Motorcycle Taxi in Shared Mobility and Informal Transportation: A Bibliometric Analysis

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Abstract

Background: Motorcycle taxi (MCT) is a form of widely used informal transportation. Over the last few years, MCT has developed from conventional public transportation into a modern business using digital technology. In these services, digitalization has received a positive response from the public and the increasing number creates many challenges. However, there is a gap in the discussion of new service models for shared mobility transportation.
Objective: This research aimed to analyze MCT, providing an overview of the services as informal transportation.
Methods: Bibliometric analysis was used to evaluate 366 articles published in the Scopus database between 2011-2023. In addition, annual publications and citation topics, most productive sources and influential articles, relevant affiliations, productive countries, location research, main topics, and future research options were identified.
Results: Frequently occurring topics were reported with past and present academic developments related to MCT services. Based on the publication themes, the main topics were arranged into five clusters, namely (a) the development of more sustainable transportation services, (b) environmental and health impact, (c) road safety, (d) risky behaviors or risk factors as MCT drivers, and (e) utilization of MCT for medical or health services. Meanwhile, the research topics comprised themes about travel behavior, health, safety-security, customer satisfaction, and advanced mobility topics.
Conclusion: This research increased knowledge about main topics, trends and future analysis options in MCT. The academic developments served as a guide to future topics.

Keywords: Motorcycle taxi, public transportation, informal transportation, shared mobility, bibliometric analysis

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I. INTRODUCTION

Over the past few years, many businesses operating under the "sharing economy" concept have been developed with Information and Communication Technology (ICT). In this context, underutilized resources are offered and shared in new and creative ways. There are many variations of business models related to the sharing economy known as shared mobility in the transportation sector. Shared mobility is a transportation concept where various modes are used [1] to reduce private ownership of vehicles. This allows people to use vehicles through mobile phone applications or online platforms. The concept includes motorized vehicles such as cars, vans, motorcycles or scooters and, bicycles. Some forms of new services are ride-sourcing, ride-spitting, e-hail, car-sharing, bike-sharing, scooter-sharing, car-pooling [1], [2], [3].

Informal transportation lacks the presence of a formal regulatory framework and the services are known as "gap fillers". This mode of transportation provides flexible services, filling the gap between private and public systems [4]. In some cases, informal transportation is more efficient and effective and meets people's needs. Most of the services are unorganized or unregulated with a variety of self-regulation and replace or complement formal state control [5], [6], [7].

Motorcycle taxi (MCT) has been widely used as a form of shared mobility and informal transportation [5], [6], [8]. The concept increases socio-economic activity by providing services and employment opportunities to many low-skilled populations [9], [5], [6], [10], [11]. The main cause is the lack of development of formal public transit to keep

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up with city growth [12]. Additionally, MCT provides mobility for people without private vehicles and possesses several advantages, including door-to-door services with cheaper rates and faster travel times.

Conventional services have evolved into a new form of MCT. In recent years, new MCT services, often called motorcycle ride-hailing, ride-sourcing, or e-hailing services, have also become popular [8]. Previously, passengers were directly on the road or at the base looking for a driver to obtain services. Payments for ordered vehicles can be made using smartphone applications. These services have also developed into multi-services, such as the delivery of goods and food with many advantages.

The increasing number of MCT has created negative externalities associated with high accident rates, contribution to carbon emissions, air pollution, noise, traffic problems and suspected crime [11]. To solve the complex problem, an in-depth analysis of MCT services is needed.

Previous research conducted literature reviews and bibliometric analyses on several types of transportation, informal and small-dimensional vehicles. Behrens et al. [13] reviewed informal transportation and shared mobility literature, including various types of vehicles. Therefore, this research found the rapid development of analyses in the field, following the dominance of articles affiliated with universities in Europe, East Asia, and North America. Vizuete-Luciano et al. [14] reviewed academic developments regarding taxi services and the service variations with the concept of shared mobility. Several research conducted bibliometric analyses of small dimensional transport modes, such as motorcycles [7], [15], [16], powered micro-mobility [17], and electric bicycles (e-bikes or e-scooters) [18]. However, there is a gap in the discussion of new service models for shared mobility transportation, particularly MCT.

This research aims to provide an overview and bibliometric analysis of MCT services as a mode of informal transportation. Conventional MCT services and new models with shared mobility are also discussed to increase knowledge about the dynamics of informal transportation. This research is helpful for practitioners who need an in-depth literature summary to understand the state of informal transportation. A general overview of current results and input for future research topics are provided.

II. LITERATURE REVIEW

A. Motorcycle taxi (MCT)

The number of MCT as a mode of commercial transportation has increased rapidly in the last few decades. This occurs in various parts of the world, specifically in Asian countries (Vietnam, Sri Lanka, China, Thailand, Indonesia), Latin America (Brazil) and many cities in Sub-Saharan Africa (Nigeria, Cameroon, Benin, Togo, Uganda, Kenya, Tanzania, Rwanda) [8], [11], [7]. There is no uniform growth with MCT fleet characteristics varying across countries and rural/urban contexts. Meanwhile, several reasons are related to the high use of this mode of transportation in African cities.

According to the classification in Phun and Yai [4], MCT is included in motorized vehicles, two-wheeled, 1-2 seat capacity, flexible route, and schedule. The concept also has many local keywords and several spelling variations. In Indonesia, Philippines, Cambodia, Vietnam, and Thailand, MCT is known as ojek, Habal-Habal, Motodop, Xe Om [4], and win motorsai, respectively [8]. Meanwhile, in several African countries, the concept is often referred to as okada in West Africa or boda-boda in East Africa [19]. MCT also has other local names, such as zemidjan, bendskin, alalok, oleyia, clando, and moto−conchos in Benin, Cameroon, Nigeria, Togo, Chad, and Dominican Republic, respectively [5], [7], [20].

B. Shared mobility

According to Shaheen et al. [1], shared mobility is an innovative transportation strategy that allows users to gain short-term access to transportation on an "as-needed" basis. The concept allows planning and booking urban trips, with real-time information and fare payment in a single-user interface [3]. Shared mobility can increase multimodality, reduce vehicle ownership and miles/kilometres travelled (VMT/VKT), as well as provide new methods to access goods and services [1], [3]. Shaheen and Chan [21] classified the concept into three based on the shared content. The three categories include sharing of (a) vehicle, (b) passenger ride, and (c) delivery ride.

The new form of transportation services in developing countries is more similar to ride-sourcing or ride-hailing services. This is known as e-hail or e-hailing and the concept uses applications.

C. Related secondary research

There is no research focused on bibliometric analysis for conventional MCT and the newest service forms. Table 1 provides a comprehensive summary of several secondary research directly related to the research theme. This research presents an extensive review of various modes of transportation, with a particular focus on informal public transport,

shared mobility, and micro-mobility or two-wheeled vehicles. Some analyses were limited to specific areas and Table 1 shows the wide range of databases, period of literature reviewed, and specific aims of each research.

Behrens et al. [13] conducted a bibliometric analysis and network mapping of 'informal public transport' and 'shared mobility modes' in eight global regions between 2010 to 2021. The eight regions include Northern America, Latin America/Caribbean, Europe, Africa, Western Asia, Eastern Asia, South-eastern Asia, and Oceania. In addition, the regions are divided into four main categories of passenger services, including flexible transportation, informal transportation, shared mobility, and for-hire transportation. Vizuete-Luciano et al. [14] conducted bibliometric analysis of urban mobility research and relation to taxi transportation such as ride-sharing, ride-sourcing, ride-pooling, and ride-splitting.

