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16th World Conference on Transport Research (WCTR 2023)

The spread of motorcycles in sub-Saharan Africa: Dynamics and public issues

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Abstract

In sub-Saharan Africa (SSA), motorcycles play a major role in daily mobility and access to the city, as well as in the local economy. Walking remains the most common mode of daily travel but it does not provide city-wide mobility. Given the cost of the car and the marginal role of the bicycle, the motorcycle is the main alternative to conventional public transport. It weaves its way through congested roads and provides access to remote suburbs. In that context, the number of households owning a personal motorcycle is increasing, whereas motorcycle taxi services are developing fast. The aim of this paper is twofold. First, it presents an overview of the spread of motorbikes in SSA and their usage. Second, it discusses two major public health issues linked to this boom: the increase in road accidents and the contribution to growing air pollution. Data remain scarce on motorcycle equipment and use in SSA. In order to address this lack of statistical data, we used two datasets. We gathered Development and Health Survey results to provide information on the evolution of household motorcycle ownership rates across SSA. Then we analyzed microdata from a household mobility survey (Dakar, Senegal) and from a survey of transport users (Lomé, Togo) to characterize the uses of motorcycles and the daily mobility they allow. In Lomé, motorcycles are very common, whereas in Dakar, they are more marginal. The results highlight a strong variation in motorcycle ownership rates between SSA regions and between urban and rural areas. Personal use of motorcycles is often long-standing and may be combined with commercial use. Survey analyses show that personal motorcycle users are more male, younger and wealthier than public transport users, and more male and younger but less wealthy than car users. Motorcycle taxi users are more female and less wealthy than personal motorcycle users. The environmental and public health issues raised by the rapid growth in the personal and commercial uses of motorcycles call for real improvements in the public regulation. From this perspective, the lack of data on urban mobility and its impacts limits decision-making and the implementation of appropriate policies. A major challenge is to improve administrative and survey data in SSA cities.

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1. Introduction

Worldwide, the use of motorized two-wheelers is on the rise, and this trend is particularly marked in India, South-East Asia (Short & Martinez, 2021) and sub-Saharan Africa (Trouvé et al., 2021). Although most of the world's motorcycles (80%) are concentrated in Asian countries, particularly in South-East Asia (Eccarius & Lu, 2020), motorcycles (among which we include scooters and mopeds in this paper) are spreading very rapidly in sub-Saharan Africa. The objective of the paper is twofold. First, it proposes a review of the state of knowledge regarding this spread and the uses to which motorcycles are put, both as personal motorcycles and as motorcycle taxis. Second, it discusses the public health and environmental issues they raise for society.

Mopeds, scooters and motorcycles first came onto the scene in sub-Saharan Africa in the 1970s (Morice, 1981). They have become more widespread both through household ownership of personal-use motorcycles and through the spectacular development of motorcycle taxi services. The locally high rates of motorcycle ownership show that, in most cases, households are more able to afford motorized two-wheelers than personal cars. Personal cars, which are more expensive both to buy and to use, are generally the preserve of the most affluent households. The difference in the purchase costs of motorcycles and cars has been accentuated since the early 2000s by the mass importation of unassembled Chinese motorcycles, which are cheaper than Japanese models (Guézéré, 2021).

Motorcycles also owe their success to their inherent performance. They can weave in and out of four-wheeled vehicle traffic, albeit sometimes at considerable risk, and thus reduce the amount of time wasted on the cities' congested roads. Often, they are the only vehicles that can use roads that are not easily passable in order to access the outskirts of cities or isolated districts. In situations where walking is the most common mode of daily travel, motorcycles improve access to urban resources and services.

Thus, a growing number of inhabitants has a personal use of motorcycles (which in the paper we shall refer to as personal motorcycles). Many factors explain this: the limited availability of public transport and the desire to be free from daily public transport use; the fact that the motorcycle has a much more positive social image than the bicycle; that it is a more affordable means of transport than the car and much more efficient in congested traffic.

These factors, plus the youth employment crisis, have created the conditions for the development of motorcycle taxi services. These services are present in more than half of the cities with populations of over 100,000 (Diaz Olvera et al., 2020a). These services play an important role in the rapid proliferation of motorized two-wheelers in sub-Saharan Africa. In many cities, they account for an extremely large part of the local economy. The sector is poorly regulated, with the attitude of the public authorities varying between the desire to exclude motorcycle taxis from certain areas or impose a complete ban (which would be difficult to enforce) and tacit acceptance. Motorcycle drivers, who are often without a license, frequently use unregistered motorcycles. To ensure their business makes a profit, they are quite willing to take risks by driving too fast or carrying several passengers or passengers with bulky luggage, for example.

Unregulated or risky practices are thus part and parcel of the operation of the sector, generating a number of public health issues that primarily concern motorcycle taxi drivers who frequently suffer from fatigue, back pain, and respiratory problems. Drivers work under pressure, especially the non-owner drivers. The fact that drivers who do not own their own vehicle have to pay a substantial amount of money to the owner of the vehicle, and the need to generate sufficient income for the driver and their family, mean they have to work long hours (Diaz Olvera et al., 2016).

While the proliferation of motorcycles in sub-Saharan Africa carries many issues with it, in particular in terms of road safety (Bishop & Courtright, 2022; Ehebrecht et al., 2018), the scientific knowledge about the spread of the motorcycle and its use is very patchy. First, this paper aims to address these shortcomings by focusing on the dynamics of the spread of motorcycles in sub-Saharan Africa and by seeking to identify the categories of urban dwellers who use them and for what types of usage and mobility. The scholarly literature on the subject focuses on the development of motorcycle taxi services, ignoring the condition of the fleet and personal use. Considering this knowledge gap, we focus our attention on personal use of motorcycles. Second, we discuss the literature on public health and environmental issues in light of findings on the spread and use of personal motorcycles and motorcycle taxis.

