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Analysis of Musculoskeletal Drivers Literature: A Comprehensive Review Of Scientific Publications

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ABSTRACT

Background: Musculoskeletal disorders among professional drivers represent a significant occupational health challenge, with prevalence rates of 78.6% globally, causing physical discomfort, reduced performance, and increased workplace injury risks. The objective of this study is to provide a comprehensive overview of MSD research development and guide future research directions based on quantitative analysis of scientific publications.

Method: A comprehensive bibliometric analysis was conducted using Web of Science database data from August 10, 2025. The search included open access English articles on "Back pain" and "Transportation" using VOSviewer and R-Bibliometrix tools to visualize inter-literature connections and research evolution. **Results:** Dominance of “Public Environmental” category is well quantified of 112 documents revealed. The United Kingdom, USA, and Australia led research contributions with strong international collaborations. Four thematic clusters emerged: Motor Themes (exposure, prevention, ergonomics), Basic Themes (driving safety, automation), Niche Themes (human factors), and Emerging Themes (occupational health, systems thinking). Key focus areas included whole-body vibration, low-back pain, ergonomic interventions, and health prevention strategies. **Conclusions:** Significant gaps exist between assessment studies and comprehensive intervention development in driver musculoskeletal health research. Despite extensive research foundations in developed countries, intervention studies remain limited, particularly in developing nations. The analysis emphasizes the need for cost-effective ergonomic interventions, longitudinal studies, and direct measurement techniques to address the complex interplay of work procedures, environment, and equipment in musculoskeletal disorder development among professional drivers.

Introduction

Musculoskeletal disorders among public transportation drivers represent a complex occupational health challenge, generally characterized by physical disability followed by decreased work performance, as well as increased risk of workplace injuries and accidents [1]. Prolonged hazard exposure related to vehicle vibrations, non-ergonomic seating positions, and repetitive movements significantly affects drivers' musculoskeletal health, potentially leading to chronic pain conditions and decreased operational efficiency [2]. To improve optimal driver performance and safety standards, drivers must be able to minimize prolonged physical stress, however musculoskeletal fatigue and discomfort can interfere with their motor control abilities and decision-making processes, making safe vehicle operation increasingly difficult to maintain [3], [4].

Reports from the International Labour Organization demonstrate that musculoskeletal system abnormalities in public vehicle operators provide substantial influence on work activities, with incidence rates ranging from 40% to 92% depending on driver population characteristics and body parts examined [5]. Approximately 60-80% of scientific research findings on occupational safety and health among professional drivers and public transportation workers show significant musculoskeletal disorder complaints. These disorders impact their work performance and quality of life. Musculoskeletal disorders generally involve pain in the lumbar region, disturbances in the neck area, and complaints in the shoulder region [6]. Musculoskeletal disorders among drivers have currently become a broader concern as they involve aspects of worker protection in the transportation sector [7].This phenomenon has drawn attention from various parties, particularly the government and industry owners, in developing more comprehensive preventive measures.

Several research findings reveal that more than 70% indicate that appropriate ergonomic improvements and proactive actions have been positively proven to reduce occupational health disorders such as musculoskeletal disorders among public transportation drivers [8], [9]. These efforts demonstrate success in improving the degree of occupational health in the transportation sector. Therefore, efforts to study and assess risk factors and treatment methods for musculoskeletal disorders need to be continuously conducted [10], [11].

Musculoskeletal disorder conditions are generally grouped into several types: those resulting from trauma, degenerative diseases, and injuries [12], [13]. However, currently no specific causes have been identified regarding musculoskeletal disorders in drivers, whether from vehicle steering wheel height, working hours, driving duration, or other aspects. These aspects that currently lack definitive standards make it difficult for vehicle manufacturers to design their vehicles to prevent musculoskeletal disorders [14]. Generally, research is still focused on ergonomic identification and treatment in the form of pain relief [15]. More effective measures such as improving skeletal muscle mass for drivers do not yet have global standards available [16].

Furthermore, greater focus has been given to comprehensive studies of driver musculoskeletal research, encompassing investigations on vibration exposure measurement methods based on biomechanical parameters indicators [17]–[19], design and construction of ergonomic monitoring systems [20], [21], research developments in postural analysis utilizing motion capture technology [22], [23], the impact of seat design on vehicle operator comfort [24]and machine learning implementation for predicting musculoskeletal abnormalities [4].

Bibliometric analysis employs statistical methodology to evaluate transformations in both qualitative and quantitative aspects within scientific research domains [25]. This approach functions as an effective instrument for monitoring the evolution of academic research [26], while simultaneously presenting visual representations of developmental trajectories and structural interconnections among various scientific disciplines. Through systematic examination of literature data extracted from the Web of Science database, it becomes possible to identify spatial and temporal distribution characteristics across diverse countries, geographical regions, research subject categorizations, and scientific publication outputs [27]. This methodology provides substantial contributions to understanding the dynamics of contemporary research development.

Knowledge cluster mapping describes an approach for illustrating multidisciplinary scientific collections, with the intention of simplifying information presentation to understand and elaborate knowledge structures [28], and can be employed to examine current circumstances along with capabilities that are growing in international research. Bibliometric analysis together with scientific knowledge visualization has experienced widespread acceptance in literature review methodologies due to its advantages that include easily digestible quantitative statistical data, bright and comprehensible visual presentations, as well as effective recognition of knowledge systems found within specific disciplinary areas or particular research domains. This method provides significant

contributions in understanding research developments and trends across various scientific fields. Previous non-bibliometric reviews indicate that musculoskeletal disorders are highly dominant among drivers with a prevalence of 78.6% [29]. Bibliometric analysis is needed to identify research gaps and current trends in MSD studies that have not been systematically mapped. The objective of this study is to provide a comprehensive overview of MSD research development and guide future research directions based on quantitative analysis of scientific publications.

Materials and Method

We follow a bibliometric analysis, incorporating both quantitative and qualitative aspect of literatur. The study adopted the bibliometric and scientometric approaches to examine and summarise studies from the Web of Science database on August 10, 2025. The selection of Web of Science was based on its extensive indexing of high-quality academic publications, robust citation analysis capabilities, comprehensive coverage of peer-reviewed journals across multiple disciplines, and reliable metadata availability for bibliometric research. The search was refined to include articles with open access availability, published in English language, and categorized under Citation Topics Meso focusing on "Back pain" and "Transportation", and published up to the end of 2025. Exclusion criteria included: publications other than systematic reviews and meta-analyses (such as narrative reviews, etc).

