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REVIEW

A scoping review on the conceptualisation and impacts of new mobility services

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Abstract

In the course of major societal developments such as digitalisation and increasing urbanisation, various forms of so-called new mobility services have emerged. Various disciplines are engaged in understanding these services. However, what is still missing is a comprehensive understanding of what the umbrella term *new mobility services* means beyond a loosely used catch-all term. This article provides an interdisciplinary overview of the concept of new mobility services and their respective impacts on mobility landscapes. These aspects are summarised using a scoping review approach by examining a total of 98 publications. Our results show that the term *new mobility services* is indeed an umbrella term for different mobility concepts that are conceptualised differently and whose impacts on mobility landscapes are manifold. However, by applying elements of formal concept analysis, we can identify several key characteristics that define the lowest common denominator for services to be classified as new mobility services.

Keywords New mobility services, Shared mobility services, Micro mobility services, Conceptual modelling, Transport planning

1 Introduction

In recent decades, the world has experienced an increase in population growth that has led to a considerable urbanisation [1, 2]. Nevertheless, this urbanisation has come along with various innovations and transformations. These changes are presently occurring in several sectors, including the transport and mobility sector, and many of those changes are to some extent driven by the ubiquitous deployment of Information and Communication Technologies (ICTs). Correspondingly, in many mobility landscapes, which we understand in this article as "integrated urban mobility system[s] in [. .] metropolitan area[s]" [3, p. 3], we are witnessing a rapid emergence of the so-called new mobility services. The term new mobility services serves as an umbrella term for various emerging mobility services [4–7]. These encompass various forms of services such as bike-sharing, e-scooter sharing, car-sharing, ride-sharing, ride-sourcing, Mobility as a Service (MaaS), among others [4, 6, 7]. New mobility services differ from traditional transport services in that they are on-demand, utilise real-time location data, and are often accessible via digital platforms using smart applications [8–10]. These characteristics suggest both a conceptual distinction of new mobility services from established forms of mobility, as well as novel forms of influencing existing mobility landscapes.

The emergence of new mobility services has gained momentum especially over the past decade [8]. The impacts of these services on mobility landscapes have therefore not yet been holistically scrutinised and understood by researchers. However, some studies have already hinted on both the positive and negative effects of using new mobility services. For instance, on the one hand, the use of new mobility services in some areas is considered as an approach for mitigating existing transport challenges such as traffic congestion, pollution,

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and inaccessibility [11, 12]. For this reason, new mobility services are conceived as mobility services bearing the potential to pave a new path towards a more sustainable and seamless mobility system [6, 8, 13, 14]. On the other hand, new mobility services are considered to be disruptive and to pose several negative impacts, which can possibly overshadow their benefits in circumstances of insufficient planning [5]. For example, micro-mobility services such as e-scooters have already been reported with safety concerns, improper parking behaviours, and blocking of sidewalks for pedestrians [15, 16]. Besides, there are concerns that the availability of services such as ride-hailing can divert people from using possibly more sustainable and active modes of transport such as public transit, cycling, and walking [17]. Similarly, previous studies have already indicated that car-based shared mobility services can lead to an increase in the Vehicle Kilometers Travelled (VKT) [18]. The presence of mixed assessments in the literature on the use of new mobility services shows on the one hand that these services have noticeable imprints on mobility landscapes, but on the other hand, it also underlines that understanding these services adequately requires a comprehensive investigation.

There are alternative terms in the literature that are used to refer to novel kinds of mobility services [19–21]. In the context of our study, we explore the terminology *new mobility services* in order to investigate whether the services comprised form a coherent concept. We further argue that this terminology seems to be inclusive and the expression '*new*' literally labels emerging players and operational models in mobility landscapes [22] as well as a developing body of research in the academic literature. However, this novelty of the research is not spurred by a single driving force, but rather unfolds from multiple research disciplines such as urban planning, geography, information and communication sciences, engineering, social sciences, environmental sciences, sustainability, etc. Due to the various disciplines addressing new mobility services, the latter have been understood, conceptualised, and characterised differently in the literature. Also, their impacts on mobility landscapes have been viewed through different academic lenses. Therefore, the primary objective of our article is to provide for a comprehensive understanding on how new mobility services are conceptualised and characterised in the academic literature. Furthermore, as a sub-ordinate goal of this article, the present review summarises the investigated and published impacts that these services have on mobility landscapes, in this way, adding to the existing spatial, social, economic, and environmental perspectives on new mobility services. The following two research questions (RQs) are posed to guide our investigation: (RQ1) How are new mobility services conceptualised and characterised in the interdisciplinary scholarly literature?; (RQ2) How does the presence and operation of new mobility services impact mobility landscapes? Due to the breadth embedded within these research questions, a scoping literature review is employed as a systematic process for approaching both questions. An in-depth unfolding of these two research questions supports the disclosure of shared structures and patterns within the identified individual mobility services.

The remainder of this article is structured as follows: Sect. 2 provides details on the employed methodological approach, detailing our literature review process and how the included studies were identified, screened, and selected for review. The individual stages and the resulting corpus are briefly summarised in Sect. 3. In addition, Sect. 4 discusses the main results on how new mobility services are conceptualised and characterised in the literature. The latter section also summarises the reported impacts that new mobility services exert on mobility landscapes. Section 5 places the results in a broader context with findings from other reviews and articles.

2 Methodology

Our review design is based on a scoping review approach. This kind of review is considered suitable, because it allows for providing a broad overview of a certain topic and it is appropriate for clarifying key concepts related to emerging and not yet fully consolidated research fields [23]. Further, Peters et al. [24] emphasise that the scoping review approach is helpful for combining multi and interdisciplinary literature that is emerging from multiple research strands. The described purposes for the scoping review approach are thus in line with the objectives of our review, which aims at identifying a large body of literature to clarify concepts of new mobility services and their respective impacts on mobility landscapes. In summary, our review adopts the following five stages suggested by Arksey and O'Malley [25]:

1. identifying research questions,
2. identifying relevant studies,
3. study selection,
4. charting of results,
5. collating, summarising, and reporting of the results.

These stages structure the remainder of this section, and each stage is outlined in one of the following sub-sections respectively.

2.1 Identifying the research questions

Scholars from different disciplines and geographies have conceptualised and characterised various types of new mobility services differently. For example, some researchers from the United Kingdom refer to the service of *car-sharing* as *car-clubs*, while *ride-sharing* and *car-pooling* services are sometimes referred to as *car-sharing* instead [7]. Likewise, in the United States, *ride-sourcing* is sometimes referred to as *Transportation Network Companies* (TNCs) [26]. Furthermore, terms like *ride-hailing* and *ride-sourcing* are interchangeably used in the literature to refer to the same concept, and thus, there is still a lack of agreement on a single term to be used [27]. Therefore, in order to clarify the differences and sort out some of the confusions among the concepts of new mobility services, and to understand why and if these should even be categorised together using that term, the primary research question (RQ1) as laid out in Sect. 1 above was formulated. Furthermore, since new mobility services and their respective modes of operation are impacting mobility landscapes in various ways [28], the second research question (RQ2) in the same section was also formulated to identify the various impacts of new mobility services on mobility landscapes.

