REVIEW ARTICLE

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Artificial intelligence and the future of the internal audit function

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Artificial intelligence (AI) can support the company's internal audit function (IAF) by delivering substantial strategic oversight, minimizing manual procedures, and making possible additional value-added auditing service. Currently, there are research gaps in the literature, such as limited studies on the topic, low AI adoption rates in the IAF across different countries and regions, and a shortage of comprehensive frameworks for effectively using AI in the IAF. Hence, this review work aims to fill the research gap by offering an outline of research avenues on the topic in the literature and suggesting a new compressive framework for the effective use of AI in the IAF. This paper undertakes a systematic literature review (SLR) approach and aspires to highlight the state of research on the use of AI in the IAF, to deliver insight for scholars and industry experts on the issue, and to reveal the implications for IAF of the new AI technology. Moreover, to quickly make artificial intelligence work in internal audit functions, the CACS framework was recommended with attributes such as commitment, access, capability, and skills development (CACS). This work provides significant contributions for guiding future research directions and the development of theoretical foundations for the IAF field. On a practical level, the work will help internal auditors to assess and understand the potential advantages and risks of implementing AI in their organization's IAF. For regulators, this review should prove useful for updating regulations on internal auditing in the context of using advanced technology such as AI and for ensuring the compliance of internal auditing practices to the evolving technology. Organizations can also benefit from this review to decide whether AI investments in their IAF are justified. This review made an initial extensive SLR on AI use in the IAF as a basis for developing new research avenues in auditing and accounting.

Introduction and motivation

Business stakeholders want to confirm that organizational management makes proper decisions regarding, such things as risk management, the preservation of transparency, and the regularization of information with appropriate monitoring (Panda & Leepsa, 2017). To satisfy those motives, business organizations must have effective governance structures and guidelines. An effective governance structure and guidelines can support the attainment of

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objectives, the management of risk, and the improvement of corporate governance (Chowdhury, 2021). The organization's corporate governance system depends on the Internal Audit Function (IAF) to deliver an independent opinion, assist with every matter, and encourage and advance improvement and innovation (Tiron-Tudor et al., 2021). The contribution of Artificial Intelligence (AI) can be measured by those improvements and innovations (Goertzel, 2014) that help organizations to generate substantial competencies.

The introduction of AI holds the promise of delivering substantial improvements in the IAF's role by empowering the IAF to process dispersed and big data of the company instantly (Ghanoum & Alaba, 2020). Instead of only offering assurance on the sample data, with the support of AI, IAF can carry out audits on the total population. An autonomous and objective assurance task which is accessible within the company could then be considered to be an internal audit function (MacRae & Gils, 2014). This enhanced capability would deliver increasing satisfaction to the stakeholders regarding company operations and governance which is the responsibility of IAF (Florea & Florea, 2016). Governed by the International Professional Practicing Framework (IPPF), the IAF is one of the compulsory components of the Corporate Governance Code, and the Institute of Internal Auditors framework (Ergen, 2019). Looking back over the past decade, it is evident that the current audit profession has changed dramatically. Internal auditors need to be even more flexible and remain current with the changing technological environment. The spread of AI technology is highlighting the need for significant improvements in the functionality of IAF (Kozlowski, 2018). It is becoming increasingly clear that the aim of IAF needs to be transformed from sample-dependent and compliance audits to more sophisticated, comprehensive, practical, systematized, problem-resolving, predictive, and fraud-discovering audits (Ghanoum & Alaba, 2020). As one example, assessing smart controls and delivering advice for their improvement has become a requirements of IAF.

Empirically, the impacts of AI on the effectiveness of IAF have been rarely assessed (Lehner et al., 2023). Accordingly, this review may substantiate the literature shortage about AI used in IAF. Considering the overall importance of AI for organizations, the use of AI in IAF is a timely and relevant topic. The paper reviewed articles from the Web of Science (WoS) database that were published between 2019 and 2023. The review found that AI and IAF (separately) are extensively studied areas. However, there are limited studies on the use of AI in the IAF (Couceiro et al., 2020; Seethamraju & Hecimovic, 2022; Ghanoum & Alaba, 2020). Although the concept and application of AI are receiving wide acceptance, they have not yet been applied in some countries. Most studies focus on Australia, China, and Oman (Zhou, 2021; Khan et al., 2021; Rehmanand & Hashim, 2022). Besides, it was found that Asia and Europe are the most studied areas (Lehner et al., 2023). The review also revealed that most of the studies used the previously developed and common TOE (Technological Organizational Environmental) framework (Seethamraju & Hecimovic, 2022; Chen et al., 2021). The review highlights research gaps in the area under study, such as limited studies on the topic and low AI adoption rates in the IAF across different countries and regions. In addition, there is a shortage of comprehensive frameworks for effectively using AI in IAF. Hence, this review work tries to fill the research gap by offering an outline of research avenues on the topic and suggesting a new compressive framework (CACS) for the effective use of AI in the IAF.

Using the systematic literature review (SLR), this paper was designed to fill the research gap through a systematic analysis of research on the use of AI in the IAF. SLR is an appropriate method to deliver critical insight into this area, enabling the expansion of understanding of the use of AI in IAF, attaining an extensive view of the present situation, and looking for future research avenues. A thorough review of the prevailing field of knowledge is vital to highlight a reliable direction for future studies (Massaro et al., 2016). Therefore, the objectives of this paper are to identify, assess, and evaluate the present state of research, to give critical insights on the publications made on the issue, and to highlight future research avenues. In this way, the paper aims to expand the understanding of what has been published on the theme and suggest future research areas that can assist organizations in using AI in the IAF.