Data on motorcycle ownership, uses and accidents is scarce or even non-existent. It does not escape the "statistical tragedy" faced by many African countries (Jerven & Johnston, 2014). In this context, we have drawn on a variety of data sources, based on health and development surveys, and daily mobility surveys. The data covers a thirteen-year

period (2010–2022). For some countries, data from 1990s was available, which allowed us to provide a longitudinal study of the dynamics of motorcycle ownership and use.

The remainder of the paper is organized as follows. Section 2 presents the data collection and the method. Section 3 analyses the evolution of motorcycle ownership in the continent before turning to motorcycle users and uses in section 4. Section 5 discusses the issues for society, in terms of the environment and road safety, associated with the increase in motorcycle use, before conclusion.

2. Data collection and method

This paper draws on data from several surveys:

- Development and Health Surveys (DHS) and Malaria Indicator Survey (MIS) conducted by US Agency for International Development (USAID). The objective is to analyze variations and changes in household motorcycle ownership rates in sub-Saharan Africa;
- Daily mobility surveys in order to identify the users and uses of motorcycles in two West African capitals, Lomé (Togo) where use is widespread, and Dakar (Senegal) where it is less prevalent.

2.1. Motorcycle ownership: DHS and MIS surveys

The DHS and MIS are national surveys which are representative of the population after weighting. Although their focus is on health, they also collect information on households, including their vehicle ownership, allowing comparisons between countries. The frequency of DHS and MIS surveys varies greatly from country to country, but when several surveys have been carried out in the same country, they make it possible to identify changes in household motorcycle ownership rates (Minang, 2020). The question asked in the surveys was as follows: "Does any member of the household own a motorcycle or scooter?". In these surveys, ownership may therefore include in some cases households in which one member uses their own motorcycle in order to work as a motorcycle taxi driver.

The database for the different surveys, which can be searched online, provides the rate of household motorcycle ownership at three levels: (1) for the country as a whole, (2) distinguishing between 'Urban' and 'Rural' zones, and (3) for the country's capital or largest city. The first DHS and MIS surveys date back to the 1990s and thus offer a three-decade perspective on household motorcycle ownership for some countries. However, the data has some inherent limitations:

- The definition of urban areas is that used in the country in question and may therefore vary from one country to another.
- The surveys used in this work were conducted over a thirteen-year period (2010–2022). Even if ownership rates change quite slowly over time for a given country or city, one should keep in mind that the comparisons of ownership rates between countries and between cities were not made at exactly the same time.
- As average household size may differ from one country to another, these household ownership rates cannot be used to assess individual access to motorcycles within the population.

2.2. Motorcycle users and usage profiles: mobility surveys

To analyze the uses and characteristics of personal motorcycle and motorcycle taxi users, we conducted secondary analyses of micro-data from two mobility surveys carried out in Dakar (2015) and in Lomé (2011). These two surveys, in which one of the authors participated, differ in nature.

The household mobility survey (EMTASUD 2015) was conducted in the Dakar metropolitan region (Senegal) with a sample of 3176 households that was representative, after weighting. Within these households, 13,416 individuals aged over 10 years were interviewed individually (Sitrass-Curem, 2016). The information collected by this survey included the trips made the day before the survey day and the respondents' access to vehicles. One hundred and fifty-four Dakar residents used a motorcycle the day before the survey. Comparing their characteristics and levels of

mobility with those of the users of other modes, such as public transport or personal car, enabled us to assess their social profile and to situate the personal motorcycle in Dakar’s mobility system.

The survey of transport users in Lomé (Togo) was conducted in 2011. The respondents were interviewed while they were travelling and not in their homes as was the case in EMTASUD. Twelve hundred and twenty transport users of over 13 years of age were questioned about their current trip and travel habits, as well as their socio-economic characteristics and their access to personal transport modes. The survey was carried out at 35 locations in the public space near to public transport hubs (Diaz Olvera et al., 2015). Focusing on the users of public transport (motorcycle taxis, collective taxis), this survey did not set out to be representative of the modal distribution of travel in the city. In particular, the survey underestimated walking and personal vehicle use in favor of public transport. The sample of individuals using their personal motorcycle was limited (78 individuals), but it nevertheless allows a comparison to be made with the sample of motorcycle taxi customers (662 individuals).

3. Contrasting ownership rates in different regions

3.1. Comparing ownership rates at country level

Motorcycle ownership varies greatly across sub-Saharan Africa and is at its highest in West Africa (Fig. 1).