2.2 Identifying relevant studies

In order to address the posed research questions, a thorough search process for the relevant literature has been conducted. The employed search avenues are the Web of Science and Scopus electronic databases. These two literature databases are selected because they offer a wide coverage of international, interdisciplinary, and multidisciplinary academic content. In addition, most of the publications listed in these databases have undergone a rigorous peer-review process. To identify relevant literature for our review, two search queries, containing a combination of 88 search terms each were formulated for both databases respectively. The search queries for the Web of Science and Scopus database are shown in Table 1. Due to the differing search operators in both databases, the query for the Web of Science database is slightly different from that used for querying the Scopus database, although the search terms and their arrangement into search queries were held consistent. Our query strings are divided into two bags of keywords: the search terms in the first section of both search queries are designed to capture the term *new mobility service* and its respective forms, inflections, and synonyms from the titles, abstracts, and keywords of the existing publications in the databases. The second section contains search terms that are intended to capture the different understandings, conceptualisations, and characterisations of new mobility services. The latter section further contains search terms that are intended to retrieve the varying connotations for the impacts. It is important to note that the lists of included keywords in our search queries were

Table 1 The search strings used for querying the Web of Science and Scopus databases

Database	Search querry
Web of Science	((TS =("new mobility service*" OR "new mobility concept*" OR "new mobility alternative*" OR "shared mobility service*" OR "shared mobility concept*" OR "shared mobility alternative*" OR "sustainable mobility service*" OR "sustainable mobility concept*" OR "sustainable mobility alternative*" OR "smart mobility service*" OR "smart mobility concept*" OR "smart mobility alternative*" OR "Mobility as a Service") AND TS= (defin* OR describ* OR explain* OR specif* OR identif* OR clarif* OR classif* OR categor* OR character* OR featur* OR propert* OR attribut* OR element* OR typ* OR form* OR mean* OR mode* OR method* OR concept* OR approach* OR strateg* OR idea* OR view* OR perspectiv* OR percept* OR perceiv* OR understand* OR interpret* OR conceiv* OR advantag* OR pro* OR importan* OR necessar* OR relevan* OR significan* OR positiv* OR objectiv* OR purpose* OR benefit* OR prospect* OR interest* OR reason* OR intent* OR improv* OR strength* OR impact* OR aspect* OR factor* OR effect* OR affect* OR influen* OR disadvantag* OR con* OR negativ* OR problem* OR weakness* OR risk* OR threat* OR struggl* OR difficult* OR disput* OR criticis* OR argu* OR demand* OR claim* OR challeng* OR barrier* OR obstacle* OR limit* OR prevent* OR hinder* OR prohibit* OR inhibit* OR restrict*)) AND PY=(2007-2022))
Scopus	((TITLE-ABS-KEY("new mobility service*" OR "new mobility concept*" OR "new mobility alternative*" OR "shared mobility service*" OR "shared mobility concept*" OR "shared mobility alternative*" OR "sustainable mobility service*" OR "sustainable mobility concept*" OR "sustainable mobility alternative*" OR "smart mobility service*" OR "smart mobility concept*" OR "smart mobility alternative*" OR "Mobility as a Service")) AND (TITLE-ABS-KEY(defin* OR describ* OR explain* OR specif* OR identif* OR clarif* OR classif* OR categor* OR character* OR featur* OR propert* OR attribut* OR element* OR typ* OR form* OR mean* OR mode* OR method* OR concept* OR approach* OR strateg* OR idea* OR view* OR perspectiv* OR percept* OR perceiv* OR understand* OR interpret* OR conceiv* OR advantag* OR pro* OR importan* OR necessar* OR relevan* OR significan* OR positiv* OR objectiv* OR purpose* OR benefit* OR prospect* OR interest* OR reason* OR intent* OR improv* OR strength* OR impact* OR aspect* OR factor* OR effect* OR affect* OR influen* OR disadvantag* OR con* OR negativ* OR problem* OR weakness* OR risk* OR threat* OR struggl* OR difficult* OR disput* OR criticis* OR argu* OR demand* OR claim* OR challeng* OR barrier* OR obstacle* OR limit* OR prevent* OR hinder* OR prohibit* OR inhibit* OR restrict*)) AND PUBYEAR > 2006) AND PUBYEAR < 2023 AND (LIMIT-TO(LANGUAGE, "English"))

The Boolean operator "OR" is used in between the search terms to widen the search coverage, "AND" is used to combine both categories of the search query while the asterisk mark (*) is included at the endings of the search terms to avoid the exclusion of plural and other forms of wording developed in a cyclic manner: through reading academic publications concerning new mobility services, extracting relevant keywords from them, feeding these back into the query strings, and repeating this process until no additional keywords appeared and we hence reached a stable keyword list. This process has been essential for identifying the different contexts for terming new mobility services in the diverse academic literature concerned in the present case.

2.3 Study selection

Our search for literature in both electronic databases has been limited to items published in English since international literature addressing new mobility services is mostly published in this language. To obtain a wide coverage from both databases, our search for the literature covers a period of 16 years, spanning from 2007 to 2022. The year 2007 was considered as the starting period for our search, because the use of smartphones, online communication technologies, and social media gained momentum in that year [29]. Since the review aims to obtain a broad coverage of the literature, there was no limitation inserted on the type of retrieved documents. All included publications fulfill at least one of the following criteria: (1) publications that provide for definition(s) or explanation(s) concerning the concept(s) of new mobility service(s); (2) publications that, in any form, provide for the characteristic(s) of new mobility services or characterise them; (3) publications that conceptually or empirically address the impacts of new mobility services on mobility landscapes from spatial, social, economic, or environmental perspectives; (4) publications that provide for an understanding of Mobility as a Service (MaaS) or its impacts on mobility landscapes (MaaS was included in our criteria separately since it often integrates various types of new mobility services); (5) comparative studies that sit between traditional forms of transport and new mobility services or among new mobility services themselves. These criteria are considered, because the underlying types of articles are expected to offer a broad range of insights and characteristics among the compared elements. A detailed inclusion and exclusion protocol is found in the attached Additional file 1. The selection of any publication from our search process depended on whether the content of the publication was within the forementioned inclusion framework. In this regard, the titles and abstracts for the retrieved publications were read by the first author of this manuscript to identify studies that are in line with our study objectives. Still, a full text for the shortlisted publications was read by the same author to evaluate their eligibility of inclusion, and in circumstances of doubt, the second author reviewed the publication to determine its relevance for our study. The list for the included publications in Additional file 1 was agreed upon by both reviewing authors.

2.4 Downloading and item management

We started querying the databases for relevant literature in March, 2021, and the search from the databases was last updated on the 14th of October, 2023. This time span reflects both our goal of regularly updating the list of retrieved manuscripts to include even the very latest studies, and the cyclical approach to keyword generation described in Sect. 2.2. All abstracts of the retrieved publications from both electronic databases were downloaded and exported to the EndNote-X9 reference manager. For each retrieved item, the exported files also include the respective title, keywords, year of publication, type of publication, name of the academic outlet, and the list of authors. After merging the files from both databases, duplicates were identified and removed. The remaining abstracts, titles, and keywords were screened to assess their relevance to our review. Those abstracts offering indications to be relevant to our work were short-listed and the full-texts for their respective publications were imported into the MAXQDA program, which is a frequently used software for collating and analysing qualitative data [30].

2.5 Collating, summarising, and reporting of the data

For a transparent synthesizing of the data in MAXQDA, relevant studies for our article were categorised into different groups. The first and the second groups contain studies that are generally addressing new mobility services and shared mobility services respectively, that is, without any further specification regarding service types. The third and fourth groups include studies addressing bike-sharing and e-scooter sharing. The fifth group is for car-sharing services, while ride-sharing, ride-hailing, and DRT services are categorised into another group six. Studies concerning shared autonomous vehicles (SAVs) have been categorised in group seven. Publications on Mobility as a Service (MaaS) were put in group eight, and comparative studies are sorted into group nine. Comparative studies have been categorised in a separate group, because these types of studies cannot be allocated easily to any other single group. Furthermore, it is important to note that many works are addressing more than a single mobility service. The above outlined categorisation of the publications into several groups is not only intended to simplify our literature review process, but it is also a first step for the pre-categorisation of the retrieved works. For the extraction of the relevant information from the included works, different conceptual codes, sub-codes, and colour-codes were developed step-wise, and then used to extract relevant information from the texts. In the results, the characteristics of the included works are summarised according to these codes. The identified sub-concepts with their respective definitions, explanations, and their impacts as presented in Sect. 4.2 were derived from the codes.

