

Evaluation of Car Following Driver Behavior: A Systematic Review

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ABSTRACT

Investigating car-following driver behavior is essential for increasing traffic safety, optimizing transportation, and developing autonomous vehicle technology. This importance has made studying this behavior in complex traffic situations and in autonomous vehicles a key research topic. The present survey provides a comprehensive overview of driver behavior in car-following with a focus on the period from 2015 to 2025. The search involving all databases combined yielded 3,870 original articles, of which 10 relevant ones were included for detailed qualitative and comparative reading. The survey underscores important behavior variables: time headway, reaction time, braking behavior, and lane-changing behavior with disparate research approaches in driving simulators, naturalistic driving data, and simulation models. Empirical evidence is provided that driver distraction, hostile driving, and high-tech automated systems greatly affect car-following behavior and traffic safety. Additionally, the need for adaptable models is illustrated through the variations across regions and societies, influencing both parameter tuning and the cross-context applicability of car-following models. Sample size variation among studies provides evidence of the importance of combining detailed individual-level data with broader system-level analysis. The review identifies gaps in geographical range, particularly in low- and middle-income countries, and calls for further studies combining naturalistic driving data and customized behavioral models to promote the safety and efficacy of car-following systems worldwide.

1. Introduction

The mobility interaction of a following vehicle in relation to the vehicle directly ahead of it is referred to as car-following behavior [1]. The constant movement within car-following behavior occurs when a driver adjusts their speed, acceleration, or headway based on their reading of the movement of the lead vehicle [2]. Car-following behavior contributes to traffic safety, traffic operations, energy consumption, and overall driving comfort [3]. Safe and consistent time headway is required to prevent rear-end crashes and minimize fuel consumption and emissions [4-6]. Driver attention, perception-reaction time, risk perception, and aggression [7].

In this case, car-following behavior is essential for conducting microscopic traffic modeling based on real driver behavior, and the technology aspect of conducting e-safety work is crucial for Advanced Driver-Assistance Systems (ADAS) and Connected Autonomous Vehicles (CAVs) [8, 9]. The driver's individual characteristics (e.g., age, identification as male, driving experience, risk tolerance, cognitive capability) are crucial in understanding how a driver follows another vehicle [10-14].

The robustness of modeling and predicting car-following behavior will also be impacted by environmental factors (such as road geometry, weather, and traffic density) and vehicle characteristics (such as vehicle size, acceleration, braking systems, and visibility) [15, 16]. Emerging Advanced ADAS and CAVs will introduce new behavioral characteristics (such as following distance, reaction times, and trust in automation) that will alter the driver's expectations and develop new levels of anxiety and uncertainty when

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following a vehicle [17-19]. While driving simulators and controlled experimental conditions offer repeatable, safe environments to study car-following behavior, they do not include many facets of naturalistic driving behavior, leading to the need for context-relevant, multi-faceted approaches to study car-following behavior in various settings and under various conditions [20-25].

The landscape of car-following behavior has changed due to the advent of advanced intelligent transportation technologies like ADAS, CAVs, and Cooperative Adaptive Cruise Control (CACC) [26-28]. Although these technologies increase safety, reduce driver burden while driving, and improve travel efficiency [29], drivers may have varying degrees of trust, flexibility, and situational awareness when interacting with automation and other connected devices/systems [30, 31].

Numerous methods have been used in empirical research to investigate car-following behavior [3, 32]. For instance, McNabb et al. compared how drivers behaved in a "follow-a-friend" scenario with a typical following scenario using a driving simulator [33]. Using the technique of investigating distraction in a platoon, Xu and Lin investigated the impact of distraction propagation. In their experimental study, they discovered that all subsequent drivers may experience a change in gap and a delayed reaction time if the lead driver is distracted [34]. When Goncu et al. used a SUMO simulation to examine car-following behavior in Germany and Turkey, they discovered differences that matched the local traffic culture norms [35].

At present, there are chances to streamline and improve the generalizability of the literature through the construction of a systematic outline that organizes and integrates the outcomes against each of the determinants of the driver's characteristics, scenario, technology use, and cultural background. By organizing, connecting, and comparing studies, we aim to build on this knowledge of car-following behaviors across different contexts and uncover wider behavioral patterns or trends moving forward [36]. Moreover, we aim to provide guidance on the development of future and more inclusive models of car-following behavior [37].