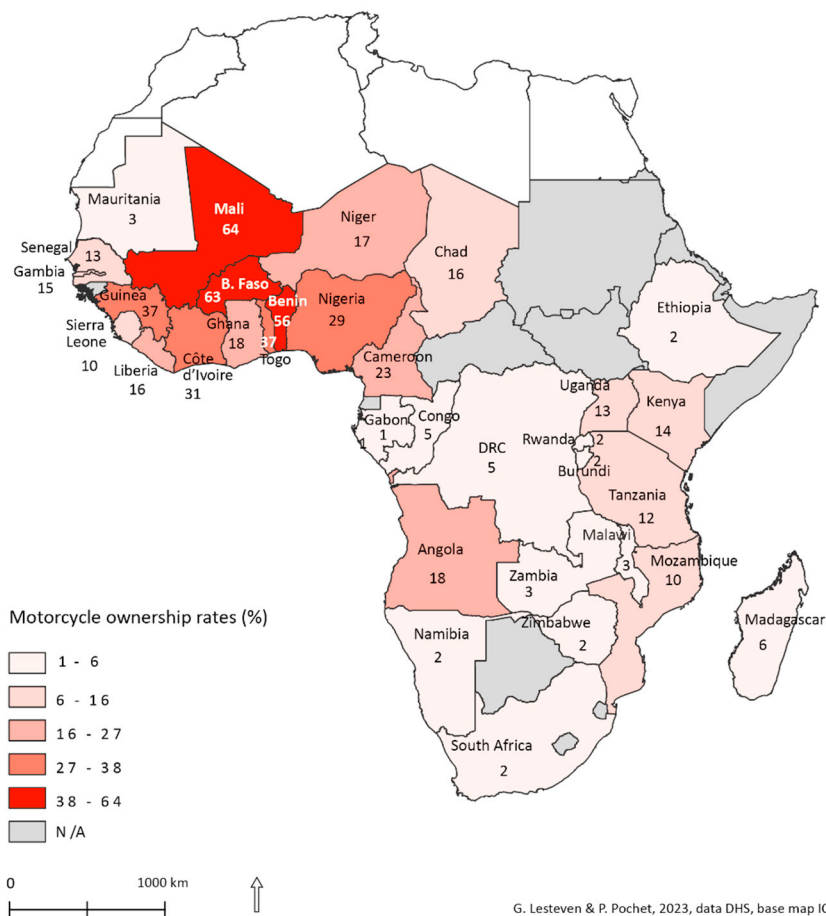


Fig. 1. Motorcycle ownership rates in countries of sub-Saharan Africa in the period 2010-2022 (% of households owning motorcycles).

* Only those countries in sub-Saharan Africa where a DHS or an MIS survey was conducted between 2010 and 2022 are shown.

Nearly two thirds of all households in Burkina Faso and Mali own one or several motorcycles, more than a half in Benin, Burkina Faso and Mali, more than a third in Guinea, Togo and Côte d’Ivoire, and almost 30% in Nigeria. The rate is between 10 and 20% in other West African countries, except Mauritania where very few households own a motorcycle. Household motorcycle ownership is also relatively high in the two Central African countries closest to West Africa, Cameroon (23%) and Chad (16%), but it is lower in the other countries of the sub-region. Household ownership rates are moderate in three East African countries, with rates of 12-14% in Tanzania, Uganda, and Kenya. Rates are very low in Ethiopia, Burundi and Rwanda. In the latter, the use of motorcycle taxis is nevertheless growing (Boutueil & Lesteven, 2024). Finally, in southern Africa, household motorcycle ownership is still marginal, except in Angola (18% of households) and Mozambique (10%). The other countries appear to be little affected by the proliferation of motorcycles in the period 2010-2022.

3.2. Comparing ownership rates between urban and rural areas

We consider the differences in household motorcycle ownership rates between urban and rural areas, focusing on countries where the rate of motorcycle ownership in urban or rural areas exceeds 10% (Fig. 2).

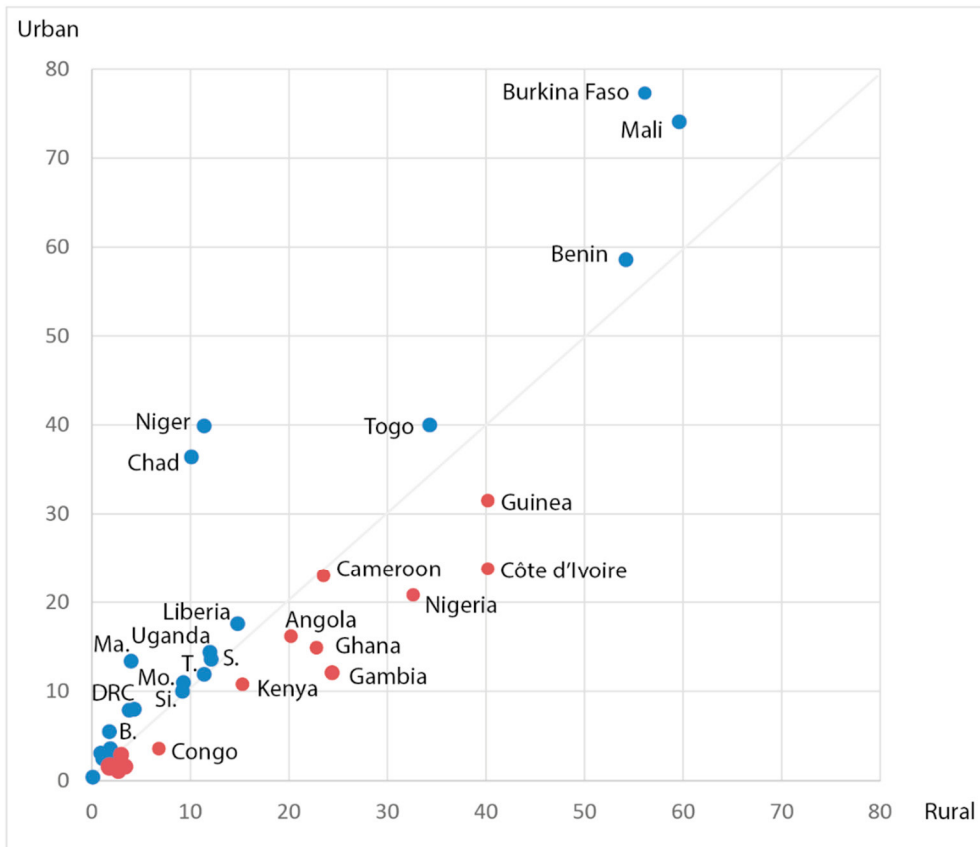


Fig 2. Rate of household motorcycle ownership according to residential location (Urban /Rural) (%)

Source: DHS surveys, compilation by the authors. Scope: countries in sub-Saharan Africa where a DHS or MIS survey was conducted between 2010 and 2022. If several surveys were conducted during this period in a given country, only the results of the most recent survey have been presented here.