TABLE 1
RELATED SECONDARY RESEARCH

Reference	Type of Review	Data Base	Periods	Concern in research question
Behrens et al. [13]	Bibliometric analysis and survey of 'informal public transport' and 'shared mobility modes'	Scopus; Web of Science (WoS), Dimensions, Engineering Village IEEE Xplorer, ProQuest.	2010- 2021	- Performance analysis (publication trends & research fields) - Science mapping (research field co-occurance analysis, research activity distributions, university/research team/researcher mapping and analysis network (country collaboration networks, country citation network, author collaboration networks, author co-citation networks)) - Identify research gap and priority research needs
Vizuete-Luciano et al. [14]	Bibliometric analysis of taxi and urban mobility research	WoS	1967 - 2021	- Performance analysis (publication & citation structure, influential articles leading authors, most productive and influential institutions & countries) - Science mapping (co-citations analysis, bibliographic coupling, co-occurrence of keyword analysis) - Identify the most recurring topics and future lines of research
Firmansyah et al. [15]	Bibliometric analysis of motorcycle research in Asia	Scopus dan WoS	1971 - 2022	- Performance analysis (total publications, most relevant sources, global citation score, local citation score, authors, affiliations and countries) - Science mapping (co-ocurrance of keyword analysis, methods, theme evolutions, theme map, topics) - Identify trends and future research directions
Diaz Olvera, et.al. [16]	Bibliometric analysis and survey of MCT services in Sub-Saharan Africa (SSA)	Google Scholar	1988- 2016	- Bibliometric analysis of academic output about the spread of MCT in SSA (number of academic documents, focus & topics) - Analyze the informalization rationales in the deployment of the MCT model in Lome (Togo)
Ehebrecht et.al. [7]	Literature review of motorcycle-taxi in Sub-Saharan Africa	Not identified	Not stated explicitly	- Evolution of MCT services in SSA - Underlying factors the growth of motorcycle taxis, supply side and demand side aspects, service organization, service regulations, safety, health and environmental impacts, spatial patterns - Emerging issues and questions for future research
Zhou et al. [18]	Bibliometric analysis of e-bike research	WoS	1976 - 2023	- Performance analysis (highly-cited articles, authors, institutions, journals, regional distribution of publications) - Science mapping (co-authorship network among the main research organization, keywords co-occurrence analysis and clustering, burst detection analysis) - Identify gaps and future research
Chalermpong et al. [12]	Literature review of Ride-Hailing Applications (RHA) in Southeast Asia (SEA)	Google Scholar, SCOPUS, WoS, Science Direct, JSTOR, and Emerald Insight	2016 - 2021	- Review the literature on topics RHA in SEA (for car, motorcycle, and tricycle services) - RHA demand and supply characteristics, impacts of RHA on travel behavior, and implications on the transportation system

Firmansyah et al. [15] conducted bibliometric analysis of motorcycles in Asian countries from 2011 to 2022. In this research, developments were discussed in the types of motorcycles and scooter vehicles. Compared to motorcycles, scooters tend to have a lighter sleeker design with lower performance and are more suitable for short trips. Diaz Olvera et al. [16] examined the development and spread of MCT in Sub-Saharan Africa in the context of globalization and informatization. Meanwhile, internet searches were carried out on academic output and local press articles over 30 years. The documents were categorized into several topics, including road safety, public health, economics, territorial development, governance, environment, and others. Ehebrecht et al. [7] conducted a literature research on providing public mobility in Sub-Saharan Africa. Insights were categorized and summarized into this transport mode covered by the reviewed research. The topics include factors of motorcycle taxi growth, supply and demand side aspects,

service organization, regulation, safety, health and environmental impacts. Chalermpong et al. [12] conducted a literature review on Ride-Hailing Applications (RHA) in developing countries in Southeast Asia (SEA). The characteristics of RHA demand and supply were comprehensively discussed with the impact on travel behavior, implications for the transportation system, and developments in the regulations in SEA. A literature review of RHA was also compared with developed countries. Moreover, Chalermpong et al. [12] discussed car and motorcycle-based RHA for providing food and parcel delivery.

This research aims to analyze MCT research, providing a comprehensive overview of services as informal transportation through bibliometric analysis. Meanwhile, Behrens et al. [13] discussed various types of vehicles used in passenger transportation. In Vizuete-Luciano et al. [14] research, taxi is regulated by local government to ensure security and the mode of transportation uses a car as the primary vehicle. However, a unique and in-depth understanding of the modes of transportation is provided. Firmansyah et al. [15] only discussed motorcycles used for passenger or goods transportation services. Diaz Olvera et al. [16] and Ehebrecht et al. [7], analyzed MCT limited to Sub-Saharan Africa region.

III. METHODS

Bibliometric analysis uses statistical and computational methods to identify patterns, topics, and relationships in scientific literature, providing visual outputs that map and explore the knowledge domain [18], [22], [23]. The method manifests across two categories, namely (1) performance analysis and (2) science mapping. Performance analysis examines a particular field and is descriptive, while science mapping focuses on the relationship between research [24], [25]. Procedures and best practices in bibliometric analysis were proposed by Donthu et al. [24]. Therefore, this research aims to provide performance analysis and science mapping of MCT as informal transportation service. The research Questions (RQ) include the following:

RQ1: What are annual publications and citations, the most productive sources and influential articles, relevant affiliations, productive countries, and location of the research related to MCT?

RQ2: What are the main topics, trends, and future research in MCT?

Bibliometric analysis was used to address the research questions. To answer RQ1, a performance analysis was carried out related to MCT research. In addressing RQ2, science mapping was performed using keyword analysis. Based on the results, research topics were evaluated on MCT from past to present and suggestions were offered for future research directions.

A. Database collection and selection

The document search steps were shown in Fig. 1 according to the steps in [24], [26], [27], [28]. In this research, the Scopus database was used as the largest indexer and included more than 20,000 peer-reviewed journals. The database provides research literature metadata, which includes article title, publication years, source title, authors, affiliates, authors with affiliates, abstract, keywords, and other information. The articles were collected using the title, abstract, and keywords search in the Scopus database with 2 categories in Table 2. The first set corresponds to MCT, as defined based on [16]. In the first set, local keywords were excluded from MCT and the second was related to publications discussing the use of motorcycles as shared mobility [1], [29], [30]. Additionally, the data were collected from April to July 2023 and 537 documents were obtained through the combination of two "search keywords" using the "AND" operator.
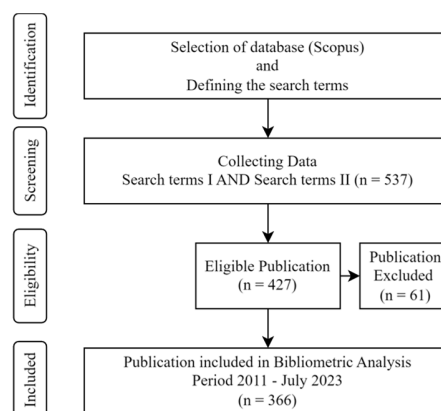

Fig. 1 Flow diagram to identify eligible research for bibliometric analysis

TABLE 2
SEARCH KEYWORDS

No	Category	Search Keywords
I	Motorcycle Taxi (MCT)	("motorcycle taxi" OR "taxi motorcycle" OR "motorbike taxi" OR "taxi motorbike" OR "taxi moto" OR "moto taxi" OR "public motorcycle" OR "public motorbike" OR "commercial motorcycle" OR "commercial motorbike").
II	Motorcycle Shared-Mobility (MSM)	(e-hailing OR "ride-hailing" OR "ride-sourcing" OR "ride-sharing" OR "online transportation" OR "application-based transport*" OR "demand responsive transport*" OR "sharing economy" OR "shared mobility" OR "demand ride services" OR "delivery service" OR crowdsourcing) AND (motorcycle OR motorbike)

B. Inclusion and exclusion criteria

From the 537 documents obtained, relevant research were selected using inclusion and exclusion criteria. The inclusion criteria are English language documents in the form of journal and conference articles, without including books, chapters, reviews, letters, and other forms. The subsequent criteria are articles published between 2011 to July 2023. This period was used to determine changes in research themes or topics after more than a decade. Using inclusion criteria, 427 articles were obtained simultaneously. Meanwhile, articles with incomplete data, duplication, and irrelevant to the topics of discussion were excluded. These comprised documents discussing scooters, helmet performance, engine oil for commercial motorcycles, performance of a motorcycle muffler, and three-wheeled motorcycle taxis. The topics were not analyzed because the main focus was centered on MCT as a mode of transport. A total of 366 articles were obtained from this stage and used for further analysis. This data is large enough to use bibliometric method in identifying the relationships, patterns, and trends in the research.