This review categorizes studies based on dimensions, such as driving scenario, type of distraction, and driver characteristics. This review brings together previous studies and highlights less explored aspects of contextual differences in driving behavior, and the changes in technology found within vehicles. This study seeks to create a conceptual framework for future research on the topics of assistance systems, data-driven smart transportation, and modeling techniques that analyze traffic behavior.

Section 2 provides details on the methodology used for the systematic review, including the search strategy and the eligibility requirements. The main conclusions are presented and discussed in Section 3, including where they occurred, how people behaved, what caused them to lose concentration and what helped them, and the most significant findings of the research that was examined. The work is concluded in Section 4, which summarizes the main conclusions, identifies research gaps, and suggests areas for further study.

2. Methodology

In order to fully understand the existing literature on driver behavior when driving behind other vehicles and its traffic safety implications, a systematic review of the literature was conducted. The review aimed at locating, critiquing, and synthesizing relevant.

2.1. Search strategy

Relevant articles were retrieved from Scopus, Web of Science, and IEEE Xplore. The search was performed using the following combination of keywords: ("driver behavior" OR "driving behavior") AND ("following vehicles" OR "car-following" OR "tailgating") AND ("traffic safety" OR "road safety") AND ("risk assessment" OR "reaction time").

A detailed scrutiny of 3,870 published articles related to car-following driver behavior, traffic safety, risk, and reaction time was undertaken with a focus on the period from 2015 to 2025. In accordance with PRISMA guidelines, the screening phase of articles included multiple steps, such as the elimination of duplicate articles, a preliminary scrutiny of article titles and abstracts, and a detailed scrutiny of articles that qualified after abstract scrutiny. Additional criteria that were used towards the elimination of articles included the absence of relevance with respect to car-following driver behavior, inadequate description of methods, inadequate data, and a lack of synchrony with the review period. After a thorough examination of papers pertinent to the review and meeting its publishing deadline, ten articles with the greatest level of rigor and relevance were ultimately shortlisted. A PRISMA flowchart (Fig. 1) graphically depicts the selection of articles as well as the quantity of articles in the scrutiny stage. The final ten papers underwent a thorough analysis with the goal of identifying the most important conclusions and any gaps in driver behavior during car following. The detailed exclusion criteria applied at each screening stage are summarized in Table 1, in accordance with the PRISMA framework.

3. Result and discussion

This systematic review contrasts car-following driver behavior research from various countries, methodologies, and regions [38]. Ten studies were selected, each of which considered various aspects, including time headway, reaction time, lane-changing behavior, braking behavior, and traffic flow stability [39]. The literature was compared primarily using driving simulators and model-based simulation, with some using naturalistic driving data or mixed-method designs [40]. External perturbations like driver distraction, aggressive driving styles, and automated systems were also taken into account. Findings show that such factors can significantly alter car-following behavior, either introduce safety hazards or modify system performance.