B.: Burundi, DRC: Democratic Republic of Congo, Ma.: Madagascar, Mo.: Mozambique, S.: Senegal; Si.: Sierra Leone and T.: Tanzania. Reading: Each point corresponds to a country. Countries above the bisecting line are characterized by higher motorcycle ownership rates in urban areas, like Togo. The point is marked in blue. On the opposite, for countries below the bisecting line, the ownership rate is higher in rural areas, like Nigeria. The point is in red. The blue points closest to the origin represent the following countries: Rwanda, South Africa, Ethiopia, Namibia, and Lesotho, while the red points, below the line, represent Zambia, Mauritania, Malawi, Gabon and Zimbabwe.

In most of the countries that are classified as the poorest on the continent, household motorcycle ownership rates are higher in urban areas than in rural areas. This is the case of Burkina Faso, Mali, Togo, Chad, Niger, Madagascar, and Uganda. One economic explanatory hypothesis is that rural households' incomes are not high enough to allow them to purchase motorcycles. The only exceptions in the category of low-income countries, where ownership rates are higher in rural areas than in urban areas are Guinea and The Gambia (Fig. 2).

In contrast, in “low- to middle”-income countries[†] such as Angola, Cameroon, Côte d'Ivoire, Kenya, Ghana and Nigeria, ownership rates are lower in urban than in rural areas. In these countries, the urban middle and upper classes, who can afford to buy a personal car, are more likely to own one than a motorized two-wheeler. And, in rural areas, it is probably for economic reasons that household ownership of motorbikes appears to be more widespread in the “low- to middle”-income countries than in the low-income countries.

The lower rates in some urban areas do not preclude the growing use of motorcycles, due to the rise of motorcycle taxi services, particularly in the urban outskirts.

These findings are consistent with the literature analyzing the spread of motorcycles as an inverted U curve, depending on the GDP per capita of the various countries. Motorcycle ownership is increasing up to a certain level of GDP and then decreasing after that, reflecting the fact that beyond a certain level of purchasing power, car ownership begins to dominate (Bastos et al., 2020; Chu et al., 2022; Nishitateno & Burke, 2014).

3.3 Evolution of ownership rates in the capitals since the 1990s

The increasing presence of motorcycles can be observed in the capitals of the various countries. In West Africa, the region where motorcycle penetration is highest, two trends are apparent (Fig. 3):

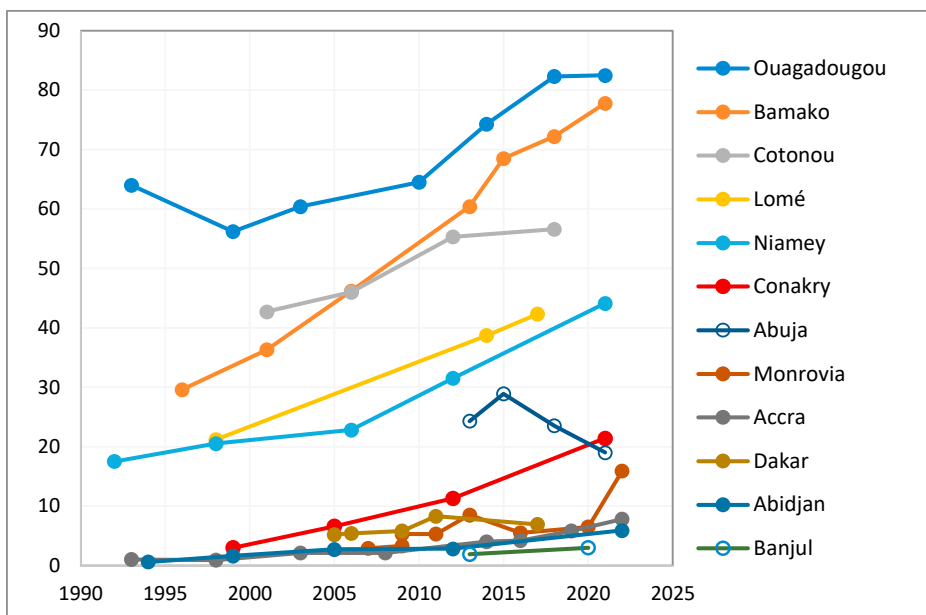


Fig. 3. Evolution of household motorcycle ownership rates in West African capitals over the last three decades. Source: DHS surveys, compilation by the authors.

According to the World Bank country by income classification. <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>, accessed 10 November 2022.

