; and people with no form of income (i.e., students, apprentices and the unemployed). Summary statistics of respondents' demographics are presented in Table 2.

4.2. Bicycle ownership

Out of the 56% of respondents who owned bicycles from Table 2, the majority (47%) were males. Among children (respondents less than 13-year-old), 76% owned bicycles. Ownership among teenagers (respondents between 13 and 19 years) and those between 20 and 39 years who formed more than two-thirds of the respondents were found to be relatively low. Fifty-seven percent (57%) of teenagers and 49% of those between 20 and 39 years respectively owned bicycles.

Concerning income, ownership was found to decline with increasing monthly income, where those with no income and those earning less than 200 Cedis (37 USD) monthly income represented 45% of the population. One would expect that the high-income earners who can overly afford bicycles in a metropolis said to be the bicycle hub may have high ownership. This, however, corroborates with the assertion by Acheampong and Siiba (2018) that individuals of relatively higher income levels are associated with private car ownership and usage.

4.3. Bicycle ridership

Seventy-eight percent (78%) of the 439 valid respondents ride bicycles. Like bicycle ownership, males dominated bicycle riding. Interestingly, 27% of 341 bicycle riders did not own bicycles (Table 1), which suggests that they either rented or borrowed to ride. The fact that people did not own but ride, coupled with the high rider percentage, indicate a high cycling potential as suggested by Acheampong and Siiba (2018).

Among those between 20 to 39 years, who had low ownership, bicycle ridership was the lowest at 69%. Ridership among teenagers, however, was high at 93% despite their relatively low bicycle ownership. Children followed with 87% bicycle ridership. Most of these teenage and child riders are students who used bicycles for school trips. This indicates why a high proportion of school trips were recorded among the trip purposes; although work trips dominate (Table 3).

Bicycle riding was high among the poor group comprising mainly of those with no source of income and those earning a monthly income of Gh¢200 (37 USD) or less (Table 2). They were more than half of the total riders; an indication of why the major motivation of cyclists in Table 4 is affordability. Cycling may therefore be said to be for the poor in Tamale Metropolis as reported for developing cities or countries by Tiwari (2008) and I-ce (2008). Those who could overly afford the mode, on the other hand, had lower cycling activities. Even though affordability is a major motivation, there is still about a quarter of the respondents who cycled mainly for health and fitness (Table 4). Recreational trips were almost one-fifth of all trips with both workers and non-workers embarked on such trips solely or along with other trips. The promotion of bicycles, especially on the premise that people are willing to ride to keep fit can therefore not be overlooked especially as bicycles are known to contribute immensely to the well-being of people.

Table 2. Summary of statistics on respondents' information.

Demographics	Description	Characteristics of respondents		Bicycle ownership		Bicycle ridership		Bicycle mode shift	
		n	%	n	%	n	%	n	%
Gender	Male	328	75	206	47	272	62	236	54
	Female	111	25	38	9	69	16	55	13
Age	<13	17	4	13	3	15	3	10	2
	13–19	120	27	68	15	112	26	94	21
	20–39	229	52	112	26	157	36	138	31
	40–59	63	14	45	10	50	11	43	10
	>60	10	2	6	1	7	2	6	1
Income/month (¢)	no income	206	62	133	40	185	56	157	48
	50-200 (9-37 USD)	29	9	17	5	22	22	18	5
	200-500 (37-93 USD)	33	10	19	6	19	19	17	5
	500-1000 (93-185 USD)	42	13	21	6	27	27	22	7
	1000-2000 (185-370 USD)	17	5	6	2	6	6	5	2
	>2000 (370 USD)	4	1	1	0	2	2	1	0
Occupation	Apprentice	42	10	30	7	38	9	33	8
	Student	130	30	82	19	119	27	98	22
	Unemployed	34	8	21	5	28	6	26	6
	Government staff	60	14	23	5	29	7	23	5
	Private worker or Businessman	153	35	75	17	109	25	95	22
	Labourer	20	5	13	3	18	4	16	3

Table 3. Bicycle trip characteristics and parking availability.

