

Review

International Research Progress in School Travel and Behavior: A Literature Review and Bibliometric Analysis

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Abstract: A deep understanding of school travel mode can help policymaking related to the optimization of the school travel structure, alleviating urban traffic congestion due to the increasingly prominent phenomenon of urban sprawl. However, existing studies in this field are based on a specific research perspective, and comprehensive reviews are rather limited. Therefore, this study aims to provide an in-depth, systematic review of school travel by using bibliometric analysis. Firstly, based on the Web of Science, TRID, ScienceDirect, and MEDLINE databases, 457 studies about school travel are selected from between 1996 and 2021. Secondly, utilizing bibliometric analysis, the research progress is summarized with emphasis on the annual performance of the literature, publication status of a country or region, literature source institutions, keywords of the literature, and co-citation network analysis. The research results show that (1) the United States, Canada, and Australia rank top in the number of studies on school travel, and they also have high citation frequency and connection strength. (2) This study collects studies published in 34 journal publications, and the “*Journal of Transport & Health*” is the main source for publishing research. (3) The choice of school travel mode is significantly affected by individual characteristics, family conditions, and social status. The built environment and parental factors play a leading role in students’ active travel to school, and independent mobility and active transport contribute to students’ healthy development. However, policy planning is necessary to further improve the transportation infrastructure sustainability and school route safety. (4) Finally, several promising directions and potential limitations are discussed for developing countries based on the research progress in developed economies.

Keywords: sustainable urban transport; school travel behavior; active travel to school; bibliometric



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1. Introduction

Since the second half of the 20th century, the phenomenon of urban sprawl produced by Americans has resulted in increasingly prominent urban sprawl in many European countries [1]. This has changed students’ travel distance and also triggered the transformation of school travel mode. Hence, there has been a great decline in active transportation over the past few decades [2,3]. According to a research report, for families within a mile of school in the United States, the proportion of students adopting a sustainable mode of school travel declined from 87 percent in 1969 to 55 percent in 2001. However, the proportion of vehicle trips increased from 7 percent to 36 percent during the same period [4]. Unfortunately, similar empirical findings for the decline rates of active travel to school have been revealed in other countries and regions of the world, such as the findings in Denmark, Norway, Finland, Great Britain [5], Brazil [6], and Hong Kong [7]. In particular, the COVID-19 pandemic continues to exacerbate this phenomenon. There are increasing concerns that early active travel patterns may have been weakened or reversed [8]. Because parents

are worried about the spread of the virus in public spaces, students may prefer to take private cars to get to school. If these assumptions can be proved, the consequences in terms of urban sustainability may be catastrophic. Furthermore, several studies reported that developing cities were already fighting a difficult battle with the auto industry even before the COVID-19 pandemic [9].

The reduction in children's active travel to school is related to childhood obesity [10,11], traffic congestion [12], and energy consumption and emissions [13,14]. The World Health Organization recommends that students should exercise for 60 min per day [15]. Previous studies pointed out that active travel to school can improve children's physical activity level, which is also the most accessible activity opportunity for students. However, the decline in active transport has weakened regular participation in physical activity [16,17]. Simultaneously, the increase in private cars brings about traffic congestion and air pollution in cities [18,19]. It turns out that exposure to traffic-related pollutants can lead to asthma and cancer in citizens, especially children and adolescents [20–22].

These reasons have led to increasing attention on school travel across the world. In recent years, studies published in international mainstream journals have emerged endlessly [23]. Most researchers explored the complicated factors that may influence school travel mode choice and school travel behavior within the constraints of social conditions. Existing studies were dedicated to fully capturing the relationship between active travel to school and health [24], school travel safety [25], school bus routes [26], and travel mode choice or escort decision in school trips [27]. Limited efforts attempted to include both the model choice and escort choice in one framework because they believed that these decisions are made simultaneously [28,29].

Compared with regular papers, reviews do not show the mechanism of exploration of school travel and the analysis of behavior methodology, but they can summarize the latest progress in certain fields. However, existing reviews are mainly summarized in specific scenarios, such as the built environment [30] and independent mobility [31], and do not provide a comprehensive quantitative analysis. Recent studies confirmed that researchers, especially early-career scholars, initially benefit from bibliometric analysis. Through a brief overview of the current research progress, they can understand the research status and future development trends [32]. This is also the motivation for using bibliometric analysis in this literature review.

In reviews, the application of bibliometric analysis is widely used [33,34]. In reality, bibliometric methods provide new perspectives on the knowledge status and trends in a certain field [35,36]. Therefore, bibliometric analysis has been increasingly popular among researchers and applied in numerous research fields, for instance, smart cities [37], transportation research [38], green infrastructure [39], maritime logistics and greening ports [40], and social innovation [41]. Bibliometric studies use quantitative methods to classify collected data and build up representative summaries [42].

Therefore, this paper attempts to show the performance of school travel as published in studies from 1996 to ~2021 with bibliometric techniques. The study aims to investigate the following four research areas: (1) the existing research on which countries or regions have published the most articles on school travel; (2) research results, for which international mainstream journals are the main sources; (3) prominent documents about school travel and the current research hotspots; and (4) potential research themes and the most active research directions for the future.

The remainder of the paper is organized as follows. Section 2 deals with the methodology, including a brief introduction of data resources, processing, and tools. Section 3 demonstrates the analysis results, consisting of an overview of publication characteristics and research themes. Section 4 discusses potential research fields in the future and the limitations of this study. Lastly, Section 5 concludes this research.

2. Methods

According to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA), “systematic literature evaluation” adopts systematic and unambiguous methods to identify, select, and critically evaluate research literature. Meanwhile, collected and analyzed research data are incorporated into the review [43,44].

This study reviewed the existing literature using the PRISMA criteria. No meta-analysis methods were considered. Following PRISMA principles, we used a systematic protocol to generate a collection of studies at different steps of the literature review. The protocol we employed consisted of three phases: (a) search strategy; (b) inclusion criteria; (c) information source. The generation of such searches and the selection of criteria may be affected by human bias. To avoid this bias, we assembled a team of different researchers. The team consisted of two researchers and a three-member advisory board. The two researchers (second and third authors) were tasked with executing all activities of the three phases, while the advisory board was responsible for overseeing and reviewing the tasks to ensure quality. The members of the advisory board were experts in sustainable transportation and transport geography. According to the PRISMA checklist, Table 1 lists the information processing for studies relating to school travel.

Table 1. The information processing for studies relating to school travel.

Checklist Item	Treatment Processing
Information sources	Web of Science, ScienceDirect, TRID (Transport Research International Documentation), and MEDLINE
Search strategy	Subject search = (“students” OR “children” OR “adolescent” OR “youth” OR “kids”) AND (“school travel” OR “school behavior” OR “school trip” OR “school mode” OR “school journey” OR “mode choice” OR “independent mobility” OR “active school”))
Eligibility criteria	(a) Publication in peer-reviewed English journals and conferences; (b) Abstract and full text of articles are available; (c) Related to the field of transportation; (d) Related to the school travel mode or school travel behavior; (e) The subjects are elementary, middle, and high school students; (f) Duplicate papers in the different databases are counted once.
Selection process	For example: (a) we exclude the route choice and destination choice, which are not consistent with the choice of school travel mode and school travel behaviors studies; (b) systematic reviews were also excluded.
Data collection process	The screening process of data is carried out independently by two researchers (the second and third authors).
Study risk of bias assessment	Assembled a team that consisted of two researchers and a three-member advisory board.
Synthesis methods	The detailed processing before the result is determined is shown in Figure 1.

2.1. Search Strategy

Four databases were searched: Web of Science, ScienceDirect, TRID (Transport Research International Documentation), and MEDLINE. The first two of these databases are integrated, and the rest of the databases contain multiple disciplines, including transport and public health.