- In five capitals: Ouagadougou (Burkina Faso), Bamako (Mali), Niamey (Niger), Cotonou (Benin), and Lomé (Togo), household ownership of motorized two-wheelers had already been observed in the 1990s, and has increased substantially since the 1990s. Three of them, Ouagadougou, Bamako, and Niamey, have been characterized by high levels of personal motorcycle use since several decades (Diaz Olvera et al., 2002). The most extreme case is Ouagadougou, where most households own a motorcycle while car ownership is rare and public transport almost non-existent. In the two other capitals, Cotonou and Lomé, both forms of use, motorcycle taxis and personal use, have been present for several decades. The commercial usage of motorcycle is omnipresent in the two cities (Agossou, 2004; Godard & Ngabmen, 2002; Guézéré, 2021). Conakry (Guinea) follows the trend. The Guinean capital has experienced more recent but rapid growth, with personal motorcycle uses and a surge in the use of motorcycle taxis (Bishop & Courtright, 2022).
- In most of the capitals where motorcycle use was initially very limited, ownership rates have changed little. This trend applies in five other capitals: Abidjan (Côte d'Ivoire), Accra (Ghana), Banjul (Gambia), Dakar (Senegal) and Monrovia (Liberia). However, these cities are also experiencing an increase in the presence of motorcycles, particularly in the form of motorcycle taxi services that are spreading inwards from their outskirts. Finally, among the different capital towns in West Africa, Abuja is the only case of a decreasing motorcycle ownership rate. The ban of motorcycle taxis from the city and their replacement by commercial tricycles (Lenshie et al., 2022) may have contributed to this decrease.

In the other regions of sub-Saharan Africa, the cities of Douala and Yaoundé[‡] (Cameroon) and N'Djamena (Chad) are experiencing growing ownership rates for use as both personal motorcycles and motorcycle taxis (Brahim, 2022; Mahamat Hemchi, 2015; Ngabmen et al., 2000). For Kampala (Uganda) and Dar es Salaam (Tanzania) in East Africa (Ehebrecht, 2023; Martin et al., 2022), and Luanda (Angola) in Southern Africa, the increasing number of motorcycle taxis appears to be the main driver of the rising use of motorized two-wheelers.

4. The socio-demographic and economic profile of the motorcycle drivers

The household mobility surveys conducted in various African metropolises between the 1990s and 2010 revealed a dominant profile of personal motorcycle users who are middle class, often male, employed or working in the formal economy, or alternatively students, and young people in general (Diaz Olvera et al., 2012; Boyer et al., 2016). Secondary analyses of the Dakar and Lomé surveys provide confirmation of these profiles.

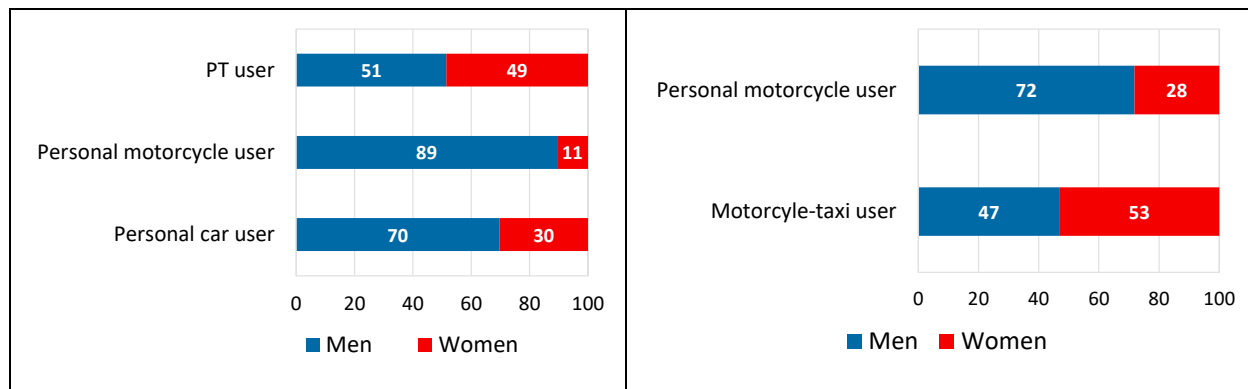
4.1. A gender inequality in motorcycle ownership and use

In Dakar, while an equal proportion of men and women use public transport, very few women use personal motorcycles (11 percent of users) (Fig. 4a). Motorcycle use appears to be more male-dominated (89 percent men) than car use, which is also dominated by men (70 percent men). In the case of cars, the majority of passengers are female. The fact that cars more frequently carry passengers than do motorcycles, to some extent brings the ratio into better balance.

In Lomé, where motorcycle use is much more common, slightly more women use the mode (they account for nearly three out of ten motorcyclists) than in Dakar, but a clear majority of the individuals using personal motorcycles are still male (Fig. 4b). This gender inequality becomes more striking when one considers that women account for a good half of all motorcycle taxi customers.

By way of comparison, in Ouagadougou, where the use of personal motorcycles is more widespread than in Lomé, gender inequality is also apparent in motorcycle ownership. This is coupled with inequality of use to the disadvantage of women, which is only slightly less marked than in Lomé, as women account for a third of personal motorcycle users in the capital of Burkina Faso (Boyer & Delaunay, 2017).

[‡] The DHS surveys do not allow us to distinguish between Cameroon's two principal cities.



a. Dakar 2015

b. Lomé 2011

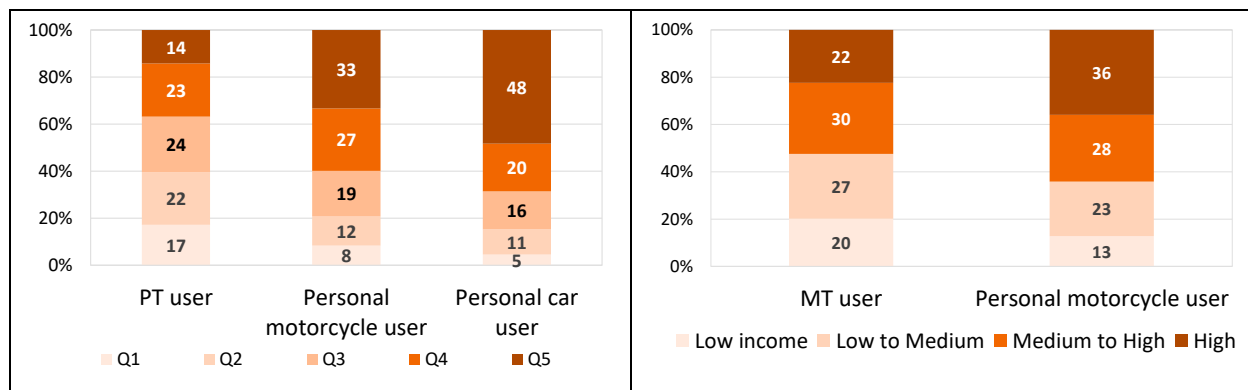
Fig 4. Distribution according to gender of the users of different motorized modes (%)