2.1.1. Tools for Bibliometric Analysis

This research utilizes two bibliometric research tools (VOSviewer and RBibliometrix) with the aim of providing visual representation of inter-literature connections, examining the evolution of research themes and emerging technological focuses, and clarifying the direction of future research development.

(1) VOSviewer Program

VOSviewer program represents a bibliometric assessment application co-created by Van Eck and Waltman (2010). The software's key strength is its capacity to produce network clustering visualizations and density mapping as analytical results, facilitating efficient thematic identification and bibliographic categorization processes

(2) R-Bibliometrix Software

Bibliometrix software constitutes an RStudio library focused on bibliometric assessment and scientific visualization applications, established and managed by Hou *et al.* (2022). This package features two principal operational modules: evaluating essential bibliometric characteristics and identifying bibliometric constructs and knowledge architectures.

(3) Excel

Bibliometric data were extracted from Web Of Scince, including key indicators such as publication metadata (titles, abstracts, and publication years), author information and affiliations, source journals, citations, author keywords, and geographic data. This dataset was exported in CSV format and subsequently processed using Microsoft Excel for initial analysis.

I have adjusted the PRISMA diagram according to the inclusion and exclusion criteria for research on musculoskeletal disorder risk factors in drivers. Following PRISMA 2020 guidelines, the systematic screening process began with 1,850 records from Web of Science Core Collection. After applying criteria including article type, publication years (2002-2024), free accessibility, English language, appropriate study designs, and statistical measures availability, 13 studies were included in the final meta-analysis.

2.1.2. Bibliometric analytical concepts

(1) Bradford's Law

Bradford's scattering law stands as a crucial bibliometric theorem that numerically defines the observed pattern of concentration and dispersion of academic papers within associated journals. The law operates by sequencing periodicals from highest to lowest based on their publication of field-specific articles, creating three equivalent zones in terms of article count: primary, secondary, and tertiary areas, with journal quantities following the ratio 1: n: n^2.

(2) H-index and M-index metrics

The H-index signifies the publication of H papers that have each garnered at least H citations. In the case of individual scholars, the H-index demonstrates temporal growth with a roughly linear progression. Therefore, the M-index constitutes the H-index adjusted for academic career length, with its calculation method outlined as follows. Where yacademic year indicates academic age, calculated as the years since the author's debut publication

$$Mindex: \frac{Hindex}{\text{Yacademic year}}$$

(3) Citation Analysis

Local citation (LC) indicates how often an article is cited within a particular dataset related to its field of study, facilitating swift discovery of seminal literature in specific domains. Global citation (GC) signifies the complete citation tally of a publication on a worldwide scale, allowing for immediate assessment of its level of recognition among the global academic community.

(4) Co-citation studies

Co-citation analysis assesses the connection between two research papers by counting instances where they are cited in conjunction, revealing the relationship between the co-referenced literature. This technique is commonly applied to analyze the underlying associations within scholarly works and investigate the progression patterns of disciplinary studies.

(5) Topic Map

The topic visualization produced by Biblioshiny assists in examining the progression of research subjects. In this mapping system, upper right quadrant themes function as motor themes, indicating research domains that possess both high significance and advanced development. Upper left quadrant themes operate as niche themes, showing substantial progress but minimal relevance to the current field. Lower left quadrant themes constitute emerging or disappearing topics—peripheral research areas with poor development that may be newly surfacing or gradually fading. Lower right quadrant themes represent basic themes, encompassing research domains crucial to the field but insufficiently developed, often containing elementary conceptual frameworks.

Results

3.1. Literature analysis

3.1.1. Annual publications and trends

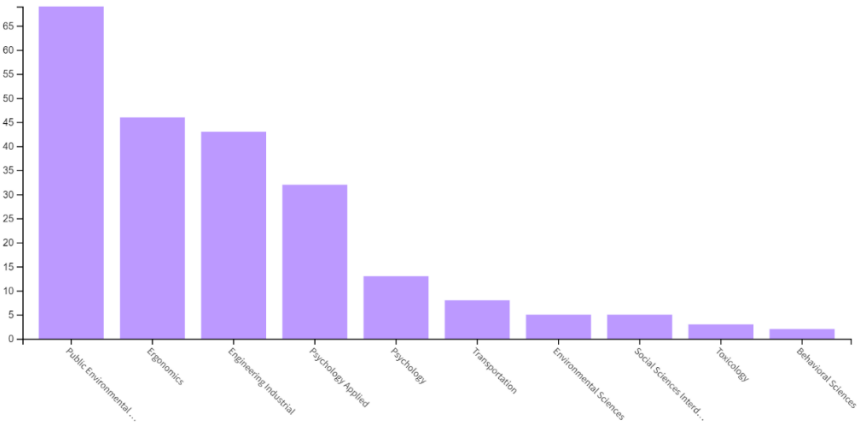

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Figure 1. Research Category

Figure 1. The distribution of research publications across various research disciplines and scope categories. Based on database analysis, ten categories can be identified with clear patterns. The most prominent category is "Public Environment" with 69 published articles, where the most dominant focus is environmental implications for society, which includes workers within the community.

The findings from the subsequent analysis relate to engineering, which consists of two groups: "Engineering" with 47 published articles and "Industrial Engineering" with 43 published articles. The focus of these findings examines solutions that tend to be of a technical engineering nature and technology implementation in the industrial sector. These results represent a concrete manifestation where workers are generally under the umbrella of industrial systems.

The next findings are "Applied Psychology" with 32 published articles and "Psychology" with 13 published articles, which indicates the role of behavior and human factors in musculoskeletal complaints among drivers. The role of psychology becomes a multidisciplinary approach in providing solutions to existing problems [32]. Subsequently, findings that are relatively fewer relate to "Transportation" with 8 published articles, "Environmental Science" with 5 published articles, "Applied Social Sciences" with 5 published articles, "Toxicology" with 3 published articles, and "Behavior Sciences" with 2 published articles. This distribution pattern shows the multidisciplinary role in the influence of musculoskeletal

disorders on drivers related to work environment, while the most recommended solutions come from engineering and psychology aspects [33].
The relatively lower numbers in transportation and toxicology suggest these are either emerging areas or specialized niches. Overall, this categorical distribution confirms the field's multidisciplinary nature while identifying its primary research concentrations and developing areas of scholarly interest.

