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Review on the Research of the Relationship between Residential Landscape and Elderly Health

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ABSTRACT: The landscape of residential is closely related to the physical and mental health of the elderly. With the increasingly aging society, how to build a healthy living environment for the elderly is one of the important issues that need to be studied. Using scientific metrology tools such as CiteSpace to conduct knowledge map analysis on relevant literature, the research trends of the relationship between residential landscape and the health of the elderly were systematically summarized. The results showed as follows: 1) The number of domestic and foreign studies has been increased significant during the past 10 years. The research areas are mainly distributed in the fields of public health and geriatrics in foreign countries, while the domestic is mainly in the fields of architecture science and sports; 2) Residential landscape factors and their mechanisms that affect the health of the elderly have been the research hot spot in both domestic and abroad. In terms of landscape elements of residential, most of studies focused on green space, water body and sensory environment, while in mechanism focused on physical activity, autonomous needs and social cohesion. 3) The existing research mainly uses the subjective and objective measurement methods such as questionnaire, health benefit scale, objective measured environment and physiological indicators measurement. The trend is gradually shifting from the qualitative approach to the combination of qualitative and quantitative methods. The current study would provide evidence for future research and practice of age-health residential landscape.

KEY WORDS: residence; landscape environment; elderly health; CiteSpace

Introduction

In recent years, our country's aging population has shown complex characteristics such as "getting old before getting rich," "getting old before being prepared," and "getting arrogant before getting rich." Problems such as aging, empty nesters, and disability have continued to increase the burden of elderly care for the whole society [1-2]. As the aging population deepens, how to achieve "healthy aging" has become an important issue for academ-

ic research [3]. In the context of vigorously promoting community-based elderly care, home-based elderly care, and institutional elderly care [4], the living environment will become an important factor affecting the health of the elderly. A large number of studies have shown that the landscape elements in the living environment are closely related to the physical and mental health of the elderly. The outdoor environment of the residential area is a place

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for the elderly to experience nature, socialize, relax, exercise, and engage in other activities [5-6]. A good outdoor environment in the residential area can improve the physical function of the elderly, improve sleep quality, relieve stress, and maintain a positive emotional state [7-12]. Therefore, creating a living environment conducive to improving the health benefits of the elderly is an important topic that needs to be approached from such perspectives as planning, architecture, and landscape architecture.

At present, with the increasing attention paid to elderly-friendly landscapes, relevant review literature has also begun to emerge in China, mainly involving urban environment, community environment, elderly care environment, rehabilitation gardens and architectural environment. For example, Dou Xiaolu et al. reviewed the current status of the construction of elderly-friendly cities in the West and summarized its standards and specific construction cases [13]. Yu Yifan et al. conducted a systematic analysis of the distribution, research history and research key points of international research on elderly-friendly environments, and clarified that "health" is the core issue in this field [14]. Many scholars have also systematically reviewed the development trends of elderly-friendly communities at home and abroad [15-16]. In the field of rehabilitation landscape research, Wang Shengfei et al. introduced the application of rehabilitation landscapes in foreign elderly care environments and analyzed the current status of planning and design of elderly care rehabilitation landscapes in China [17]. Sun Zhenning et al. summarized the needs for outdoor space of dementia patients, as well as their independent mobility, preferences and safety, and systematically sorted out the theoretical and practical experience of dementia rehabilitation gardens in the United States [18]. Although there have been review studies based on different perspectives, there is still a lack of reviews on the relationship between residential landscape environment and the health of the elderly. At the same time, with the extensive development and deepening of relevant research in recent years, it is very necessary to further sort out and summarize the existing research in this field in a systematic manner.

Based on this, in order to clarify the relationship be-

tween the landscape environment of residential areas and the health of the elderly, this paper uses scientific measurement tools such as CiteSpace to analyze the knowledge graph of literature data based on the search results in the Web of Science (hereinafter referred to as WOS) core collection and China National Knowledge Infrastructure (CNKI) database, systematically sorts out the development trends and research hotspots in this field, summarizes the existing research content and methods, and provides a reference for the research and practice of domestic elderly-friendly healthy living environment.

