IATSS Research xxx (xxxx) 1–13

Contents lists available at ScienceDirect

IATSS Research

journal homepage: www.elsevier.com/locate/iatssr

Cycling in sub-Saharan African cities: Differences and similarities with developed world cities

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ARTICLE INFO

Article history:
Received 14 October 2021
Received in revised form 30 March 2022
Accepted 27 May 2022

Keywords:
Cycling
Socio-economic
Built-environment
Attitude
Sub-Saharan African cities
Developed world cities

ABSTRACT

Cycling is a vital transport mode for many of the Sub-Saharan African (SSA) cities given the limited transport options that exist. Despite its enormous commuting importance in SSA cities, little scientific research has attempted to identify key factors influencing cycling adoption, and most existing cycling promotional initiatives are often not contextualised to the African cities. To underpin appropriate incentives to promote bicycle commuting, this study conducts a literature review to identify key determinants of bicycle use in SSA cities. Moreover, it identifies key differences and similarities with cycling studies from the developed world cities (DWC). A survey of relevant literature was conducted through the Web of Science, Scopus, PubMed and Google scholar. This allowed gathering 61 relevant empirical study materials that helped to identify main factors influencing cycling in both SSA and DWC urban contexts, based on the socio-economic, built-environment, weather conditions and environmental and attitudinal factors. The results found that the vast list of factors influencing cycling, such as gender, education level, income, street signage, road encroachment, weather change, travel distance, the opportunity for flexible jobs and image prestige present a deep difference between studies in the two urban contexts. Street lighting, rain and tree cover present more consensual understanding among researchers in both urban contexts. This study reinforces that knowledge on cycling and its promotional initiatives should not be generalized, but rather be focused on the contextual setting of a particular city. In review of the past studies the limitation observed is that some specific characteristics of cycling in SSA cities such as the use of bicycle for commercial purpose is not covered in most cycling literature from the DWC. Given the observed contextual differences between cities from SSA and DWC, the study suggests the need for further research in quantifying and comparing the strength of the similarities and differences in cycling behaviour influences.

1. Introduction

Cycling is a relevant transport mode in Sub-Saharan African cities [1,2]. It is cheaper, easier to acquire and maintain [3]. It has zero emissions, requires less road space which is perfect in busy urban centres [4,5]. Moreover, it allows easy access to areas with deficient accessibility by motorised travel modes [6], enables fast access to jobs and as well provides flexible jobs crucial for the young unemployed majority [7–9]. Improving cycling can be an effective solution to reduce congestion, encourage physical activities, promote healthy communities and also reduce car dependence for daily commuting as most families cannot afford such motorised travel modes [10]. However, one key challenge to achieve the above cited cycling benefits is an accurate assessment of factors influencing cycling behaviour in the SSA cities context. The absence of such an assessment could result in the design of less informed and inappropriate cycling policies and implementation strategies.

Cycling use is influenced by many factors among them the city size [11]. Cycling is more popular in smaller cities than in larger SSA cities [10]. The study by Kumar and Barrett [10] and Pochet and Cusset [3] found that in Addis-Ababa (Ethiopia) cycling share is 3%, Bamako (Mali) 2% and Dar es Salam (Tanzania) is 1%. For smaller cities like Kisumu (Kenya), the cycling modal share estimate is 47%, in Quelimane (Mozambique) is 35% and in Morogoro (Tanzania) is 23%, these being some of the few examples [6,12]. All these studies point to the city built-up characteristics, the high incidence of poverty, and the limited access to public transport as some of the key factors that contribute to the increased cycling modal share. To the authors' best knowledge, currently, there is limited comprehensive literature on policies and strategies to promote cycling in SSA cities. Most studies that examine cycling in SSA cities usually consider approaches imported from the de-

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https://doi.org/10.1016/j.iatssr.2022.05.003
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veloped world cities (DWC). For instance, to promote cycling in Tamale (Ghana), Acheampong and Siiba [1] consider expansion of existing cycling routes by removing street trading activities. In Bamako (Mali) and Ouagadougou (Burkina Faso), Pochet and Cusset [3] indicate that it's crucial that cycling be complementary to public transport particularly for short distance trips. These approaches are however, most often inappropriate for two reasons. First, they exclude local cultural habits, as people often shop in local markets for their daily living, therefore, inclusion of local markets on cycling routes is essential for tightening community bonds that could positively influence cycling. Second, they don't consider the deep lack of urban public transport and its limited accessibility, which forces many people to experience commute bicycle taxi for long distances which is limitedly reported in conventional travel behaviour studies. Also, while a large number of studies have explored the relationship between cycling and the socio-economic factors, built environment factors, weather conditions and environmental factors, and attitudinal factors [3,7,13–19], the influence of these factors on cycling in SSA cities is still under-studied.

This paper aims to bridge this gap by offering a comprehensive review of literature on the key factors influencing cycling while citing the main differences and similarities between the SSA cities and the DWC. The main aim is to explore the extent to which the broad range of literature explains the influence of different factors on cycling in SSA cities and their differences and similarities with cities in the developed world. The remainder of the paper is structured as follows: in the second section, methods for data collection are presented, followed by results. The fourth section presents the discussion while the fifth section is the conclusion where suitable lessons that would be useful in growing cycling share in SSA cities are presented.

2. Methods and material

To explore the differences and similarities of cycling in SSA and DWC, this section presents the methods followed to select relevant literature for this study, including databases identified, searching terms used, the procedure to ensure the searching terms used are well aligned with the keywords used in previous studies, using VOSviewer software [20]. Moreover, the criterion used for inclusion and exclusion of the papers is discussed.

2.1. Searching strategies

A list of factors influencing cycling was identified based on the review of different studies, for example [1,2,8,17,19,21–23]. These factors were extracted and grouped into socio-economic, built-environment, weather conditions and environmental and as well attitudinal factors. It was observed that some specific cycling characteristics in SSA cities such as the commercial use of cycling [24] and road encroachment caused by street vendors [10] are not well covered in peer-reviewed literature, for this reason, the search was extended to non-peer-reviewed papers, which included governmental reports, international organizations reports. The search was conducted basically in the Web of Knowledge (WoS), Scopus, PubMed, Google Scholar and *E*-libraries.

Through the browsers of the databases, we searched papers using the searching terms (ST) listed in Table 1. The ST was chosen to enable identifying the highest number of potentially eligible studies. The ST was obtained from studies by Cervero [8] and Heinen et al., [15]. The searching expressions (SE) were also used to extract eligible studies. The ST1 presents the standard characteristics of cyclists while ST6 presents characteristics of cyclists often observed in the SSA cities context. We combined ST1 with ST2–5 which are group of factors that influence cycling such as socio-economic, built-environment, weather conditions and environmental and attitudinal factors. The SE5 was limited to ST6.

Table 1
Searching expression.

Codes	Searching Terms (ST)
ST1	(Cycling; bicycling; sustainable transport; bike; active transport);
ST2	(Socioeconomic factors: age; gender; income; vehicle ownership; education level).
ST3	(Built environment factors: road pavement; road infrastructures, street lighting; road traffic; traffic volume; street signage; travel distance; built environment).
ST4	(Weather condition and environment factors: temperature; rain; heat; tree cover; shadow, weather)
ST5	(Attitudinal factors: Exercise, healthy, cheap, comfort, flexibility, attitude, psychological factors, motivation, barriers, perception)
ST6	(Bicycle-taxi SSA; boda-boda; bicycle-taxi operators; bicycle-taxi passengers; street vendors; road encroachment)
	Searching Expressions (SE)
SE1	ST1 AND ST2
SE2	ST1 AND ST3
SE3	ST1 AND ST4
SE4	ST1 AND ST5
SE5	ST1 AND ST6

This enabled capturing African literature focused on cycling and bicycle taxi.