C. Data analysis and visualization

Bibliometric analysis was performed using the software packages VOSViewer (version 1.6.17) and Biblioshiny (R version 4.3.1., Bibliometrix package). To answer the literature structure of MCT research, performance analysis was used by presenting annual scientific productions and citations, most productive sources and influential articles, relevant affiliations, most productive countries, and research locations/regions/countries.

For science mapping, keyword analysis was used to show the thematic concept of the document. These keywords often comprise subjects such as research interests, topics, fields, and objects, which play an essential role in uncovering trends [23]. In the analysis, visualizations were presented in the form of a treemap, keyword co-occurrence network map, themes evolution, thematic map, and topics. Additionally, cluster analysis was performed based on the keyword co-occurrence network map to show trends in the main topics or research areas [23], [31]. Theme evolution and thematic maps were also used to discover the development and changes. Meanwhile, thematic maps were used to map the importance and development of a theme [32], [33]. A diagram of topics was presented and the research article was identified manually.

IV. RESULTS

A. Bibliometric performance analysis

This section contains the descriptive analysis of various performance metrics from MCT research between 2011 to July 2023. The results are related to annual publications and citations, most productive sources and influential articles, relevant affiliations, productive countries, and research locations.

1) Annual publications and citations

Based on the 366 published articles selected for analysis, 292 (79.78%) were journals, and the remaining 74 (20.22%) were conference articles. Fig. 2 is a bar and line diagram depicting the annual number of publications and citations per year. The bar chart shows the trend in the number starting in 2018, with a peak in 2020 (62 publications) and 2022 (61 publications). Meanwhile, 2023 is still half a period/year with an increased number of articles. The line chart depicts the pattern of total citations per year. This chart shows a more fluctuating pattern and an increasing trend until 2020. The rising pattern is consistent with the number of publications regarding MCT research. However, there has been a pattern of decline since 2020, which can be attributed to the relatively short publication period.
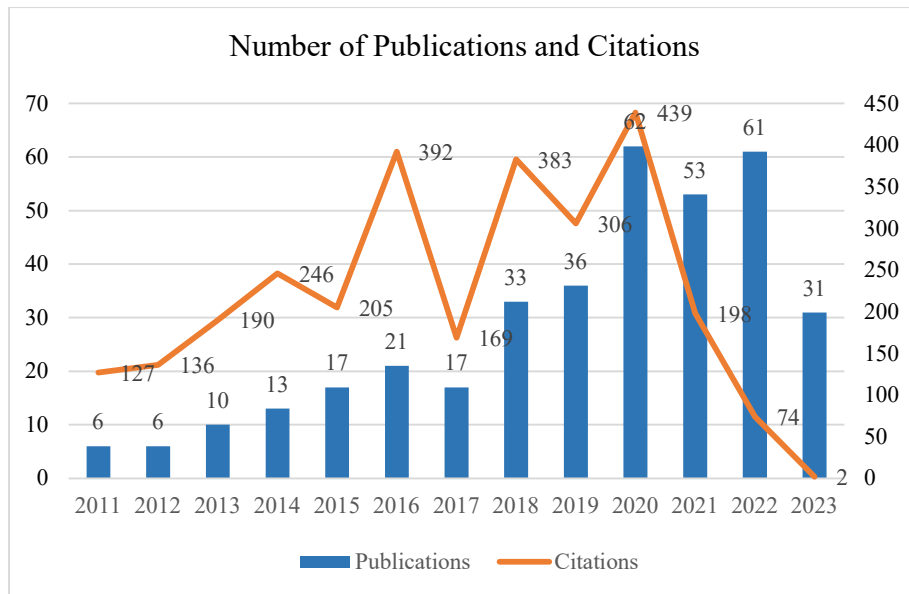
Fig. 2 Number of publications and citations per year

2) The most productive sources and influential articles

Analysis of journal sources helps to determine the characteristics of the distribution of documents discussing MCT as informal transportation service. Fig. 3 shows the journals having the most significant contribution, with a total publication of five articles. The highest ranking is Sustainability (Switzerland), and the following is Case Studies on Transport Policy. The journal Sustainability (Switzerland) has 12 articles with high citation averages including Park et al. [34] and Nguyen M.H. et al. [35]. Meanwhile, the article in Case Studies on Transport Policy with the highest citations is from Suatmadi et al. [36].
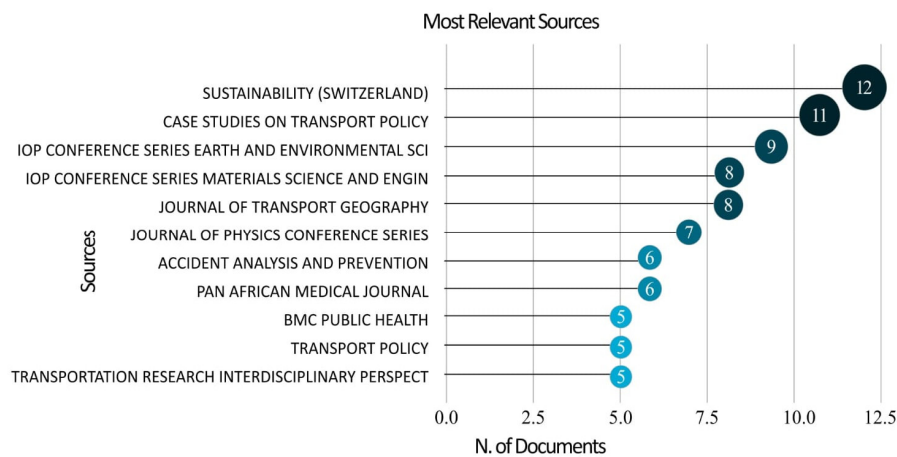

Fig. 3. Most relevant sources (>=5)

Citations are performance indicators in the research system and the number reflects the article's research value and status [23]. Table 3 shows the top 10 articles with the highest average citations (AC) and the value is obtained by dividing Total Citation (TC) by the length of time required for publication. The average citation with the highest rank is the article by Ortiz-Prado et al. [37] titled "High prevalence of SARS-CoV-2 infection among food delivery riders. A case study from Quito, Ecuador". This article was cited 38 times, with an average citation per year of 19. Fig. 2 shows a spike in total citations in 2014, 2016, 2018, and 2020, with articles that made a significant contribution, as reported in Table 3.

TABLE 3
THE TOP AVERAGE CITED ARTICLES IN MCT RESEARCH

	Title	Journal name	Author(s)	Year	TC	AC
[37]	High prevalence of SARS-CoV-2 infection among food delivery riders. A case study from Quito, Ecuador	Science of the Total Environment	Ortiz-Prado et al.	2021	38	19.0
[35]	Factors affecting the growth of e-shopping over the COVID-19 era in Hanoi, Vietnam	Sustainability (Switzerland)	Nguyen M.H. et al.	2021	30	15.0
[7]	Motorcycle taxis in Sub-Saharan Africa: Current knowledge, implications for the debate on "informal" transport and research needs	Journal of Transport Geography	Ehebrecht et al.	2018	72	14.0
[34]	A comparative analysis of the environmental benefits of drone-based delivery services in urban and rural areas	Sustainability (Switzerland)	Park et al.	2018	64	12.8
[38]	To compete or not compete: exploring the relationships between motorcycle-based ride-sourcing, motorcycle taxis, and public transport in the Jakarta metropolitan area	Transportation	Irawan et al.	2020	38	12.7
[39]	Risky behaviors associated with traffic crashes among app-based motorcycle taxi drivers in Vietnam	Transportation Research Part F: Traffic Psychology and Behavior	Nguyen-Phuoc et al.	2020	33	11.0
[40]	Exploring the prevalence and factors associated with self-reported traffic crashes among app-based MCT in Vietnam	Transport Policy	Nguyen-Phuoc et al.	2019	42	10.5
[36]	On-demand MCT improve mobility, not sustainability	Case Studies on Transport Policy	Suatmadi et al.	2019	42	10.5
[41]	Towards a geography of informal transport: Mobility, infrastructure and urban sustainability from the back of a motorbike	Transactions of the Institute of British Geographers	Evans et al.	2018	52	10.4
[42]	The effects of unhealthy lifestyle behaviors on risky riding behaviors – A research on app-based motorcycle taxi riders in Vietnam	Journal of Transport and Health	Nguyen-Phuoc et al.	2020	30	10.0