This review work provides essential contributions in both theoretical and practical aspects. For theory, it highlights the research areas which have not been investigated (research gaps), thus guiding future research directions and the development of theoretical foundations. Moreover, this review contributes to developing a theoretical framework (CACS), assisting stakeholders to understand and conceptualize the use of AI in the IAF, which can be a basis for future investigations. For practice, this review helps internal auditors assess and understand the potential advantages and risks of implementing AI in their organization's IAF. It also helps internal auditors identify the new skills required to adopt and effectively use AI in their audit tasks, highlighting training and skill development areas. For regulators, this review is helpful for updating regulations on internal auditing in the context of using advanced technology such as AI and for ensuring the compliance of internal auditing practices to the evolving technology. Finally, organizations can benefit from this review to decide whether AI investments for their IAFs are justified. For this reason, the recently introduced CACS framework with four attributes was recommended for implementing AI in the IAF. Thus, organizations can benefit from the framework to quickly implement and utilize AI in their IAF.

In framing the intellectual area of study on the use of AI in the IAF, this review's research design is based on the procedure necessary to develop the SLR. Accordingly, the research questions in this work are informed by the requisites of the SLR and in the order of the study's analysis. The current state of research on the use of AI in IAF needs to be explored before developing directions for future research interests:

RQ1. What is the current state of research on the use of AI in IAF?

RQ2. What are the future avenues of research on the use of AI in IAF?

The research questions in this review work were developed as applied by Lehner et al. (2023), Silva et al. (2021), and Bracci et al. (2019). Thus, concerning the first research question (RQ1), the review aims to highlight which journals publish the most articles and the most prolific authors. Moreover, studies on the use of AI in the IAF were identified with geographic regions and countries to identify less studied regions. Therefore, in this review, it was also essential to identify the most used research method for the topic and the trends over the years. The second research question (RQ2) aims to provide insight for future research avenues on the use of AI in IAF by revealing the regions, topics, and research methods that have been studied the least. Finally, this review will propose a framework for using AI in the IAF and elaborate the practical implications of this framework.

This review has five sections: literature review, research methods, major results, discussions, and conclusions. The first section provides a brief literature review of the arguments and existing frameworks for using AI in the IAF. The second section details the method applied (SLR) for this review work. The third section presents the major results of the SLR on the use of AI in IAF. Finally, the fourth and fifth sections discuss future avenues of research and a conclusion to summarize the results.
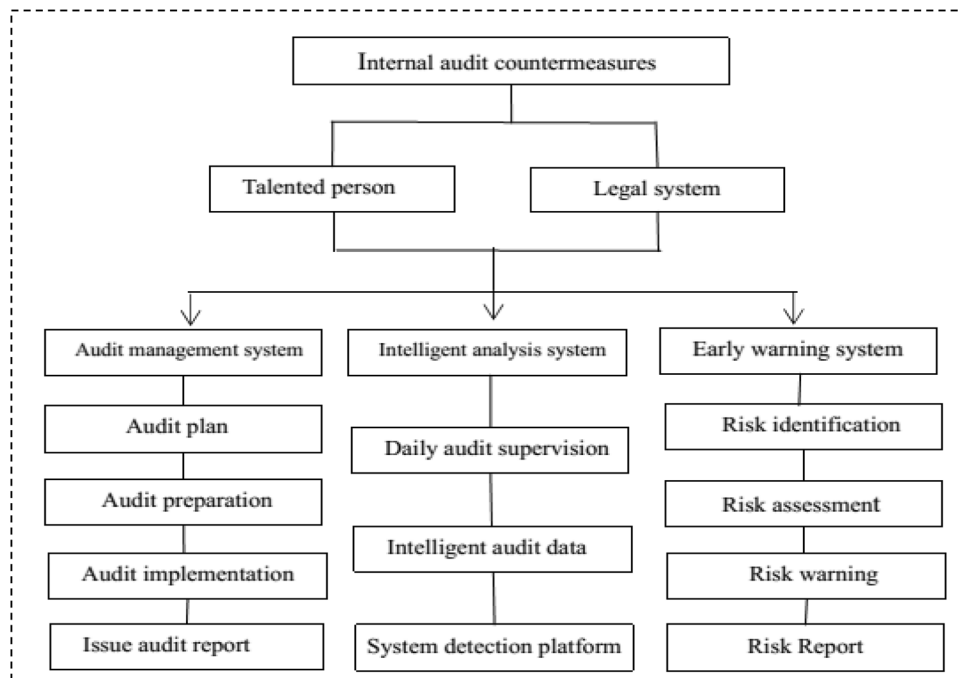
Fig. 1 Resolution of internal audit function under artificial intelligence. The figure shows the AI resolution of anomalies in the IAF of the organizations. Source: as applied by Zhou (2021).

Literature review

Artificial intelligence and internal audit function. The way of doing business is getting more complex than earlier because of technological advances and real time operation improvements; hence, companies need to employ AI and remain updated every time there are new advances (Libert et al., 2017). Nevertheless, because of various barriers related to AI implementation, many companies are not utilizing it (Ammanath et al., 2020). Currently, only large companies have easy access to AI. By applying it to their internal audit function, they gain a more competitive advantage.

AI is a mix of software and hardware that performs similarly to the human brain. Based on the available data, it can assess, decide, and perform complex judgment procedures. (Moffitt et al., 2018). It analyzes, examines, and processes a considerable amount of data, and uses this data to further refine the algorithm. By combining technical knowledge with interactive interview skills, project management skills, responsive intelligence, and logical thinking, the IAF can support AI in the early data feed (Ghahramani, 2015).

A robust structure of internal audit functions, policies, and guidelines is necessary to gain the full benefit of AI (Rehmanand & Hashim, 2022). For organizations have extensive hierarchical data and AI, numerous automated businesses have benefited from their IAF. Here, an essential task of IAF is to audit the gathering, transformation, storage, control, and compliance of automated data to verify the audit requirement for a comprehensive examination and review of the usage of the data. AI also brings new difficulties and needs for the internal audit function of an organization; the resolutions of anomalies is conducted in different ways than the practice before, with AI following a strict procedure (see Fig. 1). Thus, the State has to make official and comprehensive regulations and rules to control the legitimacy, characteristics, transformation, and usage of automated data through AI in the IAF in order to offer the legal foundation for the legal improvement of the internal audit function (Zhou, 2021).