The literature search was conducted between March and June 2021. It was limited to papers in English and published from the year 1995 onward and that focused on studies in SSA and DWC. We extended the search year to 1995 due to the scarcity of studies in SSA cities. Additionally, for African literature, we considered both peer-reviewed and non-peer-reviewed literature while for the DWC only peer-reviewed literature was considered. The search in the WoS, Scopus and PubMed took into consideration documents such as type of articles, review articles, case studies and data papers. The research area was limited to transportation, engineering, urban studies, geography, social science, behaviour science and psychology. The search was conducted following the SE1–4. Fig. 1 shows an increasing number of studies in WoS in both urban contexts on bicycle commuting, which clearly indicates that the topic is growing attention over the years, therefore worth this study.

The search in Google scholar was simple since this searching engine do not allow many filter options as WoS, Scopus or PubMed. Only scientific articles and institutional documents published between the defined searching period range were considered. In the advance search option, all articles containing the searching words in ST1 (Table 1) AND containing the exact phrase ‘bicycle taxi’, ‘boda-boda’, ‘street vendors’, ‘road encroachment’ were considered. The search criterion ‘by relevance’ was considered. The search was conducted in June 2021. Moreover, using the snowball sampling approach, the list of references in each published paper or report were used as a source of additional articles.

2.2. Bibliometric analysis

VOSviewer, a bibliometric and network analysis software was used for construction and visualization of bibliometric networks of all co-authorship by countries. This enabled perceiving country-wise distribution of selected references. In addition, we analysed the co-occurrence network of authors-supplied keywords from the selected articles to show how are they related to each other. This enabled measuring how meaningful are our searching terms, thus avoid bias while selecting the articles. This analysis was conducted for articles selected from the SE1–4. The SE5 was excluded from this analysis since their search was basically conducted in Google scholar which is not supported by the VOSviewer software.

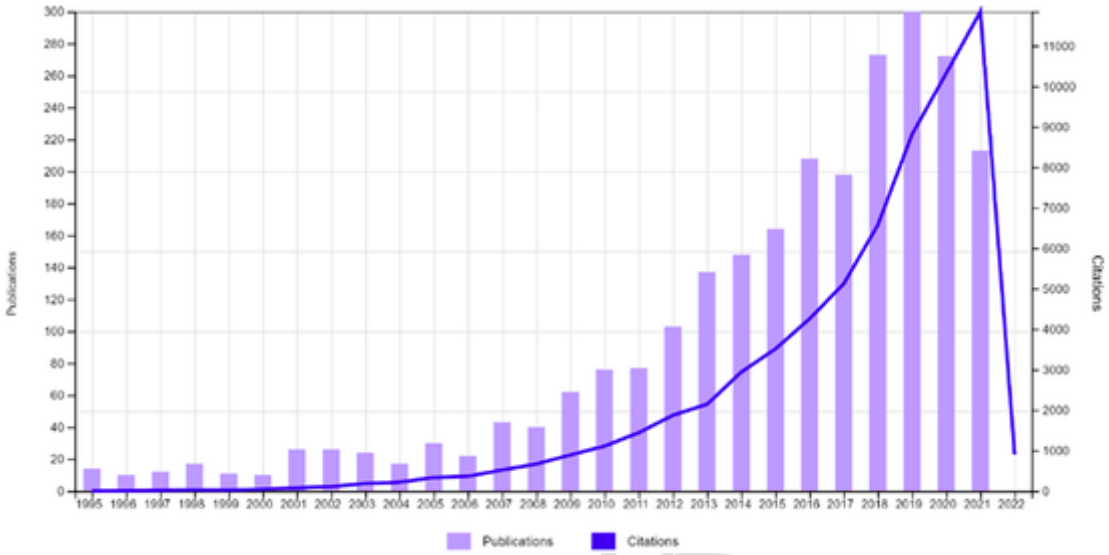

Fig. 1. Number of publications and time cited over the years (Source: Web of Science).

2.2.1. Co-authorship by countries

The co-authorship by country was visualized in VOSviewer, using density visualization. The density weight represents the weight of a country on the overall selected articles. The higher the density, the larger the number of articles from that country. From all articles selected in WoS, Scopus and PubMed database, two clusters of co-authorship by countries were observed. The first cluster (in green) contain basically articles produced in European countries while the other cluster (in blue) is a mix of countries, North America, South America, Asia and Africa. From the VOSviewer analysis, most articles selected in this study were produced in the United States (1476) followed by Australia (536). South Africa with 35 items is the African country with most articles selected. This shows that the selected articles are representative as they cover all continents. Fig. 2, for more details.

2.2.2. Authors' keywords co-occurrence

The size of each keyword in the VOSviewer graphs is determined by the number of co-occurrences. The number of co-occurrences of two keywords is the number of publications in which both keywords occur together in the keywords list [20].

Fig. 3 was generated from articles selected from SE1, in WoS, Scopus and PubMed. It is observed that most of our socio economic searching terms appear in the selected articles. The searching terms such as 'Gender' seems to have stronger occurrences, and is linked to 'age' and 'education'. Fig. 4 was obtained from articles selected from SE2. It is observed that our searching term 'built-environment' presents high co-occurrence. This is linked to other searching terms such as 'traffic' and 'infrastructures'. Fig. 5 shows the network of keywords related to weather conditions and environment (SE3). It is observed that our searching terms 'temperature', 'heat' and 'weather' are referred in selected studies and they are linked between themselves. Fig. 6 shows the relevance of our selected attitudinal searching terms expressed by SE4. The analysis shows that our searching terms such as 'exercise', 'enjoyment', 'motivation', 'psychology' and 'health' occurs as keywords in the selected articles. Overall, this analysis has demonstrated that most of the searching terms appear in many studies, showing their importance when searching for articles. This confirms that for this study we have selected the most relevant literature.

2.3. Studies extraction

The WoS search yielded 2551 scientific articles, Scopus 1449 articles, PubMed 712 articles and from Google scholar and *E*-libraries 1840 studies were found. After importing all the records to a bibliography manager software (EndNote), we used "find duplicated" function (of the EndNote Software) to remove duplicated records. This resulted to 3894 records. We then used the "advanced search" option of the EndNote software, to select articles by 'title' containing 'ST1' OR by 'ab-

Fig. 2. Density visualization of the co-authorship by country.

Fig. 3. Co-occurrence of "socio economic" searching terms.