2.6 Formal concept analysis

The synthesis of the conceptual understandings identified in the literature is inspired by elements from formal concept analysis (FCA) [31] as put forward by Ganter et al. [32]. This method allows extracting requisite information from data through the explicit formalisation of concepts [31] making it possible to investigate similarities, relations, and differences among different types of new mobility services. The methodology starts from sub-dividing concepts into a so-called formal context represented by a triplet structure $K := (G, M, I)$, where G represents a set of objects g (here: different types of new mobility services as identified in the review), M represents a set of attributes m of those objects (here: properties recurring in several works), and $I = \{(g, m)\} \subseteq G \times M$ is a set of binary relations between G and M indicating that object g possesses an attribute m [32]. The constructed formal context is reflected in tabular form in Sect. 4. Formal concepts (in the sense of FCA) refer to clusters that are characterised by sharing similar attributes. The examination of formal concepts will thus help us to understand the object-to-object relations among mobility concepts. This will aid in answering which characteristics justify the classification of extracted mobility concepts collectively under the umbrella term *new mobility services*. We are not able, however, to apply a fully-fledged FCA since we can only extract incomplete information from the reviewed papers that reflect authors' views and not complete conceptualisations. It is thus impossible in the given context to construct complete intents of robust concepts in a strong sense. This is a limitation but nevertheless the formal context as outlined will help us to identify structure in the extracted attributes.

3 Descriptive summary of the review process and the resulting corpus

This section offers a descriptive summary of the review process and the resulting final corpus of identified publications. The following first provides an overview of the retrieved, screened, and shortlisted publications before detailing some characteristics of the included publications.

3.1 Review stages

In total, 2081 abstracts were retrieved from both databases combined, among which 1212 abstracts were obtained from Scopus and 869 abstracts were identified through Web of Science. After merging both files, 452 duplicate entries were identified and removed. A total of 1629 abstracts remained for screening, and after screening, 159 abstracts were considered relevant for progressing to the next stage of full-text screening. A total of 98 studies finally meet the inclusion criteria outlined in detail in the Additional file 1. The PRISMA flow chart adapted from Moher et al. [33] and presented in Fig. 1 summarises the overall process of how we identified, screened, and eventually selected relevant works.

3.2 Characteristics of the included publications

The identified manuscripts represent a global coverage. They originate from a total of 26 countries situated on five different continents. At continental level, Europe features the largest share (61 manuscripts), followed by North America (21), Asia and Australia have eight studies each, and South America features with only two studies. At the country level, Germany accounts for the largest share with a total of 17 manuscripts, followed by the USA (15), England (12), and the rest of the works originating from other countries. Note that according to the authors' affiliations, some of the manuscripts originate from more than one country. In these cases, the countries of origin have been allocated based on the affiliation(s) of the first authors. Furthermore, we retrieved different types of manuscripts, though the majority of them are journal articles. Among all included works, 78 publications are journal articles that were published in 44 different academic journals. The breadth of these outlets ranging from traditional transportation over geography into the social sciences demonstrates that our items retrieved cover multiple research fields. Besides journal articles, 12 publications are conference papers and 8 publications are given as book chapters. The largest single contributing outlets are the journals: *Transportation Research Record*, *Transportation Research Part A*, *European Transport Research Review*, *Case Studies on Transport Policy*, in that order. Table 2 gives a list of all academic outlets contributing more than one publication to our study. Applying the nine different groups outlined in Sect. 2.5, seven works generally detail new mobility services, ten manuscripts cover shared mobility, bike-sharing works account for nine articles, e-scooter sharing works include five manuscripts, the car-sharing category features with ten papers, ride-sharing, ride-hailing, and DRT comprise of 16 works, while shared autonomous vehicles and MaaS account for 12 and 24 works respectively. Five manuscripts are comparative studies, comparing car-sharing with ride-sharing, car-sharing with bike-sharing, e-scooters with ride-hailing, shared mobility services with private vehicles, and a distinctive study that compares the

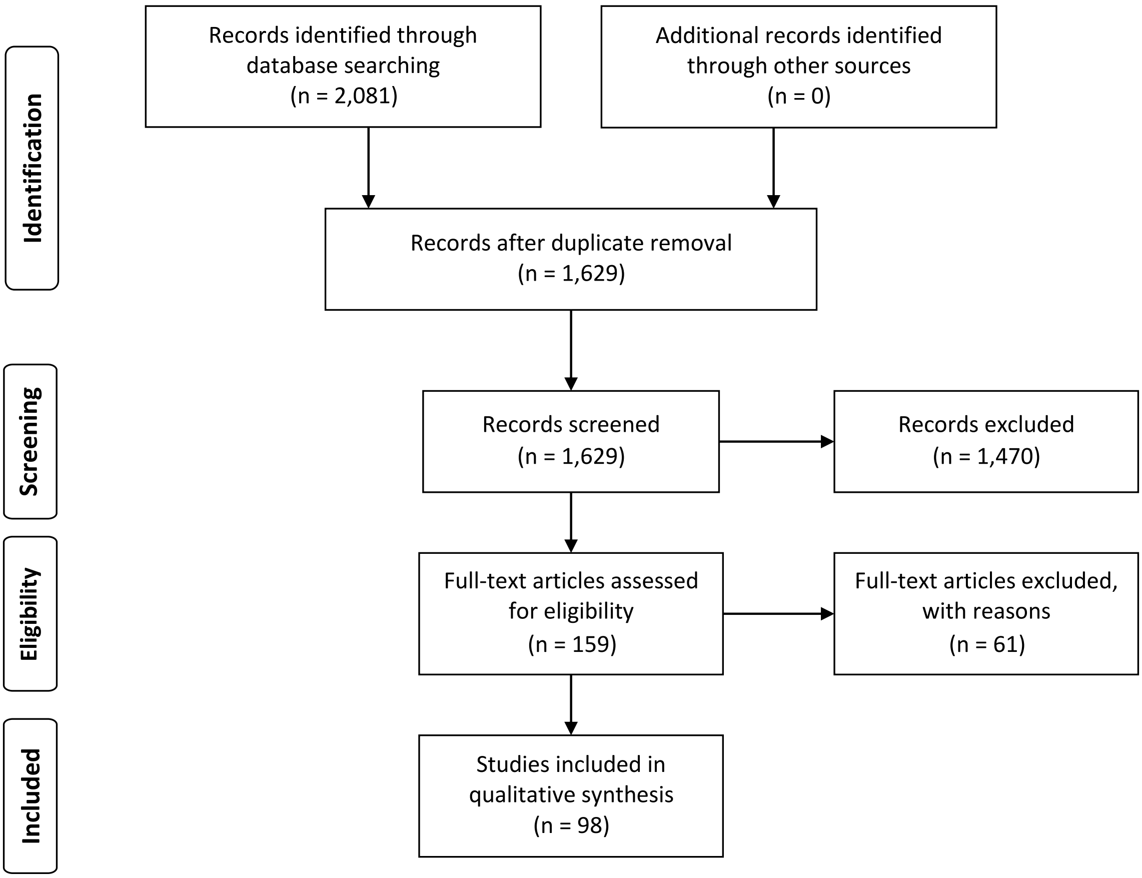

Fig. 1 PRISMA flow chart showing the process applied for identifying relevant studies

Table 2 List of academic outlets and their respective number of publications

Outlet	Number of Publications
Transportation Research Record	8
Transportation Research Part A	7
European Transport Research Review	6
Case Studies on Transport Policy	5
Sustainability	5
Transportation Research Procedia	5
Transportation Planning and Technology	4
Transportation	4
Transport Policy	4
Transport Reviews	2
Transportation Research Part F	2
Research in Transportation Economics	2
Computers, Environment and Urban Systems	2
Transportation Research Part C: Emerging Technologies	2

one-way and two-way car-sharing systems. This summary shows that our collated corpus covers various geographies and captures different types of new mobility services addressed from various angles. Besides, this corpus counterbalances both the conceptual and empirical evidence since 51 studies are empirically investigated by the authors while 47 works are based on conceptual scrutiny.

