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Use of generative AI in database courses: a role-based review

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Introduction: Generative artificial intelligence (genAI), particularly large language models (LLMs), has attracted increasing attention for its potential to support teaching and learning in higher education. However, how genAI is pedagogically integrated into specific disciplinary contexts, such as database education, remains insufficiently understood.

Method: This review examines the use of genAI in database courses through a role-based analytical framework, distinguishing the instructional function of AI as supplementary assistant, direct mediator, and new subject. Following PRISMA guidelines, peer-reviewed journal articles indexed in Web of Science and Scopus were screened. From an initial pool of 406 studies, nine empirical studies were identified.

Findings: GenAI is most commonly used as a supplementary assistant in database courses, where it supports tasks such as querying, data generation, solution checking, and error correction. The studies reported positive effects on academic performance, instructional efficiency, and time savings, with relatively few ethical or pedagogical concerns. The use of AI as a direct mediator demonstrated clear benefits but also raised concerns related to the accuracy and reliability of AI-generated evaluations. Finally, one exploratory study positioning AI as a new subject emerged as the most transformative yet risky role. While this approach offers potential for substantial instructional innovation, it may also lead to challenges related to accuracy and equity.

Discussion: This review underscores the potential and importance of role-based integration of genAI in database education and identifies key directions for future research. Research on AI usage in database instruction is still at an early stage, and further empirical studies are required.

KEYWORDS
artificial intelligence in education, database education, generative artificial intelligence, instructional roles, review, SQL learning

1 Introduction

Database instruction is important for educating technology specialists, as it provides a critical foundation for information systems development and underpins contemporary technologies such as big data and machine learning. Courses in database design and management require students to develop both conceptual understanding, including entity–relationship modeling, normalization, and functional dependencies, and procedural skills, including SQL query formulation and database implementation. These learning demands are often challenging for both students and instructors, particularly in large-enrollment courses where timely feedback and individualized support are difficult to sustain.

In parallel with these challenges, generative artificial intelligence (genAI)—particularly large language models (LLMs)—has rapidly evolved and begun to influence

teaching and learning practices in higher education (Al Issa and Maheshwari, 2025; Ocen et al., 2025; Peláez-Sánchez et al., 2024; Yusuf et al., 2024). These models demonstrate strong capabilities in natural language understanding, code generation, and problem-solving, which has led to growing interest in their potential application across a wide range of academic disciplines, including database education (Liang et al., 2025; Yusuf et al., 2024).

Current genAI review studies indicate that researchers are looking for various potential effects: GenAI is commonly used to support pedagogical enhancement, academic productivity, and professional skill development (Yusuf et al., 2024). In higher education, it is frequently framed as a driver of educational transformation, with reported implications for curriculum design, pedagogical practices, creativity, and knowledge construction, while simultaneously raising concerns related to ethics and academic integrity (Al Issa and Maheshwari, 2025; Garcia Ramos and Wilson-Kennedy, 2024; Peláez-Sánchez et al., 2024). The current genAI studies are predominantly focused on AI-supported personalization, ethical governance, and the development of AI-related competencies, reflecting the growing interest of the academic community in integrating genAI into teaching and learning processes (Figueroa de la Fuente and Farhadian, 2025).

Prior research suggests that genAI-supported systems can contribute to instruction in various ways. Review studies report that genAI can enhance personalized feedback mechanisms, automate routine instructional tasks, and support learning accessibility (García-López and Trujillo-Liñán, 2025). In addition, the studies indicated that genAI use is associated with predominantly positive effects on students' academic and cognitive skills, including idea generation, conceptual understanding, argument construction, and academic writing (Daniel et al., 2025; Liu and Zhong, 2025; Raitskaya and Tikhonova, 2025). Taken together, these findings suggest meaningful potential for genAI to support learning processes, including cognitively demanding domains such as database education.

At the same time, existing literature reports important challenges associated with genAI–supported learning. Prominent concerns include the loss of cognitive automation, instructional misuse of student data, and lack of regulatory oversight (García-López and Trujillo-Liñán, 2025). Several reviews further emphasize ethical and governance-related issues, including academic integrity and data privacy (Daniel et al., 2025; Figueroa de la Fuente and Farhadian, 2025; Ocen et al., 2025; Peláez-Sánchez et al., 2024). Reviews also question its accuracy (Peláez-Sánchez et al., 2024) and possible equity problems related to genAI usage (Garcia Ramos and Wilson-Kennedy, 2024).