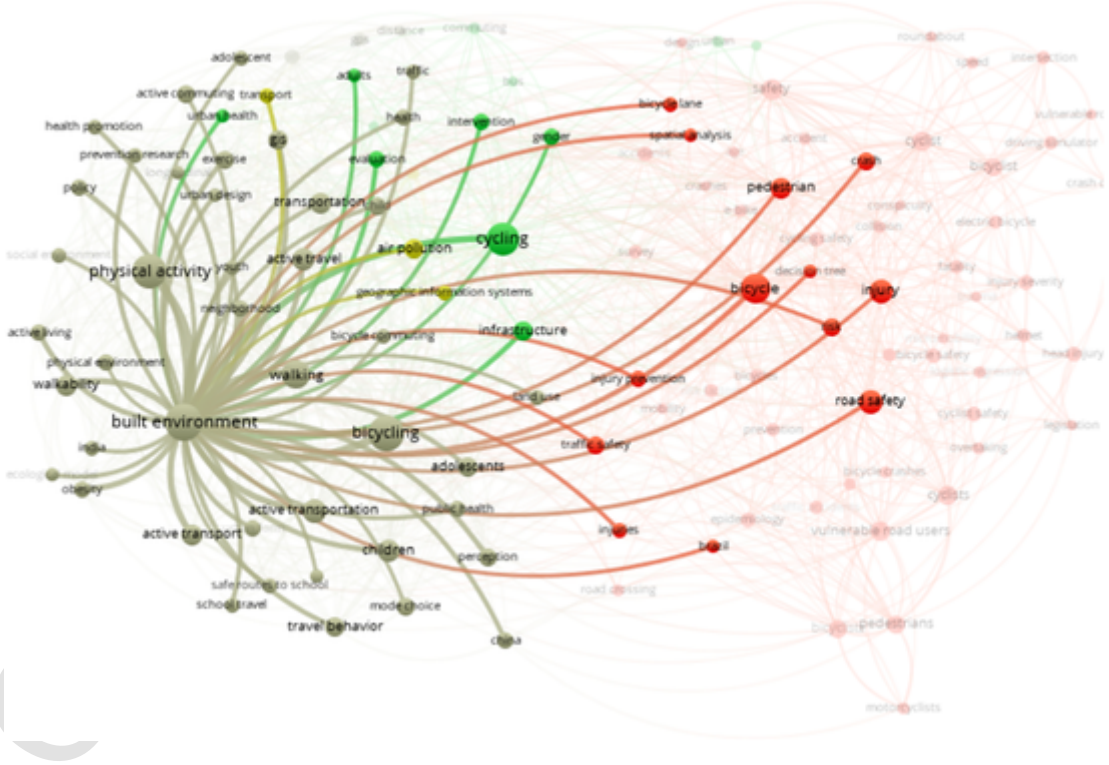

Fig. 4. Co-occurrence of "built environment" searching terms.

stract' containing only our searching terms with a 'high co-occurrence' as presented in Figs. 2–6. A total of 306 records were obtained.

After that, we manually evaluated the articles based on the titles and abstracts. For the examination of the title and abstract, we focused on the aim of the paper, evaluated the characteristics of the participants considered and the relevance of the studies considered. Considered studies were those that focus on the context of SSA cities and DWC, and specifically on cycling. Studies that were considered are those where the participants are of 16–65 years old or the average falls within this range, and not focused on specific ethnic, cultural, racial minorities. Additionally, we also considered studies that present analyses of cycling separately from other travel modes and that include quantitative and qualitative research designs. We also considered relevant studies that had to investigate the influence of socio-economic, built-environment, weather conditions and environmental and attitudinal factors on cycling. From the examination, 245 articles were excluded,

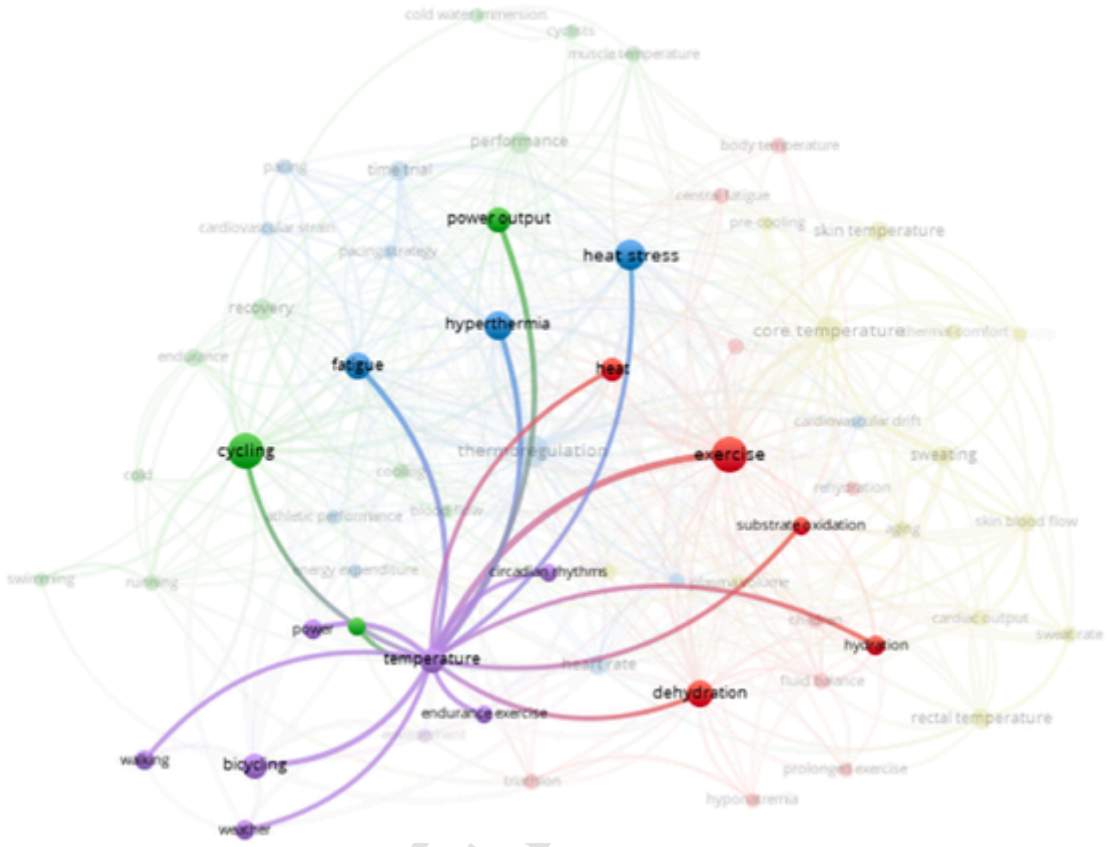

Fig. 5. Co-occurrence of "Weather condition and environment" searching terms.