This study collected research on school travel published in journals or conference papers between 1 January 1996 and 31 December 2021, and the main search terms were related to two main categories: research subjects and school travel behavior. The terms in each category were related to the Boolean operator “OR”, i.e., whenever a term appeared in each category, it was included in the search results. Between categories, we used the

Boolean operator “AND”, which indicates that both search terms must satisfy the condition. The general categories of search terms in this study were as follows:

- (1) “students” OR “children” OR “adolescent” OR “youth” OR “kids”;
- (2) “school travel” OR “school behavior” OR “school trip” OR “school mode” OR “school journey” OR “mode choice” OR “independent mobility” OR “active to school”.

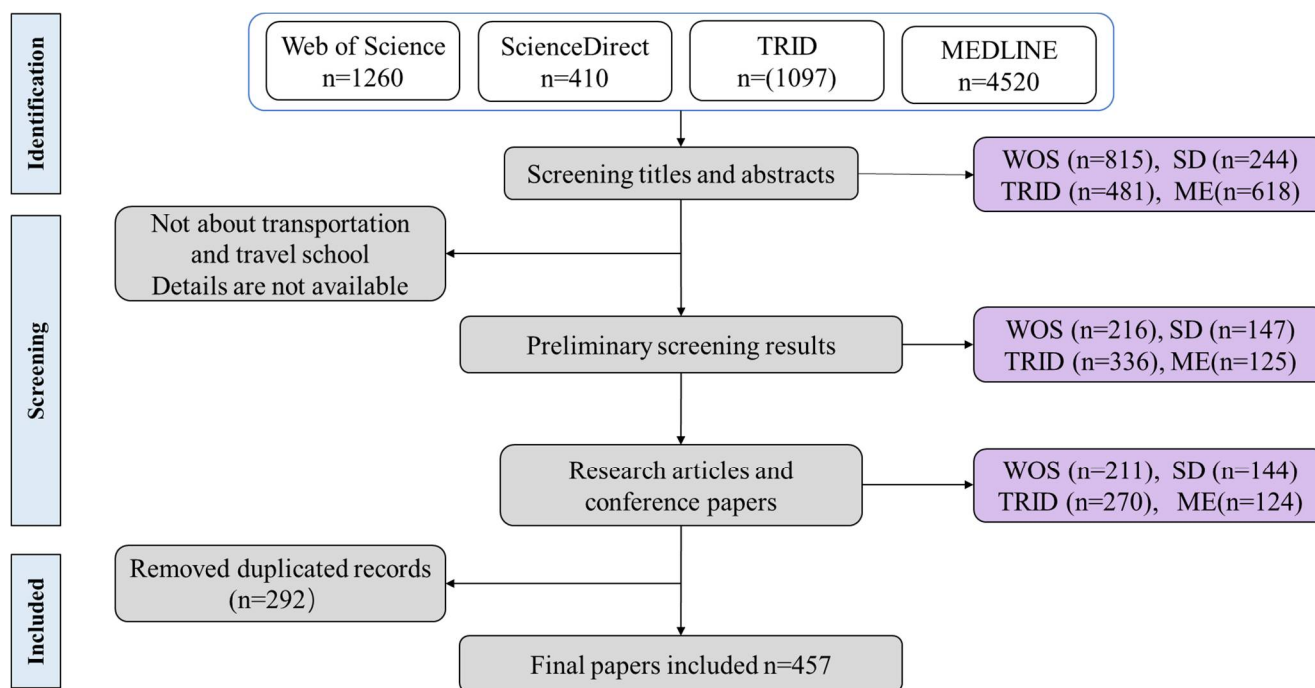


Figure 1. PRISMA flowchart of school travel study selection.

2.2. Inclusion Criteria

The title, keywords, and abstract were included since they are the default search methods from the database [45], and the above were selected for further studies. In addition, to ensure that the articles included in the review were closely aligned with the research topic of the text, the studies had to meet the following criteria:

- (1) Publication in peer-reviewed English journals and conferences;
- (2) Abstract and full text of articles are available;
- (3) Related to do with the field of transportation;
- (4) Related to the school travel mode or school travel behavior;
- (5) The subjects are elementary, middle, and high school students;
- (6) Duplicate papers in the different databases are counted once.

2.3. Study Collection

The search was conducted in April 2022, and the retrieval process was as shown in Figure 1. The numbers of papers collected from each database were 1260 (Web of Science), 1097 (TRID), 410 (ScienceDirect), and 4520 (MEDLINE). To make the acquired articles more compatible with the research purpose of this paper, we further screened the research direction during the search process. For example, research articles on “nutrition dietetics” and “computer science” were found in the Web of Science database, which were not consistent with the research direction of this paper. Therefore, this kind of research direction was excluded from the article search. It is particularly important to note that, if the choices of school travel mode and school travel behavior studies in this paper were not related to transportation or the choice of transport mode, they were not included in the reviewed literature. For instance, some papers related to research route choice

and destination choice [46,47]. In addition, to provide an international perspective, this paper only analyzed research papers and conference papers published in English. Of course, articles for which detailed information was not available were not considered for further analysis. According to the screening criteria, we conducted paper screening on four databases. After removing duplicate records, 457 papers that met all criteria were finally retained for further analysis.

The screening process of the above research data was carried out independently by two researchers (the second and third authors). Where there were differences in the screening data, the advisory board was invited to intervene and resolve the differences through friendly consultation to ensure the reasonableness of the screened data.

This paper provides some instructions related to data processing. First, some keywords have the same meaning but are expressed in different ways, such as “school travel”, “school trip” and “school journey”. To solve this problem, keywords with the same meaning were regarded as one keyword. Second, when multiple authors are from different countries, the national attribution of the paper depends on the primary author. Third, as complete, full records and citation records can be downloaded from Web of Science, the 211 articles in the WOS were used in the analysis of area performance, journal characteristics, and theme analysis in Sections 3.2 and 3.3.

2.4. Research Method

Bibliometric analysis is defined as the statistical and applied mathematical analysis of articles and books [35]. In recent years, it has become a trend to use applied bibliometrics analysis to predict and evaluate the status of different research fields [48,49]. Two methods are commonly used for bibliometrics which are descriptive statistics analysis and network analysis [50,51].

Descriptive statistical analysis can help those interested in a particular field to quickly understand the main contents and the current state of development. It can not only reveal the evolutionary pattern of a specific research topic, but also point out influential papers and journals [52]. Network analysis is the core method of bibliometric analysis. With the help of this, the complex relationships of citations between journals and coupling between articles can be networked and visualized [53,54]. The application of Mapping Knowledge Domain (MKD) contributes to the comprehensiveness and readability of network analysis. By describing nodes and the connected network framework to clarify the relationship between articles, the information acquisition process can be simplified, and the knowledge structure can be clarified [55].

Bibliometric analysis usually uses Bibexcel, VOSviewer, and Gephi. Bibexcel is a free piece of software designed by Olle Persson for academic research to assist users in handling bibliographic data from the Web of Science. VOSviewer and Gephi are mainly used for visualizing and analyzing hierarchical graphs in various networks and complex systems [56]. In this paper, VOSviewer was used for literature network analysis.

This VOSviewer (Visualization of Similarities viewer software) was developed in 2009 by Van Eck of Leiden University in the Netherlands to explore the relationship between academic journals, other literature, countries, authors, and the knowledge structure of the research field [57]. This software visually analyzes similar research and uses the co-occurrence matrix for the layout to generate a knowledge map. Moreover, it measures two high-frequency, co-occurring studies from a probabilistic perspective [58]. The core principle of VOSviewer consists of constructing a similarity matrix and layout method.

(1) Constructing similarity matrix

By normalizing the co-occurrence matrix, the similarity matrix can be obtained by adjusting the co-occurrence time differences of authors, affiliated institutions, countries, keywords, and research topics. VOSviewer uses association strength to measure the similarity of research in co-occurrence data.