1 Literature sources and research method

1.1 Data collection

The English literature data came from the WOS core collection. In order to cover the research field as much as possible, after adjusting the search strategy several times, it was finally determined to use TS = (residential OR neighborhood OR community) AND (landscape OR green space OR outdoor OR garden OR park OR greenness OR nature) AND (elderly OR old people OR elderly people OR senior citizen* OR elderly adult) AND (health OR well-being OR therapeutic OR restorative) as the search formula for retrieval. The search field was the title, the language was "English", the document types were "Article," "Proceeding Paper" and "Review," the time span was "1999-2021," and the search time was February 18, 2021. There were 725 search results in total.

The Chinese literature data came from CNKI, and the search was carried out with "residential area" (or including "residential area" or "community"), "landscape" (or including "outdoor," "green space," "green land," "landscape environment," etc.), "elderly" (or including "aging," "suitable for the elderly," "elderly care" or "old people") and "health" (or including "rehabilitation," "fitness," "health care", "healing", "recovery", "mental health", etc.) as keywords. The search field was the title, and the time span and search time were the same as above. The search results were 456 in total. After reading the search results one by one, items such as news and conference notices were removed, and a total of 365 Chinese articles were screened.

1.2 Visualization analysis method

The built-in analysis tools of CNKI and WOS, scien-

tific text mining and visualization software CiteSpace and Graphpad Prism were used to conduct quantitative visualization analysis of the literature. First, the database built-in analysis tools were used to count the annual number of domestic and foreign literature and related domestic disciplines; then CiteSpace was used to analyze and mine related domestic and foreign literature, and visualize the discipline distribution, keywords, and co-citation of literature, in order to clarify the research status and development trend of this field.

2 Overview of domestic and foreign research

2.1 Trends in the number of research studies

The annual distribution and trend of the number of research papers can better reflect the importance of this field and the degree of attention it has received. The 725 English papers and 365 Chinese papers retrieved were statistically analyzed. From the perspective of the number of papers published and the trend of change, the number of papers in this field is increasing as a whole. Relevant research has appeared in foreign countries since 2002, and the number of English articles has shown a continuous upward trend since 2009. However, the early research progress in China was relatively slow, and the number of Chinese papers has gradually increased since 2012. In general, with the deepening of social aging and the increasing number of healthy environmental studies, domestic and foreign scholars have begun to pay more and more attention to the relationship between residential landscape environment and elderly health in the past decade.

2.2 Distribution of research disciplines

The distribution of English literature in disciplines was analyzed using CiteSpace. The results show that public, environmental & occupational health is the discipline with the most research papers published abroad, indicating that this discipline occupies an important position in foreign research in this field. Secondly, geriatrics & gerontology, environmental sciences & ecology, and psychiatry are the main research disciplines in this field. The statistical results of the literature search results using CNKI's analysis tools show that the range of domestic research disciplines is relatively wide in this field, among which archi-

tectural science and engineering make up the largest proportion, accounting for 68.6%, followed by sports, Chinese politics, international politics, etc.

2.3 Analysis of main research hotspots

Keywords reflect the author's refinement and summary of the main content of the article, and keyword co-occurrence analysis shows the research hotspots and research frontiers in this field. Literature co-citation analysis can sort out the branch structure and evolution context of the research field, and co-citation network clustering analysis can reveal the research frontiers in this field. With the help of CiteSpace, the keyword co-occurrence network map of domestic and foreign research is obtained. Since CiteSpace cannot perform literature co-citation analysis on Chinese literature, it only generates a co-citation literature clustering timeline map and a structural clustering map for English literature. The co-occurrence network map shows that foreign research mainly focuses on built environment, neighborhood, mental health, quality of life and depression. The results of network clustering map analysis show that the main clusters are physical activity, social cohesion, social isolation, green space and neighborhood disorder. Relevant research focuses in China mainly include rehabilitation landscape, retirement community, aging-friendly transformation, horticultural therapy, integration of medicine and nursing, design strategy and physical activity. In summary, it can be found that the research hotspots are mainly concentrated in two aspects: "residential landscape elements from the perspective of elderly health" and "the mechanism of the impact of residential landscape environment on the health of the elderly."