Looking into the future, internal audit, staff will train AI to act without hesitation to peruse circumstances that need an extensive investigation or even forecast when the failed case on control will happen. However, AI could assist the internal audit function in additional ways as well, e.g., considering the role of AI in assessing the quality of data (Puthukulam et al., 2021). Improvements in low-cost data storage (like the cloud) have permitted the formation and accumulation of vast amounts of data subject to IAF, thus making tests of the completeness, faithfulness, accuracy, and reliability of the data difficult considering the complete due to the size of the big data. The future AI will be able to constantly manage this data and warn internal auditors in the IAF about the condition of the data being transmitted and stored as well as the prospective fraud and related disclosures (Erb, 2018).

The AI's capability to understand and perform quicker than human beings will make it generally difficult to generate innovative methods of planning and testing controls to assess the effectiveness of AI (Seethamraju & Hecimovic, 2022). This circumstance will make it even more essential for consultants to collaborate in order to assist with the challenge of closing the knowledge gap (Erb, 2018). As each of the challenges are overcome, AI will positively impact the internal audit function by concurrently discovering risks and examining procedures and control design. The initial implementers of AI in various institutions may not be a cybersecurity section but rather the IAF. Thus, future internal auditors must be considered technical experts responsible for initiating this innovative and astonishing technology (Erb, 2018).

Does artificial intelligence replace internal auditors' jobs? Many scholars have argued that AI would reduce job opportunities for internal auditors, while others have argued that it is an opportunity for them. According to Mach (2022), several companies and institutions do not utilize AI in their IAF due to the perception that AI will substitute actual employees. However, the evidence to date is that AI does not replace actual employees. It appears that internal auditors and AI can perform together to improve processes and effectiveness. AI will not replace the

auditor's assessment of interviews, decisions, and judgment. Instead, it improves their performance by providing them with advanced tools and prospective outcomes.

Moreover, according to Muspratt (2018), although many have thought that AI would terminate internal auditors' jobs, however the truth is more complex than originally perceived. It turns out that AI helps to develop the market for the work of the internal auditors' by creating further advantages for workers to emphasize their work's complex matters that need human involvement. Moreover, AI has proven useful for managing the tedious and routine procedures that frequently take the most working days. Additionally, the paper demonstrates that the AI technology is intended to support creativity and provide assistance, thus allowing internal auditors to be more effective in the tasks that they have been given to perform. Generally, the view is optimistic for AI to become a useful tool for the internal audit profession in the long run. But the development path will not be smooth and occasional troubles can be expected along the way (Q.ai-Contributor-Group, 2022).

Conversely, according to Parker (2022), people-oriented work has diminished in some industries because of capital-oriented advanced technologies. If internal auditors in the IAF in the future do not advance their skills, there is a risk that AI-powered machines could replace their positions. In addition, as one scholar has demonstrated, many people have lost their jobs because AI has replaced almost all routine activities and further tasks with computers and robots. Since it has a high degree of accuracy, almost all companies desire to utilize AI-oriented robots in their IAF. Soon, this challenge will extended to other industries, and the job loss caused by AI will become an existential matter for large classes of workers (Adhikari, 2021). Likewise, the health research funding (HRF, 2022) has argued that as AI-oriented machines are introduced to accomplish people's work faster and at lower costs, the level of jobs lost is rise with even the internal audit profession being at risk. Similarly, other scholars have contended that when AI becomes more common in organizations, it could reduce job openings because AI will be able to manage routine activities that previously were performed by employed staff (Tableau, 2021; Yakimova, 2020).

Generally, the message from the above arguments, is clear: - it is time for internal auditors to use their skills and talents in their jobs. In order to be prepared, it is essential that internal audit professionals remain up-to-date with the AI technology. By familiarizing themselves with this technology, the necessary skills and understanding will be developed. Otherwise, it will be a challenge rather than a prospect for them. In the era of AI, to qualify for work in the internal audit function, a prospective employee will need to understand the technology better, to get proper training, and to acquire the necessary mindset that the use of AI is a competitive advantage.

Theoretical framework. Several explanatory frameworks have been introduced to assess technology adoption and its impact on organizations. According to Sadoughi et al. (2019) and Rad et al. (2018), some theories comprise the technology acceptance model, the theory of reasoned action, the innovation diffusion theory, the diffusion of innovation model, and the theory of planned behavior. Above all, two well-known models were developed to measure the applicability of technologies in organizations. Those technology adoption models are the Unified Theory of Acceptance and Use of Technology (UTAUT) model and the Technological, Organizational, and Environmental (TOE) framework.

The UTAUT framework was developed by Venkatesh et al. (2003). The model was developed to identify the common factors impacting users while undertaking technology adoption selection

through various domains. The model established four significant factors that directly impact technology adoption intention and usage (performance expectancy, effort expectancy, social influence, and facilitating conditions).

The TOE framework is the combination and extension of the innovation diffusion theory (IDT) and technology acceptance model (TAM) (Hossain & Quaddus, 2011). In reaction to the criticisms and gaps in the diffusion of innovation (DOI) model in presenting the predictors of technology and innovation adoption at the institutional level and emphasizing the significance of circumstantial constructs in the adoption procedure, Tornatzky and Fleischer (1990) introduced the TOE framework. In the framework, technology adoption in organizations is projected by three symbiotic components: organizational features, external environment, and technological features (Tornatzky & Fleischer, 1990).

The CACS framework (commitment, access, capability, and skilling) was recently introduced by MetricStream (2020) and has also proven to be valuable in this review work. The framework was proposed explicitly for AI utilization in audit activities, it is also an alternative technology adoption framework. Since this framework was recently developed and takes into consideration the current technological changes and the concepts contained in previous theoretical frameworks, this review will suggest that companies implement it and that researchers consider it for use in their studies. The framework will be elaborated in the later section of the paper.