Namely:

$$S_{ij} = \frac{C_{ij}}{w_i w_j} \quad (1)$$

In the formula:

S_{ij} represents the similarity between study i and study j ;

w_i and w_j refer to the total number of study i and study j ;

C_{ij} is the total amount of co-occurrence of study i and study j .

(2) VOSviewer layout method

VOSviewer employs cluster analysis to reveal the relationships between studies and constructs the cluster label map based on the label clustering algorithm. It reflects the similarity between studies by spatial distance to determine the position and form a complete label map. The closer the distance between studies, the higher the similarity. The core idea of the VOSviewer layout method is to minimize the weighted sum of Euclidean square distance between all studies.

$$V(x_1, \dots, x_n) = \sum_{i < j} S_{ij} \|X_i - X_j\|^2 \quad (2)$$

In the formula:

Vector $(x_1, \dots, x_n)$ represents the position of study i in two-dimensional space;

n is the number of studies that need to be laid out;

$\|X_i - X_j\|$ is the Euclidean norm.

3. Results

To deeply explore the inner mechanism of school travel, this section analyzes the overall trends and characteristics of literature publication, the performance of countries (regions) and journals, and the keyword co-occurrence and the literature co-citation relationships. In addition, we focus on the highly cited literature on school travel and summarize the research methods, data, and areas. By sorting out the research progress, potential future research directions are explored. Table 2 demonstrates the main findings of the results section.

3.1. Overview of the Article Development Trends

Generally speaking, the number of papers published in a field directly reflects the development trend and scope of knowledge [59]. Within the scope of retrieval, papers about school travel research first appeared in 1996. Figure 2 depicts the trend in the annual number of studies published on school travel from 1996 to 2021. During the first twelve years of statistics, the number of studies grew slowly. Starting from 2008, the number of school travel studies grew rapidly and peaked in the number of publications after ten years (within the period of the literature statistics). The number of articles in the reviewed literature far exceeded that of conference papers, reaching 90%. In addition, we also focused on the frequency of citations relating to school travel. The total citation frequency of the 211 papers from the WOS database was 5440, with an average citation frequency of 25.78. Overall, the citation frequency increased with global researchers' attention to school travel and reached a peak of 939 in 2020. The annual citation frequency of school travel research was 320, indicating that this field maintains a high level of activity year round.

As shown in Figure 2, from 2008 to 2021, the research results on school travel were fruitful, and the number of articles published appeared to have an increasing trend year by year. Through further analysis, it was found that the literature from before 2014 mainly focused on the influence of urban form [4], independent mobility [60], safety and environment along the school route [61], and family characteristics on the choice of school travel mode [62] and also paid attention to adult escorts during school travel [63]. Within the constraints of time conditions and safety concerns, seventy percent of parents escorted

their children to school and met their own commuting needs [64]. With the extension of accompanying school behavior, school travel was correlated with the daily activities of family members.

In recent years, since 2014, the international mainstream research on school travel has shifted to “active travel to school”, and researchers have paid more attention to students’ physical activity and health. European and American countries implemented “Safe Routes to School” (SRTS), advocating the use of active transport such as walking and cycling to school [10,65]. Although walking and cycling to school are beneficial for health, traffic safety is one of the biggest barriers contributing to walking to school [66]. Given the current situation, scholars have conducted a large number of studies on the safety of children’s school trips [67,68].

After 2017, with the further enrichment of transportation modes, school behavior was relatively more diverse, including, for example, shared transportation [69], customized travel, and electric bicycle transport to school [70]. As a result of deep research on school travel behavior, school travel equity and school travel behavior of people with disabilities have also emerged in journals [71,72].

Table 2. The main findings relating to school travel.

Checklist Item	Descriptive Characteristics and Findings
Study selection	(a) Overview of the articles development trends; (b) Area performance; (c) Journal characteristics; (d) The analysis of keywords; (e) The analysis of co-citation literature; (f) Highly cited articles.
Results of syntheses	(a) Overview of the articles development trends A total of 457 papers were collected from four databases in this study, with 407 articles and 50 conference papers; the 211 articles from WOS have a citation frequency of 5441, with an average citation frequency of 25.79 and an h-index of 37.
	(b) Area performance This study collected research from 38 countries and regions; the United States ranked first in the statistical data, while Canada and Australia ranked second and third, respectively; the top 3 productive countries also have high citation frequency and connection strength.
	(c) Journal characteristics This study collected literature published in 34 journals; the “Journal of Transport & Health” was the primary source; among the top 10 journals, the number of publications accounted for 81.9% of the selected journals.
	(d) The analysis of keywords There are 211 papers, with a total of 885 keywords, in this study. The keywords were divided into three clusters: Cluster 1: Walking to school; Cluster 2: The relationship between active travel to school and students’ health; Cluster 3: The impact of built environment on school travel behaviors.
	(e) The analysis of co-citation literature 62 papers were divided into three clusters in the co-citation network.: Cluster 1: the choice of school travel mode; Cluster 2: active travel to school; Cluster 3: school travel behavior and students’ health and route safety.
	(f) Highly cited articles All of the highly cited articles came from the top eight countries. Highly cited articles focused on school travel mode choice, active travel to school, and the influence of family interactions on school behavior.

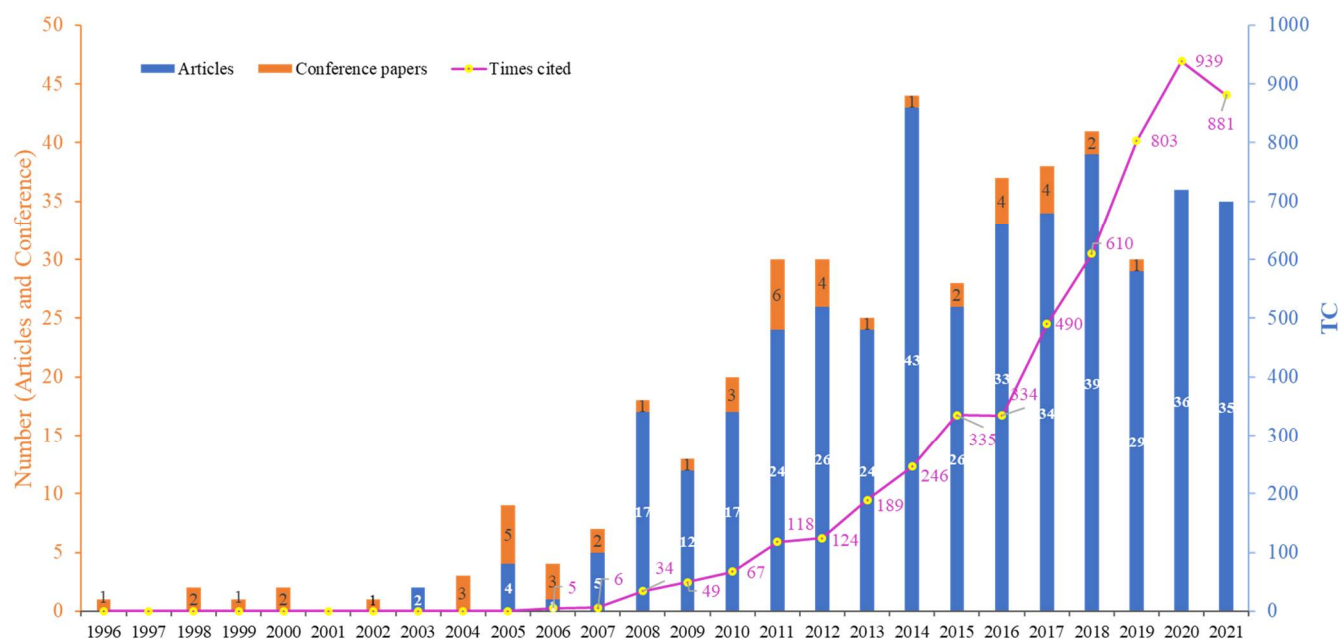


Figure 2. The performance of filtered publications on school travel. Note: the citation data contain only the literature in the WOS database.