3 Main contents and methods of research on landscape environment and elderly health in residential areas

3.1 Landscape elements of residential areas from the perspective of elderly health

3.1.1 Green space landscape

Green spaces in residential environments can promote the physical and mental health of the elderly by improving environmental conditions and providing ecosystem and environmental service functions. Green space landscape indicators that affect the health of the elderly can be divid-

ed into levels such as green space site attributes, green space accessibility, and green space vegetation characteristics. Research on living environment and aging health shows that green space attribute indicators such as green space type [19], green space quantity [20-21], green spaceratio [22-24], per capita green space area [25], green space accessibility indicators like the distance between green space and residence [26-27] and green space vegetation characteristic indicators such as visible green index [28], the normalized difference vegetation index (NDVI) [29-31], enhanced vegetation index (EVI) [32-33], the three-dimensional amount of greening [34] and the perceived evaluation of vegetation quality [35-36] will significantly affect the health of the elderly (Table 1). The above studies have involved many health-related indicators for the elderly, such as myoelectricity, mental fatigue recovery, mortality, cardiovascular morbidity, depression, positive emotions, etc. For example, an Australian study pointed out that the mortality rate of elderly residents with a high average greening rate within 300m of their residences was 9% lower than that of elderly residents with low greening rates around their residences [21]. Some studies have also shown that a higher greening rate in residence can delay the decline of walking ability and grip strength of the elderly [33]. Current research mostly uses the NDVI or green space ratio to measure the green space landscape in the residential environment. These indicators are not enough to fully express the quality of the green space landscape, and it is difficult to describe the perceived experience of and benefits from using green space by elderly residents based on them. Therefore, more refined indicators from the human perspective, such as visible green index, vegetation diversity, and vegetation canopy density, should be used to study the impact of residential area green space landscape on the health of the elderly. Although environmental indicators used for quantitative research are becoming more and more comprehensive, the following questions remain unresolved: To what extent do the spatial composition, density, vegetation types, smell, shape and other detailed characteristics of green space landscapes affect the health of the elderly? How to scientifically evaluate the green space landscape design in resi-

dential areas that is beneficial to the physical and mental health of the elderly?

3.1.2 Water features

Water features can affect physical health by increasing negative ion concentration, reducing noise, and promoting activities, and it also has the effects of relieving stress, improving mood, eliminating fatigue, and promoting mental health; it can even create a rich spatial atmosphere to support social activities [37]. Some articles have confirmed that water features can effectively promote the health level of the elderly [38-40]. Garrett et al. found in Hong Kong that the elderly who can see water feature space from their homes are more likely to have good overall health, and frequent contact with water feature space is associated with higher subjective well-being or lower depression [41] 100. Some studies have pointed out that the per capita water feature area can affect the mental health of the elderly by reducing environmental pollution, relieving stress, and promoting social interaction. Water features can bring a cool feeling in hot weather. Walking along the water-side and sitting quietly can reduce cortisol levels and make the elderly feel happy, although the water feature environment in the living environment has limited effect on promoting physical activity of the elderly [42]. The characteristics of water feature tranquility, shelter, and vastness can restore the spirit of the elderly [43]. However, some studies have shown that the elderly believe that water features in the outdoor environment of residential areas may be harmful and that they are not essential for outdoor activities [44] 11. Therefore, the health benefits of water features in residential areas and their cognitive effects on the elderly need further in-depth research.

3.1.3 Sensory environment

The sensory environment of a residential area refers to the sound environment, olfactory environment, and environmental factors such as wind, light, and heat that can make the elderly feel comfortable. Good sensory experience in the environment has a positive effect on the physical and mental health of the elderly. For example, studies have found that bird sounds can effectively enhance the elderly's pleasant emotions and sense of quietness [45]. At the same time, due to reduced immunity, the health of the elderly is easily af-

fectured by the thermal environment. They believe that good ventilation and avoiding the hot sun are essential [44]1, and there is a strong correlation between the comfort of the spatial wind, light, and heat environment and the elderly’s leisure and entertainment activities [46]. In creating a sensory experience in the residential environment, the visual needs of the elderly can be met by utilizing space, sight, color, light and shadow, the needs for auditory experience can be met by

introducing comfortable natural habitats, adding artificial soundscapes and eliminating noise, the olfactory needs can be met by creating scented landscapes, the tactile needs can be met by combining animals, plants and water features, and the elderly can be allowed to grow edible plants by setting up participatory gardening landscapes, which can satisfy their visual, tactile, olfactory or taste experiences in the process of cultivation, picking and tasting [47].