All included manuscripts were published between the years 2012 and 2022. Figure 2 provides an overview of the number of publications for each covered year. The majority of the publications were published in the year 2020 ($n = 26$), where n is the number of publications, followed by 2021 ($n = 21$), 2022 ($n = 15$), 2019 ($n = 11$), 2018 ($n = 8$), 2017 ($n = 4$), 2016 ($n = 4$), 2015 ($n = 3$), 2014 ($n = 4$), 2013 ($n = 1$) and 2012 ($n = 1$). Despite our search strategy covering a longer period, beginning from 2007, it has been identified that in general, the study of new mobility services (using this terminology) gained

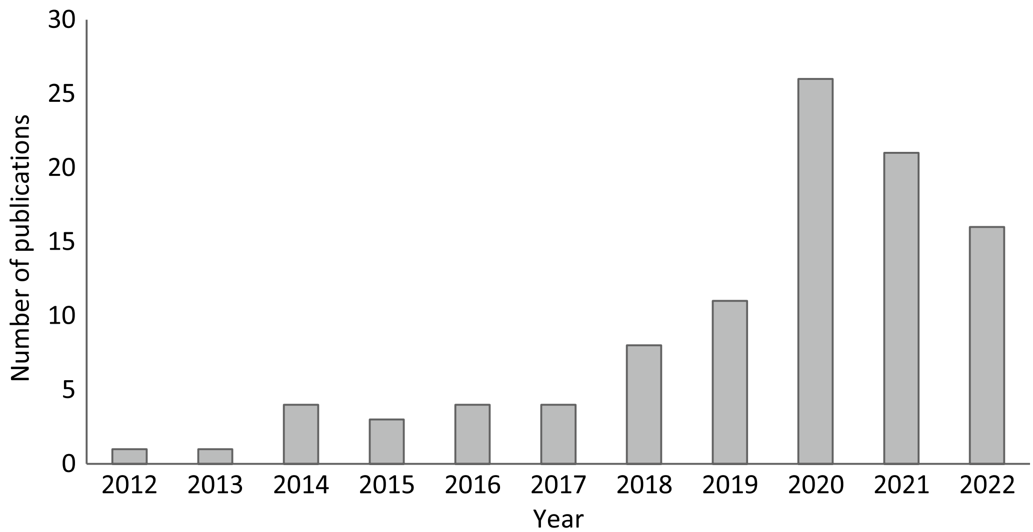

Fig. 2 Numbers of publications mapped against their respective years of publication

momentum after the year 2016. One reason for this lag could be that it took several years after the smartphone's market launch for corresponding services to emerge – and especially for researchers to take them up as an academic topic. The reason behind this might have been that, in the year 2016, the then novel mobility concept of Mobility as a Service (MaaS), which intends to integrate new mobility services, received increasing attention in the academic literature [6, 34]. For this reason, researchers started to view the different individual mobility services in a joint or packaged arrangement with the inquisitiveness of solving mobility challenges. Secondly, the sudden and accelerated emergence of new mobility services such as e-scooters in 2017 [15, 35] might have scintillated the interest of researchers to further investigate new mobility services.

3.3 Terms indicating mobility concepts

Before presenting an in-depth conceptualisation of new mobility services in Sect. 4, we briefly summarise the key terms that frequently appear across the corpus. A descriptive analysis of the full-texts is conducted to extract terms indicating frequently appearing concepts of new mobility services from the reviewed literature. The essence of this is to provide a starting point for identifying the terms and concepts to be reviewed and discussed in more detail in Sect. 4. Terms such as mobility, service, share, system, etc., appear in all the 98 included studies. Beyond these very general terms, some of the more specialised terms appear more frequently than others, such as car-sharing, which occurs 1852 times (in 68% of all reviewed publications); ride-sharing, appears 364 times (in 60% of all publications); ride-hailing, appearing 1001 times (in 44% of all publications); ride-sourcing, which occurs 668 times (39% of all publications); bike-sharing, which appears 669 times (in 54% of the publications); e-scooter sharing, occurring 615 times (in 42% of all publications); shared autonomous vehicles, being present 241 times (in 16% of the publications) and MaaS, featuring 704 times (in 61% of our corpus).

4 Results and discussion

This section presents the results of the review, including interpretations for the extracted contents. First, we provide a brief overview of the genealogy of both the individual new mobility services and of the terminology *new mobility services* itself. Second, the section continues with extracting the conceptualisations of new mobility services as they are represented in the identified manuscripts. This entails discussing the impacts of those concepts on mobility landscapes, which are summarised along the lines of spatial, social, economic, and environmental dimensions in separate paragraphs respectively. Finally, the identified conceptualisations are synthesised into a conceptual model to instantiate the unique characteristics and properties within the identified conceptualisations in the literature.

4.1 Genealogy of new mobility services and corresponding terminologies

Although many of the individual services of concern in this paper are currently considered as emerging, it is important to highlight that some of them have been in existence for quite some time. The car-sharing scheme, for example, began as early as 1948, in Zürich (Switzerland) where the "Sefage" cooperative offered this mobility service in a neighbourhood business model [36]. Bike-sharing is traced from the "White Bikes" scheme that started in 1965, where a range of 5–10 bikes were distributed on the streets of Amsterdam for shared use by the public [37]. However, this program did not last for long due to theft and vandalising of the offered bikes. Ride-sharing began in the 1970s in many cities of the United States when the fuel prices went up due to the oil crisis, and when people thus opted to share rides as a strategy of lowering their travel expenses [7]. In the same period, demand responsive transport (DRT) found its space in mobility landscapes when low occupancy public transport services were no longer cost effective [4]. In 2009, technological advancements such as smartphones becoming the norm opened up a window for ride-hailing, and hence service providers like Uber started operating in different cities around the world [38]. In the year 2014, Heikkilä [39] came up with a proposal for transforming the passenger transport sector in the city of Helsinki, Finland, and since then, the concept of Mobility as a Service (MaaS) started appearing in mobility research. Besides, e-scooter sharing can be regarded as one of the most recent concepts, because its rapid use in different cities of the globe is trialed from 2017 [40]. In addition, several academic works have pointed on the emergence of shared autonomous vehicles (SAVs) in the near future, and currently, there are some ongoing small-scale pilots on SAVs, which are expected to change several aspects in mobility landscapes such as the travel behaviours [41]. Besides these individual services, we have identified the period for starting using the terminology "new mobility services" (in the sense of this article), and this was in the year 2015 when Hinkeldein et al. [42] highlighted the main theme of supporting the lifestyle for using instead of owning, which is characterised with the use of new mobile devices (smartphones) to provide opportunities for harmonising individual mobility services. This demonstrates that, while some of the individual mobility services have a longer tradition in mobility landscapes, seeing them as instances of one seemingly coherent concept is a fairly recent phenomenon.