3.2. The Performance and Areas and Journals

3.2.1. Analysis of Area Performance

We collected studies from 38 countries and regions about school travel. Figure 3 shows the countries and regions with three or more relevant results. The figure is distributed according to the time dimension. The countries and regions studied in the early period are darker in color. The node size in the network represents the number of publications from a country or region.

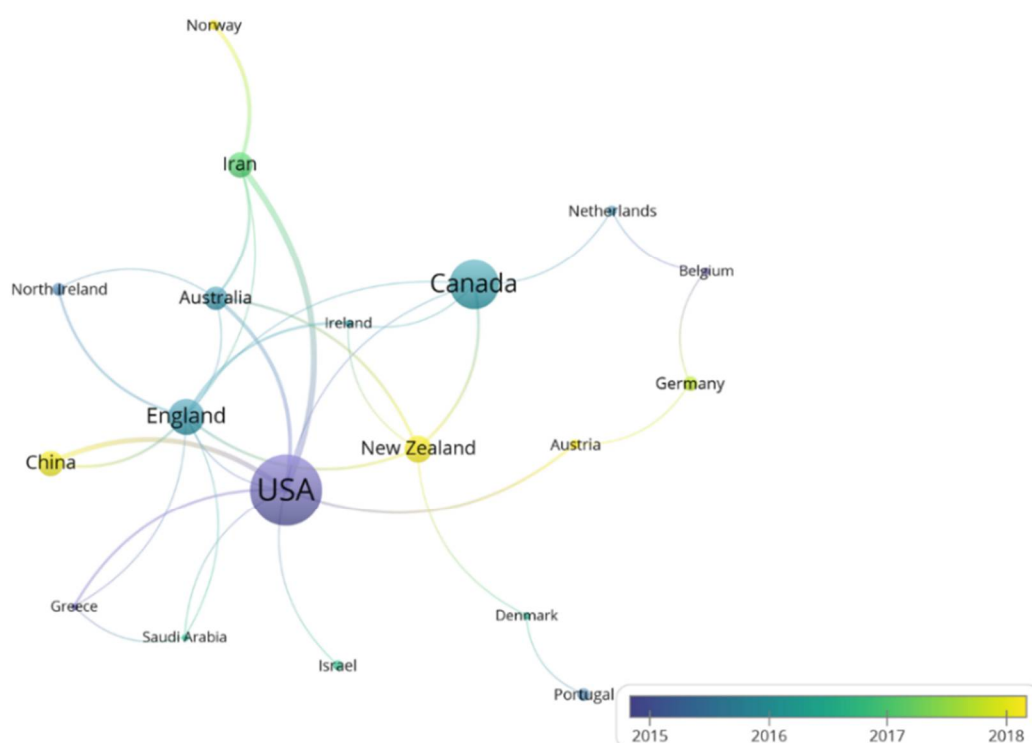


Figure 3. Countries and regions of institutions producing literature.

This research counted the top eight countries and regions in terms of the number of documents on school travel. As can be seen from Table 3, the total number of studies published in the United States was 59, accounting for 28.0% of all research results. Meanwhile, the number of articles published in the United States was 1.4 times that of Canada, 2.8 times that of the United Kingdom, and 4.2 times that of mainland China. Papers published in the United States were cited 35 times, while the citations were 1.6 times those in mainland China. From the selected studies, it was concluded that the research on school travel behavior in developed countries, such as Europe, America, and Australia, began earlier, and the literature is richly accumulated. In recent years, the countries China and New Zealand have paid more attention to school travel, and they have also contributed to more studies.

Table 3. The top 8 most productive countries for studies on school travel.

Rank	Country	Number	% (R) ^a	TC ^b	ATCP ^c	TLS ^d
1	USA	59	28.0%	2063	35.0	24
2	Canada	41	19.4%	1003	24.5	8
3	Australia	24	11.4%	479	20.0	17
4	England	21	10.0%	705	33.6	23
5	China	14	6.6%	308	22.0	8
6	New Zealand	13	6.1%	133	10.2	14
7	Iran	13	6.1%	193	14.8	12
8	Germany	12	5.7%	302	25.2	5

^a % (R): Accounting for the percentage of the total articles. ^b TC: Times cited. ^c ATCP: Average times cited of papers. ^d TLS: Total link strength.

3.2.2. Analysis of Journal Characteristics

The research we reviewed on school travel was published in 34 journals. It was found that the results on school travel were mainly in the fields of transportation, health, and sustainable urban development. In recent years, the *Journal of Transport & Health* has been the primary source of publication. In addition, some high-level journals on transportation, such as the *Journal of Transport Geography*, *Transportation Research Record*, and *Transport Policy*, have published a certain number of studies.

Table 4 shows the top 10 journals in terms of the number of publications on school travel. The number of articles in the “*Journal of Transport & Health*” accounted for 21.8% of the total studies, but the average number of times cited was 11.8, which is relatively low compared with journals in the same category. As a top journal in the field of transportation geography, the “*Journal of Transport Geography*” ranked high in both the number of articles and times cited. It is noteworthy that “*Transportation Research Part A: Policy and Practice*” ranked first in the times cited among the selected journals. A total of 211 papers was published in the top 10 journals, accounting for 81.9% of the selected journals. This shows that the study of school travel has received the attention of international, mainstream journals. Of course, this is inseparable from the current real problems and the upsurge in child-friendly city construction [73–75].

3.3. Research Theme

3.3.1. The Analysis of Keywords

Keyword co-occurrence analysis can identify keyword aggregation in academic fields and clarify the development direction of a research field. It can help to summarize research hotspots in related fields [35]. There were 211 papers with a total of 885 keywords in this study. By setting the keyword connection strength threshold to 6, we filtered out the keywords with weak co-occurrence relationships and finally obtained 61 keywords divided into three clusters, as shown in Figure 4. Table 5 shows the top 20 keywords with strong connection strength.

Table 4. The top 10 most productive journals for studies on school travel.

Rank	Journals	IF (2021)	Number	% (R) ^a	TC ^b	ATCP ^c
1	Journal of Transport & Health	3.613	46	21.8%	544	11.8
2	Journal of Transport Geography	5.899	30	14.2%	1205	40.2
3	Transportation Research Record	2.019	23	10.9%	321	14.0
4	Transport Policy	6.173	16	7.6%	587	36.7
5	Transportation Research Part A: Policy and Practice	6.615	14	6.6%	794	56.7
6	Travel Behavior and Society	5.85	14	6.6%	176	12.6
7	Transportation	4.814	11	5.2%	551	50.1
8	Transportation Research Part F: Traffic Psychology and Behavior	4.349	8	3.8%	228	28.5
9	International Journal of Sustainable Transportation	3.963	7	3.3%	106	15.1
10	Transportation Research Part D: Transport and Environment	7.041	4	1.9%	94	23.5

^a % (R): Accounting for the percentage of the total articles. ^b TC: Times cited. ^c ATCP: Average times cited of papers.