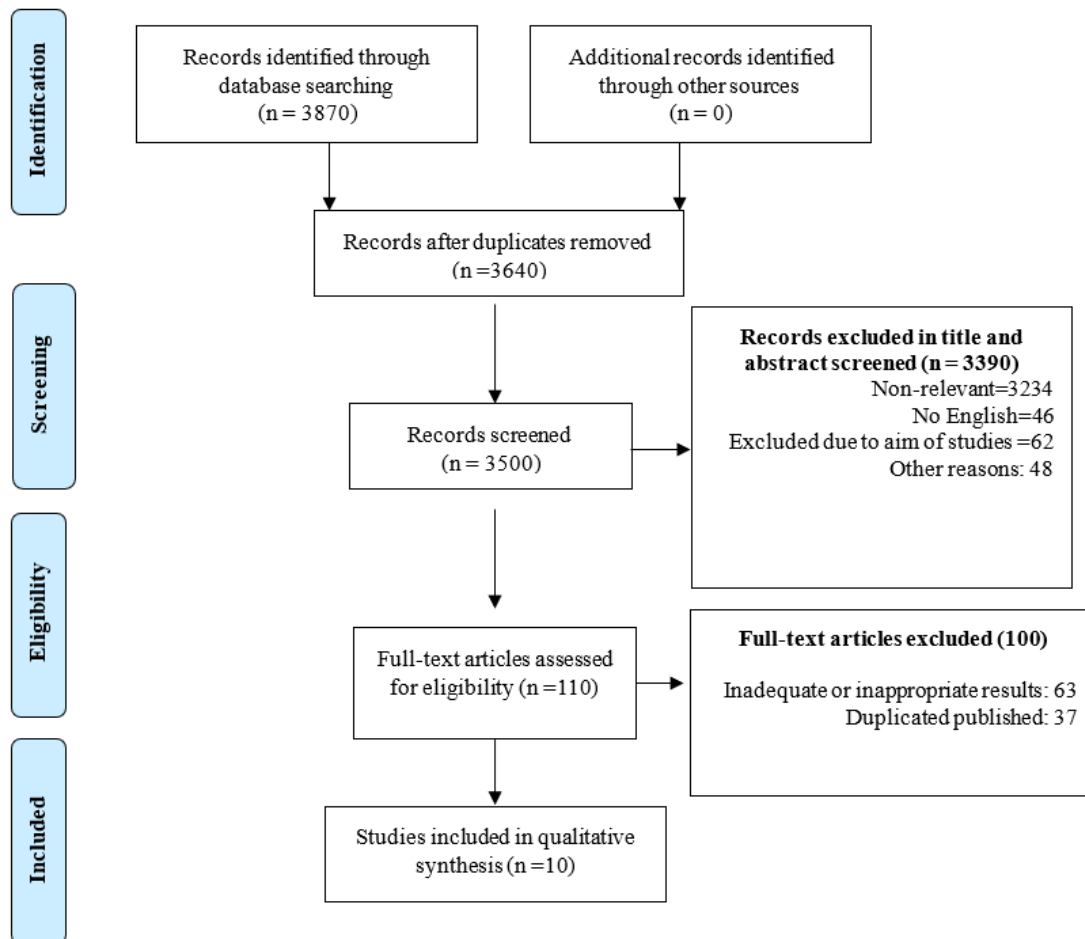


Fig. 1. PRISMA flowchart.

Table 1. Eligibility criteria for article selection before PRISMA-based screening.

Screening stage	Exclusion criterion	Number of excluded records	Explanation
Duplicate removal	Duplicate records	230	Records appearing more than once across databases were removed prior to screening.
Title & abstract screening	Not relevant to car-following behavior	3,234	Studies not directly addressing car-following behavior, driver behavior, or related traffic safety aspects.
Title & abstract screening	Non-English publications	46	Articles not published in English were excluded to ensure consistent interpretation.
Title & abstract screening	Outside study objectives	62	Studies focusing on unrelated traffic topics without behavioral or car-following relevance.
Title & abstract screening	Other reasons	48	Editorials, conference abstracts, commentaries, or papers lacking sufficient scientific content.
Full-text eligibility assessment	Inadequate or inappropriate results	63	Full-text articles lacking empirical results or methodological rigor relevant to car-following behavior.
Full-text eligibility assessment	Duplicate publications	37	Studies reporting overlapping or previously published results were excluded.
Final inclusion	Studies included in qualitative synthesis	10	Studies meeting all inclusion criteria and selected for in-depth qualitative analysis.

Several studies also mentioned the impact of cultural or traffic system differences on the applicability and calibration of car-following models [41, 42]. Each study was presented in detail, including the driving scenario, intervention type, behavioral measures, and key findings (Table 2).

3.1. Geographical distribution and regional focus in car-following behavior research

The studies on car-following behavior reveal global trends and regional variability. The United States (US) contains the largest number of studies, reflecting a large research infrastructure and an emphasis on the research of connected vehicle technologies. Germany, Turkey, India, China, Canada, Japan, and Australia are contributing to the research community in car-following behavior as well, which is important for illustrating real-world behaviors or culturally influenced behavior, and shows the need for cultural and regional calibration of car-following models.

Table 2. Studies summary.