4.2 Overview of individual new mobility services

Several related yet different terms have been proposed to refer to new mobility services including *smart mobility services*, *smart urban mobility innovations*, *sustainable mobility services*, among others [4, 17, 27, 43]. These differing ways of terming new mobility services sets a challenge of having a uniformly used terminology associated with clearly defined characteristics in the literature. Nevertheless, new mobility services can be defined as a wide range of mobility services that have emerged in recent years or are expected to emerge in the near future [7, 8]. The ones that we extracted from the reviewed literature include mobility services such as bike-sharing, e-scooter sharing, car-sharing, ride-sharing, ride-hailing, demand responsive transport (DRT), shared autonomous vehicles and Mobility as a Service (MaaS). Henceforth, we classify these new mobility services into two main categories regarding the vehicles involved: micro-mobility services and car-based mobility services. Micro-mobility services refer to a class of lightweight vehicles such as bikes, e-scooters, etc. [40], whereas car-based mobility services refer to a class of mobility services centred on activities based on car usage, and thus on using heavier types of vehicles.

Besides, there are two main themes that cut across both categories: digital infrastructural services and shared mobility services. Digital infrastructural services like MaaS aim to provide for a seamless, integrated mobility system by offering technical 'backbones' integrating user interfaces, ticketing, and other infrastructural aspects. Further, the behaviour of sharing is of course not entirely new [35]. People have been routinely sharing facilities and services in their daily lives [7]. However, the emergence of digital technology gave rise to a sharing economy [17], which refers to the behaviour of sharing products and services via digital platforms for a profit [40, 44]. Shared mobility is an offspring of this type of economy and refers to sharing mobility services such as vehicles, rides, bikes, and e-scooters [4, 7]. Thus, the primary principle for shared mobility is to share mobility services among users rather than owning the respective material and immaterial means privately [8]. In addition, within the confines of shared mobility, there are two crucial aspects, first, where the users share the provided physical assets (e.g., bikes, cars, e-scooters, etc.), and second, where the cabin space (e.g., seats in a car) is shared [45, 46]. The following sections briefly summarise characterisations of these types of services as extracted from the reviewed literature including the impacts of new mobility services on mobility landscapes.

4.2.1 Bike-sharing

Many of the transport challenges that are confronted by cities such as traffic congestion, limited public space, and excessive emissions are directly linked to private vehicle use [40, 47]. As a counter measure to some of these challenges, the importance of bikes is currently rethought and thus, mobility services such as bike-sharing are distinctly visible in many mobility landscapes [37, 48]. Bike-sharing refers to the alternative of renting bikes from a publicly provided bike-fleet for short-term use [49]. Bike-sharing can also be viewed as a mobility service where users have access to bikes without bearing the cost and responsibility of owning a bike [50]. The service of bike-sharing is usually offered in two different ways: through station-based bike-sharing (SBBS) or in the form of free-floating bike-sharing (FFBS) [37, 40, 48–50]. The SBBS refers to a model of bike-sharing where bikes can only be accessed and returned to self-serving docking stations [5, 48]. This is further subdivided into the one-way format where a bike is obtained from one station and returned to another, and the round-trip format where a bike is returned to its station of origin [49]. The FFBS (or dockless or station-less) system refers to a format of bike-sharing where users can access or drop the bikes within a specified area or region of operation [49, 51], allowing them to start and end their trips anywhere within these bounds [50].

Bike-sharing is considered in the reviewed literature to be environmentally friendly, healthy, space efficient, and affordable; and often as playing a vital role in reducing private vehicle use and dependency [37, 52, 53]. Bike-sharing is also described as an important tool in reducing exhaust emissions and downtime in traffic jams [37, 54]. In addition, bike-sharing services provide a solution for the first and last-mile problem, for instance, covering the distance from people's homes to public transport or from public transport to their workplaces [50, 52]. This, however, does not imply that bike-sharing is only a complementary service. A study from Seoul, for instance, has demonstrated that bike-sharing may also compete with traditional public transport trips when it comes to covering short distances or during peak times of traffic [55].

4.2.2 E-scooter sharing

The term *e-scooter* is not used uniformly in the academic literature [56]. In our study, we refer to an e-scooter as a two-wheeled vehicle that is designed with a standing deck where the rider stands, a front handlebar, and it is powered by an electric battery [57]. In addition, this type of e-scooter can be used without the need of having a driving licence and its maximum speed is usually capped at 25km/h. E-scooters are often offered as shared mobility services, and in a free-floating system [7]. Also, the average user of e-scooters has been shown to be young, male, and above-average educated [15, 54, 57].

The introduction of e-scooter sharing has sparked mixed assessments in the academic literature [58]. On the one hand, similar to bike-sharing, e-scooter sharing is contributing to multi-modal mobility by providing a first and last-mile solution or for short trips [4, 57]. However, Tan et al. [59] argue that the service is more likely to be used for leisure trips and less so for commuting. Severengiz et al. [56], Esztergár- Kiss and Lizarraga [60] show that e-scooter sharing has the potential to reduce fuel consumption, emissions, and traffic congestion. In addition, the service is space efficient, silent, and allows to travel faster uphill [60]. On the other hand, there are safety concerns such as traffic accidents that are associated with the use of e-scooters [54]. In fact, Mouratidis et al. [35] indicate that e-scooters are ten times more likely to be involved in an accident than bikes. Cao et al. [57] also raise concerns about the uncontrolled fleet size for e-scooter sharing services, leading to obstruction of streets and causing of disturbance to other road traffic users. Furthermore, Fishman and Allan [37] question the life-cycle for e-scooters, and whether their operating business models are economically viable and sustainable for a longer-term. In some cases, e-scooter sharing has been characterised as an expensive service to use compared to other services like bike-sharing.

4.2.3 Car-sharing

The term *car-sharing* (sometimes referred to as *car-clubs* in the UK) has seen strong growth in the past few years [61]. Although, car-sharing is considered a *new* mobility service, sharing vehicles with other people such as family members, friends, and neighbours has all along been in existence [8]. Car-sharing is thus one of the mobility services that cannot fully be considered as emerging, because this practice has been present for a long period of time [5]. However, the presence of information and communication technologies has shifted car-sharing from a small concentric to extended public use. In 2020, the service of car-sharing had more than 32 million registered users in over 50 countries [40]. Nevertheless, the term *car-sharing* is yet still lacking a uniform definition. For example, Kim et al. [44], Kortum et al. [62], Gilibert and Ribas [63] refer to car-sharing as a service offering users to rent vehicles for hours or minutes as opposed to the traditional method of *car-renting*, which offers renting vehicles for days or weeks. Similarly, Shibayama and Emberger [7] view car-sharing as a rental scheme providing vehicles for a short term, usually in minutes or hours, and is characterised by self-service reservation, pick-up, return, and automated payment. Similar to bike-sharing, car-sharing operates in either a station-based or free-floating mode [61]. Also similar to bike-sharing, the station-based car-sharing mode can be further characterised into a one-way and two-way (round-trip) model [61, 64, 65]. However, what uniquely distinguishes car-sharing are the two main models that exist in the market, because this service can either be offered as peer-to-peer (P2P) or business-to-customer (B2C) [36]. For the P2P model, the provided vehicles in the car-sharing scheme are owned by private individuals who offer their vehicles to be used by others within the same car-sharing scheme while in the B2C model, the offered vehicles to the users are entirely owned by the car-sharing scheme.

The service of car-sharing is attributed to several impacts on mobility landscapes. For example, the service is considered affordable, convenient, time-saving [47, 66], and has the potential of reducing private vehicle ownership [42, 67–69]. For instance, a study from London shows that 30% of free-floating car-sharing users avoided purchasing private vehicles, 4% disposed of their vehicles after joining the car-sharing scheme while 3% were ready to sell their vehicles in the coming months [36]. Besides, Shaheen et al. [61] point out that car-sharing increases access to distanced households without vehicles, promotes environmental awareness, and is positively correlated with active mobility (e.g., walking and biking). Regardless of the benefits that are associated with car-sharing, Moscholidou and Pangbourne [70] argue that the impacts of this service are tainted with numerous uncertainties such as increased traffic congestion, inequality, and occupation of public urban spaces for parking.