Table 1 Research on the correlation between green space landscape in the residential environment and elderly health

Category	Specific indicator	Health-related indicators	Mainconclusions
Green space attribute indicators	Green space type	Recovery of electromyographical and mental fatigue	The relaxing effect of mountain and forest landscapes is the most obvious, followed by lawn landscapes, and the effects of water bodies, farmland and wetlands are relatively weak [19]
	Green space scale	All-cause mortality	There is no significant correlation between park size and all-cause mortality [21]
	Green space quantity	Social health, mortality	There is a negative correlation between the number of parks and social health [20]; there is a significant correlation between the number of natural spaces within the 500-meter buffer zone and mortality [21]
	Green spaceratio	Self-assessed perceived health, diabetes incidence	Living in an area with park coverage of more than 8% is positively correlated with self-rated health [22]; green spaces have a positive impact on health [23]; elderly people who live in the greenest neighborhoods have a 19% lower risk of diabetes [24]
	Per capita green space area	Cardiovascular disease incidence	Compared with the elderly living in areas with low green space levels, the elderly living in areas with medium-low, medium-high, and high green space levels have significantly lower rates of cardiovascular disease [25]
Green space accessibility indicator	Distance between green space and residence	Perceived physical health	The perception of the distance to parks is a prerequisite for park use, daily physical activity and health [26]; the elderly participate in more nature-related activities, so the distance of green spaces from them should not be too large [27]
Green space vegetation indicators	Visible green index	Depression	Visible green index is negatively correlated with depression[28]
	Normalized difference vegetation index	Diagnosis rate of heart disease, body mass index (BMI), all-cause mortality, circulatory system mortality, stroke mortality	More greening can reduce the risk of myocardial infarction, ischemic heart disease, heart failure and atrial fibrillation [29]; there is an inverted "U"-shaped relationship between greening and BMI. When the level of greening is low, BMI increases with greening. When the greening level is high, BMI decreases with increasing greening [30]; the higher the green space coverage, the lower the all-cause mortality, circulatory system mortality and stroke mortality in the elderly [31]
	Enhanced vegetation index	Type 2 diabetes incidence, walking ability	Residential greening affects fasting blood sugar levels and walking ability decline in the elderly [32-33]
	Three-dimensional amount of greening	Health-related ecological service functions	The three-dimensional amount of greening is significantly correlated with the air negative ion concentration, temperature, and humidity. The tree layer and ground cover layer are significantly correlated with temperature, humidity, and negative ions [34]
	Perceived evaluation of vegetation quality	Life satisfaction, meaning of life, positive emotions	There is a significant positive correlation between the perceived evaluation of vegetation quality and life satisfaction, meaning of life, and positive emotions [35-36]

3.2 Mechanisms of residential landscape environment-affecting the health of the elderly

3.2.1 Promoting physical activity

A sedentary lifestyle can lead to common chronic

diseases in the elderly, including cardiovascular diseases, diabetes, obesity and depression [48]. Empirical studies have shown that physical activity can provide important health benefits for the elderly andthat walking for more

than 4 hours per week can effectively reduce the risk of cardiovascular disease [49]. Physical activity can also improve the symptoms of depression and loneliness in the elderly, improve the quality of life and happiness, maintain good cognitive function, and reduce the risk of falls, hypertension, stroke, and diabetes [50-51]. Studies have shown that the outdoor landscape environment in residential areas can further improve the health of the elderly by promoting their physical activity [52-53]. Elderly people who have green spaces near their homes are more willing to go out for activities [54-55]. Tan Shaohua et al. proposed a quality hierarchy of necessity, spontaneity, and sociality for the physical activity of the elderly, and found that a low-quality environment can only support "necessary" physical activities, while a high-quality environment can trigger the occurrence of "spontaneous" and "social" activities [56]. Environmental factors that are positively correlated with physical activity of the elderly include walkability, residential density, accessibility of facilities, beautiful scenery, good lighting, etc. [50]. At the same time, the residential environment and physical activity have different effects on the elderly of different ages, so it is necessary to design an environment that promotes physical activity for different age groups.