Research method

This part presents the methods used in this review to highlight the existing scholarly literature on the use of AI in IAF, explicitly using the systematic literature review (SLR). SLR is an organized and comprehensive study method that involves gathering, critically assessing, and integrating the prevailing academic literature on a particular topic or research question (Massaro et al., 2016). On a specific subject matter, it aims to deliver objective and evidence-based highlights of the existing state of knowledge. According to Massaro et al. (2016), the SLR is a method complementary to a traditional literature review. The SLR method is vital for providing existing insights, critical views, and future research interests in emerging fields like AI in IAF. Massaro et al. (2016) also state that the SLR pursues to sustain replicability using a straightforward search and sampling strategy that document the data analysis and evaluation steps that were used. Applying the SLR method includes a step-by-step plan to identify the scholarly literature, as Massaro et al. (2016) suggested. Overall, this review aims to attain insights into the emerging research field of AI use in IAF and to understand future avenues of research in the field.

Database, search, and sampling strategy. Keyword search is more appropriate for an emerging field like a review work targeted to study AI use in IAF (Massaro et al., 2016). A similar approach was applied to sampling sources for two reasons. First, the joint use of AI in IAF has been highlighted recently in a limited number of journals. However, individually (AI and IAF), large body of publications across academic disciplines for a substantial amount of time was evident. Second, with AI use for IAF research, publications have expanded in numerous academic fields of interest (Lehner et al., 2023).

Moreover, published work quality is guaranteed through a peer-review process, the most accepted approach. Due to these reasons and to ensure the study's replicability, published works from recognized databases were considered for the primary analysis. Web of Science (WoS) is one of the most extensive
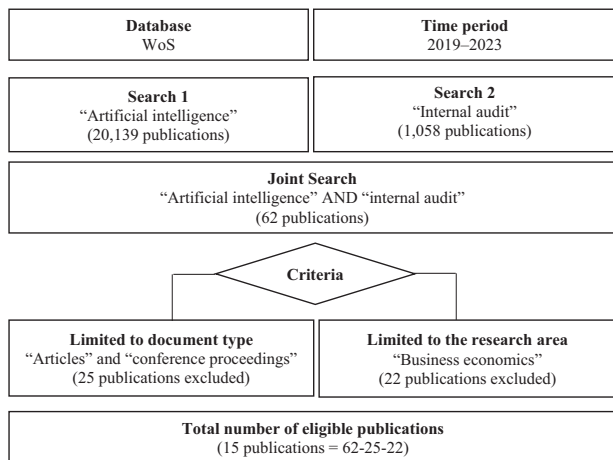
Database	Time period
WoS	2019–2023

Search 1	Search 2
"Artificial intelligence" (20,139 publications)	"Internal audit" (1,058 publications)

Joint Search
"Artificial intelligence" AND "internal audit"
(62 publications)

Criteria

Limited to document type	Limited to the research area
"Articles" and "conference proceedings" (25 publications excluded)	"Business economics" (22 publications excluded)

Total number of eligible publications
(15 publications = 62-25-22)

Fig. 2 Selection scheme of publications. The figure shows the summary of the search and sampling process of the review. Note. As applied by Silva et al. (2021).

databases comprising thousands of high-quality journals in arts and humanities, social sciences, and natural sciences. Using the database will allow all quality and reliable research undertaken in the study area to be considered for this work since it is a prominent source for books, articles, reviews, and conferences. In addition, government reports, websites, and blogs were used to support and demonstrate the primary analysis results. Government reports are helpful while making a study by providing authoritative and official data and insights on policy implications. Websites were also used to highlight current and up-to-date information and diverse perspectives on the topic (since the topic is volatile). Moreover, blogs were used to get insights from subject matter expertize and timely discussions on the topic (Wilson et al., 2015).

In three steps, the study undertakes the search and sampling process. The summary of the search and sampling process is presented in Fig. 2. First, a keyword search for "artificial intelligence" and "internal audit" was executed. In the database (WoS), the filled "Topic" was used to perform the search, including title, abstract, and indexed publication keywords. Publications made from 2019 to 2023 (period) were considered to get insights on the quickly changing technological advancements (AI) and their use in organizations (IAF). As shown in Fig. 2, the separate unrestricted search results were 20,139 and 1058 publications for the keywords "artificial intelligence" and "internal audit", respectively, from 2019 to 2021. Second, a joint search was executed using both keywords "artificial intelligence" AND "internal audit", resulting in 62 publications (only 0.3% of the total publication).[1] This result supports the literature (Lehner et al., 2023), concluding that there are limited investigations made on the use of AI in IAF.

Third, restriction criteria were applied to filter out the relevant publications on the topic (since the WoS has wide-ranging journals in numerous disciplines). The restrictions are the document type (only articles and conference proceedings included) and research areas (business economics). Articles are the best categories for a review highlighting empirical insights (Lehner et al., 2023). Similarly, considering the suggestion of Massaro et al. (2016), conference proceedings are also included to capture future research insights. The research area restriction limited the search to business economics. The database (WoS) has one research area, "Business Economics", relevant to this review. After applying both restriction criteria, the joint search ("artificial intelligence" AND "internal audit") results in 15

publications, which are the sample units for this review (see Fig. 2).[2] Notably, 13 research articles and two conference proceedings were considered out of this paper's total selected publications (15). Then, all essential information (relevant to evaluate the output) of the selected publications was downloaded, such as publication year, author(s), document title, abstract, keywords, source title and type, and document type.

Analytical framework. The necessary step of SLR before data analysis is to outline the units of analysis included in the selected analytical framework. This study used the outlines and units of analysis as suggested by Massaro et al. (2016) and applied by studies like Bracci et al. (2019). Hence, this study addressed these units in three analysis clusters to comprehensively view the scholarly literature on AI use in IAF (addressing the first research question (RQ1)).

Firstly, the relevance and novelty of selected publications on the topic were identified, measured by citation analysis and frequency distribution of publications per year. The review observed that not all publications have a similar impact on the field, confirming the argument of Massaro et al. (2016).