Source: the 2015 Dakar Household Mobility Survey (EMTASUD) and the 2011 Lomé Public Transport User Survey. PT: Public Transport.

4.1. More prestigious than public transport, but less than the car

In Dakar, motorcycle users, 80% of whom are in work, are slightly more likely to be young adults (18-34 years old) than are public transport users, while car users are significantly older. Motorcycles make fewer financial demands than cars and can be purchased by younger people. However, the top two income quintiles (the wealthiest 40% of the population) account for 60% of personal motorcycle users. Motorcycle use is socially differentiated in Dakar, even if its use is slightly less socially concentrated than that of the car (Fig. 5a).

In Lomé, access to motorcycles appears equally socially differentiated. Even though personal motorcycles are more widespread than in Dakar, the same stratification is at play, as almost two-thirds of users belong to the wealthiest half of the population (Fig. 5b). Motorcycle users are young: 83% are between 18 and 34 years old, as are 68% of motorcycle taxi users. As in Dakar, being in work also increases the ability to access a motorcycle: 80% of personal motorcycle users have an occupational activity, as do 75% of motorcycle taxi customers.



a. Dakar 2015

b. Lomé 2011

Fig. 5. Distribution of the users of motorized modes according to household per capita income (%)

Processing by the authors: based on the 2015 Dakar Household Mobility Survey (EMTASUD) and the 2011 Lomé Public Transport User Survey. PT: Public Transport; MT: Motorcycle Taxi.

The surveys conducted in Lomé in 2011 and Dakar in 2015 confirm the position of the personal motorcycle in the hierarchy of transport modes observed in the cities of the Sahel since the 1990s (Diaz Olvera et al., 2002). Although

it is not as prestigious as the car, the personal motorcycle nevertheless appears to have some prestige, particularly as compared to public transport and bicycle.

Its success is related to its inherent performance, which sets it apart from other motorized modes. Personal motorcycle users make more trips (Fig. 6), while spending slightly less time on their mobility (Table 1).

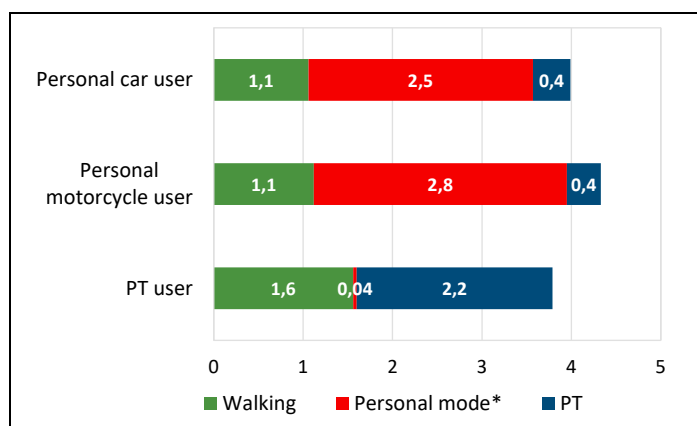


Fig. 6. Average number of trips according to the motorized mode used on the day before the survey

Table 1. Travel time budget according to the motorized mode used on the day before the survey

	Travel Time Budget
Personal car user	1h45
Personal motorcycle user	1h26
PT user	1h41

Though these surveys were conducted some time ago, they highlight the strong social and gender disparities that persist in the use of transport modes in sub-Saharan African cities. For example, the analysis of household car ownership and personal car use in Dakar between 2000 and 2015 provides evidence that, although they increased during this period, they remained concentrated among the higher income categories (Diaz Olvera et al., 2020b), and regular personal car users exhibit similar social characteristics between the two surveys. Given the importance of economic constraints and the permanence of social differentiation in the use of transport modes, it is therefore reasonable to assume that the social profile of personal motorcycle users also remains prevalent in the current decade. Further surveys are needed to consolidate these findings.

5. Private interests, public issues

The rapid spread of motorcycles in a number of African cities, both as a mode of public transport and for personal use, shows the great adaptability of motorized two-wheelers to mobility conditions and their remarkable ability to meet personal mobility needs. However, there are negative externalities associated with them, the most important of which are the high risk of road accidents and their adverse impact on air quality (Ehebrecht et al., 2018). Their rapid growth therefore raises a number of public issues for the many cities in sub-Saharan Africa where this mode has a major presence.

5.1. Road safety issues

Traffic accident risk is very high in Africa with 27 road deaths per 100,000 people compared to 18 worldwide (WHO, 2018a), despite the continent's low level of motor vehicle ownership. Vulnerable road users - pedestrians, cyclists, and motorcyclists - are particularly affected. In countries where household motorcycle ownership rates are

high, such as Benin or Mali, motorized two-wheeler users account for more than 40 percent of road-related deaths (WHO, 2018b). In addition, in countries where motorcycle taxis are common (Uganda and Côte d'Ivoire), motorcycle deaths account for one-third of all road fatalities (WHO, 2018b). Measuring and explaining this road risk is a major challenge, but is complicated by deficiencies in the available statistical data. In general, accident rates are underestimated due to under-reporting and very frequent recording errors (Bonnet et al., 2020; Vissoci et al., 2017).