3.2.2 Meeting the needs of autonomy

As their physical functions decline, the elderly are more likely to feel a loss of control over their lives. For the elderly, maintaining autonomy and independence not only means maintaining good functions at the physiological level and acting as they wish, but also means controlling their own lives at the psychological level, solving problems independently and making decisions [57]. The physical characteristics of the residential landscape play an important role in supporting or restricting the autonomy and independence needs of the elderly. A good supportive environment can enhance their sense of achievement and self-confidence in life, and positively affect their health, thereby indirectly reducing the pressure on public health services [58]. At present, most of the research on commu-

nity-friendly design for the elderly focuses only on barrier-free design. Some existing problems cannot meet the diverse needs of the elderly for physical and mental health, such as unreasonable zoning of rest areas and lack of consideration for wind environment, shade, and lighting environment [59-60]. Increasing the travel options for the elderly, providing a variety of seating options, and guiding them to participate in public activities can effectively meet the needs of the elderly for independence.

3.2.3 Improving social cohesion

Social cohesion refers to the mutual trust, social connection, and solidarity among residents [61]. Social relationships can affect health through the following mechanisms: social participation, social support (perceived or actual), social influence (such as setting norms), access to information, and social connections [62]. For example, social cohesion can improve the health of the elderly by promoting the rapid spread of health-related information, stimulating social and physical exercise behaviors, reducing negative emotions, and influencing changes in the community environment [63]. Studies have found that community cohesion is significantly correlated with the elderly's daily living activities, depression, health awareness, and subjective well-being [64-66]. A German study pointed out that the elderly with close social networks use parks more frequently and are more likely to obtain health benefits [67]. Other studies have shown that the characteristics of the residential environment can affect the elderly's identification with the community and social cohesion, and community cohesion can mediate the relationship between the neighborhood environment and the elderly's life satisfaction, meaning in life, and positive emotions [35, 68].

3.3 Main research methods based on evidence-based design

At present, the methods used in domestic and foreign evidence-based investigations of the relationship between residential landscape environment and elderly health can be divided into subjective measurement methods and objective measurement methods (Table 2).

Table 2 Measurement tools and methods used to study the relationship between residential landscape environment and health of the elderly

Category		Measurement tools and methods
Subjective measurement methods	Environmental characteristics of residential areas	Perceived Residential Environment Quality Indicators, PREQI; Neighborhood Environment Walkability Scale (NEWS)
	Health level of the elderly	Positive and Negative Affect Schedule (PANAS), Kessler Psychological Distress Scale (K10), State-Trait Anxiety Inventory (STAI), Geriatric Depression Scale (GDS), WHO 5-item Well-being Scale (WHO-5), 36-item Short Form Health Questionnaire (SF-36), EuroQol Five-dimensions (EQ-5D)
Objective measurement methods	Environmental characteristics of residential areas	Geographic vector spatial data, remote sensing image data, street view data, field survey data
	Health level of the elderly	Electroencephalography, electromyography, blood pressure, heart rate, skin conductance, eye movement, functional near-infrared spectroscopy

3.3.1 Subjective measurement methods

Currently, a large number of studies use the Perceived Residential Environment Quality Indicators (PREQI) questionnaire developed by Bonaiuto and colleagues for subjective measurement of residential environment characteristics [35]83. This questionnaire includes four dimensions of neighborhood environment characteristics: architectural and planning features, socio-relational features, functional features and contextual features. As the role of residential environment in promoting physical activities such as walking behavior among the elderly has received increasing attention, the Neighborhood Environment Walkability Scale (NEWS) has been widely used. The measured environmental characteristics include mixed use of land, street connectivity, neighborhood facilities, pedestrian infrastructure, aesthetic characteristics, neighborhood safety, etc. [53]5. The former is a more comprehensive residential environment evaluation tool that includes evaluations of physical and social levels and is suitable for studies focusing on various types of indicators of residential environment quality, while the latter focuses mainly on the evaluation of the walkability of the physical environment of the residential area. Measuring the perceived evaluation of the residential environment through a scale can reflect the residents' experience or satisfaction, but compared with objective measurement, questionnaire surveys have problems such as subjectivity and sample cognitive bias. Common subjective measurement scales for the health level of the elderly include: The Positive and Negative Affect Schedule (PANAS) [35] 86, Kessler Psychological Distress Scale (K10) [69], State-trait Anxiety Inventory (STAI) [70], Geriatric Depression Scale (GDS) [71], World