Trip purpose	Cyclist percent (%)	Frequency (days/week)				Parking Availability (%)	
		1	2	3–5	>5		
		Proportion of cyclists per trip purpose (%)				Yes	No
School	32	1	6	78*	15	84	16
Work	43	1	9	25	65*	80	20
Recreation	14	4	42*	40	14	28	72
Market	8	12	19	31	38*	35	65
Church/mosque	3	50	-	-	50	90	10

* Denotes the highest cycling frequency for each trip purpose.

Among the various challenges bicycle riders acknowledged encountering, safety (i.e., the carelessness and lack of regard and recognition of motorized vehicle drivers for them) was most significant (Table 4). Almost half of the responses (43%) pointed to this matter. This is consistent with the findings of the study conducted in Accra by Quarshie (2004) which reported a lack of safety as a significant challenge to cyclists. About a quarter of the responses (24%) were about the poor condition of road surfaces. As reported by ASIRT (2014), more than half of the roads are unpaved and in poor condition. Although designated cycle lanes are present, cyclists are sometimes forced to use motorized traffic lanes due to inadequate lanes, poor connectivity of cycle lanes, recalcitrant behaviour of some cyclists and encroachment of cycle lanes

Table 4. Views and opinions of cyclists and non-cyclists.

Description[a]	Frequency	Percent (%)
Why do you choose bicycles over other modes? (Cyclist views[b])		
It is affordable	256	51
It is the only available means of transport	51	10
It is a convenient mode in avoiding congestion	59	12
It is a means of exercise to keep me healthy and fit	121	24
It does not pollute the environment	10	2
Other views	6	1.2
Total	**503**	**100**
Views shared by more than one respondent		
I enjoy riding	2	0.39
My journeys are short in distance	2	0.39
It is relatively safe	2	0.39
What are your challenges as a cyclist? (Cyclist views[b])		
Poor road surface condition	136	24
Poor or inadequate connectivity in the bicycle network	46	8
Careless behaviour and lack of regards of drivers for cyclist	247	43
Negative or poor image of the community for cyclist	39	7
Other views	103	18
Total	**571**	**100**
Views shared by more than one respondent		
Easily fatigued	73	13
Encroached by traders, motorbike and parked vehicles	11	2
Not fast	3	1
What is your reason for not cycling? (Non-cyclist views[c])		
I prefer a faster mode	53	35
I can afford other modes	27	18
There is too much risk of injury and collisions in cycling	24	16
Adverse weather conditions	15	10
There are no dedicated lanes for cyclist	10	7
Bicycle cannot carry my household/luggage for journeys	9	6
Other views	15	10
Total	**153**	**100**
Views shared by more than one respondent		
Cycling is fatiguing	9	6
Inability to afford bicycles	4	3
Bicycles are downgrading mode	2	1

[a] Multiple response questions.
[b] Number of cyclists = 341.
[c] Number of non-cyclists = 98.

by traders and parked vehicles (Table 4). Fatigue was a demotivation to both cyclists and non-cyclist. Thirteen percent (13%) of the responses of the cyclists pointed to getting fatigued easily which may be linked to the adverse weather conditions (mostly sunny and dry) in the region. Adverse weather conditions constituted 10% of the responses of the non-cyclists on reasons for not cycling. In other places where good bicycle policies and a friendly environment are being promoted, more adverse weather conditions like snow, rainfall or hot sunny condition have not deterred people from cycling (Buehler and Pucher, 2012; Nkurunziza et al., 2012). Few (7%) claimed that riding is embarrassing since their communities attached poverty to users of bicycles.