4.2.4 Ride-sharing

Ride-sharing [sometimes called *car-pooling*; see 7] refers to a service where vehicle drivers and passengers travelling to the same destination connect to each other by a smart application [44]. Ride-sharing can also be conceived as sharing rides within confined social networks (e.g., a neighbourhood) where origins and destinations are known prior to the start of the trip [5]. Agatz et al. [71] view ride-sharing as a service where travelers with similar itineraries and travel schedules share a ride. Henceforth, ride-sharing enables users who are going to the same or closely located destinations to share the same ride [40]. The service of ride-sharing is mainly divided into two main categories, and these are: car-pooling and van-pooling [46]. Car-pooling denotes a form of ride-sharing where a group of maximum seven people shares a ride in a car while van-pooling is where a range of seven to fifteen people commute in a van [45].

In previous studies, the service of ride-sharing has been linked to being fuel saving, environmentally friendly, and providing a means for making better use of a vehicle's space by occupying empty seats, thus, reducing travel costs [72]. For this reason, Agatz et al. [71] indicate that the main essence of using ride-sharing by participants is to reduce the travel-related expenses that would have been incurred in circumstances of not sharing a ride. In a similar context, Hasselwander et al. [46] show that the service of ride-sharing is mainly operated without any profit-oriented intentions. Ride-sharing is also associated with other advantages like reducing transport-related social exclusion and private vehicle ownership [70]. Nevertheless, Tirachini et al. [73] demonstrate that ride-sharing can increase the vehicle kilometres travelled, and may lead to the substitution of traditional and environmentally friendly modes of transportation such as bus trips. For instance, early evidence, addressing the use of ride-sharing in the United States reports that users of this service potentially shift from public transport, which in return increases the use of vehicles in cities. [70]. Besides, Agatz et al. [71] highlight that issues of personal safety, social considerations, and unwillingness to share a ride with strangers are associated with ride-sharing.

4.2.5 Ride-hailing

Ride-hailing, sometimes referred to as *ride-sourcing or transportation network companies (TNCs)* [45, 46, 74] has in the past years gained more attention from academic scholars and practitioners [75]. In many cities, the emergence of ride-hailing has mainly been driven by the accelerated arrival of mobility service providers such as Uber and Lyft [76]. In simple terms, ride-hailing has a similar operation format like traditional taxis [7, 43, 44]. But contrary to taxis, ride-hailing allows private vehicle drivers to transport passengers that are in need of an immediate ride, and passengers can request for a ride via a smartphone application [46, 77, 78]. Mohamed et al. [43], Kim et al. [44] view ride-hailing as a pre-arranged and on-demand transportation service where private vehicle drivers and passengers are connected in real-time through internet-based platforms that are supported by geographic information systems (GISs) and satellite positioning systems such as the American GPS. In this sense, users without private vehicles can have access to both a vehicle and a driver through a digital broker [27]. Unlike ride-sharing which is not primarily a profit-oriented service, for ride-hailing, drivers offer their services for a profit [79].

In the literature, there seems to be confusion between ride-hailing and ride-sourcing since both concepts are interchangeably used by different authors. Therefore, it is important to note that ride-hailing is semantically equivalent to ride-sourcing since the term ride-hailing denotes passengers hailing rides from the drivers while ride-sourcing denotes drivers sourcing rides to the passengers [5]. Likewise, the term TNCs is also used in the literature [80, 81], because this was introduced by the California Public Utilities Committee (CPUC) in the USA to categorise all transportation companies that offer ride-hailing services [79]. Therefore, the terming of ride-hailing may differ depending on the intention, perception, and location of the author(s), however, in practice, the end product of ride-hailing, ride-sourcing and TNCs is the same. In addition, Shaheen and Chan [45] highlight that although these concepts are the same, the term ride-sourcing is mainly used by transportation academics, TNCs is preferably used among practitioners and ride-hailing among the popular press. Nevertheless, many academic scholars have presently gained more interest in using the term ride-hailing, and this is also reflected in the screening of our reviewed texts for mobility concepts.

The service of ride-hailing offers several benefits in mobility landscapes since it is considered to be convenient, safe, and cost-effective because it provides a cheaper alternative to private vehicle ownership [27, 82]. In addition, Mohamed et al. [43] indicate that the service of ride-hailing is easy to be requested by the passengers. Besides, both passengers and drivers are seen to benefit from ride-hailing, because passengers obtain an immediate ride while drivers are compensated for their rendered service in a payment form [83]. Furthermore, ride-hailing can be a solution to the first and last miles, however, this may cause substantial implications to active mobility such as walking and biking [76]. Also, the service is subjected to a risk of disrupting traditional travel modes like public transport [27, 82], because ride-hailing may induce users to make more trips, thus reducing the share of trips made by other sustainable modes like public transport [17, 81]. Tirachini et al. [73], Kang et al. [80] show that in many cities, ride-hailing can increase traffic congestion, because the majority of the trips are taken by a single individual.

4.2.6 Demand responsive transport

Demand responsive transport (DRT) services are based on small vehicles like minibuses that pick-up or drop-off passengers based on their demands [5, 43]. This mobility service can either be a private or public transport system and allows users to share rides, and routes or schedules are modified depending on service demand [18]. DRT is mostly offered in areas that are not well-connected to public transport or are characterised as low-demand routes. [19].

Unlike public transport, DRT is considered flexible, offers door-to-door service, and has the ability to widen transport service coverage [4, 18, 84]. In addition, the service is efficient for certain special groups such as the elderly or people with disabilities [7]. For this reason, Mohamed et al. [43] view DRT as a mobility service that can improve on social inclusion in mobility landscapes. Despite that DRT seems to offer many advantages, the service is associated with several disadvantages, too, such as increased vehicle kilometres travelled [18], and idle vehicles waiting (times of no demand) and transit time (travelling to pick up passengers) [5]. These disadvantages may compromise the economic and operational viability of this service.

4.2.7 Shared autonomous vehicles

In recent years, there has been a growing discussion concerning the realisation of shared autonomous vehicles (SAVs) and how this concept may distinctively transform the present-day transportation ecosystem [85]. The idea of initiating SAVs is mainly fostered by a simultaneous development of autonomous vehicles (AVs) and ride-hailing services [41]. In this context, SAVs can be conceptualised as autonomous vehicles that are offered in an arrangement of the shared mobility services [41]. Here, users are expected to share autonomous vehicles that provide on-demand transportation services like requesting a ride in real-time [86]. Despite that SAVs are still in their test-beds, researchers believe that a proliferate fleet size for these services will probably be visible after their emergence [87]. SAVs are anticipated to be self-driving vehicles, equipped with features like navigation system, lane keeping system, collision mitigation system, auto-parking system, night vision, etc. [83]. The presence of these features in SAVs is expected to minimise human errors, and improve on various aspects like efficiency and road safety [88]. In addition, SAVs are expected to impact people's decisions on private vehicle ownership, because some studies have already shown that one shared autonomous vehicle can replace 11 private vehicles [89]. Similarly, in the simulation investigation that was conducted in Austin, Texas, concerning the uptake of SAVs, the study concluded that every SAV could replace 9.3 privately owned vehicles [87]. Besides, Lang and Mohnen [90] state that SAVs are not only space efficient and flexible, but they are also positioned to provide exceptional travel experiences to the users at a low cost.