Nevertheless, a number of studies have been conducted on the continent, either based on dedicated surveys or hospital data. Konlan and Hayford (2022) have carried out a meta-analysis of 22 studies conducted between 2016 and 2022 on the factors responsible for motorized two-wheeler accidents in Africa. Behavioral factors, such as excessive speed and risky driving, alcohol and psychoactive substance use, stand out as the most important, while the absence of a helmet increases accident severity. The consumption of alcohol, stimulants and painkillers is common among motorcycle taxi drivers, increasing the risk of traffic accidents (Carmel et al., 2019; Oyono et al. 2021). Despite its statistically protective effect for the most serious accidents (Abdi et al., 2022), the obligation to wear a helmet and compliance with this obligation are far from widespread. In addition, helmet wearing is even rarer among motorcycle passengers - especially motorcycle taxi customers - than among drivers. In Ouagadougou where motorcycles are ubiquitous, only 7% of personal motorcycle users wear a helmet and less than 3% in Bobo-Dioulasso, the second largest city of Burkina Faso (Nikiema & Bonnet, 2021).

Situational factors specific to the driver also play a role: inadequate experience of driving a motorcycle, the high number of hours spent driving during the day and engaging in night-time driving, and fatigue (this last factor has also been identified in Vietnam, Truong et al., 2020). Based on a case-control study carried out in Dar es Salaam, Francis et al. (2023) show that, among motorcycle taxi drivers, not owning its vehicle leads to a higher risk of injury. Risky driving behaviors and the high number of hours worked by non-owner drivers partly explain this increased risk of injury.

Factors that relate to inadequate road infrastructure, as well as the poor condition and lack of maintenance of the motorcycles, also play a role. Finally, young men are highly represented among motorcycle accident casualties. But in the absence of risk exposure data, it is difficult to know whether this simply reflects their high presence among motorcycle drivers, or whether they are subject to increased risk once their level of motorcycle use is controlled.

It is difficult to gauge from this meta-analysis how much the differences and similarities between the road risk factors that apply to the users of personal motorcycles and the drivers of motorcycle taxis differ from and resemble each other. This point should be considered when a study considers both types of use. Furthermore, by studying the representations of motorcycle risk among motorcycle drivers in the northern regions of Ghana, Konkor et al. (2019) have shown that the road risk perceived by drivers differs from the statistical risk, and has significant socio-cultural dimensions (for example, due to the importance of magico-religious beliefs). These findings point to the need to take into account the socio-cultural context when formulating prevention policies, and doing so does indeed seem to have beneficial consequences. Motorcycle drivers who have had prior instruction in safe driving are significantly less likely to be involved in accidents than those who have not (Matheka et al., 2016; Konlan & Hayford, 2022). Initiatives emerged such as NGOs making films in English and local languages to teach motorcycle taxi customers how to travel safely when choosing this transport mode (Transaid, 2022).

Finally, it is important to consider not only the characteristics of the drivers and their behaviors, but also the condition of the vehicles and the infrastructure (Carnis, 2021), in order to establish a complete road safety diagnosis of motorcycle use in African cities.

5.2. Issues with regard to air quality and CO₂ emissions

Pollutant emissions from motorcycles increase air pollution in African cities (Marais & Wiedinmyer, 2016) and especially in West African capitals where they are present in large numbers (Assamoi & Lioussé, 2010), but also, for example, in Douala (Adiang et al., 2017) or in Kampala (Singh et al., 2021). Most large African cities do not have an air monitoring system and thus they lack information on pollutant emissions and air quality (Abera et al., 2021; Schwela, 2012; Singh et al., 2021). In such a situation, we can refer to motorcycle emissions measurements. These studies show that two-wheeled motorized vehicles emit CO₂ and local pollutants, such as CO, fine particles and unburnt hydrocarbons, to varying degrees depending on their date of manufacture, power and weight (Ducreux, 2008). Information on the health impacts of pollutant emissions is scarce in sub-Saharan Africa (Adiang et al., 2017; Schwela,

2012). But it is likely that these impacts are important for the most exposed populations: motorcycle taxi drivers, workers, students and other city dwellers spending a lot of time near major traffic flows, and city dwellers who live close to high-traffic or heavily congested roads.

The public health issues related to poor air quality in sub-Saharan African cities are difficult to measure and tend to be underestimated. Further studies are needed to better highlight the links between exposure to pollutants and respiratory and other health problems (Lawin *et al.*, 2018). Climate change due to CO₂ emissions from combustion engines – which are linked to local pollutant emissions –, receives more attention, even though CO₂ emissions per inhabitant from transport are undoubtedly much lower in sub-Saharan African cities than in cities in developed countries, due to a low motorization rate.