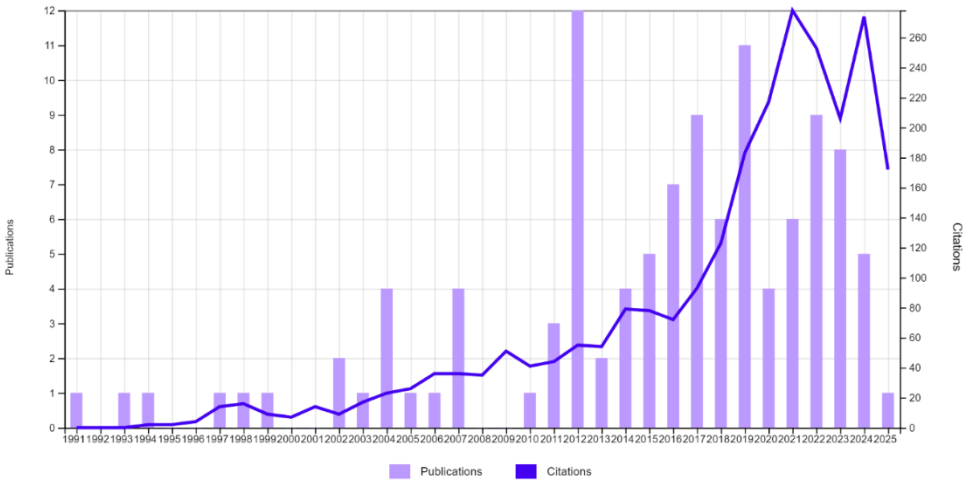

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Figure 2. Times Cited and Publications Over Time

Figure 2. The increasing trend in the number of publications in recent years related to literature and citations can reflect research and development trends in certain disciplines, this has become a concern in research and discussions in that field. In the analyzed dataset, research related to this topic shows an interesting development pattern from 1991 to 2025, as displayed in the graph. From the graph, it can be seen that research in this field first appeared in the early 1990s with very limited publication numbers (around 1 publication per year). The period from 1991 to 2003 showed stability with low and consistent publication levels, not exceeding 4 publications per year. During this period, citation numbers were also relatively low, indicating that this research field was still in its early development stage.
A significant turning point occurred around 2004, when publication numbers began to show a clearer upward trend. From 2004 to 2012, there was fluctuation and gradual increase in publication numbers, with peaks reaching approximately 12 publications in 2011. This period marked an early growth phase where research interest began to increase consistently.
The most dramatic growth occurred after 2013, with significant acceleration in publication numbers. The 2018-2021 period showed peak research activity with publication numbers reaching 11-12 per year. More interestingly, the citation pattern followed a similar trend but with more exponential growth, reaching its peak around 2021-2022 with over 280 citations.
The decline visible in 2023-2025 likely reflects incomplete data or an adjustment period after the intense growth phase. This pattern shows that this research field has evolved from an embryonic stage (1991-2003), through an early growth phase (2004-2012), to a period of rapid expansion (2013-2022), indicating the increasing relevance and importance of this research topic in the academic community.

3.1.2 Keyword analysis

Researchers conduct in-depth analysis based on keywords to conceptualize the dynamics of bibliometric studies in the literature [30]. To be able to have meaningful analysis, researchers apply filters to require a minimum threshold of two for the occurrence of specific keywords to be included in the analysis (resulting in a total of 145 keywords), and exclude non-related terms and remove keywords such as "prospective cohort", "meta-analysis", "follow up", "reliability", "validation", and "guidelines". In the final stage, researchers use 138 keywords with a total link strength of 1730, as reported in Figure 3.
The filtering process demonstrates a rigorous approach to keyword selection, where methodological terms that do not contribute to the substantive understanding of the research domain are systematically excluded. This methodological refinement ensures that the subsequent analysis focuses on conceptually relevant terms rather than being diluted by procedural or technical vocabulary that appears across various research methodologies.

The substantial increase in total link strength from the initial dataset to the final refined set (reaching 1730) indicates strong interconnectedness among the retained keywords, suggesting a cohesive research domain with well-established conceptual relationships. This high link strength value reflects the maturity of the field and the presence of core themes that consistently appear across multiple studies, creating a robust network of scholarly discourse.

The reduction from 145 to 138 keywords, while maintaining such high link strength, demonstrates the effectiveness of the filtering criteria in preserving the most meaningful and interconnected terms while eliminating noise from methodological artifacts. This careful curation process enhances the reliability and interpretability of the subsequent bibliometric visualization and temporal analysis presented in the study [34].

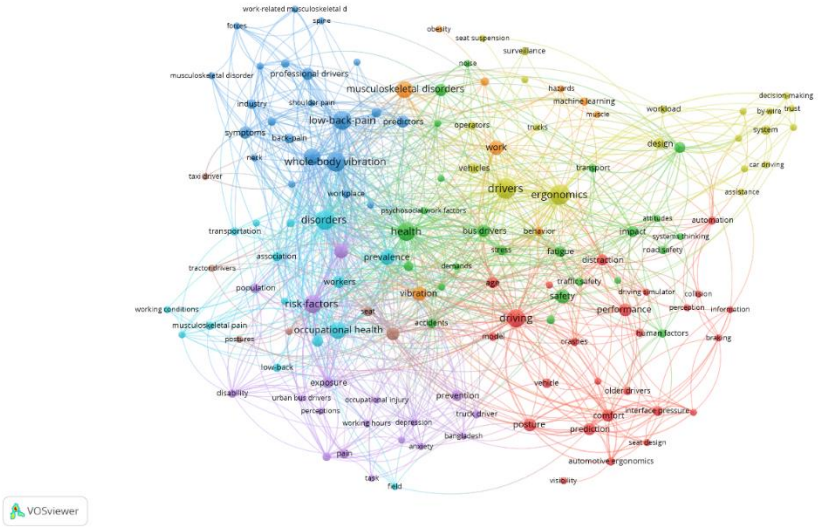

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Figure 3. Keyword/cartographic analysis