Although encroachment of cycle lanes by motorized traffic and traders was mentioned in earlier studies in the metropolis (Damser-e-Derry and Bawa, 2018; Acheampong and Siiba, 2018), its mention again as a hindrance to cycling in this current study depicts that the situation persists. Also, the non-cyclists attributed their lack of interest in bicycles to mainly their preference and ability to afford faster modes of transport. Other than speed, others claimed, among various reasons that cycling was risky due to possible injuries and collisions (Table 4). Few non-cyclists (1%) attributed their non-usage of bicycles to the perception that cycling is for the poor or socially downgrading. These views, and that shared by cyclists as challenges, indicates that people in the Tamale metropolis may be considering speeds, distance, fatigue as well as infrastructure more, in their choice to use bicycle modes. Those with relatively low or no incomes are left to cycle more due to their possible inability to afford other modes deemed fast, hence the saying that bicycle is a poor mode as reported for some cities in developing countries (Tiwari, 2008; I-ce, 2008). The paradigm shift in the southern part of Ghana, where people in Accra were said to not use bicycle modes largely due to lack of safety. Quarshie, in a survey in 2004 revealed that 60% of people in Accra do not cycle due to lack of safety. However, in line with Quarshie (2004), 16% of the responses associate cycling with a high risk of injury and collisions – a safety problem that prevents them from cycling.

4.4. Significance of sociodemographics to bicycle ownership and ridership

Although the relevance of the sociodemographics: gender, income, occupation, and age, on bicycle ownership and ridership has been descriptively explained, a relationship between the dependent variables, riding or owning a bicycle and the independent (predicting) variables was further determined by using binary logistic regression. For the purpose of this study, factors with p-value ≤ 0.05 were considered to be statistically significant. A bivariate correlation check of the independent variables showed that income and occupation were strongly correlated with a coefficient (r) of 0.932 in Table 5. Income was, therefore, eliminated from the regression modelling effort.

Table 6 presents the results of the binary logistic regression modelling of bicycle ownership and ridership among respondents in the Tamale metropolis. Age was found to be insignificant (with $p > 0.1$) in determining bicycle ownership and ridership status. This indicates that any age category can be associated with owning or riding bicycles. On the other hand, gender and occupation were found to be significant. Males were found to be 3.16 times more likely to own bicycles than females and 2.82 times more likely to cycle than females. These results are consistent with the findings of Acheampong (2017) in Kumasi, Ghana, and in other cities in some developing or developed countries (Tiwari, 2008; I-ce, 2008; Pucher and Buehler, 2008), where male bicycle ownership and ridership were found to be high compared to females'.

The unemployed persons (student, unemployed or apprentice) were respectively 2.34 and 2.19 times more likely to own and ride a bicycle than the employed persons. The employed persons were people who worked in private businesses, government institution or were freelance labourer. Non-motorised modes, which include bicycles are considered to be relatively cheaper modes (I-ce, 2008). These modes (i.e., walking and cycling) however suffer the social stigma of being viewed as a means of transport for the poor. Poor people do not have the resources to purchase cars or motorcycles (United Nations Centre for Regional Development, 2018). They, therefore, depend on the availability of affordable modes to undertake their daily activities (United Nations Centre for Regional Development, 2018; Movin'On LAB, 2020). It is therefore not surprising for the unemployed group, who has no income to be 2.193 more likely to ride bicycles. Moreover, the respondents who own bicycles were also 5.543 more likely to ride than those who did not. This finding corroborates with that of Cervero et al. (2009) who asserted that access to or increase in bicycle ownership could promote utilitarian cycling as a result of the high correlation between the availability of bicycles in households and utilitarian cycling in Bogota.

4.5. Mode shift and promotion of bicycles

Eighty-five percent of the riders indicated their desire to shift from bicycles. They comprised 69% males and 16% females. Despite the low percentage of females by their representation, it is alarming to observe in Figure 3 that as high as 81% of the female cyclists desired to shift from bicycle mode. Similarly, 87% of males cyclists desired to shift to other modes.

The majority (85%) of the 207 bicycle riders who earned nothing or less than 200 Ghana Cedis (37USD) are desirous to shift from bicycle modes. Table 7 revealed that the ability of cyclists to afford other modes was the most popular reason for their shift from bicycle modes. Individuals with high incomes can purchase and/or use other costly modes including cars, motorcycles and tricycles. It is therefore not surprising that possible increased income levels are associated with a high desire to shift from bicycles usage (Figure 3). Since 79% of the cyclists fall within the low-income group (i.e., no income and 50-200 Cedis income range), they may not afford to purchase or patronise relatively expensive preferred modes and as such may be captive riders of bicycles. In terms of age, more teenagers and respondents between 20 and 39 years, who are considered youthful and agile desire to shift from bicycle riding. Tamale

Table 5. Correlation check on the demographics (Independent variables).