In this context, international studies and projects aiming to carry out experiments on the motorized two-wheeler fleet abound on the African continent (Collett *et al.*, 2021; Galuszka *et al.*, 2021), especially towards electrification (Amedokpo & Boutueil, 2022). At present, electric motorcycles do not seem to be economically and socially viable in sub-Saharan African cities, but the costs of electric motorized two-wheelers, as well as the charging infrastructure and its organization, may evolve in the future, facilitating their local adoption. On the environmental side, the overall CO₂ balance sheet of the electrification of motorized two wheelers must also take into account the CO₂ emissions generated by the production of electric *vs* conventional motorcycles (Weiss *et al.*, 2015). The environmental sustainability of electrification in terms of reduced CO₂ emissions is therefore questionable if we consider the entire energy balance sheet including the energy required to manufacture electric scooters and motorcycles. It is even more hypothetical when the electricity produced to manufacture and then run the motorcycles is carbon-based (Weiss *et al.*, 2015), which argues for a general development of renewable energies. Arroyo Arroyo & Vesin (2022) studied the potential for electrification of motorcycles in Bamako (Mali) and Ouagadougou (Burkina Faso). As said earlier, personal use of motorcycles dominates in Ouagadougou whereas in Bamako, motorized two-wheelers are used for both personal and commercial uses. CO₂ emissions from motorcycles, mostly vehicles with 110cc to 250cc four-stroke petrol engines, account between 50 and 60 percent of overall vehicle emissions in these two cities. Once considered the energy mix of each country, electric motorcycles would have 67 percent lower CO₂ emissions than conventional motorcycles in Bamako and 57 percent lower in Ouagadougou. But, to date, the existing electricity production is not adequate to support a rapid transition to electric mobility, even without considering the stability of electricity provision and frequent blackouts (Arroyo Arroyo & Vesin, 2022).

The possibility and ease of recharging batteries is crucial to the success of electric motorcycles in sub-Saharan Africa. Ayetor *et al.* (2023) advocates for battery swapping development policies and call for the implementation of electric vehicle and battery standard to improve the effectiveness of battery-swapping operation. The environmental impact of this move towards the electrification of motorized two-wheelers also depends of the organization of battery recharging points, and the type of electricity used at these recharging points. Booysen *et al.* (2022) highlight the challenges for African cities to couple the electrification of informal transport modes and the development of battery charging points based on local solar energy production capacities.

Nevertheless, without consideration of its feasibility in economic terms nor in electricity production, the gain of electrification in terms of public health (through reductions in local pollutants) appears tangible, as electric motorcycles produce zero tailpipe emissions when in use in the cities (Weiss *et al.*, 2015).

6. Conclusion and research perspectives

The spread of motorcycles in sub-Saharan Africa is occurring both through the purchase of motorcycles by households for their own use and through the unregulated increase in motorcycle taxi services. These phenomena are substantially increasing the number of motorized two-wheeler users. Personal motorcycles and motorcycle taxis are playing an increasing role in meeting the daily mobility needs of city dwellers in sub-Saharan Africa. And the motorcycle taxi sector is a major contributor to the subsistence economy that is developing in cities. This proliferation of motorcycles in African cities raises major issues in terms of public health, due to the high number of road accidents and the pollution emitted.

Our findings, based on secondary analyses of development and health surveys and daily mobility surveys, underline that household motorcycle ownership rates differ across the continent, from one country to another and from one city to another. They reveal particular issues in West Africa where motorcycles are very common and in cities where

motorcycle taxi services play a dominant role. Motorcycle taxi drivers are usually young men, while their customers are characterized by diverse levels of income and socio-demographical profiles. Among them, women are dominant. Those driving personal motorcycles are predominantly male and young, with higher income. When analyzing the impacts of motorcycle use in terms of road safety, pollutant emissions or CO₂ emissions, it is important to consider that the mobility services provided by personal motorcycles and motorcycle taxis do not benefit the same categories of population.

We confronted our findings to a literature review on motorcycle adverse impacts. Motorcycle accidents reflect the current uses of motorized two-wheelers. But the accident data suffer from many shortcomings due to the under-reporting of accidents and the lack of data on the affected population and exposure to motorcycle risk, both in the case of personal motorcycles and motorcycle taxis. This is due to the dearth of household mobility surveys in sub-Saharan African cities. Similarly, the lack of administrative data on motorcycle fleets, whether for personal use or use as motorcycle taxis, and the lack of knowledge about their daily travel pattern, real fuel consumption, pollutants, and CO₂ emissions, are serious impediments to the drawing up of an environmental and public health assessment (Martin et al., 2023; Amedokpo & Boutueil, 2022). Because of this lack of knowledge of the current situation, the public health and, *a fortiori*, the climatic benefits of the envisaged electrification solutions are difficult to estimate.

A limitation of our study is the availability of surveys on daily mobility practices and the use of motorcycles and, where they exist, the age of these surveys. Future research direction should be dedicated in priority to the production of new data and how to improve public statistics. The shortage of data on mobility is a major issue in sub-Saharan African cities and complicates the implementation of sustainable mobility policies (Collett & Himmer, 2021). The gap between existing data and needs can be observed in both administrative data (motorcycle fleet and characteristics, spatial distribution) and survey data (on the travel behavior of inhabitants, as well as on the commercial operation of motorcycle taxis). Additionally, existing data often needs updating. Conducting household mobility surveys and operator surveys is crucial to better estimate household motorcycle ownership and to better understand travel patterns and the use of motorcycles in light of other transport modes. In particular, gaining a better understanding of the habits of early adopters of electrically powered motorcycles, whether motorcycle taxi drivers or personal motorcycle owners, is important. Their satisfaction and user experiences are central for the possible future dynamics of use of these new vehicles (Amedokpo, 2024). Therefore, electric motorcycle early adopters deserve special attention in future surveys and research.

There is also an urgent need to improve the recording of road accidents and the monitoring of air quality. The improvement of public statistics will deepen the knowledge on the determinants of motorcycle use and the adverse collective impacts associated with it. The increasing personal and commercial use of motorbikes is a major challenge for public authorities in charge of mobility systems in African cities. From this perspective, improving administrative and survey data will help to inform decision-making and contribute to the implementation of appropriate policies.

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