* TC= Total citation, AC= TC/year

3) The most relevant affiliation, the most productive countries, and research locations

Fig. 4 presents the top relevant affiliations in research with more than or equal to 10 (>=10). The five institutions with the most relevant affiliations are University of Indonesia, Makerere University, University of Abomey Calavi, Gadjah Mada University, and Chulalongkorn University. Several institutions in developed countries have contributed to MCT research, including Duke University (USA), London School of Hygiene and Tropical Medicine (LSHTM), University of Washington, and University of Michigan. For example, research from Duke University contributed to road traffic injuries and several prevention strategies [43],[44]. Patel et al. [43] collaborated with the State University of Maringá (Brazil) and Rwanda School of Medicine to conduct mapping and analyze spatial data from the Road Traffic Crash (RTC) in Kigali (Rwanda) by creating a hotspot map of crashes. Sumner et al. [44] collaborated with the University of North Carolina at Chapel Hill and Kilimanjaro Christian Medical Center (Tanzania) to improve MCT driver safety. Kuteesa et al [45] [46], from London School of Hygiene and Tropical Medicine, partnering with the Medical Research Council (MRC)/UVRI and LSHTM Uganda Research Unit, and the International AIDS Vaccine Initiative (IAVI) (Nairobi, Kenya), studied the risks of alcohol use and HIV infection in several occupational groups in Sub-Saharan Africa.
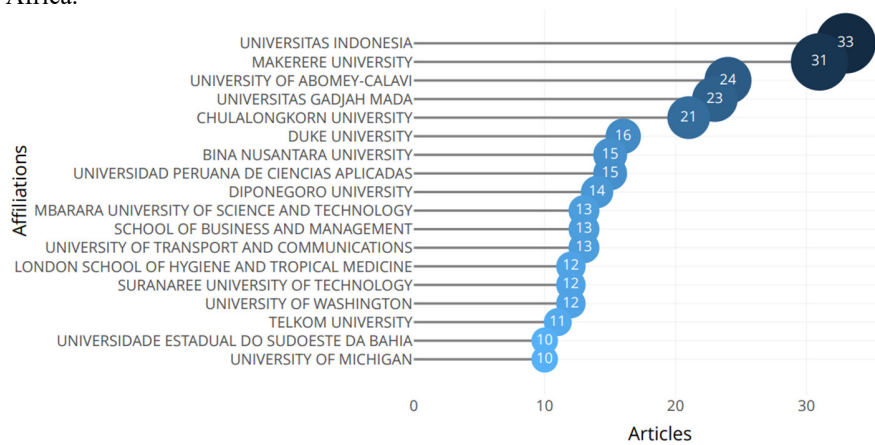

Fig. 4. Most relevant affiliations (>=10)

Table 4 shows the locations where the research was conducted, with the number of articles above 5. The places or locations of research were undertaken mainly in Indonesia (26.78), Uganda (9.29%), Vietnam (7.38%), Thailand (6.56%), and Nigeria (5.74%). Meanwhile, 5.46% used more than one location or countries found across Asia, Africa, and Latin America.

TABLE 4
NUMBER OF ARTICLES (>=5) BASED ON RESEARCH LOCATION (COUNTRIES)

No	Countries	Number of articles	%	No	Countries	Number of articles	%
1	Indonesia	98	26.78	11	Tanzania	8	2.19
2	Uganda	34	9.29	12	Colombia	7	1.91
3	Vietnam	27	7.38	13	Korea	7	1.91
4	Thailand	24	6.56	14	Ghana	6	1.64
5	Nigeria	21	5.74	15	Peru	6	1.64
6	Brazil	12	3.28	16	Philippines	6	1.64
7	Kenya	10	2.73	17	China	6	1.64
8	Benin	8	2.19	18	Liberia	5	1.37
9	Cameroon	8	2.19	19	Several countries	20	5.46
10	Rwanda	8	2.19	20	Others	45	12.30

B. Science mapping

Keywords in an article are phrases selected to summarize the topics or contents. These phrases can identify a scientific publication and the main focus is conducting science mapping. Fig. 5 is a tree map presenting the 40 most frequently occurring keywords in MCT research. The five most frequently used keywords are motorcycles (126), adult (122), male (115), human (92), and female (84).
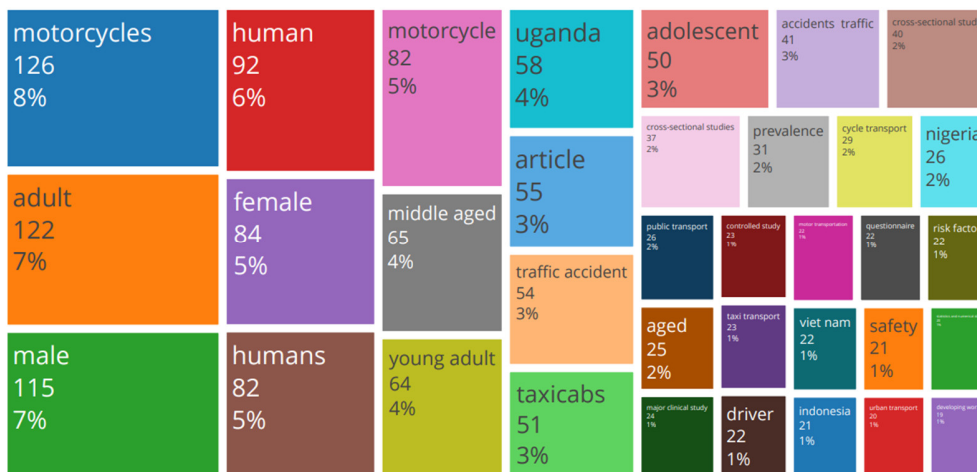
Fig. 5 Treemap of the keywords of MCT research

1) Keywords co-occurrence analysis

Co-occurrence analysis shows a list of keywords classified based on number of occurrences and total link strength. Fig. 6 shows a network visualization of co-occurrence of keywords, which is VOSviewer output. The frequency of keywords determines the size of the node. The higher the usage frequency, the larger the node size. In addition, keywords in clusters with the same colour correlate strongly [18]. A minimum number of 5 is used as occurrence keywords and only 206 were selected.

A total of large clusters representing different aspects were identified and assigned a specific colour. The first or red cluster (47.6%), consists of keywords namely accidents, behavioral research, COVID-19, customer satisfaction, cycle transport, electric motorcycles, electric vehicles, fleet operations, information management, motor transportation, motorcycle taxi, poverty, rural areas, and taxicabs. Some keywords in the cluster but not visible in Fig. 6 are commerce, delivery service, developing countries, food delivery, ride-hailing, informal transportation, intelligent systems, mobile applications, online motorcycle taxi, ride-hailing, ride-sharing, risk assessment, service quality, sharing economy, sustainable development, transportation planning, transportation policy, transportation safety, transportation system, travel behavior. These keywords are not visible in the image due to the small occurrence value or total link strength.

The differentiation into several subtopics was carried out based on the keywords from the red cluster. The first subtopic is related to shared mobility, commerce, ride-hailing, ride-sharing, online motorcycle taxis, food delivery, and mobile applications. In addition, the subtopic is related to behavioral research, behavior, and service quality. The presence of ride-hailing services has influenced customers' travel fashion choices. Several research related to this subtopic are Irawan et al. [38], Suatmadi et al. [36], Rizki et al. [47], Kuswanto et al. [48], Nguyen-Phuoc et al. [40]. Irawan et al. [38] examined the substitution of these services for the existing public transport and conventional taxis in Jakarta, Indonesia. Suatmadi et al. [36] investigated the online introduction of MCT and analyzed capital shifts with carbon footprints in various population segments. Rizki et al. [47] explored the effects of on-journey, before-journey, and multi-tasking advantages when using ride-sourcing in Bandung, Indonesia. In addition, Kuswanto et al. [48] analyzed the effect of service quality on trust, satisfaction and loyalty in Indonesian ride-sharing services. Nguyen-Phuoc et al. [40] investigated the prevalence and factors associated with road traffic crashes among application-based motorcycle taxi riders in Vietnam. Several topics related to COVID-19 pandemic era discussing the influence on customer behavior include Nguyen M.H. et al. [35] and Ortiz-Prado et al. [37].