Second, the review targeted the assessment of the research method of the publications encompassed in the sample since evaluating how the theory is used in the studies is necessary. Specifically, as applied by Bracci et al. (2019), the study assessed the theoretical contribution provided by the study in three different sets: no framework was proposed, applying a previous framework and proposing a new framework.. The review also assessed how the theoretical contribution linked to the research method applied (interviews, historical analysis, case study, survey, and conceptual analysis). This analysis is used as a proxy for evaluating theoretical superiority and methodology fit within the research area (use of AI in IAF) (Bracci et al., 2019).

Finally, the research context considered in each selected publication was assessed since it previews the publications in time and location. It offers a way to forward suggestions on how AI in IAF research can be furthered (which also answers the second research question (RQ2)) through assessing the link with theory, enlarging geographical coverage, or undertaking comparative investigations. Table 1 shows the summary of the sampled publications used for this review and a detailed analysis to be covered in the latter sections of this paper.

Main results
Research area– identifying the research novelty in time on the use of AI in IAF. As more and more journals continue to accept theoretical outcomes of articles published in this area, the research area's continuity and novelty will be confirmed. Table 2 shows the journals with sampled publications regarding the use of AI in IAF. Moreover, as Massaro et al. (2016) stated, field-level relevance is shown through the journal's impact factor. The review found that the International Journal of Accounting Information Systems (with a 1.159 impact factor) has published the most by contributing 2 (13.29%) publications.[3] Considering the impact factor (based on Scimago Journal Rank (SJR) 2022), the Accounting, Auditing & Accountability Journal (with 1.729 impact factor) was found to be the second most published journal, contributing one article. Moreover, Minds and Machines (with a 1.232 impact factor) and the Australian Journal of Management (with a 1.132 impact factor) followed the third and fourth journals by contributing one article each. The result shows that publications are made in journals relevant to the topic (journals focusing on auditing and information systems).

In the sampled periods, the review found that the topic shows a substantial increment of publications in auditing and information

Table 1 Summary of publications reviewed in the literature.

Publication date/author/country	Title	Journal	Framework	Method	Key findings
07-12-2019 Jans and Hosseinpour Belgium	"How active learning and process mining can act as Continuous Auditing catalyst"	International Journal of Accounting Information Systems	Proposes a new model	Case study	• The transaction verification framework was developed. • Basic principles of continuous auditing were confirmed. • Data mining could complement the approach.
12-06-2020 Westland US	"Predicting credit card fraud with Sarbanes-Oxley assessments and Fama-French risk factors."	Intelligent Systems in Accounting, Finance and Management	Proposes a new model	Historical analysis	• The most important predictors for credit card fraud are: • Audit firm fees • The Fama-French risk factors coefficient • The Fama-French 3-factor model R^2
28-02-2021 Zhou China	"Research on the problems of enterprise internal audit under the background of artificial intelligence."	Journal of Physics: Conference Series	Proposes a new model	Conceptual	• The development of enterprise management that has contributed to a regularly optimized internal audit with an advanced intelligent system.
05-01-2021 Nonnenmacher et al. Germany	"Using Autoencoders for Data-Driven Analysis in Internal Auditing"	The 54th Hawaii International Conference on System Sciences	Applies previous models	Case study	• The quality of internal auditing can be improved through autoencoders, which support auditors' engagement.
5-11-2021 Chen et al. China	"Enterprise's internal control for knowledge discovery in a big data environment by an integrated hybrid model"	Information Technology and Management	Proposes a new model	Survey	• The control environment is the top dimension in a big data environment. • Information technology control construction is the top criterion in a big data environment.
5-11-2021 Mökande et al. UK	"Conformity Assessments and Post-market Monitoring: A Guide to the Role of Auditing in the Proposed European AI Regulation"	Minds and Machines	Applies previous models	Conceptual	• Amendments are suggested in some aspects to: - Add verifiable criteria for vague concepts - Improve controls on conformity assessments
29-06-2021 Allbabidi Jordan	"Hype or Hope: Digital Technologies in Auditing Process"	Asian Journal of Business and Accounting	Applies previous models	Survey	• Technology–organization–environment framework factors found significant in affecting the utilization of digital technologies • Auditors' performance can be enhanced by utilizing digital technologies
10-07-2021 Khan et al. Australia	"AI-based audit of fuzzy front-end innovation using ISO56002"	Managerial Auditing Journal	Applies previous models	Interviews	• The development of a Fuzzy front-end artificial intelligence audit tool results in a 92% enhancement in efficiency and 95% effective than the human auditor
17-11-2021 Puthukulam et al. Oman	"Auditors' Perception on the Impact of Artificial Intelligence on Professional Skepticism and Judgment in Oman"	Universal Journal of Accounting and Finance	Applies previous models	Survey	• Machin learning-assisted, and AI-based audit systems have significant impact and relation with: - Professional judgment - Professional scepticism

Table 1 (continued)

Publication date/ author/country	Title	Journal	Framework	Method	Key findings
28-02-2022 Korol et al. Ukraine	"Elaboration of recommendations on the development of the state internal audit system when applying the digital technologies"	Eastern-European Journal of Enterprise Technologies	Proposes a new model	Historical analysis	• It was suggested to use indicators for overall financial control measures for state internal audit. • The proposed mechanism is to establish the impact of digital technologies on the state's internal audit development.
07-07-2022 Seethamraju and Hecimovic Australia	"Adoption of artificial intelligence in auditing: An exploratory study"	Australian Journal of Management	Applies previous models	Interviews	• The following technology-organization-environment (TOE) factors were found to be significant in influencing AI adoption: - Perceived benefits, compatibility, and maturity (T) - Organizational readiness, data quality, and trust (O) - Audit standards, regulation, and client readiness (E)
15-07-2022 Xavier et al. Brazil	"Tax evasion identification using open data and artificial intelligence"	Brazilian Journal of Public Administration	Proposes a new model	Historical analysis	• A 98% prediction accuracy was attained in companies evading tax by validating after-fine improvements. • They created a web-based solution for tax offices.
19-08-2022 Rehman and Hashim Oman	"Can internal audit function impact artificial intelligence? Case of publicly listed companies of Oman"	AIP Conference Proceedings	Applies previous models	Survey	• IAF significantly affect AI since the organization's IAF offers the input data.
11-08-2022 Zhang et al. Australia	"Continuous monitoring with machine learning and interactive data visualization: An application to a healthcare payroll process."	International Journal of Accounting Information Systems	Applies previous models	Case study	• In continuous monitoring, information overload can be solved through machine learning and interactive data visualization technologies. • The efficiency of irregularity detection, loss deterrence, and risk assessment can be improved through technological mergers.
19-02-2023 Lehner et al. Austria	"Artificial intelligence-based decision-making in accounting and auditing: ethical challenges and normative thinking."	Accounting, Auditing & Accountability Journal	No model proposed	Conceptual	• AI-based decision-making in accounting faces the following five significant ethical challenges: - Objectivity - Privacy - Transparency - Accountability - Trustworthiness