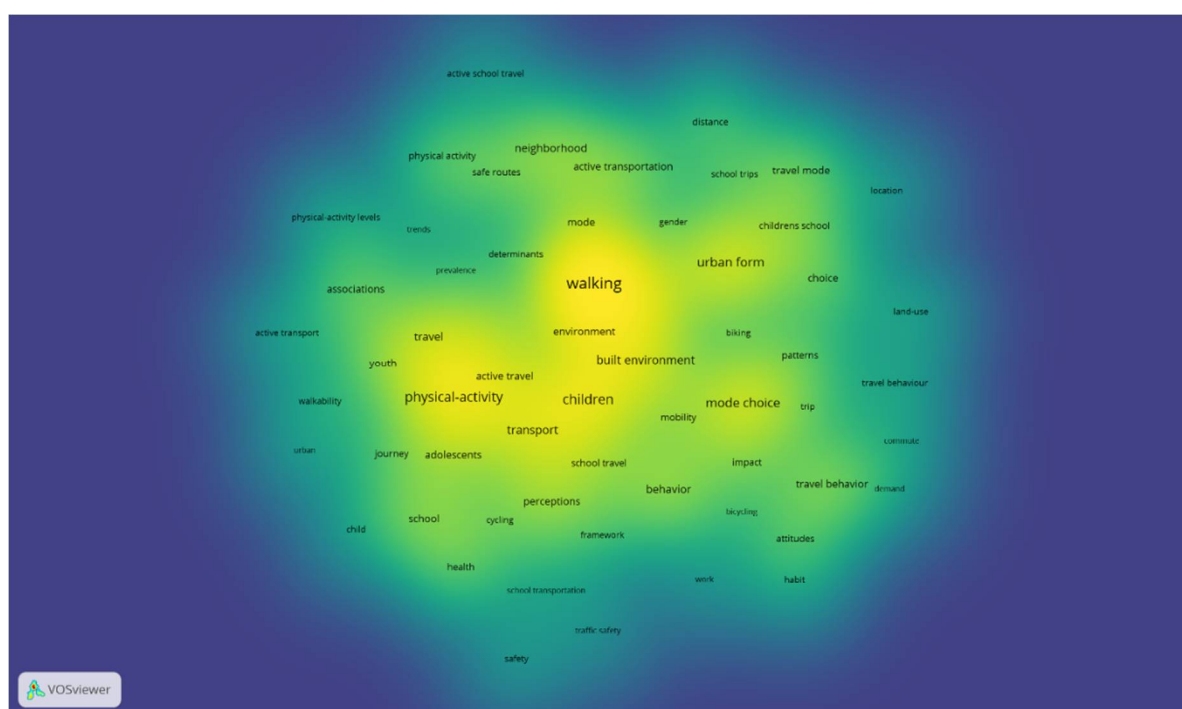


Figure 4. Co-occurrence density graph of keywords relating to school travel.

Cluster 1: Walking to school under the influence of city design and family factors.

This cluster contained 23 keywords: walking, urban form, environment, perceptions, choice, patterns, school trips, travel mode, determinants, gender, etc. The visualization results showed that walking, urban form, environment, and family factors were co-occurring, high-frequency words.

Table 5. The connection strength and co-occurrence times of hot words relating to school travel.

Rank	Hot Words	Connection Strength	Co-Occurrence Times
1	walking	681	97
2	physical activity	424	60
3	urban form	414	54
4	children	386	57
5	built environment	305	42
6	mode choice	274	50
7	transport	265	42
8	neighborhood	258	31
9	active transport	222	28
10	environment	220	28
11	travel behavior	214	34
12	perceptions	206	28
13	independent mobility	182	25
14	travel mode	178	23
15	association	172	23
16	children school	171	20
17	health	128	19
18	safe routes	128	17
19	mobility	93	16
20	land use	74	10

Previous studies pointed out that walking to school can promote students' daily physical activity, but urban infrastructure needs to enhance the safety and convenience of the walking environment. Obviously, urban form and convenient infrastructure influence the probability of students taking active transportation to school [11]. However, family factors also have a potential influence on the walking behavior of different groups [76]. A study from North America that considered race and walkability showed that Asian race was negatively associated with walking to school, while being Hispanic generally had a positive correlation. The relationship between race, culture, and transportation geography in the United States is unique, and these findings may not be useful outside the United States [77]. In addition, an interesting survey that indicated parental factors showed a low correlation between the most highly educated parents and children walking to school. At the same time, the interaction effect between urban design and society also influences families' decision-making in school travel mode. For example, families that are geographically close together in a community may influence or observe each other and be influenced by each other's behavior [78]. In general, individual and family characteristics have a stronger correlation than the social environment; however, these relationships are complex because the social environment may help to shape an individual's social characteristics and social relationships.

Cluster 2: The relationship between active travel to school and students' health.

The second cluster contained 22 keywords, mainly, children, physical activity, active travel, youth, distance, health, and perceptions.

In recent years, the rapid development of urbanization and industrialization has led to environmental pollution. To protect students' health, some schools have restricted students' sporting activities. Simultaneously, due to the pace of life and the burden of study pressure, students perform less physical activity after class [79]. In the context of declining physical activity levels among children and adolescents [80], a growing number of studies focused on the relationship between active travel to school and physical activity and explored the policy measures for active transport. Relevant studies showed that active travel to school can promote students' mental health, and there is a strong positive correlation with children's happiness [81]. Merom's work confirmed this conclusion; his team investigated school attendance frequency, timing, and related factors in New South Wales. It turns out that the travel time between transit and the private car is shorter, just 4 min (survey group median). Sustainable transport, such as walking and cycling, takes 7 min to reach

the destination. The shift from passive (i.e., motorized) to active travel to school also contributes to environmental sustainability and economic benefits. A longitudinal study in Canada found that the proportion of active travel to school increases from about age 6, peaks at age 10, and declines thereafter [82]. The results were influenced by different age groups (teenagers or young children). By examining changes in school travel patterns over time, researchers found that early interventions can help students to establish positive habits. Furthermore, policies and measures related to active travel programs can support the development of sustainable transportation modes [83].

Cluster 3: Influence of built environment on school behavior and safety.

The last cluster contained 16 keywords, mainly, behavior, built environment, neighborhood effect, school travel, independent mobility, and land use.

Recently, studies have found that built environment and distance between schools have a significant impact on school behavior and safety [84]. For example, related research focused on the individual-level predictors of school behavior and the impact of physical community characteristics [85]. However, some scholars discovered that the distance between school trips is significantly correlated with the frequency of walking to school [86]. At the same time, school safety and school distance significantly affect students' experience of active travel to school in urban and suburban areas [87]. Overall, education policies, urban designs, and levels of urbanization vary greatly across countries. The behavior mechanism of transport mode choice needs to be studied in certain countries [88].

It is undeniable that studies on the measurement of school behavior are inconsistent across ethnic groups, time frames, and places. Currently, there is not a good consensus on how to better measure school travel behavior. Furthermore, under the framework of the built environment, fundamental methodological issues, such as the Modifiable Areal Unit Problem (MAUP) and Uncertain Geographic Context Problem (UGCoP), appear when investigating the environmental influences on active travel to school. MAUP and UGCoP refer to the effects of spatial scale and partition on spatial and temporal uncertainty [89]. Differences between studies in different spatial units may influence comparisons between findings, as the role of variables within articles may change depending on the geographical area defined in the study. Therefore, there may be other factors related to school travel behavior that have not been established due to difference in measurement scales.

3.3.2. The Analysis of Co-Citation Literature

In 1973, American scientist Small first proposed the concept of co-citation, which means that two studies are jointly cited by the same third study [90]. Moreover, co-citation is also used to analyze the relationship among research authors [91]. The co-citation relationship is augmented with the increase in citation times. Some studies can be gathered within groups, which are defined as clusters for classification. Complicated network theory can help to reveal hidden features and new aspects of the topological framework [92].

We used the VOSviewer to display the co-citation network of the school travel research literature [93]. There were 6170 cited references in 211 studies. We filtered out studies of weak association strength by repeatedly adjusting the connection strength threshold. Ultimately, using 14 as the minimum threshold, we identified 62 papers. Figure 5 illustrates the co-citation clusters. The size of the network nodes in the graph represents the total frequency with which the document was cited. The larger the node, the higher the cited frequency of the document. The color of the network node represents a cluster with the corresponding documents, and different colors represent different clusters. Documents of the same color have greater similarity in research theme. By screening the literature, we finally obtained three clusters.