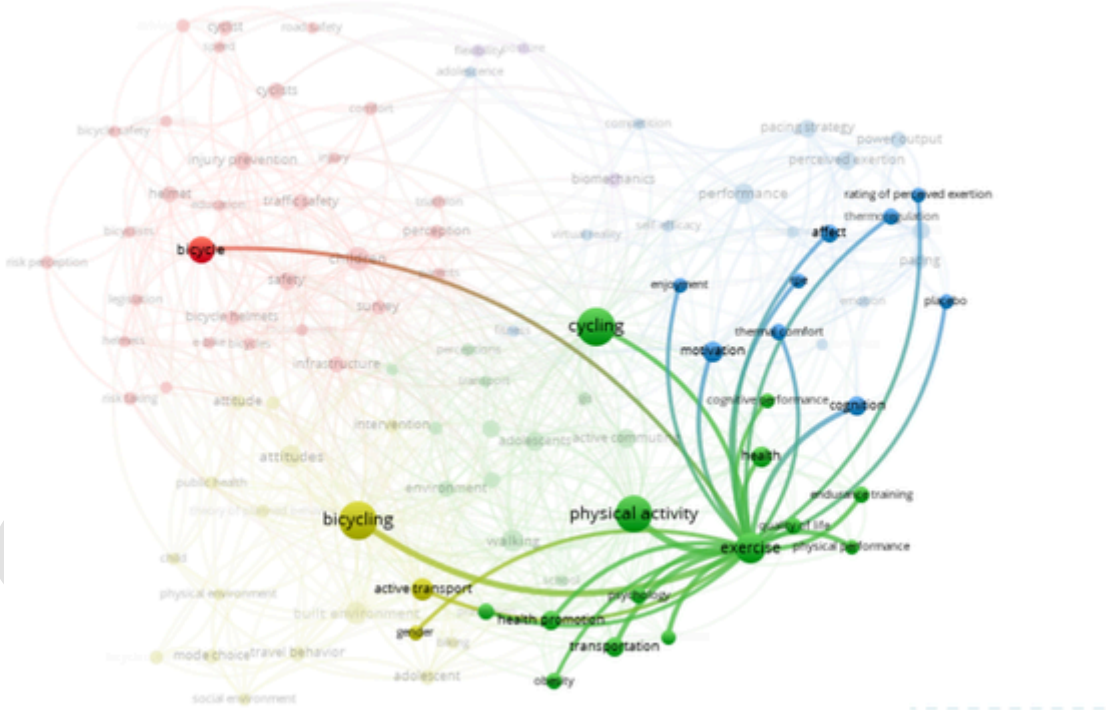

Fig. 6. Co-occurrence of "Attitudinal" searching terms.

resulting in 61 selected records used in this study. Summary of the results was categorized according to their similarities or differences between studies in SSA and those in DWC, Tables 2-5.

3. Results

3.1. Socio-economic factors

In SSA cities, cycling appears to be strongly associated with a mix of young and adult age, particularly for ages between 18 and 45 years [3,6,13]. Age yield different results in different studies in DWC. Guo et al., [25] and Wardman et al., [26] in their studies in US and UK cities point out that age in cycling is irrelevant. Other studies indicate that cycling declines with age [27,28].

Overall studies conducted in both urban contexts indicate that cycling is more appreciated by men than women. For instance in Tamale Metropolis in Ghana, being male is positively associated with bicycle commuting [1]. In Ouagadougou, 71% of men indicate that they have cycled frequently [3]. For Nkurunziza et al., [2] more than 80% of men in Dar es Salaam are likely to take cycling action. Gender is irrelevant when cycling share is low. For example, in their study conducted in Melbourne, Australia, Gerrard et al., [29], show that low rates of utilitarian cycling indicate more male than female cycling. Dill and Voros [28] and Xing et al., [30] in their studies in the US, found that cycling is more popular among men. However, some studies found that women cycle more than men. For example, in their study in Belgium, Vandenbulcke et., [31] found that women over 60 years cycle more than men of the same age. Witlox and Tindemans [32] found that women cycle more than men.

The link between cycling and income is not consensual among studies in both urban contexts. For instance, studies conducted in SSA cities like Ouagadougou and Bamako by Pochet and Cusset [3] and in Quelimane, Mozambique by Mendiate et al., [6] show a strong association between cycling and poverty. Meanwhile, evidence from Johannesburg suggests that cycling is highly correlated to medium and high-income individuals and less correlated to low-income individuals [33]. Similarly, a study conducted in Cape town indicates that high-income individuals produce 0.5 bicycle trips per person while low-income individuals produce 0.3 bicycle trips [16]. For cities in the developed world, the link between cycling and income is still unclear. Research by Fernández-Heredia et al., [34] shows that there is a strong correlation between cycling intensity and income. Li et al., [35], indicate that cycling is common among individuals with income slightly below the mean. For Handy and Xing [36], income is not a significant cycling explanatory variable in US cities.

Cyclists in SSA cities often have a low education level. For instance, a study conducted in Mzuzu (Malawi), points that 60% of the bicycle-taxi operators attempted primary education [37]. The study by Mutiso and Behrens [24], found that most bicycle taxi operators in Kisumu have received some formal education. Similarly, Acheampong and Siiba [1] found that non-tertiary educated individuals were 2.5 times more likely to cycle for utility purposes compared to those having a higher level of educational attainment. Li et al., [35] had different findings, in their study in China, they found that highly educated individuals have a

Table 2
Summary of the influence of socio-economic factors on cycling by urban context.

Author and year	Age	Gender	Income	Education level	Household composition	Employment status	Vehicle ownership	Key findings
Studies in Sub-Saharan African cities								
Acheampong and Siiba [1]		+ + +		+ + +			+ + +	Males are more likely to cycle than females. Cyclists are more likely to be non-tertiary educated. Bicycle ownership correlate positively with bicycle commuting.
Jennings [16]			+					Low-income people cycle less
Mendiate et al., [6]	+ + +		+ + +		+	+ + +		Young and adults cycle more. Low income individuals cycle more. Individuals in Large households cycle less frequently. Self-employed /informal workers cycle more frequently
Mutiso and Behrens [24]							+	Hiring bicycle taxi operators cycle long hours.
Studies in Developed World cities								
Dill and Voros [28]	+ + +	+ + +						Younger adults and men were more likely to be regular and utilitarian cyclists
Fernández-Heredia et al., [34]			+				+ + +	Bike use seems less associated in groups with income above the mean. Bicycle ownership works in favour of cycling.
Fernández-Heredia et al., [21]					+ + +			Large family size is associated positively with bicycle use.
Gerrard et al., [29]		+ +						Gender has no significant influence on cycling
Heinen et al., [15]						+ + +		Among employed individuals, part-time workers commute more frequently to work by bicycle than fulltime workers
Handy and Xing [36]			+ +					Income is not significantly associated with bicycle commuting.
Li et al., [35]			+ + +	+	+			Income is generally lower in segments of individuals with a high willingness to use the bicycle. Highly educated and married people (large households) may either have a low willingness to use the bicycle or not.
Pucher and Renne [18]						+		Full time employers are expected to make fewer bicycle trips
Xing et al., [23]				+ +				The influence of employment status on bicycling was insignificant
Wardman et al., [26]	+ +							The probability of cycling to work falls as age increases, although the effect is not strong
Witlox and Tindemans [32]		+						In the active population, men cycle less than woman.

Notes: The marks indicate the influence of the variable on cycling (Scale: + + + = Positive; + + = Neutral; + = Negative).

Table 3
Summary of the influence of built-environment factors on cycling by urban context.