Variable Name		Gender	Age	Income/month	Occupation	Bicycle Ownership
Gender	Pearson Correlation	1	-.210**	.018	.020	.250**
	Sig. (2-tailed)		.000	.749	.675	.000
Age	Pearson Correlation	-.210**	1	-.456**	-.473**	-.014
	Sig. (2-tailed)	.000		.000	.000	.768
Income/month	Pearson Correlation	.018	-.456**	1	.932**	-.085
	Sig. (2-tailed)	.749	.000		.000	.121
Occupation	Pearson Correlation	.020	-.473**	.932**	1	-.170**
	Sig. (2-tailed)	.675	.000	.000		.000
Bicycle ownership	Pearson Correlation	.250**	-.014	-.085	-.170**	1
	Sig. (2-tailed)	.000	.768	.121	.000	

** Correlation is significant at the 0.01 level (2-tailed).

Table 6. Binary logistic regression models of bicycle ownership and ridership.

Variable Name	Model 1: Own or not own a bicycle		Model 2: Ride or not ride a bicycle	
	Coefficient	Odds ratio	Coefficient	Odds ratio
Individual factor: Social demographics				
Gender (male)	1.151***	3.16	1.036***	2.819
	[0.245]		[0.305]	
Age (13–19yrs)	-0.895*	0.409	1.256*	3.51
	[0.62]		[0.898]	
Age (20–39yrs)	-0.899*	0.407	-0.471*	0.625
	[0.626]		[0.857]	
Age (40–59yrs)	-0.012*	0.988	-0.383*	0.682
	[0.688]		[0.928]	
Age (>60yrs)	-0.612*	0.542	-0.812*	0.444
	[0.907]		[1.156]	
Occupation (unemployed)	0.851***	2.342	0.785***	2.193
	[0.245]		[0.327]	
Bike Ownership (yes)	Na	Na	1.713***	5.543
	Na	Na	[0.294]	
Constant	-0.288*	0.75	-0.364*	0.695
	[0.643]		[0.875]	
Valid N	439		439	
Nagelkerke R^2	0.155		0.345	
Model Chi-square	52.506		112.118	
P-value	0.0000		0.000000	
Cases correctly classified (%)	62.4		81.3	

***, ** and * denotes 1-5%, 5-10 % and >10% levels of significance respectively, and standard errors are reported in parenthesis [ ].
Age <13 years is the control or reference for all age variables.
Na denotes "not applicable".

is a youthful metropolis (GSS, 2014), therefore, the thrive of the mode will need the indulgence and patronage of teenagers who have been known to contribute highly to the success of cycling in the Netherlands through their high patronage (Pucher and Buehler, 2008; Buehler and Pucher, 2012). Children have a high cycling rate and are also said to be active in cycling. It is therefore worth noting that about half of the child cyclists (47%) indicated no desire to shift from bicycle modes.

Apart from income increment being a catalyst for their intended shift, most riders desire faster modes and modes that allow them to travel far without fatigue and carry other logistics or family. Fatigue was reported by riders of bicycles in Table 4 as one of the challenges faced. It is therefore expected that 90% of registered vehicles by the Drivers and

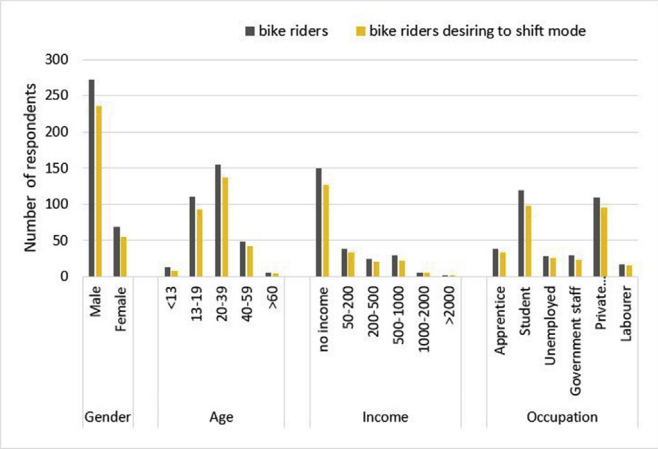

Figure 3. Distribution of cyclists and those desirous to shift from bicycle mode.