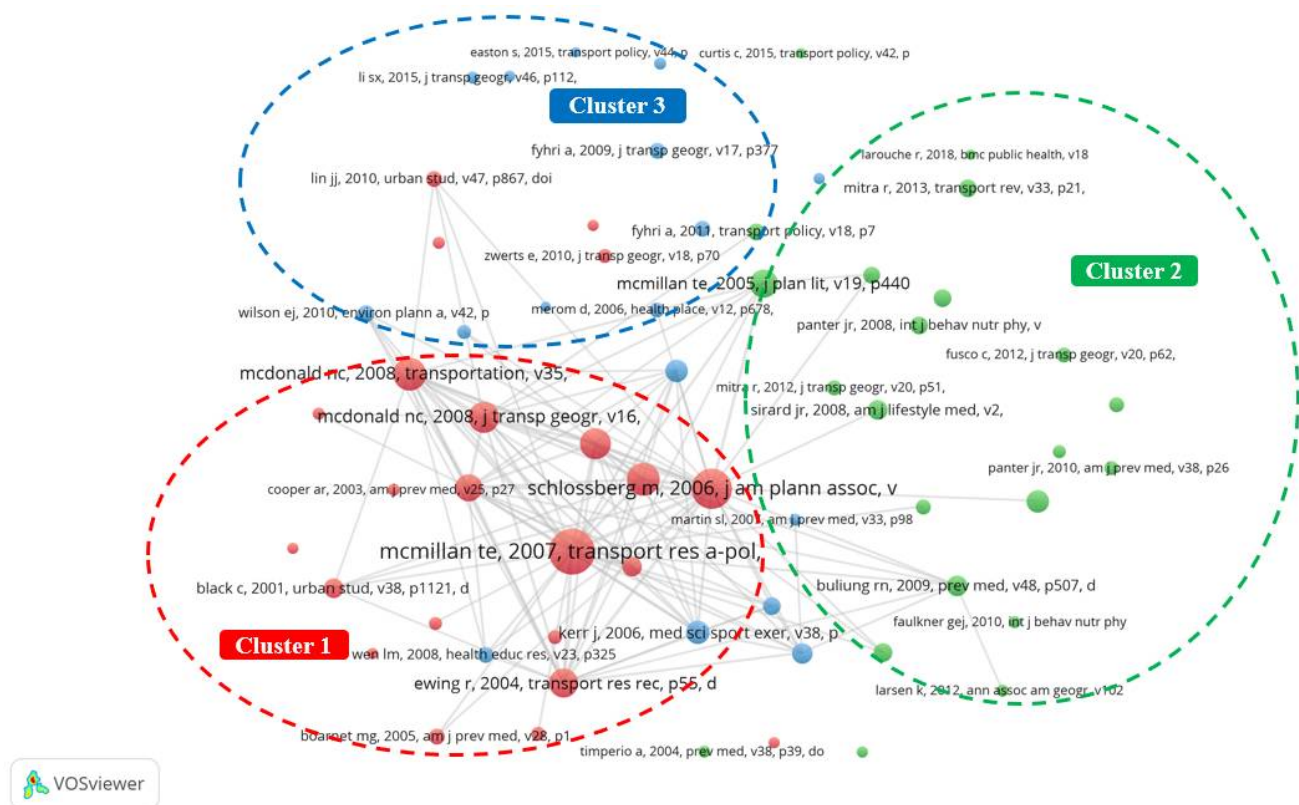


Figure 5. Co-citation analysis of literature on school travel.

Cluster 1: Study the factors of school travel mode choice.

Cluster 1 was the largest in the co-citation analysis network. The most cited was Mcmillan, published in “Transportation Research Part A: Policy and Practice”, discussing the effects of factors of urban morphology on school travel mode [4]. This document measured the effect of urban form on students’ travel mode. It was evident that urban form is an important element affecting school travel mode, but not the sole factor. Community safety and road traffic safety also play an important role. For the students’ mode choice in school trips, McDonald published a series of high-level articles [27,77,94]. These studies discussed the impact on children’s travel mode in terms of home and school distances and parental commuting mode choice. Furthermore, he systematically reviewed the evolution of adolescents’ choice of school travel in the United States from 1969 to 2001 [77]. The results showed that the proportion of students that walks and rides a bicycle to school decreases due to the increasing distance to schools.

In general, the choice of school travel mode is not determined by a single factor. It includes a comprehensive consideration of individual characteristics, family conditions, and social status [71,95]. It is acknowledged that household features play an important role, including family economic status indicators (e.g., vehicle ownership, income, etc.), household structure, and the interaction between family members. Some recent systematic reviews further considered the relationship between household and school travel mode. It was found that students from unemployed families are more likely to walk [96], and children with siblings are more likely to cycle or walk [94]. Moreover, the work conducted by [97] put forward that those students are more likely to be sent to school when their mothers are staying at home, while the absence of adult caregivers increases the probability of taking transit.

Most research on the choice of school travel mode emphasized the view of parents. Children are often perceived as immature and, therefore, not taken seriously when their needs are discussed. However, qualitative research from [98] suggested that children

provide different insights and perspectives on school travel. As proposed by [99], the ECAC (Ecological and Cognitive Active Commuting) framework argues that parents are the primary decision-makers in how students go to school, but children's ideas may be fed back through family conversations. For example, children can express to their parents what they like or dislike about walking to school or discuss their favorite or dangerous environment. This feedback might be taken into account when parents decide how their children will get to school in the future.

Cluster 2: The influence of built environment on active travel to school.

The literature in cluster 2 focused on the impact of the built environment on active travel to school. Faulkner took the lead in defining active travel to school [100]: completing the travel behavior from home to school and back home from school by walking, cycling, or other nonmotorized travel. Since the concept of active travel to school was put forward, it has received extensive attention from international scholars. In the meantime, a large number of studies proved that active travel to school has many benefits, such as providing physical exercise, formation of positive living habits, and promotion of sustainable urban development [101].

There is a large body of research demonstrating that home–school distance is the major obstacle to active travel to school [12,27,85], whereas short distances between home and school encourage students to walk and bike. Therefore, children living in cities tend to undertake more active transport than rural children [16]. However, what is a short distance? Different research reports had various thresholds. For instance, Kelly's studies on Irish students [96] observed that 2 km was the guiding “dividing line” between active and motorized modes of travel. In another study, from Canada [102], a home distance of 1.5 km from school was identified as the threshold for students to switch from driving to walking or cycling. These differences in studies may be due to transportation infrastructure, urbanization, social norms, and environmental factors. Research from [10] confirmed the hypothesis that variables associated with urban forms, such as increased residential density, main road density, and land mix entropy, reduce the possibility of Finnish students active traveling to school. As for transportation infrastructure, Kamargianni [103] pointed out that the characteristics of the transportation network, such as the availability of bicycle lanes, non-motor-vehicle parking spaces, and sidewalk width, significantly affect the choice of active transport modes.

According to previous studies, there is a positive relationship between active travel to school and street connectivity when using a 1 km buffer zone [104]. Students living in neighborhoods with high intersection density were three times more likely to use active travel to school than those in low-density neighborhoods. However, this finding was contrary to other studies in the US [105], Canada [106], and Australia [95]. These results showed that intersection density is negatively associated with active travel to school. Streets that are highly connected may be more easily used by motor vehicles. Hence, adolescents living in those areas may be more exposed to high traffic flow and less likely to use active travel. When exploring the effect of residential density on active travel to school, all studies showed that an increase in residential density leads to a decrease in the trend of active travel [105,107,108], except a study from KITC. The differences observed in the KITC study were due to the relatively small sample size (compared to other studies) and the program's focus on medium- or high-density communities [109]. To investigate this further, researchers considered the interrelationships between built environment variables associated with active travel to school. An interesting discovery was obtained that residential density interacts with distance to school. In particular, low residential density and a short distance to school were positively correlated with active travel to school. A shorter distance to school has a greater impact than residential density, so these findings must be interpreted with caution.

Cluster 3: Study of school travel behavior and students' health and route safety.

Cluster 3 was the smallest in the co-citation analysis network, but it was the cluster most closely adjacent to Cluster 1 and Cluster 2. This section mainly explored the relationship between school behavior and students' health and route safety.