Taken together, existing research suggests that genAI offers meaningful opportunities to support learning while also introducing various risks. In a more specific area, the context of database education, there is a need to understand how genAI functions pedagogically. Moreover, existing reviews usually adopt a broad perspective across various disciplines without distinguishing the different instructional roles. A role-based functionality analysis in such a unique field would provide specific opportunities and challenges.

To address this gap, the present study conducts a review of peer-reviewed research on genAI in database education, guided by an AI role–based analytical framework that distinguishes different instructional roles of AI in learning contexts (Xu and Ouyang, 2022). According to Xu and Ouyang (2022), AI can assume different instructional roles depending on how it is integrated into the learning process. When used as a supplementary assistant, AI supports learning by providing optional assistance without altering the core instructional design. As a direct mediator, AI becomes an essential component of specific instructional processes, such as assessment or feedback, by directly mediating interactions among learning participants. Finally, when positioned as a new subject, AI takes the responsibilities traditionally held by instructors, effectively acting as a tutor or primary source of guidance. Building on these conceptualizations, this study distinguishes among three instructional roles: AI as a supplementary assistant, AI as a direct mediator, and AI as a new subject. Therefore, the current review aims to identify the opportunities and challenges of existing genAI research studies for database instruction with a role-based lens.

2 Methodology

To review AI implementation in database instruction, a literature review was conducted following PRISMA guidelines to ensure transparency, accuracy, and replicability. Figure 1 shows a flow diagram for the study selection process, including inclusion and exclusion criteria.

To create a comprehensive literature review, Scopus and Web of Science (WoS) databases were included. In the databases, AI-related keywords ("genAI" or "LLMs"), database-related keywords("sql", "database design"), and instructive purpose-related keywords ("education", "teaching", "learning", or "students") were included as search keywords. By providing these keywords, 406 records were identified (187 in WoS, 219 in Scopus). Then, English peer-reviewed journal articles are filtered, and duplicated items are removed. In this process, 305 articles were excluded, and 101 records remained.

Next, the author analyzed the articles according to the research intention of both "instructional usage", "database orientation" and "empirical application". After this review, 89 articles were found not oriented with defined filters; the majority were either not database-oriented, or no instructional purpose was stated. Moreover, two articles found "a very weak connection with AI usage in database education", and one article's full text cannot be reached. As a result, only 9 articles remained for final review. The review was conducted in December 2025, no time restriction was applied in the review.

Finally, the 9 remaining articles are reviewed in detail; their AI intention categories according to role based analytical framework and main findings are analyzed. In order to identify the existing role of AI usage in database instruction, three research questions are asked as follows:

To what extent is genAI effective in database courses, and what are the benefits and risks of it:

RQ1. When it is used as a *supplementary assistant?*
RQ2. When it is used as a *direct mediator*?
RQ3. When it is used as a *new subject?*