Vehicle Licensing Authority between 2009 and 2013 in Northern Ghana were motorcycles (Damsere-Derry and Bawa, 2018) since motorcycles are associated with relatively less fatigue, and are a faster mode than bicycles. Although most (43%) of the bicycle riders' responses considered careless behaviour and lack of regards by motorized vehicle drivers for cyclists as a major challenge (Table 4), few of the responses (5%) surprisingly considered safety as a reason to inform their shift from bicycle mode to other vehicular modes (Table 7).

Generally, almost all the riders showed the desire to shift from bicycle mode. This view is not only shared by the populace of the Tamale metropolis but also in other parts of Ghana like Accra, where a survey revealed that 65% of cyclists desire to shift from cycling (I-ce, 2008). The irony is that there is a high latent desire to shift from bicycle mode in the Tamale metropolis where there exists a high bicycle ridership relative to ownership and possibly a high cycling potential as mentioned by Acheampong and Siiba (2018). It is of essence that for a sustainable transport system, the existing cycling potential is preserved to avoid the realization of this latent desire.

The association between the respondents' desire to shift from bicycle mode with their socio-demographics was statistically determined by the chi-square test of independence; the results are presented in Table 8. Age, gender and occupation had p-values more than the 0.05 significant threshold. There is, therefore, not enough evidence to suggest an association between the demographics (i.e., age, gender, and occupation) and the desire to shift from bicycle mode. In other words, the desire to shift from bicycle use is not determined by gender, age, or occupation. There was, however, a statistically significant association between bicycle ownership and the desire to shift from bicycle mode, $X^2(1, N = 340) = 5.383$, $p = 0.02$, Cramer's $V = 0.126$. Although the association was weak, the fact that bicycle owners in the purported cycling hub expressed a desire to shift from the mode should be a concern for government, policymakers or local authorities who may need to act to reverse the possible

Table 7. Reasons for the possible shift from bicycle mode and bicycle usage promotion.

Description[a]	Frequency	Percent (%)
What will make you shift from bicycle to other modes? (Cyclists' view[b])		
Ability to afford other modes like motorbikes	162	30
Ability of other modes to travel long distance without getting tired	159	29
Ability of other modes to travel faster	157	29
Ability of other modes to carry luggage or entire household for trips	33	6
The safety of other modes	26	5
Other views	7	1
Total	**544**	**100**
Views shared by more than one respondent		
When travelling under rainy conditions	2	0.32
When sending or picking up my children from school	2	0.32
When transporting farm products from the farm to the market	3	0.36
What will promote the use of bicycles in Tamale Metropolis? (All respondents[c])		
Provision of more, continuous and dedicated lanes for cyclist	273	31
Provision of streetlights along cycle routes	74	8
Creation of public awareness on cycling relevance and the need for giving them priority	192	22
Provision of adequate and secured parking facilities	53	6
Reduction in the cost of bicycles	166	19
Provision of electric bicycles (faster bicycles)	72	8
Other views	45	5
Total	**875**	**100**
Views shared by more than one respondent		
Enforcement of road traffic regulations	15	**1.7**
Expansion road width and network	6	**0.6**
Provision of speed calming devices on the road	4	0.5
Introduction cycling competition programmes	2	0.2

[a] Multiple response questions.
[b] Number of cyclists = 341.
[c] Number of valid respondents = 439.

rapid decline or extinction of cycling interest and fortunes in the cycling hub of Ghana and in the entire nation, whose transportation vision was to attain 10% non-motorized transport to improve accessibility and mobility with societal benefits of improved health and clean environment (Abane et al., 2019; Ministry of Transport, 2008).