Table 2 Distribution of publications per journal.

| Publication source (Journal)	SJR Impact Factor 2022	No. of publications	%
International Journal of Accounting Information Systems	1.159	2	13.29
Accounting, Auditing & Accountability Journal	1.727	1	6.67
Minds and Machines	1.232	1	6.67
Australian Journal of Management	1.132	1	6.67
Intelligent Systems in Accounting, Finance and Management	0.625	1	6.67
Managerial Auditing Journal	0.606	1	6.67
Information Technology and Management	0.534	1	6.67
Eastern-European Journal of Enterprise Technologies	0.283	1	6.67
Asian Journal of Business and Accounting	0.224	1	6.67
Journal of Physics: Conference Series	0.183	1	6.67
AIP Conference Proceedings	0.164	1	6.67
Brazilian Journal of Public Administration	–	1	6.67
The 54th Hawaii International Conference	–	1	6.67
Universal Journal of Accounting and Finance	–	1	6.67
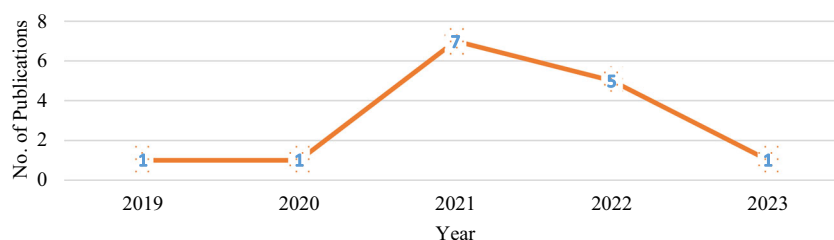
Fig. 3 Publication distribution per year. The figure shows the trend of sampled publications from 2019 to 2023.

Table 3 Top five most cited publications in 2023.

Year	Authors	Article title	Total citations
2021	Jakob Mökander; Maria Axente; Federico Casolari; Luciano Floridi	"Conformity Assessments and Post-market Monitoring: A Guide to the Role of Auditing in the Proposed European AI Regulation"	11
2019	Mieke Jans; Marzie Hosseinpour	"How active learning and process mining can act as Continuous Auditing catalyst."	10
2021	Jakob Nonnenmacher; Felix Kruse; Gerrit Schumann; J. Gómez	"Using Autoencoders for Data-Driven Analysis in Internal Auditing"	9
2023	Othmar Manfred Lehner, Kim Ittonen; Hanna Silvola; Eva Ström; Alena Wührleitner	"Artificial intelligence based decision-making in accounting and auditing: ethical challenges and normative thinking."	6
2021	Mohamad Hesham Adnan Allbabidi	"Hype or Hope: Digital Technologies in Auditing Process"	3

technology research. The trend/distribution of sampled publications from 2019 to 2023 is presented in Fig. 3. It shows that in 2019 and 2020, the topic did not get substantial attention since only two publications (one publication for each year) were made. Surprisingly, in 2021 and 2022, the topic became more visible and contributed to 12 publications. In 2023, until this review was done, only one publication was found, and this may be due to the year not ending yet. However, the increment of publication over time varies significantly from year to year.

The five most cited publications in the sample are presented in Table 3 (all self-citations were removed). This analysis helps us understand the publication's importance (Massaro et al., 2016). In the database (WoS), the most cited publication in the sample is the one contributed by Mokander et al. (2021), having 11 citations[4], followed by Jans and Hosseinpour (2019), with 10 citations. Three of the most cited papers were published in 2021. Except for the study made by Jans and Hosseinpour (2019), the other most cited studies used previous frameworks.

Research methods– emerging theoretical superiority. The distribution of sampled publications per research method used is
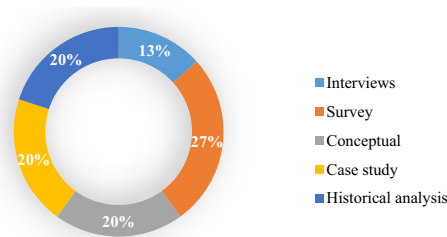

Fig. 4 Distribution of publications per research method. The figure shows the distribution of sampled publications per research method used.

presented in Fig. 4. The criteria to classify the research methods were used as applied by Bracci et al. (2019). Those methods include interviews, surveys, conceptual studies, case studies, and historical analysis. The result shows that most publications tend to be classified as surveys (27%). Hence, much of the research area is enriched with empirical evidence. Three methods with similar scores (20% each) were utilized in the study: conceptual,
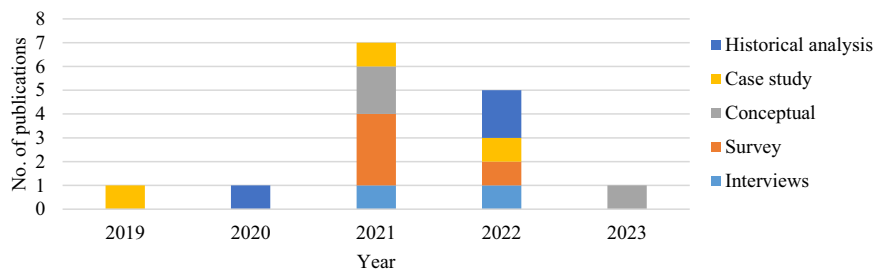
Fig. 5 Distribution of publications per research method and year. The figure shows the trends of the methods adopted over time in the selected publications.
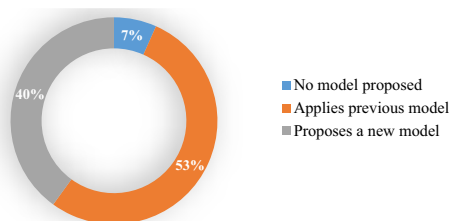