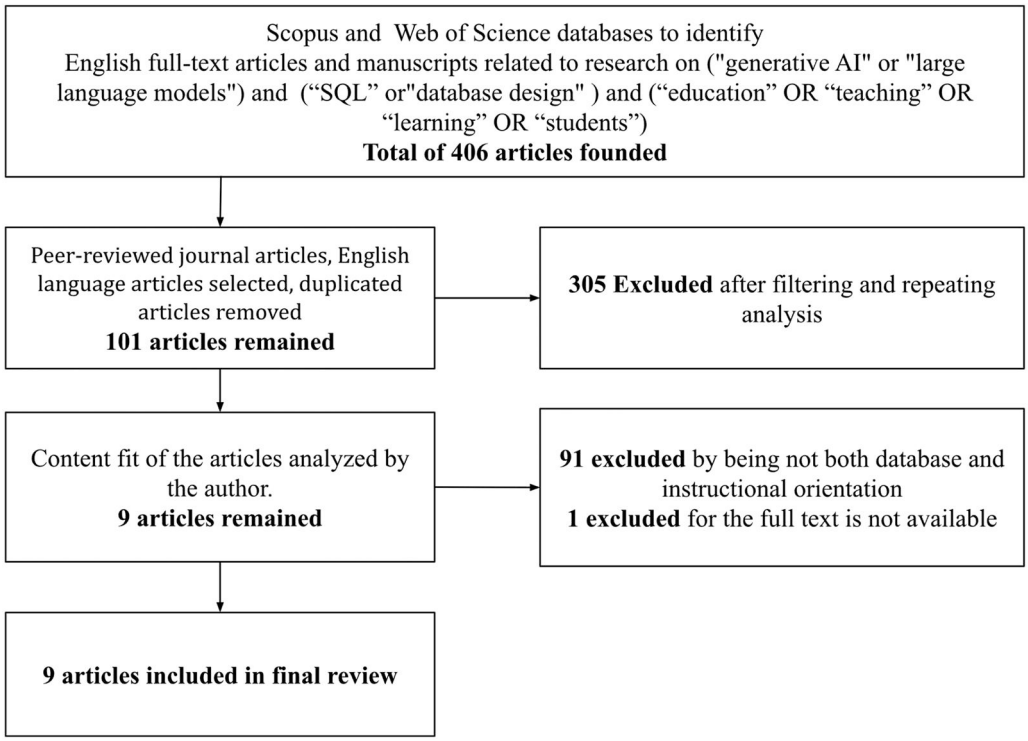

FIGURE 1
Review 'inclusion-exclusion criteria' flow chart.

3 Results

Data analysis of the review is shaped by the "role of AI in database instruction" intent by the AI role-based analytical framework (Xu and Ouyang, 2022). The topics, study designs, main AI roles, pedagogical functions, and key findings of the 9 articles are analyzed and reported in Table 1.

As a result of this review, although the number of "genAI in database instruction" articles was relatively low, the database topics found in the studies are diverse. Three studies focused on entity–relationship (ER) design and modeling (Rahmanian et al., 2025; Zhan and Chen, 2025; Zhang, 2025), four studies examined SQL querying and assessment (Hsueh and Wang, 2025; Manikani et al., 2025; Ning et al., 2024; Taipalus et al., 2025), and two studies addressed broader aspects of SQL learning, database management, or database design theory (Jamil, 2025; Obionwu et al., 2025).

Moreover, the methodological approaches across the reviewed studies were diverse. Two studies employed experimental designs (Ning et al., 2024; Rahmanian et al., 2025), one study adopted a quasi-experimental teaching case approach (Zhan and Chen, 2025), one study was conducted as a case study (Zhang, 2025), one study is qualitative (Taipalus et al., 2025), one study is an analytical evaluation study (Jamil, 2025), and three studies followed design-based, design-oriented research approaches (Hsueh and Wang, 2025; Manikani et al., 2025; Obionwu et al., 2025). Importantly, there were different predominant AI roles in the studies: three studies implemented genAI as a direct mediator (Manikani et al., 2025; Rahmanian et al., 2025; Zhan and Chen, 2025), one study explored the potential of AI toward an emerging new instructional subject role (Jamil, 2025) and five studies as supplementary assistant (Hsueh and Wang, 2025; Ning et al., 2024; Obionwu et al., 2025; Taipalus et al., 2025; Zhang, 2025).

The reviewed articles employed genAI for a range of purposes in database courses: Five studies primarily utilized AI for assessment, feedback functionalities, including the evaluation of ER diagrams and getting better support for SQL queries (Manikani et al., 2025; Ning et al., 2024; Rahmanian et al., 2025; Taipalus et al., 2025; Zhang, 2025). In addition, two studies positioned AI in a tutor-like role, where the systems were used to provide explanations and problem-solving support (Jamil, 2025; Zhan and Chen, 2025). The remaining studies employed AI for supporting roles, including synthetic data generation for SQL learning analytics (Obionwu et al., 2025) and natural language–based database querying (Hsueh and Wang, 2025).

These studies indicated various positive effects and concerns of AI usage in database instruction that would be reported within different instructional roles.

3.1 AI as a supplementary assistant in database courses

Five studies positioned genAI as a supplementary assistant in database education. Obionwu et al. (2025) investigated the use of LLMs to generate synthetic SQL learning interaction data and reported that AI-generated SQL statements are very similar to real student data, thereby AI can support the development of scalable AI-driven educational systems. Hsueh and Wang (2025) focused on natural language querying of educational databases, enabling instructors to access learning data without SQL expertise. The study reported that LLM-based sequential

TABLE 1 Analysis of the included articles.