Fig. 6 Keyword co-occurrence network map of MCT research

The second subtopic is the use of electric and autonomous vehicles or drones (unmanned aerial vehicles (UAV)) in providing services. Research that discussed the topics were Park et al. [34], Ruensumruay et al. [49], Chutiprapat et al. [50], and Waluyo et al. [51]. Park et al. [34] evaluated the environmental impact of delivery services using MC versus drones such as unmanned aerial vehicles or UAV. Ruensumruay et al. [49] developed a model for the energy consumption of motorcycles using Artificial Neuro-Fuzzy Inference Systems (ANFIS) method. Chutiprapat et al. [50] presented ANFIS model of electric vehicle energy consumption for Power Development Plants, considering passenger cars, taxis, motorcycles and buses. Meanwhile, Waluyo et al. [51] explored the willingness to adopt electric motorcycles among ride-hailing drivers by specifying the preference.

The third research subtopic is related to transportation planning, systems, and policies. The keywords include informal transportation, intelligence systems, traffic management, transportation infrastructure, transportation planning, transportation policy, transportation safety, transportation systems, sustainable development, and risk assessment. Several research that discuss the theme were Sengers & Raven [52], Turner [53], Sopranzetti [54], and Evans et al. [41]. Sengers and Raven [52] analyzed the evolution of MCT industry in Bangkok by using platforms such as taximeters to enable the modernization of informal transportation. Turner, S [53] discussed the injustice regarding the plans of Hanoi officials in Vietnam, who wanted to ban MCT from operating on the city's central streets.

Meanwhile, Sopranzetti [54] reconstructed the shifting use of the local concept of "informality" over the last 35 years in Bangkok, with particular attention to MCT business in the 1980s, development after the 1997 economic crisis, and transformation since the arrival of Ride-Hailing applications in 2016. According to Evans et al. [41] showed how qualitative mobile and GIS methods report the relationship between informal transportation and urban fabric to support lives and livelihoods.

The second cluster consists of green nodes and the keywords (15%) include air pollution, automobile driving, car driving, carbon monoxide, cross-sectional research, educational status, environmental exposure, health risk, male, middle-aged, occupational exposure, occupational health, public health, psychology, work environment, work conditions. These keywords refer to research related to environmental and health impact as reported by Lawin et al. [55], [56], [57], Arphorn et al. [58], and Sanchez et al. [59]. Lawin et al. [55] article used cross-sectional research to examine the influence of urban air pollution on drivers' MCT work related to respiratory disorders. In addition, Lawin et al. [56] evaluated the role of exhaled carbon monoxide (exhCO) as a potential biomarker of exposure to ambient carbon monoxide (ambCO) from outdoor air pollution (OAP). The effect of exceeding the US ambient air quality standard was assessed for carbon monoxide (CO) on motorcycle taxi driver's respiratory health [57]. Arphorn et al. [58] investigated lung function decline in motorcycle taxi drivers by analyzing closed-vehicle taxi drivers. Sanchez et al. [59] compared the quality of life and work abilities of taxi and MCT drivers.

The third or blue cluster (15%) consists of keywords including accident prevention, accident traffic, craniocerebral trauma, crowdsourcing, head injury, head protective devices, helmet, injuries, injury severity, motorcycle, motorcyclist, prevention and control, road safety, safety, traffic accident. The keywords in this group refer to road safety, research topics related to traffic accidents, accident prevention, and head protective devices. Several research in this group includes Sumner et al. [44], Matheka et al. [60], Patel et al. [43], Nguyen T.D. et al. [61], Chung, et al [62]. The article by Sumner et al. [44] tested the effects of removing cost barriers through the provision of safety equipment, and fluorescent motorcycle safety vests, on the utilization among a population of MCT drivers in Tanzania. Matheka et al. [60], explored the characteristics of road traffic accidents (RTI) related to 2- and 3-wheeled vehicles in Kenya. Patel et al. [43] described the epidemiology of ISR in Kigali Province, Rwanda and created an accident hotspot map from police data. Meanwhile, Nguyen T.D. et al. [61] characterized the prevalence of injuries and safety habits among MCT drivers, as well as different methods to improve road traffic safety. Chung, et al [62] analyzed the injury severity of vehicle-to-motorcycle crashes during delivery.

The fourth or yellow cluster (13.6%) consists of keywords including adolescent, alcohol consumption, alcohol drinking, attitude to health, epidemiology, risk behavior, HIV, HIV infections, human immunodeficiency virus infection, knowledge, occupation, risk factors, risk-taking, and young adult. The keywords included in this cluster are related to research on behaviors, habits, or attitudes to health. Nguyen-Phuoc et al. [39], Van Nguyen et al. [63], Van Huy et al. [64], Ogundipe et al. [65], Kuteesa et al. [45], [46] Lindan et al. are classified under the yellow cluster. In addition, Nguyen-Phuoc et al. [39] investigated the incidence of risky driving behavior and the association with application-based MCT driver characteristics and traffic accidents in three Vietnam cities. Van Nguyen et al. [63] identified factors that predicted drug use among male MCT drivers in Hanoi, Vietnam. Subsequently, Van Huy et al. [64] examined the prevalence and factors associated with HIV testing among Male MCT drivers in Vietnam using a modified Attitude Skills-Knowladge (ASK) model. Ogundipe et al. [65] studied excessive alcohol consumption in the morning among drivers, which was at risk of causing traffic accidents through impaired psychomotor activity and concentration. A total of 107 motorists consisting of young adults were sampled in Ekiti State, Nigeria. Kuteesa et al. [46] conducted a systematic literature on key occupational groups in Sub-Saharan Africa. As MCT drivers, an important occupational group is at higher risk of HIV transmission and drug use. Meanwhile, Kuteesa et al. [45] conducted a thematic synthesis of qualitative data on the determinants and context of alcohol misuse and illicit drug. Lindan et al. [66] evaluated MCT drivers in Kampala, Uganda, to determine the prevalence of HIV/sexually transmitted infections.

The fifth cluster consists of purple nodes and 8.8% of the keywords are classified in this group namely emergency care, emergency health service, emergency medical services, health care delivery, human, female, follow-up, newborn, and Uganda. The keywords are related to MCT used as a mode of transportation or the drivers' ability to obtain knowledge and skills for first aid in dealing with injuries. Several research discussing the keywords comprised Delaney et al. [67], Hancock et al. [68], and Ndile et al. [69]. Delaney et al. [67] examined the implementation of a prehospital lay first responder (LFR) program in Eastern Uganda. Hancock et al. [68] investigated the development of LFR program in rural Chad as well as the feasibility of leveraging existing transportation providers to improve prehospital emergency care. Ndile et al. [69] discussed the implementation of Post-Accident First Aid (PFA) Training program in Tanzania. Meanwhile, research related to health services for mothers and newborns included Muhumuza et al. [70], Semwanga et al. [71], Alfonso et al. [72] and Curtis [73]. Muhumuza et al. In this context, [70] examined community referral of pregnant women through a commercial motorcycle voucher referral system. Semwanga et al.

[71] developed a quantitative simulation model to improve neonatal healthcare service delivery using motorcycle coupons to facilitate access to health facilities during childbirth in Uganda. Alfonso et al. [72] conducted a quasi-experimental trial to analyze the cost-effectiveness of voucher scheme (VS) combined with health system strengthening in Uganda. Meanwhile, Curtis [73] increased access to emergency obstetrical and neonatal care (EmONC).

2) Themes evolution, thematic map and topics

Fig. 7 shows the evolution of keyword themes of MCT research from 2011 to mid-2023 using the 'bibliometrix' package, built under R version 4.2.3. This diagram shows the evolution of the main themes from one phase to another. The nodes or boxes under a phase represent keywords serving as the main themes. The size of the node is proportional to the relative significance or frequency of the keyword. In addition, nodes in one phase may be connected to others represented by lines. The flow between nodes depicted by lines represents the direction of research evolution [15], [74].