Although SAVs are considered sustainable due to their capability to tackle problems like environmental pollution and oil dependency that are associated with private vehicle usage [91], Stocker and Shaheen [41] indicate that SAVs are tainted with multiple hurdles and will take long to mature. Furthermore, some studies have shown that SAVs can drastically increase the number of motorised trips and traffic congestion [92], because there will be a challenge of coordinating SAVs with other conventional vehicles on road networks. In addition, Winter et al. [93] highlight the challenge of providing parking spaces for idle vehicles in a large SAV fleet since space is usually scarce and constrained in urban contexts. Raposo et al. [88] unleash other effects of using SAVs like developing of new business models for these services, leading to the obsolete of some occupations (like for drivers) and suffering of the insurance sector due to improved road safety. Lastly, Galich and Stark [89] warn that users with luggage are less likely to use SAVs during their trips, nevertheless, SAVs are anticipated to be attractive to people travelling with children.

4.2.8 Mobility as a Service (MaaS)

The concept of *Mobility as a Service (MaaS)* is still in its developmental stages despite its first appearance in the year 2014 [94, 95]. Since then, the concept has received a lot of attention in the academic literature [21, 96]. There are several MaaS schemes and pilots in different countries such as Ylläs Around (Finland), Mobility Broker (Germany), Mobility Mixx (Netherlands), among others [97, 98]. MaaS refers to a service that integrates various mobility alternatives within a single digital interface, and offers possibilities for booking, payment, and travel information [99–101]. Similarly, Arias-Molinares and García-Palomares [34] view MaaS as a type of system offering a comprehensive range of mobility services to the users through a single service provider. Utriainen and Pöllänen [102] view MaaS as a concept that is aimed at combining different transport modes and services over a single platform to enable seamless trips while Hietanen [103] view MaaS as a service where users' mobility needs are met over one interface offered by a service provider. MaaS has no single definition, although all the definitions are aimed at integrating different mobility services within a single digital interface. For this reason, Kamargianni et al. [6] point out the three main elements characterising the MaaS process, which include ticketing and payment, mobility package (combination of mobility services), and ICT integration.

Previous studies on MaaS have demonstrated that an effective implementation of this service in mobility landscapes can trigger a transformation towards more sustainable transport systems [104, 105] by decarbonising transport for the coming generations [100, 106]. This infrastructural service is expected to reduce the use of private vehicles [95, 96, 107, 108] through providing a competitive, convenient, and cheaper alternative [21, 109]. Although MaaS is associated with a range of positive expectations, empirical evidence of its impacts in practice is still largely lacking [110]. Also, Alyavina et al. [94] stress that MaaS requires to be trialled to test its efficiency in offering reliable information and realistic travel alternatives (e.g., routes) in circumstances of disruption. MaaS is also viewed as a broker or aggregator that combines both private and public transport services, in this context, it is still unclear who will take up the main role in the MaaS development since transport operators (companies) are keen to protect the one-to-one relationship with their customers (service users) and are not ready to share losses in MaaS arrangement [111].

4.3 Conceptual model for new mobility services, and their impacts

This section presents how authors using the term *new mobility services* conceptualise the individual services from Sect. 4.2 together under this umbrella term. Approaching this understanding from the bottom up, starting with the individual services, does not provide an exhaustive understanding of the latter. It rather helps to understand what makes these services different and unique from other forms of transport from the point of view of the sub-community operating with the terminology with which we are concerned in this review. In order to identify respective patterns, our analysis begins by viewing the scrutinised terms as separate concepts. Although these concepts differ in the reviewed literature, they seem to be organised around similar ideas with abstract principles that jointly constitute the main theme of new mobility services. It appears that these ideas are convened from various aspects such as the type of service, method of operation, forms of sharing (e.g., sharing a vehicle or a cabin), accessibility elements, user characteristics as well as other factors. We thus show in the remainder that these mobility concepts together share common facets. Against this background, we have reviewed the literature, and singled out the indispensable characteristics that are consistently attributed to new mobility services beyond the scope of only single publications.

Table 3 offers a catalogue of 26 attributes extracted from the literature and is reflective of the *formal context* as introduced in Sect. 2.6. It is noticeable that multiple forms of new mobility services closely share several types of attributes. From this, we can extract sub-groups of attributes (e.g., all services that offer shared rides), and within these sub-groups, we can identify concepts that share the same attributes. It is also noticeable that some attributes are limited to only a few services. For instance, station-based and free-floating services are examples of this, which makes it clear that the respective services differ from other services regarding their spatial arrangement and design in the way they are used on site. The remainder of this section introduces these kinds of sub-structures and focuses on identifying those characteristics that are most likely to be decisive for considering the individual services outlined in Sect. 4.2 together as an overarching concept called *new mobility services*.

Most of the mobility concepts featured in Table 3 are strongly associated with the elements 'emerging' (understood in the sense of novel and developing) and are digitally accessible. Furthermore, the authors of the papers examined in this study consider the services to be predominantly environmentally friendly [see; 8, 112] and mention only few corresponding disadvantages. This is also reflected in Sect. 4.2, but is contestable in a general sense, as more critical assessments exist in the wider literature beyond the subset of authors using the terminology of new mobility services [e.g., 40]. Nevertheless, the fact that the authors emphasise this feature rather

Table 3 Relations among new mobility services and their attributes

Characteristics	BS	ES	CS	RS	RH	DRT	SAVs	MaaS
Temporal								
Emerging	x	x	x	x	x	x	x	x
Pre-existent	x		x			x		
User-related								
Young adults	x	x	x	x	x	–	x	x
Educated	x	x	x	x	x	–	x	x
High income	(*)	x	x	x	x	(*)	(*)	(*)
Small households	x	x		x	x	–	–	x
Households with children			x		–	x	x	–
People with disabilities					x	(*)	x	–
Environmentally friendly	x	x	x	x	x	x	x	x
Technical travel mode								
Car-based			x	x	x	x	x	
Micro-mobility	x	x						
Operational								
Digitally-accessed	x	x	x	x	x	x	x	x
Real-time location	x	x	x	x	x	x	x	x
Shared service	x	x	x	x	x	x	x	x
Shared ride				x	x	x	x	x
On-demand				x	x	x	x	x
Unified platform								x
Station-based	x		x					
Free-floating	x	x	x					
Trip-related								
Short distances	x	x			x		(*)	(*)
Long distances	(*)		x	x	x	x	x	x
Commuting trips	x	(*)	–	x	x	x	x	x
Leisure trips	(*)	x	(*)		(*)	–	(*)	x
Usage context								
Urban	x	x	x	x	x	x	x	x
Suburban	(*)	(*)	x	x	x	x	x	x
Rural					(*)	x		

The character x refers to a relationship, (*) indicates varying evidence in the literature, and – stands for lacking evidence. Empty table cells indicate irrelevance of an attribute to a service. BS = bike-sharing; ES = e-scooter sharing; CS = car-sharing; RS = ride-sharing; RH = ride-hailing; DRT = demand responsive transport; SAVs = shared autonomous vehicles; MaaS = Mobility as a Service

consistently could mean that they consider new mobility services as a whole as a concept of environmentally friendly services, regardless of whether the individual services are actually that favourable. Another fairly consistent finding (although somewhat more controversial in the literature reviewed) is that most services are used on average by high-income earners living in either urban or suburban areas [113]. In addition, most services attract young and educated adults, with DRT being the only exception. The reason for this is that young adults often live in urban areas and that they are often more tech-savvy, thus better informed about the use of digital platforms than their older and/or less educated counterparts [80, 113]. A similar socio-demographic pattern is also observed in the use of other digital services such as volunteered geographic information projects and location-based social media [114, 115].