Health Organization 5-item Well-being Scale (WHO-5) [41] 102, 36-item Short Form Health Questionnaire (SF-36) [72],EuroQol Five-dimensions (EQ-5D), etc. Among them, PANAS, K10, STAI, GDS and WHO-5 scales are used to assess different emotional characteristics and mental health levels of the elderly, while SF-36 and EQ-5D scales are multidimensional health and quality of life measurement methods that can comprehensively assess physical, psychological and social health. Compared with the measurement of objective physiological indicators, the subjective health scale measurement method has the advantage of high operability, but it cannot present the real-time human-land interaction status and environmental health performance characteristics in the real time-space.

3.3.2 Objective measurement method

Based on existing research, it can be found that the data sources for objective measurement of residential environmental characteristics can be divided into four categories, including geospatial data (land use type, road network data, POI data, etc.), remote sensing image data (NDVI, EVI, green space ratio, etc.), street view data and field survey data (wind speed, humidity, temperature, etc.). The data volume of geospatial data and remote sensing image data covers a wide range, but people in the same spatial unit share the same environmental characteristics, and the research results may deviate from the actual situation. At the same time, since street view data can be obtained only for open compounds but not for closed compounds, the environmental features extracted from street views may not represent all types of residential areas. However, data collection for field surveys requires a lot of time and manpower, and it is difficult to obtain more large-scale data.

For objective measurement of the health level of the elderly, many studies have adopted non-invasive, minimally intrusive, and safe methods, such as measuring EEG, EMG, blood pressure, heart rate, skin conductance, functional near-infrared spectroscopy and eye movement activity [73-74].

4 Research evaluations and prospects

This paper reviews the relevant research on the relationship between residential landscape environment and the health of the elderly, which can provide reference for the systematic research and planning and design practice of the elderly-friendly healthy residential environment in the future, and is of great significance for alleviating the pressure of society to cope with aging and improving the welfare and quality of life of the elderly. A summary of existing research shows the following. 1) In terms of research methods, most foreign studies are quantitative studies of correlation exploration, mainly using cohort studies, sampling questionnaires, cross-sectional surveys and other methods. Most domestic studies are qualitative studies, and quantitative studies are relatively rare. Regarding the trend of development, domestic and foreign research in this field has gradually shifted from qualitative research to a combination of qualitative and quantitative research. 2) In terms of research content, domestic research started later than foreign research, and most of it focused on the design of elderly-friendly community environments, and there were relatively few interdisciplinary studies with the field of elderly health. In terms of exploring the mechanism of the impact of residential landscape environment on the health of the elderly, domestic and foreign research still lacks in-depth research on the specific elements of the landscape environment. 3) In terms of research indicators, although the indicators used to study the characteristics of residential landscape are becoming more and more comprehensive, most of them are concentrated on the study of green landscape and use a single indicator or a combination of simple indicators. The selection of indicators in subjective evaluation scales of the residential environment is mostly based on subjective experience, and there is a lack of research combining subjective and objective indices.

In summary, in the future, it is necessary to deepen

the interdisciplinary cooperation and research content of the residential landscape environment based on the health of the elderly, build a more scientific evaluation system for the landscape environment of elderly-friendly healthy residential areas, and further explore the intrinsic impact mechanism of the residential landscape environment on the health of the elderly through quantitative analysis. In the field of practice, it is urgent to incorporate the concept of "elderly health promotion" into the planning and design of the outdoor landscape environment of residential areas, pay attention to improving the quality, accessibility, comfort and sustainability of the landscape environment at the micro level such as green space, water features, sensory experience, and create a residential environment dedicated to promoting physical activities of the elderly, meeting autonomy needs and improving social cohesion. At the same time, in the future, new research technologies and methods such as portable biofeedback instruments, machine learning, and big data analysis can be combined to collect massive environmental and health data, dynamically evaluate and manage the residential landscape environment at multiple scales to maximize its elderly-friendly health benefits. However, the restrictive conditions set during data collection in this study determined that its results had certain limitations. For example, only the CNKI and WOS databases were searched, and relevant literature from other databases was not included, resulting in an incomplete survey and room of improvement for similar studies in the future.

Figure and table sources

Tables 1-2: Created by the author based on the literature.

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