Author and year	Pavement quality	Street lighting	Traffic volume and speed	Street signage	Road encroachment	Travel distance	Key findings
Studies in Sub-Saharan African cities							
Bryceson et al., [7]			+ + +		+ + +		Bicycle taxi operators often concentrate on busy roads or markets. Bicycle taxi Operators show a preference for busy markets to find many potential passengers.
Howe and Bryceson [12]						+ + +	Weekly cycling distance is between 2 and 5 km
Kareem et al., [45]		+ + +					Cyclists usually renounce a travel if the street or neighbourhood access road is not well-lit.
Mendiate et al., [6]	+						Poor road conditions beyond the city-periphery make cycling safer.
Mutiso and Behrens [24]						+	For bicycle taxi operators, the short distance means less revenue
Nkurunziza et al., [2]				+ +		+ +	No bicycle crossing signals at road intersections present an insignificant influence on taking cycling action. Far distance to work place is an insignificant barrier for cycling action
Pochet and Cusset [3]			+		+		Cyclists feel unsecure on busy streets. Street vendors reduce road capacity, posing safety hazards for cyclists.
Ribbens et al., [41]	+ + +						Limited paved roads provided is a major problem for cyclists in south African townships
Studies in Developed World cities							
Broach et al., [48]				+ + +			In conflicting road junctions, cyclists perceive the positive effects of signals to be more outweighing than the negative
Fajans and Curry [49]				+			A route lined with stop signs is not necessarily desirable for cyclists
Heinen et al., [15]						+ + +	The perceived convenience of a cycling trip declines with an increase in the travel time.
Jacobsen et al., [47]			+ + +				People will become more cautious of cyclists if they are in great numbers
Muñoz et al., [17]			+ +				Traffic aggression was not considered as a significant cycling barrier
Segadilha and Sanches [42]	+ + +	+ + +					Cyclists avoid cycling on dark and unpaved roads
Winters et al., [19]			+				Cyclists prefer calm traffic around the route between the trip origin and destination

Notes: The marks indicate the influence of the variable on cycling (Scale: + + + = Positive; + + = Neutral; + = Negative). In shade, factors with a similar influence on cycling in both urban contexts.

high willingness to bicycle use. Xing et al., [23] in their study in US cities found that the level of education has an insignificant influence on bicycle use.

The influence of household composition on bicycle use is different per urban context. When looking at the classical large household in SSA (married or single mother with children), Acheampong and Siiba [1] found that being married is negatively associated with cycling to utility purposes. For Mendiate et al., [6] households of single mothers with children in Quelimane, lead to a relatively low cycling frequency. In DWC, however, a study conducted in the Netherlands by Boumans and Harms [38], points out that large households are likely to produce more cycling trips. According to Gerrard et al., [29] and Fernández-Heredia et al., [21], family size has a direct relation with bicycle use. For instance, large family size is positively associated with bicycle use. For Li et al., [35] being married and having children under 12 years old contributes to low cycling willingness.

The relationship between employment status and cycling shows that in SSA cities, self-employed and informal workers are expected to cycle more [6,7]. Full-time workers are less likely to take cycling action than part-time and self-employed workers [2]. In DWC, Pucher and Renne [18] in their study in Netherlands and Germany, had similar findings. They found that full-time formal workers are expected to cycle less. For Heinen et al., [15] and Boumans and Harms [38], Part-time workers cycle more frequently than full-time workers.

From SSA, the study by Acheampong and Siiba [1] found that bicycle ownership increases the odds of utility cycling by 3.137. Similarly, Nkurunziza et al., [2] cite that having a bicycle in Dar es Salam increases the likelihood of taking cycling action than not having a bicycle. Differently, Mutiso and Behrens [24], found that among the bicycle taxi operators in Kisumu, hiring operators cycle 12.1 h compared to 11.9 h of owner-operators. In the DWC, while car ownership reduces the likelihood of cycling, bicycle ownership increases cycling odds [36]. Bicycle availability has some positive relationship with bicycle use [21]. For details, see Table 2.

3.2. Built environment factors

Most studies in SSA cities and DWC indicate the following built environmental factors, such as pavement quality, street lighting, allowed traffic speed, traffic volume, street signage and distance to activities, as relevant cyclists' behaviour influences [1,6,17,19,39]. Moreover, in SSA, road encroachment by street vendors is also pointed out as a factor that influences cycling [10].

Regarding the relationship between pavement quality and cycling, Acheampong and Siiba [1] in their study in Tamale Metropolis found that good quality roads encourage bicycle commuting as cyclists prefer paved main roads. The study by Tulu et al., [40] in Addis Ababa indicates that poor road quality do not encourage people to cycle. Ribbens et al., [41] indicate that cyclists in the townships of South Africa are discouraged from cycling due to poor road quality. Differently, Mendiate et al., [6] in their study in Quelimane, Mozambique found that when commuting between the city periphery and sub urban area, cyclists avoid paved roads. In DWC, several studies point out that cyclists prefer paved streets [42–44].

Table 4
Summary of the influence of weather conditions and environmental factors on cycling by urban context.

Author and year	Weather conditions	Rain	Tree cover	Key findings
Studies in Sub-Saharan African cities				
Acheampong [13]	+ +			Sweating while cycling in hot weather is not a significant cycling barrier
UN-Habitat [59]			+ + +	Shade along cycling paths has a significant influence on cyclist's route choice
Diaz Olvera et al., [56]		+		The rains make the streets flooded and daily bicycle journeys difficult.
Rwebangira [55]		+ +		Discomfort of cycling due to rain, appears to be of minor significance.
UNEP [60]			+ + +	The presence of tree cover makes walking and cycling pleasant and safe by providing physical barriers to motorised vehicles
Studies in Developed World cities				
Bergström and Magnusson [51]	+ + +			The number of bicycle trips decreases more significantly in winter
Mertens et al., [61]			+ + +	People living in neighbourhoods with more trees, were more likely to cycle commute
Buehler. and Pucher [54]		+ +		By comparison, annual precipitation and the number of cold and hot days were not statistically significant predictors of bicycle commuting in large cities.
Wadud [53]	+ +	+		The very high or very low temperatures reduce bicycle use. Most studies found that cycling decreases in the presence of rain

Notes: The marks indicate the influence of the variable on cycling (Scale: + + + = Positive; + + = Neutral; + = Negative). In shade, factors with a similar influence on cycling in both urban contexts.

Studies in both developed world and SSA urban contexts point out that lack of street lighting can decrease the levels of cycling [41,42,44]. Ribbens et al., [41] indicate that cyclists avoid poorly lit streets in the townships of South Africa. Kareem et al., [45] indicate that cyclists in the suburbs of Kampala are likely to forego a trip if the access road is not well-lit. Similarly, Winters et al., [19] in their study in Vancouver (Canada) cite that not well-lit bicycle lanes are strongly linked to the reduction of cycling rates. In addition, Chandra and Radhakrishnan [46] indicate that people avoid cycling in areas with cycle paths that do not have street lights at night.

A study in Ouagadougou (Burkina Faso) and Bamako (Mali), points out that cyclists are afraid to cycle on heavy and fast-moving traffic roads [3]. Differently, Moyo [9], Mutiso and Behrens [24] and Bryceson et al., [7], found that bicycle-taxi operators often opt for busy streets. On the other hand, there is a substantial variation in how traffic volume and speed influence cyclists' route choices in DWC. For example, Winters et al., [19] found that cyclists avoid routes with heavy traffic volume and fast speed. Other DWC studies reveal that cyclists often prefer busy roads [47]. Muñoz et al., [17] in their study in Madrid, found that cyclists perceive traffic aggression as an insignificant statistical cycling predictor.

The effect of street signalization on cycling is a subject of different understanding [42,43,48]. Studies conducted in SSA cities found street signalization to have little influence on cycling [2,39]. However, studies in DWC cite that well-signalized streets are very attractive, particularly for individuals with relatively less experience in cycling [43]. Broach et al., [48] indicate that junctions without traffic signals have a significant negative association with cycling levels. Fajans and Curry [49], show that routes with many stop signals have a negative influence on cycling.