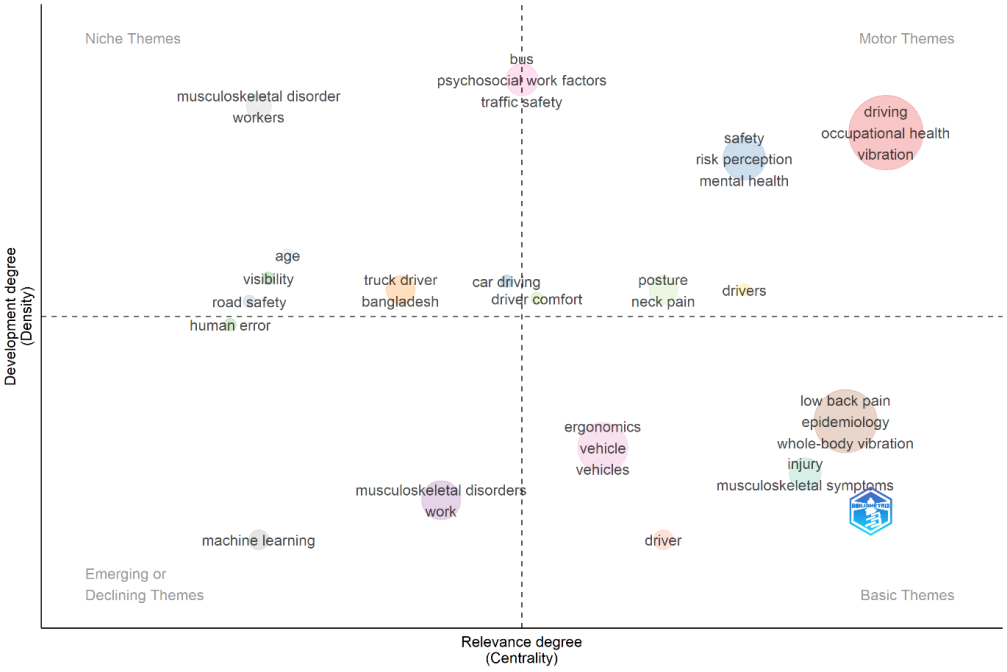

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Figure 4. Topic map

3.1.3. Analysis of Thematic Map Distribution

Figure 4. As shown in the thematic map, research themes are strategically distributed across four distinct quadrants based on density level and level, revealing the current state and future potential of various research areas within the field [35]. The Motor Themes quadrant (upper right) contains the most developed and central research areas, including "exposure," "prevention," "disorders," "whole-body vibration," "low-back pain," "drivers," "ergonomics," and "health." These themes have attracted significant scholarly attention and achieved substantial research results, similar to how driving fatigue detection research has flourished through face recognition and electroencephalography-based approaches [36]. The prominence of ergonomics and health-related themes indicates well-established research foundations with high practical relevance.

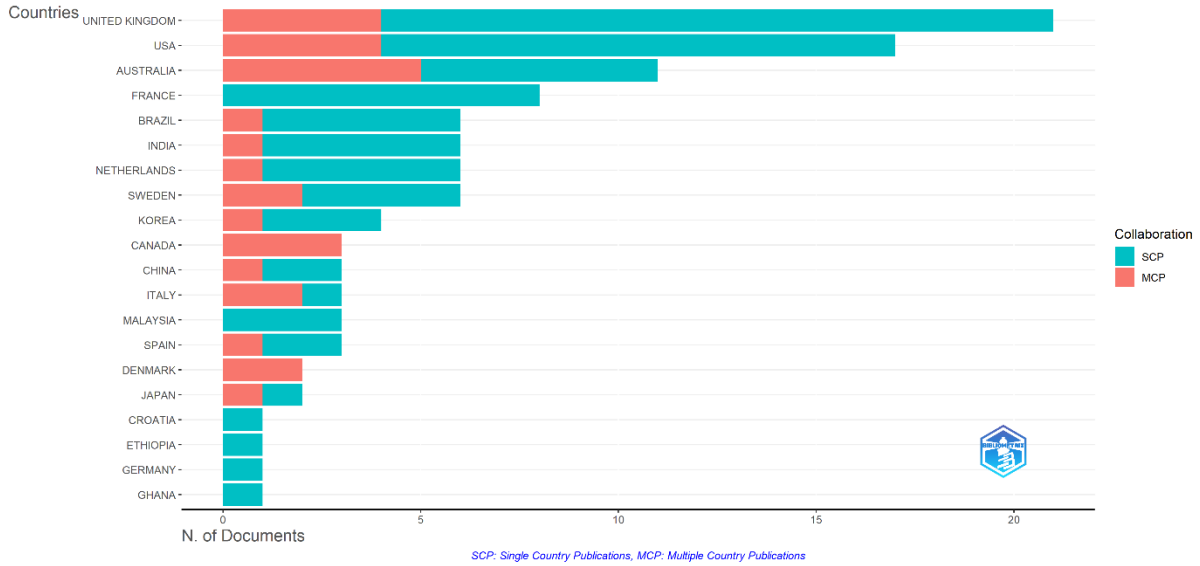

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Figure 5. Corresponding Author's Countries

3.1.4 Analysis of Corresponding Author's Countries

The distribution of corresponding author's countries reveals global research leadership and international collaboration patterns. The chart displays countries ranked by document output, with teal representing Single Country Publications (SCP) and coral indicating Multiple Country Publications (MCP) [37].

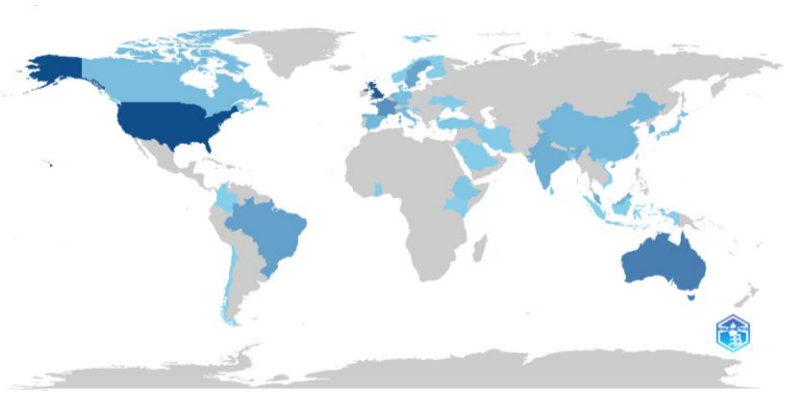

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Figure 6. G**lobal distribution of research**

The United Kingdom leads with approximately 20 documents, showing balanced distribution between domestic and international collaborative research, indicating strong research capacity and active global partnerships. The USA follows closely with similar output and collaboration patterns, reinforcing Anglo-American dominance in research leadership.