As for the exploration of Cluster 3, there was some correlation in previous studies (choice of school travel mode, influence of built environment on active travel to school). There is no doubt that parents' perception of community safety has a significant impact on children walking or biking to school. For example, the automobile-based culture in North America allows for the continuous development of built environments with an automobile-based culture, and, in this context, more and more parents are concerned about road safety, which influences the decision of mode choice [110]. The study conducted by Ermagun [29] provided evidence that parents worry about the safety of the route, and they insist on escorting children to school. However, such parents often prefer private cars and school buses to serve school trips. Likewise, [111] revealed that parents who are concerned about transport reliability prefer school buses.

Combined with social and environmental factors, the barriers to using active travel to school include unsafe road crossing, dangerous driving, stranger danger, and fear of crime [4,108,112]. In addition, New Zealand adolescents perceive cycling to school as less safe than walking [113]. Stranger danger and crime in New Zealand have not decreased over time. Thankfully, the situation appears to be improving, with Transport New Zealand recently working to propose safer community opportunities in the Auckland Regional Road Transport Plan 2018–2028. For example, creating and improving streets and sidewalks for active travel to school and supporting safer driving behaviors [114]. This also aligns with the World Health Organization's guiding principles for creating a positive society [115]. The integrated approach to people and systems at all levels, from upstream (i.e., social and environmental factors) to downstream (i.e., individual factors), is the key to creating a safe environment and promoting active travel to school.

3.4. Top 10 Cited Articles

Although the thematic analysis of a paper can explore the structure of knowledge in the field, it is equally important to focus on the content of the paper. In the research world, a highly cited article means that it has been critically read. The key elements of one paper mainly include research methodology, research objectives, research areas, and data sampling. Therefore, in this subsection, the top 10 cited articles are analyzed.

The information on the top 10 cited papers is listed in Table 6. Interestingly, almost all of the highly cited articles came from the top eight countries. Among them, eight were from the US and UK, which is reflected in the high h-index of these countries. Four of the selected articles focused on school travel mode choice, and four articles focused on active travel to school. There are also two articles exploring the influence of family interactions on school travel behavior. It is worth noting that the survey data of Denmark, Finland, Great Britain, and Norway relate to children's mobility to school [5]. The results showed the same trend in all four countries: that car use has increased while bicycling and walking have decreased. The distance to school has increased as a result of the expansion of school units and the number of children in private schools. Transportation is an important factor in driving children to school, but parental convenience is also a part of the equation.

From a horizontal perspective, most highly cited articles adopted descriptive statistical models to analyze the relationship between independent and dependent variables, such as multinomial logit, nested logit, and cross-nested logit models. Statistical models have the advantage of being able to identify factors and measure effects so that the vital variables can be used as an input for prediction [116]. In the course of the research, the independent variables widely used in most papers were usually individual and family characteristics, built environment, and travel time. The table shows that surveys are a common method of data acquisition, including household surveys, interview surveys, etc. In addition, American Household Travel Survey data were also the main source for articles. The research subject was mainly primary and secondary school students in the United States.

Table 6. Review of highly cited literature relating to school travel.

Literature	Research Method	Independent	Dependent	Research Area and Subject	Data Type and Sample	Time Cited
Timperio [95]	Pearson chi-square analysis, logistic regression model	personal factors, parental perception, socioeconomic status, neighborhood environment	active commuting to school	Melbourne, Australia (elementary schools)	questionnaires (912)	539
Mcmillan [4]	binomial logit model	urban form, social\cultural norms, traffic\neighborhood safety, household options, socio-demographics	travel mode to school	Southern California (elementary school)	questionnaire	365
Kerr [108]	logistic regression	parent concerns, perceived\objective environment, walkability	active commuting to school	Seattle (5–11, 11–18 years)	questionnaires (259)	361
Schlossberg [104]	chi-square analysis, multinomial logit regression	urban form, distance, route directness	“primary” modes of travel (active transportation to school)	Oregon (four middle schools)	survey (292)	267
Ewing [117]	multinomial logit model, nested logit model	travel time, built environment, school size, land use	school mode choice	Alachua Country, Florida	regional travel diary surveys ^a (709)	250
Mcdonald [27]	multinomial logit model	trip distance, walk travel time, auto travel time, family conditions	mode choice for elementary and middle school children	United States	National Household Travel Survey (4394)	212
Fyhri [5]	/	distance to school, accompanying children, leisure travel, traffic safety	children’s mobility and activity	Denmark, Finland Great Britain, and Norway	National Travel Survey ^b	208
Mcdonald [94]	chi-square test, binary logit model	personal factors, family environment	the mode choice of school travel for family factors	US (elementary middle and high school)	National Household Travel Survey (8231)	150

Table 6. Cont.

Literature	Research Method	Independent	Dependent	Research Area and Subject	Data Type and Sample	Time Cited
Mitra [106]	binomial logistic regression	travel distance, block density, signalized intersections, walking density, low-income neighborhoods	active travel to school	Toronto, Canada Children (11–12 years)	travel data from TTS ^c (2190)	141
Yarlagadda [28]	econometric model	characteristics\ parents, built environment, land use	mode choice decisions	San Francisco Bay Area	travel surveys (4352)	134

^a Regional travel diary survey consists of two stages: The first survey during the first half of 2001 under the auspices of the Gainesville Metropolitan Transportation Planning Organization (MTPO). The second survey was conducted in the latter half of 2000 by the Florida Department of Transportation (FDOT). ^b NTS: the NTS gives socio-demographic information about the respondent household, travel activity on a particular day, work trips and other work-related questions, access to cars, and quality of public transport. The NTS represents the whole population of the four countries. ^c TTS: Transportation Tomorrow Survey; the TTS is a repeated cross-sectional survey of travel behavior in Southern Ontario, Canada, conducted on a 5% sample of all households in the study area.

4. Discussion

4.1. Future Research Work with Sustainability

School travel behavior is an essential factor affecting the development of sustainable transport and the increase in carbon emissions [118]. In this section, we review the previous studies and discuss future research directions. Figure 6 shows the changing trend in the research topics over time.

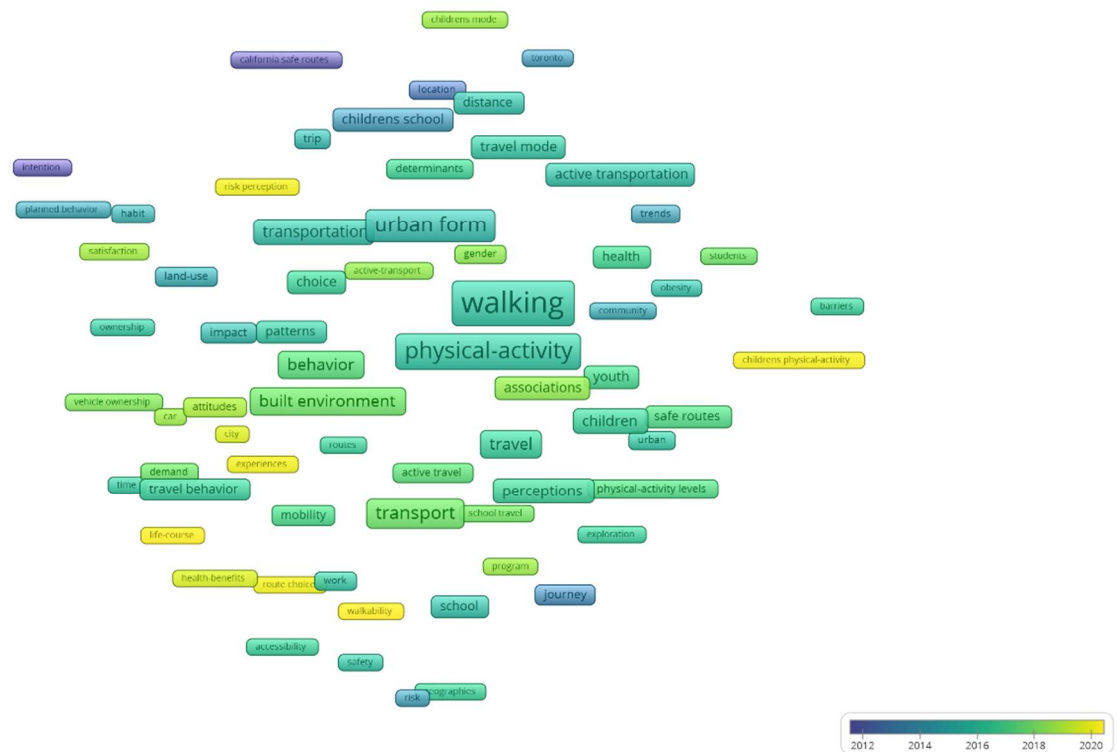


Figure 6. The trend in the study of school travel.