No.	Author(s) and year	Country name	Sample size	Distraction / Intervention	Behavioral variables	Key findings
1	McNabb et al., 2017 [33]	USA	16 drivers	None	Speed, Time Headway, Lane Change	“Follow-a-friend” increases risky behavior
2	Xu & Lin, 2018 [34]	USA	36 (12 platoons)	Cellphone texting	Reaction Time, Headway	Distraction spreads behavioral risk in a platoon
3	Zhou et al., 2023 [43]	USA	72 participants	CAV control settings	Time headway, CF behavior, Lane change	CF behavior affected by CAV control, congestion, and demographics; string-stable CAV preferred
4	Goncu et al., 2022 [35]	Turkey & Germany	Model-based	None	Traffic flow, Throughput	Cultural differences affect CF modeling
5	Adavikottu et al., 2023 [44]	India	58 drivers	Aggression profile	Tailgating, Reaction Delay	Aggressive drivers show higher tailgating & crash risk
6	Fricke et al., 2015 [45]	Germany	40 drivers	System intervention	Brake/steer reaction	Users resist automation unless briefed in advance
7	Ozkan & Ma, 2021 [46]	Canada	Not stated	CAV interaction	Fuel use, Following pattern	CAV improves follower fuel use; varies by driver type
8	Hatazawa et al., 2023 [47]	Japan	Not stated	LSTM modeling	Model accuracy (R ²)	LSTM models benefit from tuning; high personalization potential
9	Rahman et al., 2017 [48]	USA	Model-based	CACC system	Acceleration, String Stability	OVM model offers better comfort/dynamics than IDM
10	Hussain et al., 2025 [49]	Australia (based on institutional affiliations)	61 participants	Speed limit + lead vehicle	Rear-end risk, Headway, Demographics	Female, young, and low-experience drivers = higher crash risk

However, the presence of regionally-informed studies indicates that behavioral tendencies are not universally consistent and that transportation systems or driver assistance technology may not apply or translate cleanly from one region to another. The review encourages a higher proportion of geographically representative studies in the future, especially in low-and-middle income countries with typical driver behavior and relevant regulatory context that may differ markedly from high-income countries. This is necessary for developing adaptive and globally relevant car-following models that will contribute to improved safety and system efficiency in increasingly diverse traffic environments [50].

3.2. Sample size

The studies reviewed for car-following behavior analysis have different sample sizes, which were based on several factors, including experimental groups, models, and the exact number of participants was often not disclosed. The differences in sample size reflect the differences in methodology and served a different research purpose. Even though conducting research with a small sample size permits greater detail in the analysis of individual-level behavior, a smaller sample size will limit generalizing findings to other populations. Traffic bottlenecks and system-level interventions have been the main focus of model-based and simulation-based research. They typically don't, however, offer insights into behavioral analysis at the individual level. Larger and more varied sample sizes are generally better at approximating individual variability in driver attributes (e.g., age, gender, or driving experience) that are directly linked to risk and car-following behavior. In order to improve future repeatability and support more thorough meta-analyses, several researchers failed to disclose the sample size in their study. The aforementioned assessment of car-following behaviors' variations in sample size offers valuable opportunities to investigate both macroscopic traffic system dynamics and microscopic driver behavior [16, 36, 51]. In order to improve the ecological validity of studies that simulate car-following behavior, future research should benefit from bigger, more diversified sample sizes as well as sample sizes collected through naturalistic driving.

3.3. Distraction and intervention factors

Fig. 2 illustrates the effects of different distractions and interventions on driving behavior using the index of Normalized Behavioral Change Index (NBCI) measures. The index measures the variations in the following distances away from a baseline standard of a safe following distance. A positive index score represents greater instability and increased variations in distances, and a negative index score represents stabilizing effects, which improve safe distances. The analysis shows that the main risk factors for behavior are closely linked to aggressive driving and influence from others, which suggests a significant increase in NBCI, around +0.6 to +0.8. Cognitive distractions, like texting while driving, lead to a moderate increase in risk, with an NBCI value of about +0.15. On the other hand, speed control rules and limits from the vehicle in front show a lower but steady risk effect, with an NBCI of about +0.25. On the other side of how things are being implemented, there are technological tools like Cooperative Adaptive Cruise Control (CACC), Connected & Autonomous Vehicles (CAV), and the Long Short-Term Memory (LSTM) Control System. These tools have a negative effect on NBCI, which means they help make driver behavior more stable. The effect ranges from -0.15 to -0.25. This outcome makes it clear how technological tools are capable of effectively decreasing the deviations observed in the safe following distance.