Australia ranks third with around 12 documents, demonstrating substantial contribution relative to population size and strong collaborative tendencies. France shows approximately 8 documents comprised entirely of single-country publications, suggesting independent research approaches or robust domestic networks.

Brazil, India, Netherlands, and Sweden contribute moderately (4-6 documents each) with varying collaboration patterns. Netherlands and Sweden show predominantly collaborative research, reflecting European integration, while Brazil and India display mixed approaches.

Asian representation includes Korea and China with emerging research presence. Korea demonstrates balanced collaboration, while China shows primarily single-country publications, possibly reflecting rapid domestic expansion.

Remaining countries (Canada, Italy, Malaysia, Spain, Denmark, Japan, Croatia, Ethiopia, Germany, Ghana) contribute smaller numbers but represent diverse geographical participation. Countries showing only single-country publications may indicate developing research infrastructure, while established nations with limited representation suggest field-specific focus rather than capacity limitations.

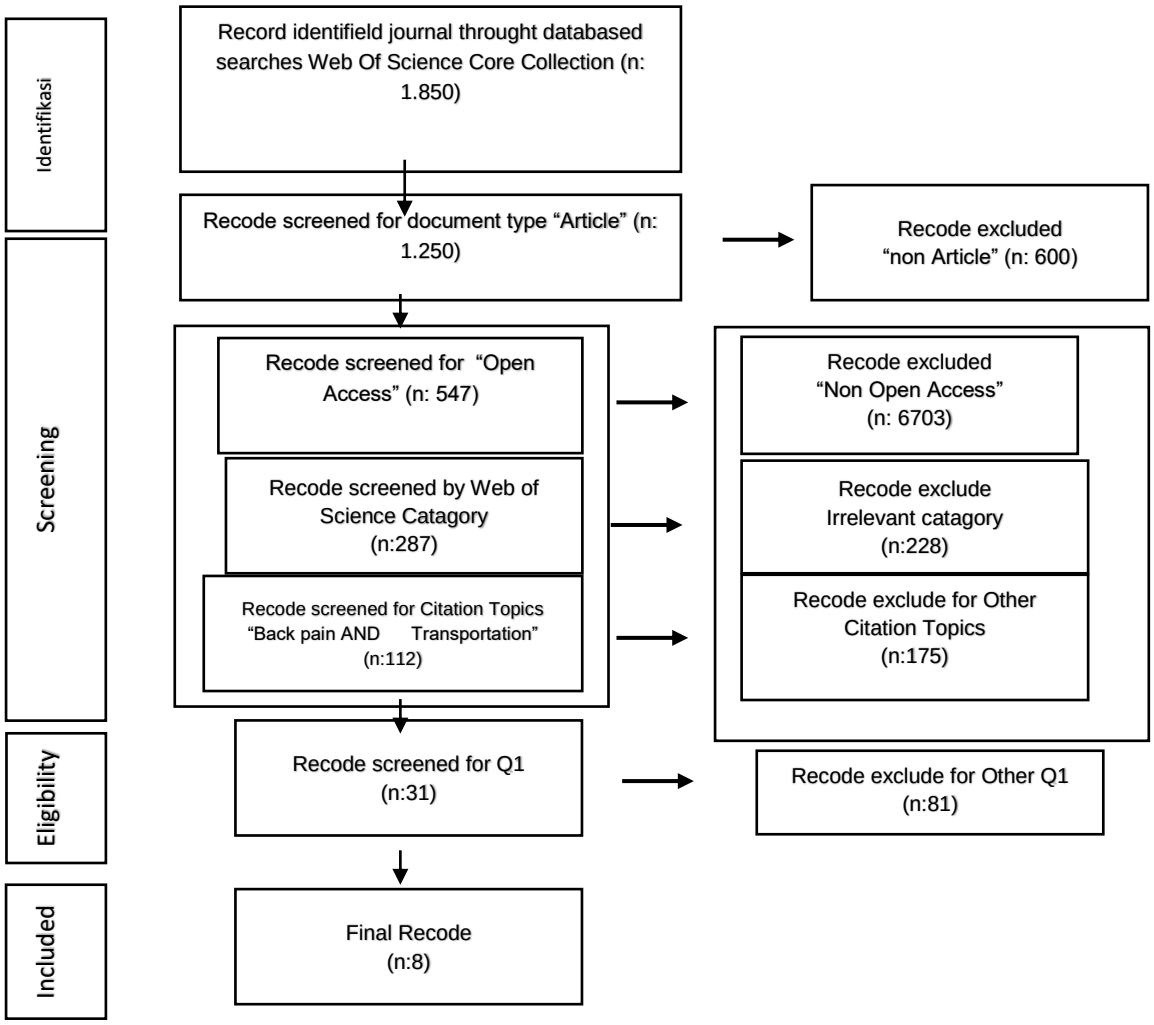

Figure 7. PRISMA Flow Diagram of Literature Review Process for Fire Protection Systems