The influence of road encroachment on cycling is mostly discussed in developing countries' literature [3,8,24,50]. Even so, researchers are not consensual about the correlation between road encroachment and cycling route choice. Based on Pochet and Cusset [3] and Sietchiping et al., [50] cyclists often avoid busy street vending junctions. On the contrary, street vendors strongly influence travel patterns of bicycle-taxi operators as they often include these points in their cycling itinerary [7,8,24].

The relationship between distance and cycling frequency is less consensual in SSA cities while in DWC it is more consensual. A study by Howe and Bryceson [12] found that in Morogoro (Tanzania) cycling is preferable for short to medium distances. Nkurunziza et al., [2] indicate that far distance to the workplace does not have a strong influence on taking cycling action. Different from most literature, a study conducted in Kisumu by Mutiso and Behrens [24], found that bicycle-taxi operators avoid short bicycle taxi trips. Similarly, Mendiate et al., [6] found that in Quelimane (Mozambique) frequent cyclists often cycle long distances (more than 5 km). In DWC, the relationship between cycling and distance is unanimous. Cycling is preferable for short distances. Studies by Heinen et al., [15] cite that the bicycle is mostly used for short distances. Distances between 0.5 km to 3.5 km are the most preferred for cyclists. More details are in Table 3.

3.3. Weather conditions and environmental factors

Studies point out that weather conditions such as high or low temperature, rain and tree cover along the streets are some of the most cycling influencing weather conditions and environmental factors [42,51–53]. In SSA cities, a study conducted in Dar es salaam by Nkurunziza et al., [2] found that weather is an insignificant cycling action motivator. Similarly, Acheampong [13] when exploring attitude and perception among adult cyclists in Ghana found that weather is a statistically insignificant cycling attitude predictor. In DWC, Buehler and Pucher [54] found that weather is a statistically significant predictor of bicycle commuting in large US cities. Wadud [53] in his study in London found that there is no clear relationship between temperature and cycling ridership. Bergström and Magnusson [51] in their study in Sweden found that weather has a clear influence on bicycle use. They point out that in winter the number of cyclists decreases by 47%.

The relationship between cycling and rain is more consensual among researchers. For instance, a study in Dar es Salaam and Nairobi by Rwebangira [55] found that rain appears to be of minor significance on cycling. Diaz Olvera et al., [56] in their study in Dar es Salaam cite that during rainy seasons, cycling is difficult and occasionally dangerous. Similar findings from studies conducted in DWC confirmed the same [53,57]. These studies found that cycling declines with rain. Nevertheless, few studies have found that rain has no significant statistical influence on cycling [54,58].

Continuous tree shade reduces the temperature, making it more comfortable for people to walk and cycle, especially during summer afternoons [59]. UNEP [60] in their study in African cities, added that the presence of trees can even protect cars from invading spaces meant for cycling. Studies in DWC found that bicycle commuters tend to choose roads with dense tree cover for providing shade, comfort, and above all fresh air [42,44]. The presence of trees along the roads increases by 15.65 times the odds of cycling for transport [61]. More details are in Table 4.

Table 5
Summary of the influence of attitudinal factors on cycling by urban context.

Author and year	Health improvement	Cost	Comfort and Flexibility	Provision of flexible jobs	Image prestige	Key findings
Studies in Sub-Saharan African cities						
Acheampong [13]	+ +					Cycling to promote good health is considered insignificant among people who cycle.
Chilembwe [37]				+ + +		Bicycle taxi service has resulted to increased income and reduced daily transportation costs
Kipandula and Lampiao [65]	+					Cycling has been linked to genitourinary problems, including nerve entrapment syndromes and erectile dysfunction
Nkurunziza et al., [2]		+ + +				People cite low bicycle purchase cost as a key motivator and shows a positive likelihood towards cycling.
Pochet and Cusset [3]		+ +	+ +		+	Low bicycle pricing policies risk being counterproductive as most cities are not bicycle friendly. Traditional bicycles are robust and less comfortable. Cycling gives "village-like" image.
Tulu et al., [40]	+ + +					Cycling contributes to healthy life style
Studies in Developed World cities						
Fernández-Heredia et al., [21]	+ + +		+ + +			The idea of cycling convenience is related to many viewpoints such as health improvement. Convenience and flexibility have a positive influence on bicycle use
Heinen et al., [15]		+ + +				Cycling is relatively cheap
Li et al., [35]			+			The desire for comfort has a negative influence on the perception towards cycling
Muñoz et al., [17]		+ +			+ +	The low cost of cycling and image prestige were not significant cycling attitudinal beliefs
Pojani et al., [70]					+ + +	Cycling is fashionable

Notes: The marks indicate the influence of the variable on cycling (Scale: + + + = Positive; + + = Neutral; + = Negative). In shade, factors with a similar influence on cycling in both urban contexts.

3.4. Attitudinal factors

Among the attitudinal factors influencing cycling, researchers are unanimous that cycling is healthy, cheap, comfortable, flexible [1,2,13,15,30,51,62]. While literature in SSA cities also points that cycling enables flexible jobs, it is also perceived as an inferior and rural-like transport mode [3,16,63,64].

Cycling is widely perceived as a healthy means of transport [14,15,63]. In SSA cities, for instance, Acheampong [13] in their studies in Kumasi (Ghana) found that among people who used to cycle, health improvement is not a strong cycling motivator. Moreover, findings from Kipandula and Lampiao [65] study indicate that cycling is perceived as prejudicial to health among bicycle taxi operators in Mzuzu (Malawi). On the other hand, Tulu et al., [40] in their study in Ethiopia found that 98.9% of cyclists perceive that cycling has various benefits including health. In DWC, different studies conducted in Madrid found that cyclists strongly agreed that cycling has health benefits and this perception is similar among frequent and non-frequent bicycle commuters [17,21]. This finding is similar to many other studies conducted in DWC [14,15,30,35,36].

The link between bicycle purchase cost and cycling is a subject of different discussions among researchers and even among studies in similar urban contexts. For instance, Nkurunziza et al., [2] cite that in Dares-Salaam, lowering bicycle purchase costs would increase 1.31 the likelihood of maintaining cycling. Similar findings are by MWT_Uganda [66] who cite that the affordability of bicycles and their maintenance is crucial to keep people cycling in Uganda. Studies by Acheampong [13], Sietchiping et al., [50] and Diaz Olvera et al., [64] found that frequent cyclists do not perceive the low cost of using a bicycle as a significant motivator for bicycle use. In developing world cities, for example, Heinen et al., [67] when estimating cycling use models, found that frequent cyclists consider cheap the costs of using a bicycle. While, Muñoz et al., [17] found that the cheap costs of bicycle commuting were not a significant cycling explanatory variable.

In regard to the influence of comfort and flexibility, Acheampong [13] in his study of adults with different cycling experiences in Ghana indicated that comfort and flexibility have little influence on cycling for both frequent and non-frequent cyclists. Pochet and Cusset [3] in their study in Bamako and Ouagadougou found that traditional bicycles do not appear to be a comfortable means of transport, however, they found this mode flexible. Such a perception is also similar to studies from the DWC. For instance, Li et al., [35] found that frequent cyclists in China had a moderate to low desire for comfort. For Muñoz et al., [17] and Fernández-Heredia et al., [34] comfort and flexibility present a significant bicycle use predictor. However, Pucher and Buehler [68] in their study in the US cities found that cycling comfort is not a statistically significant predictor for bicycle use.