The Study	Database Topic	Study Design	Main AI Role	Pedagogical Function	Key Findings
Jamil (2025)	Database design theory assessment	Analytical evaluation study	New Subject	AI tutor replacing human instructor	Frequent, confident but incorrect explanations; equity concerns
Rahmanian et al. (2025)	ER diagram design & evaluation	Experimental evaluation	Direct Mediator	Automated assessment & feedback	High alignment with human grading in ER design assessment; cardinality remains challenging
Manikani et al. (2025)	SQL query formulation	Design-based empirical study	Direct Mediator	Autograding & instant feedback	High accuracy in SQL assessment; significant reduction in grading time
Zhan and Chen (2025)	Database management & capstone projects	Teaching case/quasi-experimental	Direct Mediator	Primary instructional agent	Improved performance in graduate cohorts
Zhang (2025)	ER modeling & SQL	Teaching tip/ instructional case	Supplementary Assistant	Reflection & enrichment	Enhanced understanding and positive perceptions of AI usage for checking database problem solutions
Obionwu et al. (2025)	Example SQL data generation	Design-based technical study	Supplementary Assistant	Synthetic data generation	SQL data generated for testing purposes, that closely mirrored real student behavior
Hsueh and Wang (2025)	Database querying accuracy	System design & evaluation	Supplementary Assistant	Natural language querying in databases	Sequential queries improved execution accuracy compared to agent-based approach
Ning et al. (2024)	SQL error recovery	Within-subjects experimental design	Supplementary Assistant	Error explanation and recovery	AI is accurately functioning; fewer variants, explanation and example feedback methods better for novices
Taipalus et al. (2025)	SQL error clarity	Qualitative empirical research	Supplementary Assistant	Providing error clarity for error recovery	Providing error position, using clear natural language and giving hints for error-fixing are perceived effective

querying improved execution accuracy with respect to the agent-based approach

Ning et al. (2024) used error-handling mechanisms and empirically validated feedback strategies. The study shows that genAI can be utilized for providing more accurate (up to 85%) and consistent feedback during query formulation. While alternative error fixing methods did not result in better error fixing, users performed better with fewer variants in queries, explanation and example-based feedback methods were more useful for non-experts. Similarly, Taipalus et al. (2025) used AI to support learners by clear, actionable, and learner-centered error messages for SQL errors. The study shows that providing error position, stating the wrongness with clear natural language, and showing hints to fix the error are perceived as the most effective methods

Zhang (2025) explored the use of AI tools in undergraduate database courses for reflection, comparison, and enrichment in problem-based assignments. Students first completed ER modeling and SQL tasks independently and then compared their solutions with AI-generated solutions. It results in positive student perceptions and enhanced conceptual understanding.

As a result, the majority of the articles in this review used AI as a supplementary assistant to support database learning within existing instructional designs. These studies positioned AI in an optional, supportive role within instructional or instruction-related contexts. The reviewed studies mainly reported positive and supportive outcomes, indicating that AI can contribute to the efficiency, scalability, and effectiveness of database instruction as a supplementary assistant. No major problems or risks were prominently reported in these studies.

3.2 AI as a direct mediator in database courses

Three studies positioned genAI as a direct mediator in database education, assigning AI a mandatory role in specific learning processes in which it mediates between learning participants. Rahmanian et al. (2025) examined the use of genAI to evaluate student-generated ER diagrams. Results showed substantial alignment between AI-generated evaluations and human grades. However, some challenges were observed in interpreting relationship cardinalities. Manikani et al. (2025) investigated an LLM-powered SQL autograder deployed in a university database course. The system demonstrated high grading accuracy and dramatically reduced evaluation time compared to manual grading. Almost all participants found the auto-graded SQL system useful. Finally, Zhan and Chen (2025) reported a teaching case in which ChatGPT was embedded as an interactive instructional support tool within a database management capstone project. The system guided students during ER modeling, SQL development, and iterative design refinement processes. It provided instructor-like cognitive support in addition to the teacher's regular instructional support. The results showed improved learning outcomes for graduate students and increased learner autonomy.