Fig. 6 Distribution of publications per framework used. The figure shows the distribution of the theoretical frameworks used in the selected publications.

case study, and historical analysis. However, the review found that most studies were explanatory, indicating the need to study the research area further. Moreover, the result shows that it was easy to transform the concepts of the topic into variables, allowing us to undertake quantitative analysis (through a survey). The publications that applied conceptual methods used a qualitative approach to argue and debate the subject matter.

The trends of the methods adopted over time are presented in Fig. 5. This work recognized substantial phenomena from the trend. First, the review observed using different research methods during the peak periods (2021 and 2022). Four different methods were used during those periods. Moreover, most of the studies were empirical from the peak period publications. They indicate that the authors contribute substantial empirical insights for applying frameworks for using AI in the IAF (to real-world contexts). However, the limited publications made as conceptual work indicate that AI use in the IAF still needs more theory development and shared views (in definitions). The result confirms that a survey was the most adopted research method, as shown in Fig. 5.

Regarding the theoretical framework related to the use of IA in the IAF, the theoretical contribution of the studies in the sample was assessed (see Fig. 6). As studies introduce new frameworks, it may confirm the research topic's novelty and an emerging interest in the subject area. Similarly, applying the existing frameworks reflects the effort needed for the replicability and continuity of contributions on the topic (Lehner et al., 2023; Massaro et al., 2016). Both approaches are vital in further identifying the emerging state of theory and development of AI in the IAF (Lehner et al., 2023). Considering the recent and quickly changing technological advancement, this work expects a heterogeneous distribution of frameworks.

The review found that most studies (53%) included in the sample used previous frameworks to study the topic (see Fig. 6). The technological–organisational–environment (TOE) was the most utilized framework in the selected studies. For instance, the study of Seethamraju and Hecimovic (2022) used the framework to study AI adoption in auditing. They conclude that AI can enhance audit quality and provide value-adding services to the

organization. However, the AI adoption needs to reconsider the audit practice with the expected lack of control in AI 'black-box', which may be exposed to extensive examination of the audit quality.

In contrast, only one study did not use any specific framework, representing 7% of the publications selected for this review. In addition, 40% of the sampled studies proposed new models to use AI in the IAF. Fortunately, these studies addressed the topic by investigating the adoption and use of AI in the IAF (Chen et al., 2021; Korol et al., 2022). Other authors also offered new insights on the use of AI in the IAF by pursuing to resolve the complexity of AI use holistically.

The relation between the research method and the framework used by the sampled publications is presented in Fig. 7. It shows the relevance and expansion of methods on the topic. In the interview category, the two studies used the previous frameworks.

Moreover, three studies used the previous frameworks in the survey category, while one proposed a new one. Likewise, three publications were found in the conceptual category with no model, used previous frameworks, and proposed a new model (separately). Two studies used the previous frameworks in the case study category, while one proposed a new one. Finally, all three studies proposed new frameworks in the historical analysis category. The results indicate the quantitative nature of the research on the topic, and the area still needs further theoretical debate. In this review, it is also important to note that the interview is not a widely used research method.

Research context– placing publications in time and location. The distribution of sampled publications per location (country and region) is presented in Table 4. This analysis is essential to get insight into the locations studied in the literature and identify the areas yet to be explored, thus assisting in identifying future research avenues (Massaro et al., 2016). This review analyses the location in two categories: country and region. Considering the country, most of the studies are located in Australia, representing 20 per cent of the sample, followed by China and Oman with the same score (13.32%). Considering the region, Asia and Europe have the most studies, representing 33.33 per cent of the sample. Australia was the second region, constituting 20% of the sampled articles. However, North America and South America are the least studied regions, each only contributing 7% of the publications. The review observed two phenomena from the results. First, the selected studies considered single-country cases, indicating no comparative analysis was made (between cases from two or more countries). A comparative analysis is vital for the topic (AI in the IAF) to measure and conceptualize it in diverse contexts. Second, most of the studies on the topic were conducted in developed countries and regions, indicating the shortage of research in other contexts. This phenomenon confirms the study of Allbabidi (2021), who stated that most of the studies on adopting and using AI for auditing are undertaken in developed
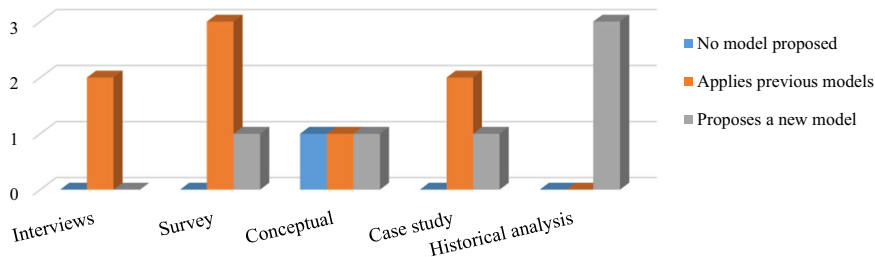
Fig. 7 The relation between the research method and the framework used. The figure shows the relation between the research method and the theoretical framework applied in the sampled publications.