Based on the evolution themes, the period is divided into two phases, namely 2011-2020 and 2021-2023. A total of 15 specific thematic keywords were obtained in these two phases or periods. These included Bangkok, cycle transport, motorcycles, taxicabs, electric vehicles, humans, surveys, public transportation, sustainability, intelligent systems, Kampala, and coronavirus disease 2019. In 2011-2020 and 2021-2023, 8 and 12 keywords became a theme, respectively. There was some evolution of themes in both periods. For example, research in 2011-2020 were related to the theme of cycle transport but shifted to motorcycles, public transport, sustainability, urban transportation, and Bangkok 2021-2023. Similarly, the survey theme in the initial period shifted to intelligent systems, motorcycles, and public transport in metropolitan areas. The theme of humans at the beginning of the period also shifted to COVID-19 pandemic and motorcycles.
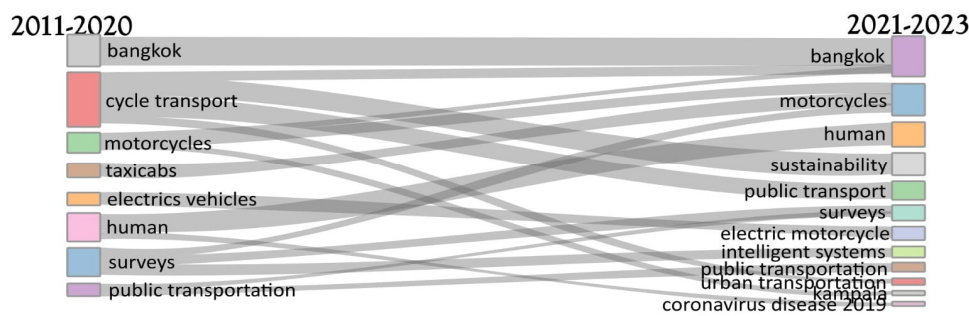

Fig. 7 Thematic evolution of MCT research in 2011-2023

A thematic map of MCT research from 2011 to mid-2023 was analyzed to understand the position and relationship between the themes comprehensively. The themes shown through these keywords are characterized by centrality and density. Centrality shows the relevance of a theme in the context of the research domain, while density describes the level of maturity. Nodes in a thematic map visually represent a research theme or topic. The size node shows the volume or intensity of research related to the theme. In a node, three labels are shown related to the theme. This thematic map is visualized in a two-dimensional diagram, with centrality and density on the horizontal and vertical axis. Meanwhile, there are four quadrants in the thematic map. The upper right quadrant (Q1) represents motor themes which are well-developed and relevant in the research field. The upper left quadrant (Q2) represents niche themes, which are highly developed but need to be more connected to others. The lower left quadrant (Q3) represents declining themes that are less developed and connected. Additionally, the lower right quadrant (Q4) represents underdeveloped basic and important themes [28], [32], [33], [75].

The thematic map was reported using two figures based on periods. Fig. 8(a) shows a map for 2011-2020 period. Based on 221 publications about MCT research, 8 groups of themes were obtained. Basic themes (Q4) include cycle transport and taxi transport, while motor themes (Q1) comprise motorcycles with humans. Electric vehicles and Bangkok (Q2) are related to niche themes. Meanwhile, declining themes (Q3) include surveys and public transportation.

Fig. 8(b) shows the thematic map for 2021-2023 obtained based on 145 publications. From Fig. 8(b), 14 theme groups were obtained and motor themes comprised motorcycles, humans, COVID-19, and Kampala. Themes on public transportation, intelligent systems and electric motorcycles were reported in niche themes. Meanwhile, declining

themes were about public surveys, sustainability, bicycles, and Bangkok. Themes related to urban transportation, public transport and electric motorcycles are included in basic themes.
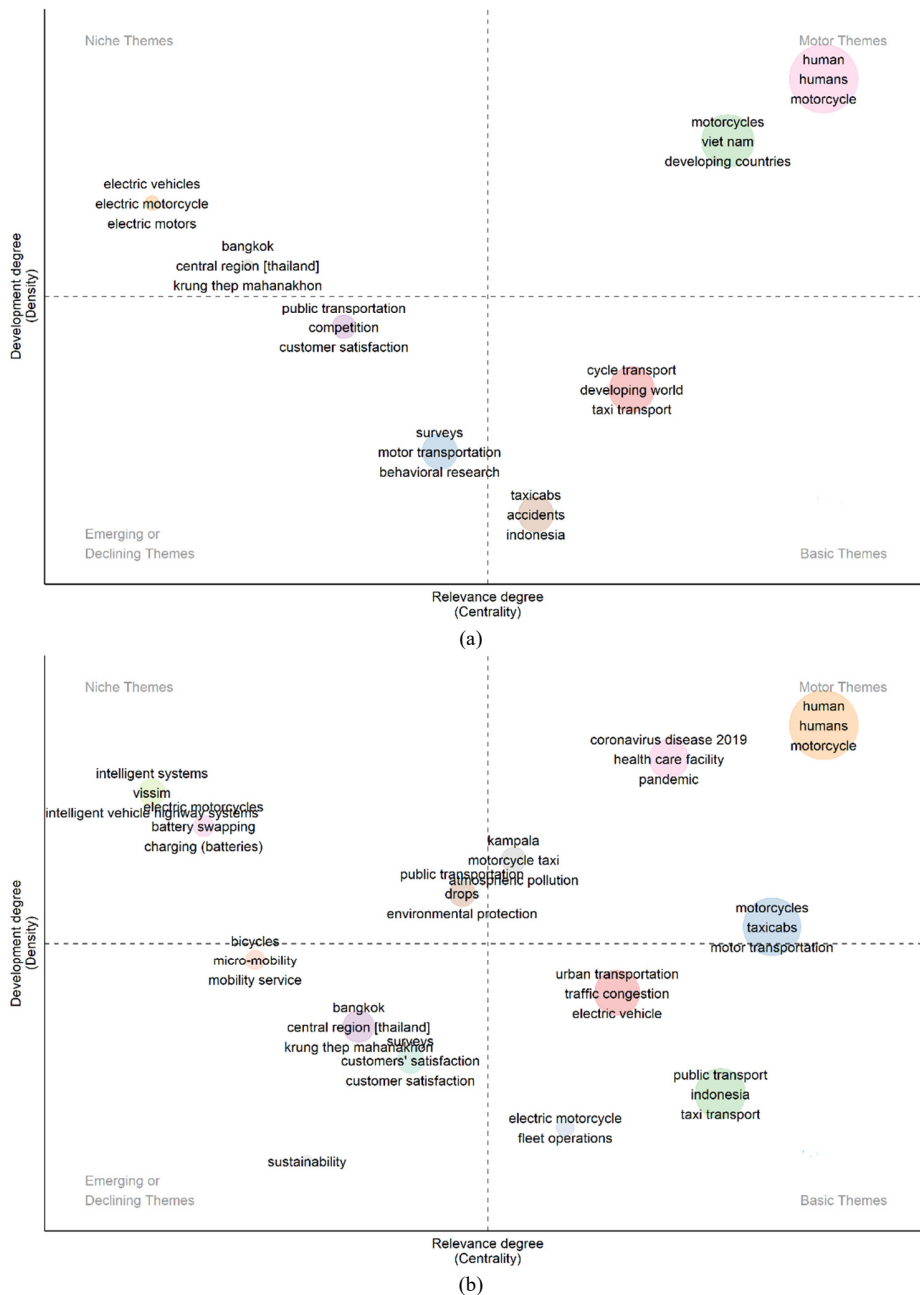

Fig. 8 Thematic map of MCT research during (a) 2011 - 2020; (b) 2021 – 2023

Fig. 9 shows trends in topics over time using the 'bibliometrix' package. The development of articles is reported in terms of keywords. The size of the node reports the frequency of the keywords. Meanwhile, the line in the image is the time range, with the left, node and right boundary being Quartile 1 (Qr1), median and Quartile 3 (Qr3) of the year the article was published. Based on articles published in the starting period of 2011 to July 2023, the trends were concentrated on environmental impacts, safety and health but shifted to keywords such as "male", "adult", and "human". At the end of the period, research topics on MCT shifted to topics related to "transportation systems", "risk assessment", and "vehicle safety".