These three studies showed that AI can support specific functions in database courses, particularly assessment and instructional support, when used as a direct mediator. However, they also pointed out some concerns, including the need for

safer and more carefully designed pedagogical uses. Importantly, current studies focus on evaluative applications and instructional support for project development, while other instructional uses of AI as a direct mediator remain underexplored.

3.3 AI as a new subject in database courses

One study explored the suitability of positioning AI for the instructor role. Jamil (2025) evaluated LLMs as database design tutors, focusing on functional dependencies, normalization, and key identification. The study showed that although LLMs could generate detailed explanations like a tutor, they also produced confident but sometimes incorrect reasoning. These findings raised important concerns regarding accuracy and potential equity implications, particularly when learners rely on less capable models.

While this role is promising, the only database study that explored the suitability of the new subject role in database courses reported concerns related to the accuracy of instructional content and equity in education. Therefore, careful and critical consideration is needed when positioning AI in such an instructional role, and more studies are required to better analyze the effectiveness of AI in this role.

4 Discussion

4.1 Overview of findings and role-based patterns

This review focused on how genAI is currently integrated into database education by concentrating on instructional roles assigned to AI. In the review, genAI is most commonly positioned as a supplementary assistant. A previous review examining AI roles in blended learning reported that the dominant role of AI was direct mediation (40%), followed by supplementary assistant (20%) and new subject (17%) (Park and Doo, 2024). This difference probably resulted from the instructional needs and practical AI support requirements across disciplinary contexts.

The subject topics, research methods, and pedagogical foundations varied across the reviewed studies. Although the number of applied studies remains limited, the existing evidence demonstrates that genAI has been implemented across a range of database-related functions. These functions include querying, synthetic data generation, feedback, and assessment-related processes. This diversity of applications suggests the potential of genAI to support multiple stages of database creation and learning.

4.2 Findings and implications of AI roles in database instruction

The first research question examined the opportunities and risks associated with using AI as a supplementary assistant in database courses. When AI is positioned in this role, existing studies indicate that it primarily provides accurate and time-saving functionalities that support academic tasks. This support includes creating example SQL interaction data, a solution checking mechanism for SQL and ER models, generating SQL with natural language and providing better and more accurate feedback. These findings aligned with broader reviews that indicate; AI-supported tools can enhance educational efficiency and learning outcomes when used in supportive roles (García-López and Trujillo-Liñán, 2025) and their potential for automatization and personalization in learning (Peláez-Sánchez et al., 2024; Ocen et al., 2025). The reviewed studies reported only a few ethical concerns, indicating that the use of AI as a supplementary assistant is generally perceived as a relatively safe, effective, and time-saving approach in database education. Therefore, the supplementary assistant role does not appear to involve the commonly stated challenges of AI instruction, including equity and accuracy concerns (Garcia Ramos and Wilson-Kennedy, 2024; Ocen et al., 2025).

The reviewed studies in the supplementary assistant role support the use of AI as an assistant for improving the traditional educational process of database instruction. Compared to traditional approaches, AI integration enables instructors to develop richer instructional materials, including sample student data, query examples, and assessment resources. Similarly, students can use LLMs to practice SQL statements or evaluate their own work, supporting self-directed learning. Personalized feedback plays a critical role in facilitating students' independent learning processes. Although the reported risks are relatively limited in this role, ethical considerations—such as data privacy, academic integrity, and content accuracy—remain important. Accordingly, the responsible use of AI as a supplementary assistant should be clearly communicated to both instructors and students.

The second research question focused on the opportunities and risks of using AI as a direct mediator. In the reviewed studies, AI-mediated approaches were primarily implemented for assessment and feedback-related processes. Given the structured nature of database content and assessment criteria, AI-mediated evaluation was found to be mainly accurate. In addition, it provided meaningful support for database project. So, this role is essential in terms of transforming specific functionalities to AI in a controlled way that helps automatization, personalization, and time saving (Manikani et al., 2025; Ocen et al., 2025). But specific challenges—such as errors related to cardinality constraints—were reported (Rahmanian et al., 2025). In addition, the previously stated concerns like accuracy of generated content (Jamil, 2025; Peláez-Sánchez et al., 2024), ethical and integrity issues (Ocen et al., 2025) are still critical for this role.