Since the implementation of the “SRTS” in Europe and the United States at the end of the last century, scholars have studied the safety of students in relation to four aspects: education, engineering, encouragement, and enforcement [119]. In addition, there have also been policies implemented, such as children’s walking programs, to promote physical activity. As a result of these programs, the proportion of students which travels through active transport during school travel has improved [120]. Through a five-year research survey of nearly 800 schools in Washington, Texas, Florida, etc., MacDonald compared the implemented SRTS plan with an unimplemented plan. His study found that the proportion of students walking and cycling to school had increased by 40%, which greatly promoted the physical activity of the students [121]. To date, more and more scholars have paid attention to the impact of the interaction between urban form, land use, and transport planning on the school travel mode. Relevant studies illustrated that the distance between school trips is greatly affected by the built environment. High residential density and degree of land use mixture are positively correlated with active school trips [108,122]. Perhaps reshaping a region’s urban form is conducive to reducing the proportion of car travel. Given the above research hotspots and the latest research trends, the following suggestions are given:

First of all, for the choice of school travel mode, the promotion of “active travel to school” is an effective measure for sustainable urban development in the future. A study from Germany showed that it is a good policy to promote bicycling ability tests for students. However, other alternatives, such as “walking buses”, should also be promoted among children [123]. At the level of social perception, a study in New Zealand showed that

teenagers who attend schools closest to home are five times more likely to perform active travel to school than their peers and have a lower rate of using electric transport to get to school [124]. Hence, community choice and school location may have a greater impact on the likelihood that children and adolescents use active travel to school. Meanwhile, as Murtagh explored in [125], the subject and environment are inextricably linked in a behavioral relationship, and a particular environmental characteristic may drive individuals to engage in active school travel behavior. Surveys from the United States also found that creating vibrant cities through “active travel modes” is considered a priority for urban sustainability and health. Policy practices in urban design also strongly support increasing active physical activity [126,127], yet the places currently inhabited do not always reflect active travel preferences. Frank and colleagues found that many people desire to walk, but do not live in walkable built environments [128]. A recent, systematic review also provided strong evidence of the impact of built environment changes (improved sidewalks, side streets, improved bicycle parking, safe walking places, and traffic buffers) on children’s active commuting [129].

Secondly, in terms of research methodology, the statistical results in Table 6 show that, in early studies, the multinomial logit model or improved logit model, such as the nested logit model, was used to analyze the influence of school travel. In recent years, researchers have begun to explore the school travel pattern through sophisticated analytical methods, for example, the structural equation model and discrete equation model. As a multivariable analysis tool, the structural equation model provides an effective method to discuss the complicated relationship between the latent variable and multivariable variables. Meanwhile, [95] pointed out that the impact factors of school travel behavior are various, and only a small number of the studies [28,116] integrated the influence of multiple factors. In the future, the study of school travel behavior can drive the exploration of various factors by constructing a complete theoretical framework. In the field of sustainable health behavior, integrating the theoretical framework of effect factors has become a critical step in the successful development of behavioral disturbance. The significance of assessing the existing literature on school travel is to distinguish those studies that are not rigorous in survey design, not fully correct in the use of modeling methods, and are not supported by a theoretical framework. The results of systematic research provide a reliable theoretical basis for designating effective travel strategies and school planning.

Finally, from the perspective of research: strengthen the comparative study of school travel behavior in developing countries and developed countries. When summarizing the content of the school travel from Figure 3, it was found that developed economies such as the US, Canada, and New Zealand conducted these studies earlier, and their research development has been relatively mature. Nevertheless, developing countries, such as China, India, etc., started relatively late in their exploration of school travel. If scholars from developing countries want to break through the traditional methods in the study of school travel behavior, we can discuss the difference between eastern and western school travel behavior. For example, most developing countries are now going through a stage of rapid urbanization. In addition, the concept of Transit-Oriented Development (TOD) is receiving increasing attention. How does this situation affect the field of school travel? Will it promote a change in students’ attitudes toward school travel or alter school travel modes? Meanwhile, these research results can also be used for reference in other developing countries.

4.2. Research Limitation

In this paper, we demonstrated a bibliographic analysis of the documents published in school travel fields. However, this analysis depended on data provided by four databases. In fact, it may have had certain limitations. For instance, we did not perform a formal risk-of-bias assessment; retrieval bias and language bias also led to errors in the results, which is a limitation of the review. At the same time, the keywords contained in the articles were often non-standardized and lacked a theme. Furthermore, some authors used different

versions of keywords. Even citation counts could be problematic, as authors may not have cited papers correctly. Citations for all papers increased over time, possibly leading to biased results. We recognize these limitations and adjusted for these factors where possible. Meanwhile, we believe that subject-field expertise provides context to understand the output of the bibliometric analysis.

5. Conclusions

This paper reviewed the results published related to school travel in the context of bibliometrics. First, 457 articles were analyzed, and the number of articles increased steadily from 2008 to 2021. Second, this study provided insight into the academic performance of countries and journals. The three countries with the most published papers were the US, Canada, and Australia. The Journal of Transport & Health and Journal of Transport Geography have had a high impact in the field. Third, we visualized the keywords and the co-citation literature to capture the hot topics in school travel research. In this section, although there were differences among studies, there were some results that achieved consensus. For example, distance to school is one of the most influential factors, especially walking to school. We observed differences in family characteristics in the choice of school travel mode, although the effect is more pronounced for younger children. The built environment has a significant impact on active travel to school. In addition to infrastructure that may encourage walking or cycling, a safe school environment is also found to be important in the decision-making process. At the same time, there may be a non-linear relationship between the built environment and active travel to school, for instance, there is a low proportion that supports active travel to school in low-density and high-density communities. Therefore, authorities and researchers can further investigate the effects of factors, such as home-to-school distance and street connectivity, on active travel to school. Fourth, this paper analyzed highly cited articles to gain a deeper understanding of the selection of school travel studies. Finally, we looked ahead to potential research directions to provide scholars with an innovative perspective. Furthermore, school policies and practices intervention are also considered to be valuable and meaningful. For example, sound “Travelwise” programs and active travel rules can promote active school behavior in children. However, lenient school zone policies (e.g., allowing children who live outside the school zone to register) and picking up and dropping off children (allowing parents to drive at school sites) can discourage this behavior. At the same time, setting traffic police and speed limit zones around schools can also enhance students’ enthusiasm for active travel to school [130]. School choice policies (i.e., attending a school outside the neighborhood) reduces the probability of active travel to school at alternative schools (magnet or charter) compared with neighboring schools.

We hope that research can benefit from this exploration of future research directions, which could provide research innovation. Similarly, the research results provide policy analysis for authorities, such as exploring school planning and promoting sustainable modes of transport. Simultaneously, it is worth noting that translating theoretical research into policies that guide practice may also require extensive collaboration between researchers and multidisciplinary teams. If theoretical findings can be put into practice, the primary beneficiaries of research to improve healthy living will be the communities in which we live [131].

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