Table 1. Characteristic of Reviewed Studies

Author	Methods	Results	Objectives	Research Gap
[38]	- The research paper employs an intervention program aimed at changing behavior aspects towards whole body vibration (WBV) exposure, utilizing the ASE model, which focuses on attitude, social influence, and self-efficacy. - The effectiveness of the intervention is evaluated based on the main outcome of reduced WBV exposure, which is measured according to the international ISO standard 2631-1 and the VIBRISKS Protocol. - Data collection includes the use of a self-administered VIBRISKS questionnaire to assess WBV exposure and health surveillance measures for both workers and the working environment.	- The paper discusses the implementation of an intervention program aimed at reducing whole-body vibration (WBV) exposure among drivers. - It emphasizes the importance of health surveillance, which should lead to effective interventions to mitigate WBV risks. - The results of field measurements regarding WBV exposure will be communicated to drivers through newsletters and to employers via general reports, enhancing awareness of exposure levels. - The effectiveness of the intervention will be evaluated based on a decrease in WBV exposure and changes in attitudes towards WBV among drivers, contributing to long-term reductions in related health issues.	- The primary objective is to reduce whole body vibration (WBV) exposure among drivers through behavior change interventions - The intervention aims to increase awareness of WBV risks and promote behavior changes to mitigate exposure - The study hypothesizes that reducing WBV exposure will lead to decreased low back pain (LBP) risk over time. - The research utilizes the ASE model to develop strategies for changing attitudes and behaviors regarding WBV exposure.	- There is a lack of evidence on effective strategies to reduce WBV exposure, necessitating reliance on previous studies and literature. - The paper identifies a need for more research on the effectiveness of intervention programs targeting WBV exposure. - The determinants of WBV exposure are not fully understood, particularly regarding behavior aspects. - The study highlights the necessity for a participative and multifaceted approach in intervention strategies.
[39]	- Linear regression analysis was performed to compare drivers' anthropometry with seat dimensions using R software version 3.3.1. - Two-sample t-tests were conducted to assess differences between anthropometric data and seat dimensions for various truck brands. - Data collection involved structured questionnaires completed by truck drivers and a control group. - The sample size was determined	- The study found significant mismatches between truck seat dimensions and Bangladeshi drivers' anthropometric measurements. - Recommended seat dimensions were appropriate for 82%, 79%, 76%, 98%, and 100% of drivers respectively. - The analysis indicated that existing seat dimensions were inappropriate for nearly all truck brands. - Ergonomically correct seat designs are expected to reduce health issues and enhance comfort for drivers. - The study utilized statistical modeling to derive optimal seat dimensions.	- The study aimed to investigate the fitness of existing truck seats for Bangladeshi truck drivers based on their anthropometry - It sought to analyze the mismatch between seat dimensions and drivers' anthropometric measurements. - The research intended to recommend optimal seat dimensions to enhance driver comfort and safety. - The study also aimed to develop guidelines for designing ergonomically correct truck seats.	- There are no prior studies on truck drivers' anthropometry and seat dimensions specific to Bangladesh. - The study highlights a significant mismatch between seat dimensions and drivers' anthropometry. - Existing seat dimensions were found inappropriate for Bangladeshi drivers, indicating a need for better ergonomic designs.

Author	Methods	Results	Objectives	Research Gap
	using Hicks' method with a 90% confidence level. - Anthropometric measurements of 120 truck drivers aged 30 to 60 years were analyzed. - Recommendations for ergonomically correct seat dimensions were developed based on the analysis.		- Statistical modeling was used to derive appropriate seat dimensions for Bangladeshi truck drivers.	- The research suggests developing guidelines for truck seat design, which remains an area for further exploration.
[18]	- The paper discusses the assessment of occupational disease risks among passenger bus drivers, focusing on the impact of hazardous hygienic factors in their working environment. - It utilizes formulas to determine scores that assess the likelihood of disease based on the intensity of harmful work-related factors, as proposed by Professor Minko V.M. - The methodology includes evaluating the safety level of the working environment and calculating the generalized risk level associated with various harmful factors such as noise, vibration, and harmful substances. - The study emphasizes the need for unified methodological approaches to effectively assess professional risks.	- The paper presents a comprehensive assessment of the risks of occupational diseases among passenger bus drivers, highlighting the impact of various harmful work-related factors. - It identifies specific consequences of these factors, such as noise leading to hearing loss and increased blood pressure, and vibration causing cardiovascular and musculoskeletal disorders. - The results include calculated generalized risk levels based on work experience and the deviation of actual risk levels from maximum admissible limits. - The findings emphasize the need for improved safety measures in the working environment of bus drivers to mitigate these health risks.	- The objective is to describe occupational health risks for passenger bus drivers that lead to deteriorating health. - It aims to assess the impact of hygiene hazards on drivers' health. - The research seeks to predict occupational diseases related to cardiovascular and musculoskeletal systems.	Not addressed in the paper.

Author	Methods	Results	Objectives	Research Gap
[40]	- The study employed a combination of objective and subjective data collection methods to investigate professional bus drivers' experiences and acceptance of the narrow navigation system (NNS). - Data were gathered through interviews, questionnaires, and video recordings during and after the test-drive. - A thematic analysis was conducted on the interview data to identify themes and patterns, while questionnaire data were compiled to complement the interview findings. - The triangulation of methods allowed for cross-checking findings and compensating for the weaknesses of individual methods, enhancing the robustness of the conclusions drawn.	- The study found that professional bus drivers exhibited high levels of trust and acceptance towards the narrow navigation system (NNS) designed for automatic docking at bus-stops. Participants described their experience as "comfortable," "fun," and "exciting," with positive ratings on the acceptance questionnaire, particularly regarding the system's usefulness and appropriateness for the task. However, concerns were raised about the reliability of the system and its impact on control during docking. The docking process was perceived as slow, which could potentially affect timetabling and increase stress levels for drivers. Overall, the findings highlighted the importance of considering user acceptance across different operational levels.	- The study aims to develop knowledge on professional bus drivers' experiences with an advanced driver-assistance system (ADAS) for docking at bus-stops - It investigates user acceptance and trust in the narrow navigation system (NNS) during test-drives . - The research focuses on collecting both objective and subjective data to assess perceived benefits and challenges of the NNS . - The study seeks to analyze how different levels of acceptance affect user experience and system design .	- There is limited research on advanced driver-assistance systems (ADAS) in buses despite their growing interest in the sector - The study highlights the need for considering organizational issues in user acceptance of automated systems - Existing acceptance scales may not adequately account for differences between operational, use, and work system levels . - The paper suggests that factors influencing trust and acceptance may be overlooked without considering all three levels.
[4]	- The study employed a genetic algorithm (GA) for optimization, with mutation rates ranging from 0.01 to 0.1 and a crossover rate of 0.8. - The roulette wheel selection method was utilized to select individuals from the population for reproduction during the GA process. - The Cooper-Harper rating scale was used to evaluate participant preferences regarding the	- The study demonstrated that the AR-HUD interface optimized using the IVPM-GA method significantly outperformed the BP-GA method in terms of driving performance. - The findings indicated that the IVPM-based genetic algorithm effectively optimized interface design while enhancing user experience and improving driving performance. - The results highlighted the potential of optimized AR-HUD interfaces to lower cognitive load and reduce visual	- The study aims to optimize AR-HUD visual interaction for professional drivers using machine learning techniques to reduce cognitive load and visual fatigue. - It focuses on developing an optimized AR-HUD interface design using the IVPM method and comparing it with the BP-GA method. - The research assesses the implications of optimized AR-HUD interfaces for occupational health	- Future research should assess the OSH effects of real-time image processing, focusing on cognitive load and distractions. - There is a need to optimize user interfaces to reduce cognitive load and distractions. - Future studies should explore the implications of OSH in driving scenarios