The commercial use of the bicycle is probably the major cycling motivator for both bicycle taxi operators and users in SSA cities. However, this is not deeply discussed in literature from the DWC as cycling in these cities is not likely to be used as bicycle taxi service. For operators, bicycle taxi provides livelihood support to large family [12]. For Mutiso and Behrens [24] bicycle taxi users consider fares charged fair and less than those charged by motorcycle taxi across all trip length categories. Similarly, a study in Mzuzu, Malawi by Chilembwe [37] found that more than 80% of the bicycle taxi users perceive this service as accessible and affordable.

The link between image prestige and cycling is different among people in SSA cities and DWC. In SSA, the bicycle is perceived by many as an inferior, a rural, and a transport mode for the poor. This cycling image has been pointed out by many researchers as the main reason for a negative attitude towards cycling in these cities [1–3,13,16,63,64]. Literature from DWC shows mixed findings. For example, Muñoz et al., [17] show that image prestige is not a significant cycling use predictor. Cepeda Zorrilla et al., [69] in their study in Mexico found that social image and prestige were the most important factors influencing intention to cycle. When comparing beliefs towards cycling between the Balkans and the Netherlands, Pojani et al., [70] found that in the Netherlands, cycling increases image prestige. More details are in Table 5.

4. Discussion

In this systematic review, we explored studies on key factors influencing cycling in SSA cities and identified main differences and similarities with cycling literature from the DWC.

The socio-economic factors present different effect on cycling in both urban contexts (Table 2). In SSA cities, cycling is popular among a mix of young and adult men. This is consistent with Bryceson et al., [7] whose study points that due to the physical and mental skills necessary to withstand the harsh cycling in SSA cities, young and adult men endure cycling in such an environment than the elderly and women. In DWC researchers had a different perception. Some studies in DWC point out that cycling declines with age, others point out that age is irrelevant. In regard to gender, some studies show that men cycle more than women, while others point out that gender has little influence, and others even indicate that women cycle more than men. In line with Vandenbulcke et al., [31], the general pro-cycling policies in DWC contribute to a safe and comfortable cycling environment that encourages cycling over different age groups and gender. In SSA cities cycling is strongly linked to poverty. This is consistent with Pochet and Cusset [3], who cite that in SSA cities, cycling is a pragmatic response to unemployment among the young, and inadequate access to faster and most affordable alternative travel modes for daily commuting. In DWC, the link between income with cycling is unclear. Some studies point out that high-income individuals cycle more, while others point out that they cycle less. According to Fernández-Heredia et al., [34] in DWC it is difficult to isolate the effect of income level on cycling, as this mode is popularly used for the last mile connections, sport, or leisure, thus popular among people in different income groups. In regard to education level, studies in SSA cities indicate low educated individuals to cycle more frequently, different from studies in DWC where highly educated individuals cycle more frequently. For SSA cities this is consistent with Acheampong and Siiba [1] who indicate that a low level of education attainment proxies the individual's socio-economic status, often low-income, not owning a car, and who cycles more frequently. For DWC, in line with Xing et al., [23] the educated individuals cycle more for social, economic, environmental, and personal benefits. Studies in SSA cities found that people in large households are less likely to cycle frequently. This is consistent with the study by Diaz Olvera et al., [64] which stresses that since the majority poor and large households in SSA cities cannot finance their daily trips, they often reduce their travel expenditure to the most essential activities where the priority usually goes to those household members who help to support it. This probably could explain why large households in SSA cycle less. In DWC, the link between household composition and cycling is still unclear. Large families are either likely to cycle more or less frequently. In line with Garrard et al., [29] people shouldering large households do multiple errands, or carry household groceries which obviously imply making many cycling trips. For Sener et al., [43], families with children (less than 16 years of age) may have increased number of chain activities like dropping off children at school before proceeding to work, which obviously makes cycling less suitable for commuting. In both urban contexts, the linkage between employment status and cycling indicates that full time workers cycle less frequently than part time workers. This is as expected since a bicycle is slower than a car and very physically demanding and inappropriate for daily commuting [13,67]. Moreover, based on Howe and Bryceson [12] findings, in SSA informal workers cycle as a source of livelihood and hence they are forced to cycle more frequently. In SSA, the literature point out that owning or not owning a bicycle influences positively bicycle use. This is confirmed, for example, by Pochet and Cusset [3] who cite that in SSA cities, lack of suitable transport alternatives for daily commuting favour bicycle use for those owning a bicycle. In addition, Mutiso and Behrens [24] cite that those not owning a bicycle experience cycling as bicycle-taxi passengers or as hiring bicycle-taxi operators. In DWC, Handy and Xing [36] stress that in US cities the bicycle-friendly urban environment significantly affects positively bicycle ownership, and therefore bicycle use as well.

The influence of the built-environmental factors on cycling present some similarities in SSA cities and DWC (Table 3). The findings indicate that good road quality has a positive influence on cycling in both urban contexts. This is consistent with Acheampong and Siiba [1] and Sener et al., [43] who cite that paved roads minimize vibration that creates discomfort. However, few studies in SSA point out that cyclists opt for non-paved roads for safety reasons. This is consistent with Mendiate et al., [6] who find that non-paved roads offer a safe cycling environment due to reduced vehicular volume and traffic speed. Studies in both SSA cities and DWC are unanimous that street lighting has an enormous influence on cycling. In line with studies by UN-Habitat [59] and Winters et al., [19], lack of street lighting can contribute to poor visibility, perception and fear of crime thus decreasing bicycle use. This is particularly relevant in SSA due to the generalized lack of security and safety. The influence of traffic volume and speed on cycling is subject to different understanding among different researchers even within similar urban contexts. In SSA cities, cyclists avoid busy streets with fast-moving vehicles. This is consistent with Pochet and Cusset [3] who cite that cyclists are not respected in traffic and, if there is an accident, the car drivers do not stop. On the other hand, some studies in SSA point out that a certain segment of cyclists such as bicycle taxi operators prefer busy roads. This is in line with Mutiso and Behrens [24] who indicate that at busy junctions, bicycle-taxi operators could intersect many potential passengers. In DWC, some studies point out that cyclists prefer busy streets. This is consistent with Jacobsen et al., [47] who cite that cyclists feel safe in number. On busy roads, car drivers are expected to adjust their driving behaviour in the expectation of finding cyclists. Other studies point out that cyclists prefer less traffic volume and slow speed roads. For instance, in line with Winters et al., [19], calm streets proved a safe cycling environment. On the other hand, some studies point out that traffic volume and speed are insignificant cycling predictors. According to Fernández-Heredia et al., [21] this could be due to the existence of a bicycle path network that physically separates bicycles from the other travel modes. Studies in SSA are unanimous that street signage has little influence on cycling. This is as expected, based on Moyo et al., [39] motorists often disrespect the few existing street signage, by deliberately parking on the cycling path. In DWC, however, studies had different and mixed findings. Some point out that well-signalized roads have a positive effect on cycling. Based on Sener et al., [43] this could be due to the fact that street signage enables better interaction between different modes thus contributing to a safe cycling environment. Other studies point out that a well-signalized road has a negative effect on cycling. This is in line with Fajans and Curry [49] who cite that well signalized roads require an additional cycling effort to stop and again shortly after, resuming the trip. The discussion on the influence of road encroachment on cycling often takes place in SSA cities and even so the results are contradicting. Some point out that road encroachment has a negative influence on cycling, while others perceive the opposite. This is consistent with Sietchiping et al., [50] who found crowded road junctions as a conflicting area with other transport modes due to reduced space available for cycling, consequently contributing to road accidents. Differently, Mutiso and Behrens [24] study cite that bicycle-taxi operators perceive these places as important trip generation areas. The relationship between distance and cycling frequency is less consensual in SSA cities while being more consensual in DWC. In SSA cities, some studies point out that people often cycle short to medium distances, while majority cycle long distances. This is consistent with Mendiate et al., [6] who stress that cycling is meant for the majority poor who often reside far from jobs located in the inner city, therefore they are expected to cycle long distance daily. Additionally, Mutiso and Behrens [24] cite that bicycle-taxi fares are defined based on travel distance, therefore cycling long distances is more profitable for the segment of bicycle taxi operators. In DWC, cycling is ideal for short distances. This is

consistent with several DWC studies including Fernández-Heredia et al., [34], whose study indicates that cycling is the feeder for public transport service, thus used for short distance trips.