The keywords related to adult, young adult, male, female, middle-aged, adolescent, aged, and child were included in the 'human' theme group. Several research discussed the association of MCT with various demographic groups. Each age group has different needs and priorities for transportation.
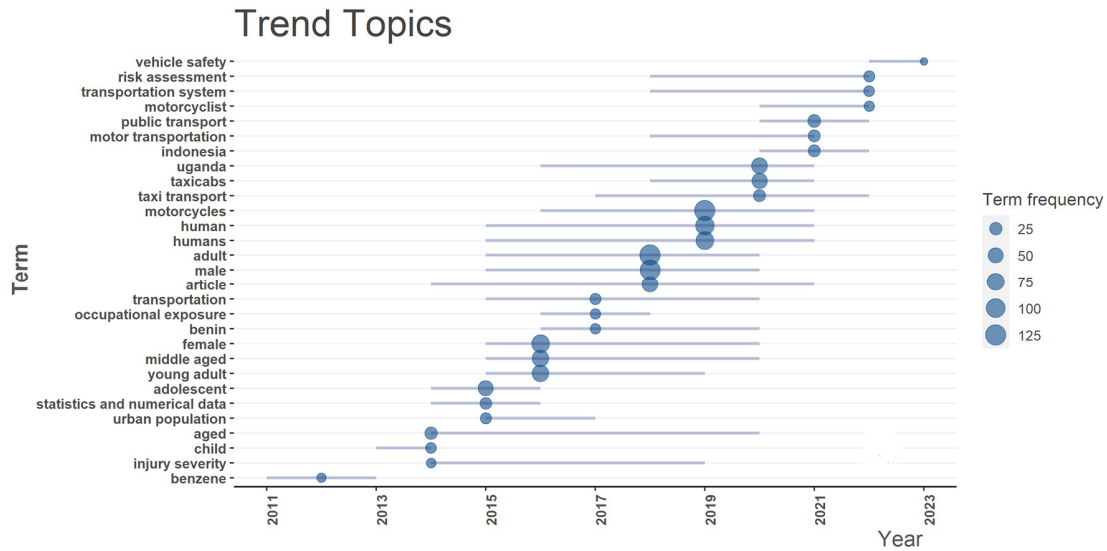
Trend Topics

Fig. 9 Keyword trend topics of MCT research in 2011-2023

The topics of the articles were identified using manual methods. Table 5 contains research topics, the number of publications and the percentage of total publications per period. The topics include health, safety, environment, economic, social, or political implications, operational management, infrastructure support, labour/workers and drivers' associations, policy or regulation, customer satisfaction, travel behaviors, and advanced mobility topics. Meanwhile, advanced mobility topics comprised the use of ICT in transportation services, Intelligent Transportation Systems (ITS), transportation planning and technology, electric motorcycle taxi (e-MCT), crowdsourced delivery services, and unmanned or uncrewed vehicles (drone delivery). An article can discuss more than one topic since the total number of publications is more than 366. From 2011 to 2015, nearly half of the documents discussed health and safety topics. In 2016-2020 and 2021-2023, the percentage of the topics declined even though the value was high. Increased topics since 2016 were travel behavior, customer satisfaction, and advanced mobility.

TABLE 5
RESEARCH TOPICS (%) OF MCT RESEARCH

Topics	2011-2015		2016-2020		2021-2023		Total	
	Total	%	Total	%	Total	%	Total	%
Health	14	24.6	20	10.2	22	13.0	56	13.3
• Occupational health	(9)	(15.8)	(14)	(7.1)	(16)	(9.5)	(39)	(9.2)
• Public Health	(5)	(8.8)	(6)	(3.1)	(6)	(3.6)	(17)	(4.0)
Safety	14	24.6	33	16.8	32	18.9	79	18.7
Environment	5	8.8	11	5.6	2	1.2	18	4.3
Economic, social, or political implications	9	15.8	14	7.1	14	8.3	37	8.7
Operational management	4	7.0	8	4.1	6	3.6	18	4.3
Infrastructure support (road, power, credit)	0	0.0	9	4.6	7	4.1	16	3.8
Labour/workers & drivers' associations	0	0.0	7	3.6	6	3.6	13	3.1
Policy or regulation	2	3.5	19	9.7	9	5.3	30	7.1
Travel behavior	5	8.8	29	14.2	30	17.7	63	14.9
• Drivers	(4)	(7.0)	(10)	(5.1)	(12)	(7.1)	(26)	(6.15)
• Passengers	(1)	(1.8)	(18)	(9.1)	(18)	(10.6)	(37)	(8.75)
Customer satisfaction, service quality	0	0.0	13	6.6	8	4.7	21	5.0
Advanced mobility topics	4	7.0	33	16.8	28	16.6	65	15.4
Others	0	0.0	1	0.5	5	3.0	6	1.4
Total	57	100	196	100	169	100	422	100

V. Discussion

MCT has become informal two-wheeled transportation system, specifically in many developing countries. The increase in MCT has helped fill the gap in mobility needs, specifically in big cities. The services are a fast and efficient alternative in urban areas with heavy traffic. In addition, accessibility and comfort are provided for the public, specifically in areas where conventional public transportation may be difficult to reach. The need creates additional employment and income opportunities for drivers but the presence has given rise to negative externalities, such as high accident rates, contribution to air and noise pollution, traffic jams, and suspicion of crime [11].

A. Descriptive analysis

The number of academic productions through SCOPUS was small but relatively experienced an increase in 2018. This pattern was similar to Diaz Olvera et al. [16], who conducted a literature review on topics in Sub-Saharan Africa between 1988 and 2016. Even though the periods and database selection differed, Diaz Olvera et al.[16] also reported increased publications.

The number and growth rate of publications from academic articles are high. Based on Vizuete-Luciano et al. [14], a turning point in academic production started in 2012, with the entry of the company UBER into the taxi and mobility sector. In 2018, topics regarding urban mobility and taxi sector showed an increasing pattern as a research trend. A similar pattern of increase also occurred in MCT research, which experienced a rapid increase in the number of publications.

According to Behrens et al. [13], which conducted a bibliometric analysis of informal transportation for various vehicle types during 2010-2020, there are geographic gaps in the literature, particularly in Sub-Saharan Africa. In this area, Behrens et al. [13] showed relatively strong trends in publication growth in Europe, East Asia, and North America. This increased growth is consistent with the development of businesses with shared mobility. Compared with global developments, there are several research on shared mobility, such as bike sharing, car sharing, and car-pooling. This has resulted in fast, efficient, convenient services and transparent service provision [8].

In Table 4, there are significant contributions from countries in Asia, Africa, and Latin America. According to Firmansyah et al. [15], the main contributors to motorcycle research are Asia, North America (United States, Canada), Europe and Australia. Based on bibliometric analysis of e-bikes analyzed by Zhou et al. [76], the main contributors were countries in Europe, North America (United States, Canada), Australia and Asia. Meanwhile, publications on powered-mobility research by the most significant contributors are the United States, China, Netherlands, and Australia [17].

B. The main topics in MCT research

The main topics were grouped regarding MCT research into 5 clusters. This was based on keyword co-currence analysis using network visualization and the five topics included:

1) Development of more sustainable transportation services

The first topic is related to the steps in making MTC services better. The digitalization of previously conventional services has developed into two-wheeled online transportation supported by ITC developments. The concept of shared mobility has become a global phenomenon and has spread to various countries. Developing countries adopt the concept according to need and the type of services are ride-hailing or ride-sourcing. These include motorcycle-based e-hailing or RHA motorcycle services in great demand. A literature research from Chalermpong et al. [12] shows that application-based MCT are more common in developing countries, specifically in Southeast Asia, than taxi or car RHA.There are many potential benefits from the digitalization of the service. Khavarian-Garmsir et al. [77] conducted a literature review on social, economic and environmental impacts of ride-sourcing services. However, most of the articles reviewed are the results of research in the US and China and focus on taxicab services. This main topic concerns using electric and autonomous vehicles or drones in transportation services. Electrification in MCT services is associated with many positive impacts in various aspects, including environmental, health, economics, and social benefits [11]. The method of implementing electrification in developing countries must differ from developed countries. According to Collet et al. [78], some welds are differences in mobility patterns and vehicles in the transportation system, availability of capital, and an unreliable electricity system.