Author	Methods	Results	Objectives	Research Gap
	interface design optimized by the IVPM-GA method. - The research emphasized the integration of advanced technologies, such as Augmented Reality Head-Up Displays (AR-HUD), to enhance driver safety and occupational health.	distractions, ultimately enhancing driver safety. - The majority of participants preferred the IVPM-GA method, indicating its effectiveness in occupational health and safety contexts.	and safety (OHS) of professional drivers . - It aims to predict cognitive load in AR-HUD design and evaluate its impact on driving performance and user experience. - The study lays a foundation for future OHS policies and training programs based on its findings.	with real-time image processing. - The integration of real-time image processing with driver assistance systems requires further investigation. - Research should focus on performance and efficiency while considering OSH implications in AR-HUD technology.
[41]	- A post-hoc analysis was conducted from a survey exploring TNC drivers' beliefs and views on climate change and COVID-19. - Data collection occurred between October and December 2020 in Washoe County, Nevada. - Two post-hoc survey questions were added regarding TNC driving experience during the pandemic. - Participants were categorized based on their beliefs and concerns about COVID-19 and climate change. - Open-ended responses were analyzed using inductive content analysis. - The study received exempt determination from the University of Nevada, Reno Institutional Review Board. - Content analysis and descriptive statistics were used to analyze the collected data.	- A total of 16 participants were full-time TNC drivers, while others drove for additional income or during retirement. - Participants reported an average of 2.3 years of TNC driving experience. - The COVID-19 pandemic significantly affected TNC business, altering driver availability and ride lengths. - More participants believed in COVID-19 than in climate change, but fewer were concerned about COVID-19. - Some participants felt the pandemic positively impacted the climate by reducing air pollution. - Few participants believed climate change could lead to future pandemics.	- The study aimed to understand TNC drivers' professional experiences during the COVID-19 pandemic. - It also sought to explore their opinions on climate change and future pandemics. - The research intended to investigate the intersection of climate change and pandemic impacts on TNC drivers. - The study aimed to identify solutions for occupational health needs related to these crises.	- The study had a small sample size due to late IRB approval, indicating a need for larger studies. - Future research should explore the intersection of climate change and pandemics over time. - There is a lack of understanding among participants regarding the connection between climate change and pandemics. - Future studies could utilize validated survey instruments to enhance data reliability. - The impact of climate change on public health messaging needs further investigation. - The study suggests exploring the experiences

Author	Methods	Results	Objectives	Research Gap
				of other essential workforces affected by both crises.
[42]	- A cross-sectional study design was employed to assess low back pain (LBP) prevalence among professional bus drivers in Bangladesh. - The study involved 368 professional bus drivers who were surveyed using a semi-structured questionnaire. - The Nordic Musculoskeletal Questionnaire (NMQ) subscale was utilized to measure the presence of LBP among participants. - Multivariable logistic regression analysis was conducted to identify factors associated with LBP, allowing for the adjustment of potential confounders. - Written informed consent was obtained from each respondent prior to participation in the study.	- The study found that 34.51% of the 368 professional bus drivers reported experiencing low back pain (LBP) in the last month. - Factors positively associated with LBP included being over 40 years old (aOR: 2.07), earning more than 15,000 BDT per month (aOR: 1.91), working over ten years (aOR: 2.53), working more than 15 days per month (aOR: 1.93), and working more than 10 hours per day (aOR: 2.46). - Additionally, poor driving seat conditions (aOR: 1.80), current smoking habits (aOR: 9.71), illicit substance use (aOR: 1.97), and sleeping four hours or less per day (aOR: 1.83) were also linked to LBP.	- The study aimed to estimate the prevalence of low back pain (LBP) among intercity bus drivers in Bangladesh. - It sought to assess possible contributing factors to LBP among this population. - The findings are intended to assist policymakers in prioritizing risk-reduction actions. - The research also aims to address the existing knowledge gap regarding LBP among Bangladeshi bus drivers.	- There is a considerable research gap regarding low back pain (LBP) among Bangladeshi intercity bus drivers. - The study did not include whole-body vibration, psychosocial factors, and night shift driving as risk factors. - Limitations in concluding causal relationships were noted due to the study's design. - The target sample size of 380 was not met, impacting the study's comprehensiveness. - The paper highlights a lack of reports on illicit substance use among bus drivers in Bangladesh.

Author	Methods	Results	Objectives	Research Gap
[43]	- The study utilized the Cervical Range of Motion (CROM) method to assess cervical mobility, employing a smartphone clinometer and compass application validated by Khan RA et al. for capturing cervical movements in various planes. - A total of 100 participants were recruited from local car and bike driving communities, with specific exclusion criteria to ensure the integrity of the sample. - Proprioceptive accuracy was evaluated using the Joint Position Error (JPE) Test, which measures the ability of participants to accurately return their head to a neutral position after movement.	- The study found that Forward Head Posture (FHP) adversely affects the positional sense of the cervical joint, leading to altered proprioceptive feedback due to modified muscular and capsular tension in the cervical spine. - Participants with FHP exhibited differences in neck pain, mobility, and proprioception compared to those without FHP. - The research utilized Surgimap software to measure FHP and assessed cervical range of motion, revealing significant findings related to neck discomfort among drivers. - Overall, the results align with existing literature on the negative impacts of FHP on neck health.	- The research aims to devise targeted interventions for correcting Forward Head Posture (FHP) in drivers. - It seeks to inspire further investigations in vehicle ergonomics and driver education - The overarching goal is to improve drivers' health and quality of life, particularly regarding musculoskeletal issues. - The study emphasizes the need for longitudinal analyses and a diverse participant pool for broader insights . - It aims to explore the relationship between FHP, vehicle type, and driving habits .	- The study identifies a need for longitudinal studies to better understand the effects of FHP over time . - A broader participant pool is necessary to enhance the generalizability of the findings. - There is a gap in comparative assessments between different vehicle types and their impact on FHP - Future research should explore the intricate relationship between FHP, vehicle type, and habitual driving patterns . - The study suggests that tailored interventions based on vehicle type are needed, indicating a gap in current intervention strategies .