The studies indicated that in traditional learning processes, genAI positioned as a direct mediator, can support learning by appropriate instructor follow-up. For example, AI-based assessment may still involve accuracy limitations; instructor oversight remains necessary to identify and correct potential errors. For this reason, AI-mediated assessment should not be used as the sole basis for decisive evaluation purposes. In addition, students' personal data should not be shared with AI systems; only non-personal evaluation data should be used in assessment-related processes. Across scenarios, AI integration has the potential to significantly accelerate evaluation workflows

and to provide timely, individualized feedback during instructional activities. For example, during problem-solving or project development phases, students may consult AI systems to receive immediate guidance rather than relying exclusively on the instructor. Nevertheless, such feedback should be monitored by the instructor, who remains responsible for correcting inaccuracies when necessary. Especially in large enrollment courses, this form of AI-supported mediation may contribute to more efficient feedback processes and improved learning support.

The final research question examined the opportunities and risks associated with positioning AI as a new subject. This role represents the most transformative and potentially disruptive form of AI integration. In this role, only one study (Jamil, 2025) explored the possibility, and it reported concerns related to accuracy and equity. The concerns are consistent with the previous ones, including equity, accessibility, and governance challenges (Figueroa de la Fuente and Farhadian, 2025; Garcia Ramos and Wilson-Kennedy, 2024). While AI as a new subject may offer promising use cases for controlled conditions, the associated risks suggest that clear distinctions between safe and risky implementation scenarios are essential. To deal with the evident concerns of AI implementation, Peláez-Sánchez et al. (2024) recommend using human oversight to ensure quality and accuracy.

Although using genAI as a new subject has the potential to alter traditional learning settings of database courses. Practitioners should exercise caution in its implementation. It might work for simpler tasks that have less accuracy risk, like teaching introductory SQL queries or JSON education, but future studies need to test this kind of safer usage as well. In all cases, human oversight should accompany AI-supported instruction.

4.3 Limitations, challenges, and future research of AI roles

In this review, only nine genAI studies were identified for database instruction, which indicates that AI-supported database education research is still at an early stage. Especially, the number of studies that explore AI roles as direct mediation and new instructional subjects in database instruction is very limited.

The existing research presents several challenges and highlights clear requirements for future research. The review reveals that ethical issues remain open to discussion for each AI role. For direct mediation and new instructional subject roles, accuracy and equity emerge as additional critical concerns. Future research should aim to identify effective, safe, and reliable usage scenarios that take into account both pedagogical benefits and potential risks. More studies—especially longitudinal and design-sensitive research (Daniel et al., 2025)—are required to better assess these potential benefits and risks.

The current findings should also be interpreted in light of the study's scope, which was limited to peer-reviewed journal articles indexed in the Web of Science and Scopus databases. As only a relatively small number of database instruction–focused GenAI studies were identified, the conclusions of this review should be regarded accordingly.

5 Conclusion

This review examined the use of genAI in database education through an AI role–based analytical framework, synthesizing empirical and instructional studies published in recent years. The nine studies identified within the scope of database courses provide insights into how genAI is positioned across different instructional roles. Among these roles, AI was most commonly used as a supplementary assistant, a role in which studies generally reported strong accuracy, reliability, and minimal ethical concerns.

When AI was implemented as a direct mediator—particularly in assessment and feedback-related processes- it was found to offer benefits such as instructional support and time efficiency. However, studies adopting this role also reported concerns, primarily related to the accuracy of AI-generated evaluations. Finally, according to exploratory research, the use of AI as a new subject emerged as the most risky role, as it assigns AI responsibility for critical instructional functions that may not be accurate or reliable across all contexts.

Overall, these findings indicate the need for a greater number of empirical studies to develop a more comprehensive understanding of AI integration in database education. In particular, issues related to accuracy and equity require careful consideration, especially when adopting AI in direct mediator and new instructional subject roles within database courses.

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OA: Project administration, Data curation, Writing – original draft, Visualization, Conceptualization, Resources, Methodology, Writing – review & editing, Formal analysis.

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Generative AI statement

The author(s) declared that generative AI was used in the creation of this manuscript. The author declares that generative AI tools (ChatGPT) were used only for language refinement and limited conceptual clarification. All analytical decisions, interpretations, and final formulations are the sole responsibility of the author.

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