The weather conditions and environmental factors present a more consensual influence on cycling in both urban contexts (Table 4). However, the influence of temperature on cycling is particularly different in both urban contexts. In SSA cities, weather change has little influence on cycling while in DWC cycling is deterred by hot or cold weather. This is as expected since most SSA cities present similar weather throughout the year [2]. In line with Wadud [53] due to average cold weather in most DWC, an increase in the temperature also increases outdoor activities like cycling. The influence of rain and tree cover on cycling is perceived unanimously in studies conducted in both urban contexts. Cycling declines with the presence of rain. This finding is consistent with Flynn et al., [57] and Diaz Olvera et al., [56] as cycling exposed to rain causes discomfort. In line with Diaz Olvera et al., [56], lack of proper road drainages in SSA cities contribute to road flooding and disconnection, making cycling difficult. In addition, continuous tree shade reduces the road average temperature making cycling more comfortable. This is especially important in SSA cities with humid climate or harsh daytime sun [59]. For DWC, the green infrastructure improves the perceived thermal comfort particularly during the summer which is comfortable for cycling [52].

Table 5 presents the influence of attitudinal factors on cycling. In regard to health benefits, studies in SSA cities present mixed findings. Some studies point to the perceived health benefits of cycling as positive or moderate cycling motivating factors, while others find cycling even health prejudicial. In DWC, the perceived health benefits of cycling are a strong cycling motivating factor. This is consistent with previous studies in both urban contexts such as Acheampong [13], Moudon et al., [27] and Handy and Xing [36] who indicate that cycling improves health for being a physically active mode of travel. However, a medical study conducted in Malawi by Kipandula and Lampiao [65] concluded that excessive long cycling distance and often loaded with heavy goods is causing health problems to bicycle-taxi operators. This could probably explain the negative influence of cycling on health. The link between cycling and bicycle purchase cost is perceived similar in both urban contexts. In both SSA and DWC contexts, some studies found that the low bicycle purchase and operational cost is a significant cycling predictor while in other studies it is not considered a significant cycling predictor. This is well in line with Pochet and Cusset [3] study findings, where it is referred that in SSA cities, the bicycle is the cheapest mode to purchase and operate. On the contrary, Jennings [16] states that bicycles at the lowest pricing scale can cost some three times the weekly minimum wage for an unskilled worker in South Africa. This can probably explain the divergent cost influence on cycling in SSA cities. In DWC, Fernández-Heredia et al., [21] cite that bicycle operational costs dominate for usual urban travel distances, however, for long cycling distances these costs are notably high. Researchers in SSA cities find comfort less linked to bicycle use while flexibility was found strongly linked to cycling. These findings are in line with a previous study which indicate that most bicycles in Uganda are of a roadster design and do not have gears, and are well adapted to having a rear load-carrier, uncomfortable to ride and requiring enormous physical effort [66]. In consistency with Pochet and Cusset [3] and Mendiate et al., [6] studies, cycling is flexible for enabling fast connection in the narrow and discontinuous roads in the city periphery. In DWC, the influence of comfort and flexibility is not consensual. Some studies found these factors as significant cycling predictors and others found the opposite. This aligns with evidence from previous studies which indicate that cycling provides considerable flexibility vis-a-vis other modes of transport [62], and enables exploring the surrounding [71]. On the contrary and in line with Muñoz et al., [17] cycling is slow, weather dependent, stressful in traffic. The link between cycling and job opportunities is specific to SSA cities. Cycling is perceived as an opportunity for earning livelihood and for the bicycle taxi users it's an affordable means of public transport. This is consistent with Cervero [8] who mentions that due to huge youth unemployment rates associated with the lack of effective urban public transport in most SSA cities, bicycle-taxi is seen as an opportunity for informal public transport. The link between image prestige and cycling is perceived differently by researchers in both urban contexts. In SSA, a bicycle is perceived as an inferior and rural transport mode while in DWC it is perceived as a fashionable mode of travel. This is consistent with Pochet and Cusset [3] study, which indicates that a bicycle is a means of transport mainly for the poor and often loaded with goods, reinforcing its image of a rural transport mode. On the contrary, in line with Pojani et al. [70], cycling is fashionable and being environmental conscious.

4.1. Limitations of the study and directions for future research

This study has limitations: It is subject to some biases as some of the analyses do not include all the material used in this study. For example, when analysing the country-wise distribution, year wise distribution and authors keywords co-occurrence of the selected articles, only studies from WoS, Scopus and PubMed were considered. Most articles related to SSA cities were excluded, as they are not archived in respected scientific databases and thus not supported by most bibliometric software. Additionally, some specific characteristics of cycling in SSA cities, such as commercial cycling use, road encroachment by street vendors, are not covered in the DWC literature, thus not allowing an easy comparison between the two urban contexts. Furthermore, the results of this study, reveal that some factors show similar cycling influence in both urban contexts. In the study, it was not possible to measure the degree of such similar cycling influence in both urban contexts. Since these cities have profound contextual differences, it is therefore recommended that future quantitative studies compare the strength of such similarities.

5. Conclusion

This study brings a systematic gathering of relevant cycling literature in SSA cities and compares it with that from cities in the developed world. The study has drawn attention to cycling behaviour literature by exploring key factors influencing cycling in SSA cities and examined their main differences and similarities on cycling with those from DWC. This has provided insights into the contextual potential policies and interventions needed to promote cycling in different urban contexts. This study brings three main contributions. First, since cycling in SSA cities presents many peculiarities, and most policy initiatives to promote cycling are often drawn from other urban contexts and not adapted to the local context, a deep understanding of what contextual factors are most important is crucial for cycling policy-making in SSA cities. Second, this study has illustrated that cycling in SSA cities is influenced by many contextual factors such as road encroachments and the perception of cycling as a working tool, which is less discussed in conventional literature. Third, for travel behaviour studies, this research has shown that the link between travel distance and cycling in SSA cities is not as presented in conventional literature since some cyclist segments (bicycle taxi operators) prefer long cycling distances to increase their bicycle taxi earning and profits. A better understanding of these contextual factors is key for designing informed cycling promotional strategies in SSA cities.

Declaration of Competing Interest

None.

Acknowledgment

This research is funded by the Ministry of Science and Technology, Higher and Technical Vocational Education of the Republic of Mozambique. The authors would like to acknowledge the funding support of the TRANSyT-UPM.

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