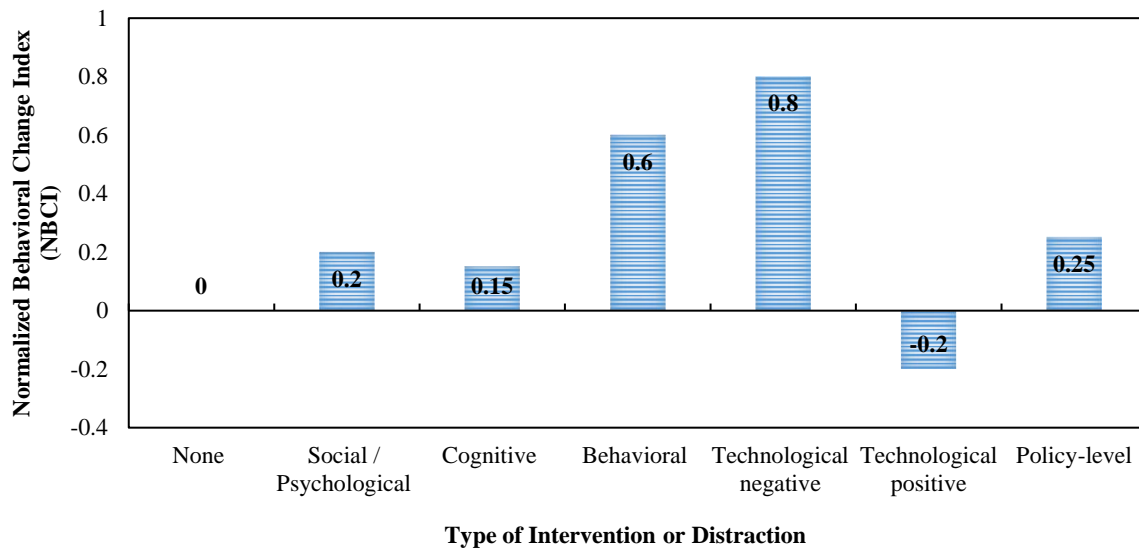


Fig. 2. Normalized Behavioral Change Index (NBCI) across different distraction and intervention types in car-following behavior studies.

3.4. Behavioral variables

Researchers use a variety of behavioral variables in the studies included in this review, such as system-level, driver reaction, and temporally/spatially defined measures. Time headway, gap distance, gap speed, and other factors are both geographically and temporally specified. Researchers are interested in how closely and safely drivers follow lead vehicles in car-following experiments that use these metrics [52]. Reaction time, trajectory adjustment timing, steering inputs, and avoidance behaviors are examples of driver response metrics. These metrics evaluate a driver's ability to react to traffic's dynamic alterations. The efficiency and safety of the wider traffic system are also measured by researchers using system-level and modeling metrics, such as flow, throughput, string stability, and fuel consumption.

The variety of behavioral variables used in the studies in this review highlights the complexity of car-following behavior and illustrates the need for models studying car-following behavior to move towards a holistic understanding that combines micro-level human responses to traffic change with macro-level system performance indicators (Fig. 3). Additionally, some studies include extended variables that can adequately describe events like lane changes, tailgating behavior, and demographic measures of drivers. These extended variables can help provide additional insight into the heterogeneity present within driver populations and indicate that more individualized approaches are likely required in the study of traffic behavior.

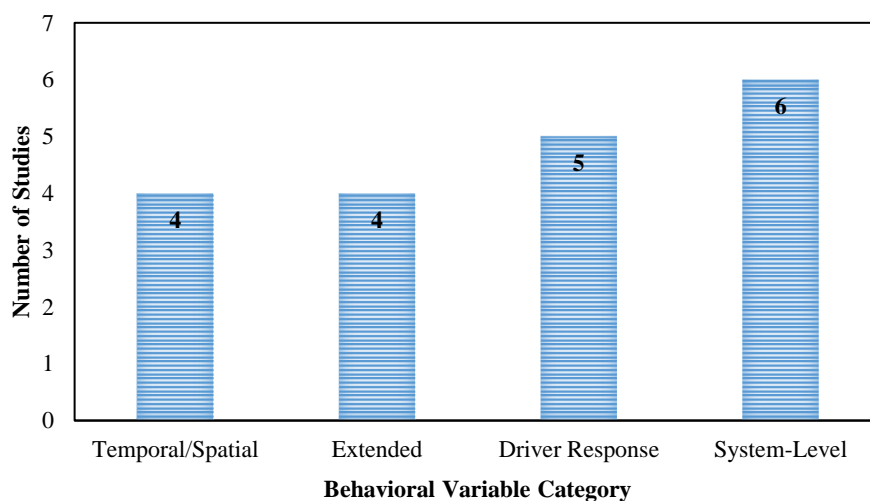


Fig. 3. Study distribution by behavioral variable category.