3.1.5 Analysis of Country Scientific Production Distribution

On Figure 6. The global distribution of scientific production reveals significant geographical patterns in research capacity and output across different regions. Based on the world map visualization, countries are color-coded according to their research productivity levels, with darker shades indicating higher scientific output [44].

North America, particularly the United States, demonstrates the highest research concentration with the darkest blue coloring, establishing it as the dominant global contributor. This reflects substantial research infrastructure, extensive university networks, and robust funding mechanisms.

Europe shows considerable regional strength with several countries displaying medium to high productivity levels. Germany, the United Kingdom, and France appear as notable contributors, while Nordic and Western European nations demonstrate moderate activity, indicating strong regional research ecosystems and collaborative networks.

Asia presents varied research landscapes. China exhibits significant output (darker blue), reflecting rapid research capacity expansion and increased scientific investment. Japan, South Korea, and India show moderate contributions, indicating emerging regional research capabilities. Australia stands out in Oceania with substantial research contributions relative to its population, demonstrating efficient resource utilization and focused research priorities.

Africa and South America predominantly show gray coloring, indicating limited research output in this field. This pattern likely reflects resource constraints, infrastructure limitations, and different research priorities.

The distribution reveals clear concentration in developed economies, highlighting global inequalities in scientific capacity. The pattern suggests established research leaders in North America and Europe, emerging powerhouses in Asia, and significant opportunities for enhanced international collaboration to address research gaps across underrepresented regions, particularly in developing countries.

Discussion

Even though many studies have raised this topic about public transportation drivers related to musculoskeletal disorders and recommended various interventions, only a few studies have resulted in comprehensive intervention development [45]. Even more specifically, studies that conduct post-intervention assessments to evaluate the effectiveness of these programs [46]. Studies on occupational health hazard assessment have been conducted worldwide [18], however the majority of intervention studies are mostly reported from developed countries [47]. Despite high numbers of assessment studies from developing countries like India and Brazil, comprehensive intervention studies remain limited [48]. There is a clear need for preventive efforts in driver occupational health, including improved ergonomic tools and specialized training programs [49]. In LMICs, policy barriers such as inadequate funding, poor regulatory enforcement, and exclusion of informal drivers from labor protections significantly hinder intervention implementation, requiring comprehensive policy reforms to address these systemic challenges.

If the main causes that lead to environmental injuries among drivers can be identified, then effective interventions can be designed. It is necessary to conduct scientific categorization of driving task responsibilities, exposure duration, and related threats [50]. As most literature concentrates on cross-sectional studies, longitudinal studies can ensure evidence-based research [51]. Majority of assessment research is questionnaire-based, requiring direct measurement techniques such as whole-body vibration analysis and real-time postural assessment [52], [53].

The consequences of combining several interventions without scientific evidence among professional drivers result in the most significant impact in reducing musculoskeletal disorders [40], although independent technical and administrative controls can also provide positive effects. Work procedures, work environment, work equipment, and workload significantly cause musculoskeletal disorders among driving workers [54]. The resulting impacts must be considered holistically, as technical requirements may be highly dependent on workload, visual fatigue, and muscle fatigue [55].

Interventions that are beneficial in developed countries may not be suitable for application in developing countries due to social and economic reasons [22]. In countries like India, driver occupational health management systems face socioeconomic, infrastructural, and legal barriers. Commercial vehicle drivers are exposed to significant hazards, requiring specific intervention

measures [56]. Elderly and female drivers in developing countries are not considered in the literature, although they are often forced into driving work due to economic pressures. Specialized studies must ensure intervention adaptability among vulnerable groups. Specific interventions should be developed for these marginalized populations.

This research demonstrates several strengths including comprehensive coverage of global trends and international collaboration patterns, clearly articulated methodology with specific database and analytical tools, and effective identification of concrete research gaps in intervention development. However, it has notable weaknesses such as lack of quantification for average annual publication growth rates, overly specific and potentially irrelevant search date, and insufficient elaboration on policy barriers in developing countries

No studies on evaluation and improvement of personal protective equipment for professional drivers have been reported, despite many assessment studies recommending their use [57]. Occupational risks associated with driving tasks are influenced by personal safety equipment such as ergonomic seat belts, protective clothing, masks, or back braces. Informal drivers usually work without minimum protective equipment due to cost constraints [58]. Cost-effective ergonomic interventions have maximum acceptance potential. Workers often avoid personal protective equipment because it is inconvenient, difficult to use, or of poor quality. There is scope for investigating effectiveness of driver-specific personal protective equipment.

Conclusion

This bibliometric analysis systematically examined three decades of musculoskeletal driver health research using the Web of Science database, analyzing publication trends, geographical distribution, international collaboration, research categories, and keyword co-occurrence patterns. Research experienced sustained growth from the early 1990s with rapid expansion post-2013, initially led by developed nations including USA, UK, and Europe, recently joined by emerging contributors such as China, India, Brazil, and Australia. Publications span diverse disciplines, dominated by "Public Environmental" research with 69 publications, followed by "Engineering" categories. The UK, USA, and Australia lead international collaborations, with four thematic clusters identified: Motor, Basic, Niche, and Emerging Themes. Core research focuses include whole-body vibration, low-back pain, and ergonomic interventions representing mature domains with established theoretical foundations. Future directions emphasize technological integration, automation, and comprehensive health monitoring approaches for developing evidence-based driver health interventions globally.

Declaration

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Conflicts of Interest: n/a

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