Table 7 shows that the effort to promote bicycle usage covers several areas including infrastructure enhancement, public education and sensitization, and policymaking. Almost a third of responses (31%) suggested that more, continuous and dedicated bicycle lanes should be provided. However, the provision of parking facility was mentioned but the proportion of responses that suggested that is low (6%). This is not surprising because for most of the regular trip purposes such as school, work, and mosque the individual may already have a parking place as shown in Table 3. Very few also suggested street lights as a measure to promote cycling. Public education and enlightenment of the populace on cycling and its benefits were among the major measures suggested. Educational programmes can be created in schools and colleges as a way of promoting safe cycling among students. The culture of cycling can be promoted in schools through the formation of bicycle clubs and creation of cycling-related competitions. A substantial proportion of respondents also suggested a reduction in the cost of bicycles in promoting cycling. The cost of bicycles, as a policy direction, can therefore be made cheaper through government subsidies which will make them more affordable and attractive. Educational policies could be directed towards supporting children in rural communities who might otherwise have to walk to school. Also, only 8% of the responses suggested the introduction of electric bicycles as a measure for promoting cycling. This could be as a result of a lack of awareness and personal experience with electric bicycles and their potential, among the general population of the Tamale Metropolis. As clearly indicated in Table 7, respondents prefer faster modes and modes that require less physical energy in travelling long distances to the conventional bicycles. Electric bicycles present such capabilities and contribute to sustainable green environments (Nematchoua et al., 2020; Cherry et al., 2016). They are therefore likely to attract more riders if the public is made aware of their benefits. The government can therefore invest in their introduction as a policy direction for promoting green transport by subsidizing their cost which will be a major contribution to achieving aspects of the sustainable development goals (SDGs) including, "Improving energy efficiency in the transport sector (Goal 7)"; "Making cities and human settlements inclusive, safe, resilient and sustainable (Goal 11)"; and "Climate impacts on transport and mitigation and adaptation measures (Goal 13)" (UN-Habitat et al., 2015; UNCG Ghana and CSO Platform on SDGs, 2017).

Table 8. Test of association between demographics and modal shift.

	Demographics Association:	
	Shift or not shift from bicycle use	
Variable Name	X^2	Cramer's V value
Gender	1.526*	0.067*
Age	5.655*	0.129*
Occupation	0.172*	0.023*
Bike Ownership	5.383***	0.126***

***, ** and * denotes 1-5%, 5-10 % and >10% levels of significance respectively.

5. Conclusions and recommendations

5.1. Conclusions

The study which made use of questionnaires to assess bicycle ownership and utilisation in the Tamale Metropolis revealed that there is a high bicycle riding potential in the metropolis as people who do not own bicycles, ride. The main motivation of cyclists was the affordability of bicycles. Cyclists may not have to pay much or pay at all to use bicycles, especially where homes had bicycles.

Bicycle ownership and ridership were observed to decline with increased income, such that the unemployed had relatively high ownership of bicycles and ridership than the employed. The binary logistic models indicated that gender plays a significant role in cycling ownership and ridership. Males were found to be more likely to own and ride bicycles than females. However, age was insignificant to owning and riding bicycles – teenagers and children were found to own and ride as much as the older age groups. Another important factor that significantly influenced ownership and ridership of the bicycle is the occupation status of the individual. An unemployed individual was found to be more likely to own and ride bicycles. This finding corroborates with the earlier finding in this study that ownership and ridership decline with increased income since the unemployed are associated with low income. As expected, individuals who own bicycles were found to be more likely to cycle than those who do not own. This suggests that programmes or interventions that seek to increase ownership of bicycles can indirectly increase ridership.

Our findings of this study show that affordability, health benefits and avoidance of congestion, in the order of significance are the three most important reasons why cyclists choose bicycles over other modes. Unsafe roadway conditions and poor infrastructure conditions were found as the two most important challenges among cyclists. Also, our results suggest that factors that discourage non-cyclists from cycling are mainly individual attitude and physical environmental conditions. Specifically, the preference for faster modes, ability to afford other modes and the high risk of injury associated with cycling are the three most significant factors that discourage non-cyclists to cycle.