3.5. Key findings

Behavioral risk factors, driver variability, technological influence, and modeling implications are the four primary categories into which each of the previous studies divides the complex structure of car-following behavior (Fig. 4). Additionally, specific situations described as greater headways are necessary for car-following behaviors; this cluster is known as Behavioral Risk Factors [53, 54]. Driver demographics also play a role, as seen by the increased risk of rear-end crashes for young, female, and inexperienced drivers [55]. Automation and technology solutions have conflicting effects. While CACC improves string stability and comfort, user resistance to automation unless drivers are properly briefed reduces the advantages. These issues are exacerbated by culturally specialized AI, culturally impacted modeling, and customized prediction models. In order to develop culturally acceptable adaptive

driver technologies, it is important to address all of these levels. The research highlights that the effectiveness of the assistance systems is increased when these technologies are tailored to the unique regional features.

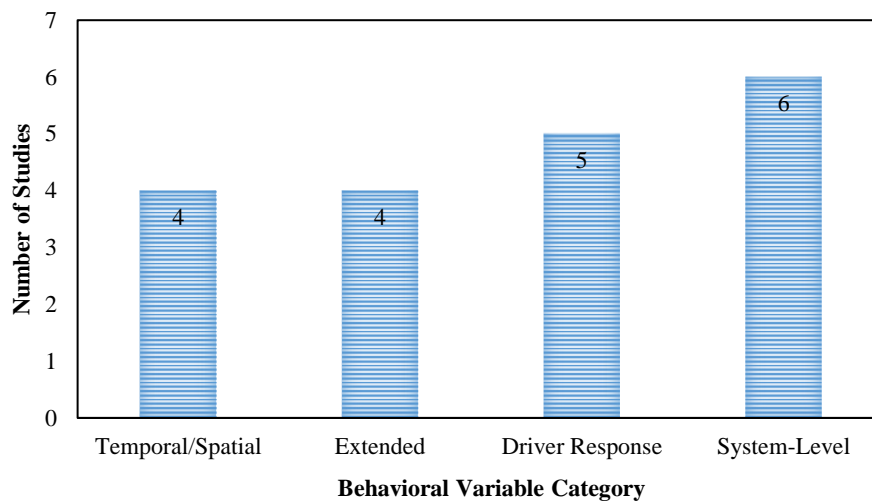


Fig. 4. Number of reviewed studies by category of key findings.

4. Conclusion

This study examines how people drive when they are following another car. It discusses the various factors that can influence this behavior, including the road they are driving on and the technology in the vehicle. It also looks at what other people have discovered about this topic. The following are the main points this study makes about people driving when they are following another car:

- Describes how automated driving features, aggressive driving, and attention-related factors affect car-following behavior.
- Car-following models and driver assistance systems should be applied appropriately to specific situations; this means that these models and systems should be tailored for different contexts and should not be universally applied to all traffic scenarios.
- Car-following models and driver assistance systems need to consider the traffic circumstances; they are not good for every situation; they should be made to fit the context in which they are being used.
- Highlights the consequences for safety analysis, traffic simulation research, and the creation of adaptive driver support systems.
- Determines that in order to enhance external validity, further studies with bigger sample sizes and naturalistic driver observations are required.
- Draws attention to the spatial concentration limitations of current studies and suggests broadening the scope of research.
- Recommends improving car-following models to include both system-level and individual behavioral components.

Statements & Declarations

Author contributions

Mirbahador Yazdani: Investigation, Formal analysis, Data curation, Software, Writing - Original Draft.

Hadi Shadlouy: Project administration, Supervision, Resources, Writing - Review & Editing.

Bahram Shirini: Conceptualization, Methodology, Software, Writing - Review & Editing.

Omar Faraji: Conceptualization, Methodology, Software, Writing - Review & Editing.

Jamshid Nazari: Conceptualization, Methodology, Software, Writing - Review & Editing.

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Data availability

The data presented in this study will be available on interested request from the corresponding author.

Declarations

The authors declare no conflict of interest.

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