The external negative from the existence of MCT has given a negative image among decision-makers and planners in the transportation sector. The existence of MCT has varying impacts in various regions. In responding to negative impacts, governments in various regions tend to take varied methods for MCT services. Several methods have been taken, such as accepting MCT with tolerance and integration to control the operation of services by enforcing strict regulations, or gradual elimination. Discussions and systems related to transportation planning and MCT are a trend in the cluster.

2) Environmental and health impact

The second topic is related to environmental and health impacts, as well as the existence of two-wheeled vehicles. Some of the environmental impacts include noise pollution, exhaust emissions, and fuel use. According to Ehebrecht et al. [7], several research show that motorcycles have a significant environmental impact than motorized public transport. In addition, the driving profession is detrimental to drivers' health in the long term. Drivers who work outdoors are exposed to outdoor air pollution and this affects respiratory health. According to Diaz Olvera et al. [79], full-time drivers working long hours can cause back pain, vision problems, fatigue, headaches, and problems related to constant exposure to air pollution, noise, and poor road conditions.

3) Road safety

The third topic is related to road safety issues. Road traffic injury (RTI) is the eighth-highest cause of death in the world. RTI occurs most frequently in Low- and Middle-Income Countries (LMICs). According to World Health Organization (WHO), around 1.35 million people die due to traffic accidents. More than half of the deaths occur among vulnerable road users, namely pedestrians, cyclists and motorcyclists [61], [80]. The injury has become a global health problem and several international organizations and governments are working to improve road safety.

4) Risky behaviors or risk factors as MCT drivers

The fourth topic is related to the issue of behaviors, habits, or attitudes to health. MCT drivers have minimal levels of education, low socioeconomic status, and limited employment options. In the context of the background, there is limited access to health services and the drivers are more vulnerable to health problems [64]. Several research examined the habits, behavior or attitudes of drivers who are at risk of having accidents or contracting diseases, such as HIV. Compared with the manual document classification in Table 5, the number of publications related to travel behavior shows a balanced number for each period between 5% to 7%.

5) Utilization of MCT for medical or health services

In several developing countries, MCT provides fast access to medical services, specifically for remote or hard-to-reach areas. The fifth topic is related to the use of MCT for the services. According to WHO data, RTI is the leading cause of death in Africa. WHO recommends programs to increase the responsibility and accessibility of health services. Some of the programs include LFR Training Program and PFA training programs for laypersons. Delaney et al. [67] and Hancock et al. [68] are related to LFR Training Program, while Ndile et al. [69] are related to PFA training programs for laypersons. Several regions are implementing Maternal and Newborn Health Quality Improvement (MNH QI) and Emergency Obstetrical and Neonatal Care (EmONC) programs due to the high maternal, newborn and under-five mortality rates, specifically in sub-Saharan Africa. According to Muhumuza et al. [70] and Curtis [73], this program improves health services for mothers and newborns and reduces mortality rates.

Firmansyah et al. [15] reviewed research on motorcycles in Asia and the results were several similarities and differences in the clustering keywords. The five clusters obtained were accident and human factors, traffic and policy, air pollution, motorcycle engineering and performance, and technological innovation. In connection with the cluster regarding technological innovation from [15], the results were included in the group regarding 'development of more sustainable transportation services. The topics related to motorcycle engineering and performance were not discussed. However, there was a fifth cluster, namely the 'utilization of MCT for medical services or health services'. This topic is widely examined in the African region.

6) Future research options

Based on science mapping, several options were identified for future research. The content of the motor theme (Q1) in both periods is related to humans. The theme has been well developed and shows high priority in the context of analysis. Several keywords with a high frequency of occurrence included in the group are related to humans, motorcycles, and keywords about various age groups. These comprised adults, young adults, males, females, middle-aged, adolescents, aged, traffic accidents, road safety, helmets, drivers, alcohol consumption, behavior, and many other keywords with a smaller occurrence. The keywords are primarily associated with drivers' travel behavior, health, and safety. Several research discusses MCT concerning various demographics since each age group has different needs and priorities.

The digitalization of two-wheeled informal transportation services has substantially changed the services in the past decade. The services have shifted from physical to online environments and the topic is the research of customer satisfaction carried out through surveys. The theme is in quadrant three and the research on the topic of customer satisfaction tends to increase. Another important theme is the travel behavior of passengers regarding the choice of mode of urban transportation.

The company also provides food and goods delivery services using applications. Many problems need to be resolved, such as the working system of delivery sequencing operations, minimizing the risk of accidents, and comparing delivery services with motorcycles and drones.

An effort to reduce air and noise pollution is to substitute petrol-fueled motorcycles for electric. The themes in Figs. 7, 8.a, and 8.b are related to electrification, electric motorcycles, electric vehicles, battery swapping, charging, fleet operations, urban transportation and traffic congestion.

Another theme in niche time is intelligent systems, vision, intelligent vehicle systems, microsimulation, and operational behavior. Several research were carried out to resolve the problem of traffic jams caused by MCT and maintain order in transportation activities. The main problem is the provision of shelters for carrying out activities to maintain traffic order, such as drop-off and pick-up. Another theme relates to Last Mile Problem, which is the problem of commuters or suburbanites travelling quickly between homes and desired destinations. A solution to the problem is to use micromobility to cover shorter travel distances. In Table 5, themes regarding crowdsourced-based delivery services, electrification, intelligent systems, micromobility, transportation planning and technology are included in the advanced mobility topic. There are limited analyses discussing the topic, hence, further research is required.

Keywords regarding electric vehicles, autonomous vehicles, sustainable development, and optimization of urban mobility have been actively discussed when compared to the review by Vizuete-Luciano et al. [14] about taxis and urban mobility. New areas to be explored are related to big data, GPS, Smart Cities, resource optimization, sustainability, urban mobility, shared economy, shared mobility, sustainability, customer preferences and legislation for taxis and urban mobility. Vizuete-Luciano et al. [14] mapped out the most frequently used keywords and the relationships between actors, leading academic journals, institutions and state publishers.

According to Behrens survey (2018), priority research includes issues of integration with mass public transportation, regulation of service providers, use of electric vehicles, and digitalization of operational aspects. Chalermpong S et al. [12] investigated shared mobility in Southeast Asia and showed research gaps in the literature. These gaps are mainly related to the influence of RHA on tourist behavior, transport operators, environment, and issues regarding the regulatory framework. Some of the critical issues from Ehebrecht et al. [7] in Sub-Saharan Africa were the current role of MCT and potential in transport systems. Martin et al. [11] investigated topics in digitalization and electrification of MCT services in several large cities in East Africa, including the benefits of digitalization. Electrification is in the early stage and plans must be made to integrate MCT into the transportation system. However, the issues are highly dependent on each region or country, including differences in (a) economic, social and cultural conditions, (b) technology and digital adoption, (c) transportation infrastructure, and (d) regulations and government policies.

VI. CONCLUSIONS

In conclusion, the expansion of MCT services was a global topic, specifically in developing countries. The challenges faced by each region or country were very different. In this research, a systematic review of MCT was carried out as informal transportation in many countries and a structured method was adopted through bibliometric analysis. Additionally, 366 articles consisting of journals and conference proceedings were analyzed from 2011-2023. There were significant contributions from countries in Asia, Africa, United States, Europe and Australia.

Based on science mapping and keyword analysis, 5 clusters were reported, namely the development of more sustainable transportation services, environmental and health impact, road safety, risky behavior, and the utilization of MCT for medical or health services. Almost half of the documents had a health and safety theme in the initial period of 2011-2015. The percentage of the topics decreased but remained high. Increased topics since 2016 were travel behavior, customer satisfaction, service quality and advanced mobility topics. Trends in MCT research included health, safety, travel behavior, customer satisfaction, and advanced mobility topics. For future research options, important topics should be related to environment impacts, socio-economic implications socio-economic impacts, operational management, infrastructure support, policy and regulations.

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