Most of the demographics (i.e., gender, age and occupation) were not significantly associated with mode shift. However, a clear trend between the income of respondents and their desire to shift mode was revealed which suggested income play a crucial role in mode shift. Individuals with higher levels of income are more likely to shift from bicycles to other faster modes. Interestingly, the desire to shift from bicycle modes was however weakly associated with bicycle ownership. Few children and students were desirous to shift from bicycle mode. This finding shows a great prospect for increasing cycling-oriented residents in the metropolis if the children and students are trained and made to know the wide range of benefits of cycling. Aside from individual attitudes, cyclists also consider mainly the characteristics of the other modes when deciding whether to shift from bicycles or not. The study shows that cyclists are likely to shift modes if they can afford other modes; if they travel long distances with other modes without stress; and if the other modes travel faster than bicycles. Surprisingly, few cyclists consider trip purposes in their mode choice.

5.2. Recommendations

The findings of this study suggest that multi-faceted strategies are necessary for promoting cycling within the metropolis. The strategies cover areas including infrastructure, cost, awareness, mode improvement and regulation enforcement. We recommended that promotional programs on cycling and competitions should be initiated and organised regularly to hold their interest in cycling and indulge others in the process. Moreover, transport planners should provide a conducive environment for cycling by incorporating the needs of cyclists into the designs and masterplans of roadway infrastructures in the city. Well-planned dedicated cycling infrastructure which was highly recommended by the respondents is recommended to increase the sense of safety among cyclists. Since most of the population prefer faster modes to conventional bicycles, awareness should be created towards electric bicycles and their potentials to meeting the transport need of the population. Electric bicycles which are relatively faster but still require some physical effort enable the achievement of some level of health enhancement (Gojanovic et al., 2011) can be a positive replacement for motorcycles. Fyhri and Sundfør (2020) concluded in their study that the use of bicycles for daily travels doubled for those with e-bikes. Additionally, efforts should be made by the government towards the formulation of policies like tax exemptions to make the traditional and electric bicycles very affordable and accessible to grow sustainable modes. Public schemes such as the free distribution of bicycles to school children, and public training on cycling are recommended. The free bicycle distribution program among school children by State Governments in India and the bicycle-sharing scheme among students of the University of Nairobi are clear success examples of approaches that increase cycling culture among the youth and children (Movin'On LAB, 2020; United Nations Centre For Regional Development, 2018). It is worthy of note that successful cycling planning and implementation can be realized if two or more strategies are combined effectively. For example, greater benefits could be achieved when infrastructure improvements are combined with policy measures and interventions that promote the culture of cycling among the dwellers of the city. Such measures include free bicycles distribution programme among students, the introduction of educational programmes in schools, embarking on public awareness campaigns, creating of cycling clubs, introduction of cycling competitions among others.

It worth noting that this study used data from Tamale metropolis which has experienced cycling over several years. The results may therefore not be generalizable to other urban or rural areas which have inhabitants who have no experience or contact with cycling/cyclists in their day to day life and may therefore have different attitudes and perceptions. Further, the models in this study were limited to mainly socio-demographic characteristics of the respondents. However, bicycle ownership, ridership and mode choice could be influenced by other factors including attitudes, trip purposes and trip characteristics (e.g., trip lengths, and time of day, travel time, trip cost, and trip frequency). These factors can be considered in future studies to improve the understanding of factors that significantly influence cycling ownership, ridership and mode shift. Moreover, the cyclists showed that they have a preference for faster modes and modes that are associated with lesser stress. Notwithstanding, few selected electric bicycles as an alternative mode although they have the aforementioned characteristics. There is therefore the need for studies in this area to ascertain how popular electric bicycles are among inhabitants of the cities, and the feasibility of introducing them (electric bicycles) amidst the conventional ones.

Declarations

Author contribution statement

Akua Pokuaa Timpabi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kwame Kwakwa Osei: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Charles Anum Adams: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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