Comparing individual services one-by-one, it appears that bike-sharing and e-scooter sharing are often seen as closely related services. Both concepts entail sharing, often with similar operating formats (free-floating), and are described as being used especially for short distances such as covering the first and last mile of a trip. Nevertheless, bike-sharing and e-scooter sharing also show differences: bike-sharing emerged prior to e-scooter sharing, the former is more often offered in a station-based manner, and e-scooters are predominantly electric. Also, it is worth mentioning that bike-sharing is often used as a service for commuting [49], while e-scooters are mainly attributed to leisure trips [60]. Nevertheless, some manuscripts highlight the importance of e-scooter sharing in commuting trips [e.g., 15, 57], indicating varying evidence regarding this characteristic. Besides bike-sharing and e-scooter sharing, car-sharing is also somewhat similar to both concepts. Car-sharing is a shared service and has closely similar operating formats (station-based and free-floating). Some of the dissimilarities lie in the actualities that the free-floating car-sharing system has a wider operating area than bike or e-scooter sharing services. Further, car-sharing users more often live in households with children, while bike-sharing users mainly originate from small households without children [52].

Ride-sharing and ride-hailing seem to be closely related mobility concepts, because both services offer shared rides that are on-demand. However, the major discrepancy between both concepts is that ride-sharing mainly provides its services to constrained social networks [5], and it seems to be more favourable for commuting purposes [71] while ride-hailing offers a taxi-like service where drivers with personal vehicles pick-up passengers and can provide a door-to-door service [116]. Ride-hailing tends to offer a wider range of options since it can as well be hailed in rural areas, used for leisure trips, and as means of transport for people with special needs, since ride-hailing drivers are usually trained to assist passengers with physical disabilities like those in wheelchairs [27]. In this sense, ride-hailing is closely related to DRT since the latter is also on-demand and capable of transporting special groups of people. Nevertheless, DRT is predominantly offered in areas that are less well served by regular public transit and using medium-sized vehicles such as vans [18, 72, 78, 84].

Shared autonomous vehicles share similar characteristics with ride-hailing services since both services are car-based, can be digitally hailed or requested by the users, and are accessible for people with special needs or disabilities. Furthermore, other studies have indicated that SAVs are in another way identical to ride-sharing, because users of SAVs are also expected to share the cabin space within the provided vehicles [117]. Similar to ride-sharing, previous studies have demonstrated that early adaptors of SAVs are expected to be young, educated, and more tech-savvy commuters [117]. However, Galich and Stark [89] argue that private vehicle owners (especially men) might not be willing to give up their cars in preference of sharing a ride in SAVs except those living in multi-vehicle households.

To conclude our concept-to-concept comparison, we regard MaaS as an overarching concept for all other discussed mobility concepts, because it is not only a digital interface as it is usually regarded [34] but it also demonstrates intensive infrastructural bonds with all the shared and on-demand services. For instance, this concept provides the whereabouts of the access points, routes, transits and stops for the users of different mobility services [98]. Thus, fostering the multi-modal and intelligent mobility management and distribution system in mobility landscapes [34].

In summary, exploring the relations among the attributes of mobility concepts, long distances, and commuting trips are mainly covered by car-based mobility services such as ride-sharing, ride-hailing, DRT, among others. Micro-mobility services are predominantly used in a free-floating system by small households for mainly leisure trips. Similarly, unified platforms are strongly linked with small households, shared and on-demand rides, and services. Most importantly, the characteristics that are shared by all considered services are *emerging*, *high income*, *environmentally friendly*, *urban*, and *suburban*. Therefore, these are the characteristics that we revealed from the reviewed literature as the main characteristics forming the least common denominator of *new mobility services*, at least as the terminology is used in the interdisciplinary literature to date. However, as reflected in our review, it is important to distinguish that the term 'emerging' does not necessarily mean that all the new mobility services are entirely contemporary, but it rather indicates the innovative and noticeable traces of how these services are offered by mobility operators or accessed by the users.

5 Conclusions

This scoping literature review focuses on understanding how new mobility services are conceptualised and characterised in the academic literature. In addition, we look into the impacts of these services on mobility landscapes. In our study, it has been ascertained that the term *new mobility services* is broad in nature, and encompasses a variety of individual mobility concepts. However, it is revealed that these services share certain attributes in aspects such as their operating formats, user characteristics, etc. From a holistic point of view, new mobility services can be divided into micro-mobility services, car-based mobility services, and online digital platforms such as MaaS. We have worked out that all revealed services have five essential characteristics: they are urban or suburban modes of transport, they are disproportionately used by affluent and educated people, who are often young adults, and they come with the premise of environmental friendliness. It is thus possible to define a class of *new mobility services* despite the apparent heterogeneity of the sub-concepts that fall into this class. The following concluding paragraphs relate our findings to the wider literature.

The conclusions that we draw from our review go beyond the immediate answers to the posed research questions. From the perspective of an impact assessment appraisal, micro-mobility services such as bike-sharing and e-scooter sharing are identified as relevant for covering short distances and leisure trips by small or single households, while car-based mobility services are more often considered as useful means of transport for long distances and are found to be attractive to households with children. Further, bike-sharing and e-scooter sharing have almost similar impacts on mobility landscapes, bike-sharing and car-sharing are closely similar in their operating formats, ride-sharing and ride-hailing fulfil the same need for offering a ride or renting a seat rather than a vehicle, ride-hailing and DRT operate with the same principle since they are both on-demand services. In addition, ride-hailing and shared autonomous vehicles demonstrate similarities, because the concept of SAVs partially emerged from the ride-hailing concept and both services are vital for special groups of people like the disabled and children. Jointly, MaaS bonds all mobility services into a digital and unified infrastructure. These findings show that our research not only reveals the minimum requirements for new mobility services in general but also interesting patterns between individual services.

Our review contributes to an interdisciplinary body of literature that broadly addresses new mobility services. Comparable publications include the study of Shibayama and Emberger [7] offering a taxonomy of new mobility services. This taxonomy was developed in relation to the role of Internet and Communications Technologies (ICT) in the modes of operation of these services. Similarly, Castellanos et al. [17] reviewed new mobility services by exploring the origin and importance of shared mobility from a shared economy perspective while Calderón and Miller [5] studied new mobility services by establishing the foundations for a generalised conceptual modelling framework with the use of platform-based models and market mechanisms. In addition, Storme et al. [8] provide a critical review study on new mobility services' impact assessment, addressing their social, economic, and environmental aspects. Zhang and Kamargianni [118] very recently explored new mobility services in the context of micro-mobility and MaaS with the aim of identifying the main theoretical frameworks that are crucial for the adoption of new mobility technologies and services. Our study complements the findings from the aforementioned works by identifying the minimum requirements for a service to qualify as a *new mobility service*. Based on a synthesis of the existing literature, this provides future research with a better understanding of how the services studied here can be differentiated from other digital mobility solutions such as Smart Mobility or others. This will contribute to greater conceptual clarity in the dynamic and heterogeneous research landscape.

As far as limitations are concerned, we acknowledge that the topic of new mobility services is very broad and encompasses various dimensions. Therefore, some aspects are not sufficiently covered in our studied corpus of literature. For example, we found that many studies in our corpus tend to focus on the positive impacts of new mobility services without sufficiently investigating their negative impacts. Future studies should therefore strive to capture the negative impacts of these services. Similarly, the work we have examined focuses predominantly on Western countries, as most studies of new mobility services to date have come from these countries. However, a look at other cultural world regions may reveal interesting differences to our findings. Moreover, aspects such as social benefits, pricing of the use of new mobility services, and their impact on public transport are some of the factors that are not addressed in detail, at least in the literature that uses the terminology of new mobility services (and as we reviewed it in this work). Therefore, future studies should find ways to better address these aspects as well.

Supplementary Information

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Additional file 1. Detailed review protocol and list of reviewed publications.

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Author contributions

IM: Conceptualisation, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing—Original draft, Writing—Review & editing, Visualisation, Project administration. RW: Conceptualisation, Methodology, Investigation, Writing—Review & editing, Visualisation, Supervision.

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The authors declare that they have no competing interests in this research.

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