Table 4 Distribution of publications per location.					
Country	**No. of publications**	**%**	**Region**	**No. of publications**	**%**
China	2	13.32	Asia	5	33.33
Oman	2	13.32	–	–	–
Jordan	1	6.67	–	–	–
UK	1	6.67	Europe	5	33.33
Belgium	1	6.67	–	–	–
Germany	1	6.67	–	–	–
Ukraine	1	6.67	–	–	–
Austria	1	6.67	–	–	–
Australia	3	20.0	Australia	3	20.0
US	1	6.67	North America	1	6.67
Brazil	1	6.67	South America	1	6.67

countries. Thus, studies must further investigate the topic in developing countries and regions (e.g. Africa).

Discussion: future research avenues

This review generally highlights that, as a research field, the use of AI in the IAF has yet to reach a substantial level of consideration. The analysis reveals that there is a fluctuating contribution of publications per year. It shows that in 2019 and 2020, the topic did not get substantial attention, and in 2021 and 2022, the topic became more visible, contributing to most of the publications (12 articles). The limited number of publications may initiate debate on the relevance of the research interest in using AI in IAF. This review also found that 40% of sampled studies proposed new models to use AI in the IAF, and they investigated the adoption and use of AI in the IAF (Chen et al., 2021; Zhang et al., 2022).

The analysis demonstrated that the publications contribute to understanding AI's concepts, definition, and operation in different applications. Nevertheless, in an IAF context, the review revealed a lack of in-depth studies and fewer attempts to bring existing theories to AI implementation and auditing. The finding signals that additional investigations must be undertaken, although methodological and theoretical risks are expected. Future researchers can contribute to the field by conceptualizing the topic and use of AI in the IAF and investigating how to implement AI in the IAF. Moreover, they may contribute to how to measure the implementation level from theoretical and practical backgrounds. Research attention in such queries initiates insights built on the use of AI in the IAF topics and main arguments: How can AI contribute to developing IAF? What are the benefits, and how does AI affect the decision processes of IAF and policymakers? Similarly, how is AI affected by auditing concepts?

From the review, it was evident that several scholars believe that utilizing AI in the IAF will minimize human errors and provide efficiency. For instance, using AI for the organizational process minimizes human errors, assists the decision-making process, and provides more advantages for the company (Parker, 2022; Q.ai-Contributor-Group, 2022; Adhikari, 2021; Tableau, 2021; Opr, 2020; Couceiro et al., 2020). With the assistance of AI, judgements in IAF are made from the earlier information collected through employing a definite mix of algorithms—subsequently, a significant likelihood of attaining accuracy to a greater extent of precision. Puthukulam et al. (2021) demonstrated ample usage of big data and analytics in the IAF of large companies. The robotics of IAF and the utilization of AI could get forward actionable predictions that could assist internal auditors in making the correct insights. AI could assist the IAF in auditing tasks efficiently and effectively (Muspratt, 2018; Seethamraju & Hecimovic, 2022).

Although AI creates opportunities for researchers on how to use it in the IAF and how it progresses the efficiency of IAF, it is also relevant to investigate the dark side of using AI. For example, in the application of AI technology, it is possible to experience information loss or damage for many reasons, such as (but not limited to) machine impairments or Cyber-attacks (HRF, 2022). Other scholars argue that AI's implementation and maintenance cost is another challenge (Edmondson, 2020). Such views call for additional investigations on the potential use of AI in the IAF.

Methodologically, researchers may undertake comprehensive studies on how the use of AI in the IAF is conceptualized and may introduce new models for its measurement and application. In this context, this review finds that many researchers (Chen et al., 2021; Jans & Hosseinpour, 2019; Xavier et al., 2022; Westland, 2020; Zhou, 2021; Korol et al., 2022) tried to study the topic by introducing new models. The efforts of those researchers encouraged other scholars to contribute new insights into the theoretical frameworks in the field. In addition, it was found that measuring the use of AI in the IAF was not complex. Most studies in this review applied the survey method, indicating that quantitative approaches are the most utilized. However, the limited publications made as conceptual work indicate that AI use in the IAF still needs more theory development and shared views (in definitions).

Considering the locations in previous publications, this review found that no study was undertaken considering two country cases (comparative analysis). Moreover, it was found that most studies undertaken on the topic are based in developed countries, confirming Allbabidi's (2021) study. In those circumstances, future researchers can contribute by undertaking comparative analysis and covering different locations, especially developing regions (like Africa) and countries.

Overall, there are limited studies on the use of AI in the IAF (Couceiro et al., 2020; Seethamraju & Hecimovic, 2022; Ghanoum & Alaba, 2020). Although the concept and application of AI are getting wide acceptance, they have not yet been applied in some countries. Most studies are in Australia, China, and Oman (Zhou, 2021; Khan et al., 2021; Rehmanand & Hashim, 2022). Besides, it

was found that Asia and Europe are the most studied areas (Lehner et al., 2023). The review also revealed that most of the studies used the previously developed and common framework, which is technological–organizational–environmental (TOE) (Seethamraju & Hecimovic, 2022; Chen et al., 2021). The review highlights research gaps in the area under study, such as limited studies on the topic and low AI adoption rates in the IAF across different countries and regions. Besides, there is a shortage of comprehensive frameworks for effectively using AI in IAF. Hence, this review work tries to fill the research gap by offering an outline of research avenues on the literature topic and suggesting a new compressive framework (CACS) for the effective use of AI in the IAF.

Accordingly, considering the review, this study suggests that future researchers can use and validate the newly introduced commitment, access, capability, and skilling (CACS) framework, which is a wide-ranging step in this direction (Metricstream, 2020). AI could let organizations and their internal audit functions grow quicker due to the difficulties of data analysis and management of risk. The journey of AI can be accelerated with the help of IAF, given the CACS framework displayed in Fig. 8. Implementing the suggested CACS could be the turning point for internal audit, letting people move away and creating a method for AI to evaluate the big and disorganized data.

Using the CACS framework (Fig. 8), the advanced audit performance needs commitment and specific focus. The first step in the path of a technology-oriented mindset is the acceptance and recognition of innovative technologies to assist IAF (Khan et al., 2021; Zhou, 2021). The values of AI would be better recognized when there is an organizational commitment to discovering sections of IAF that could be brought under the fold of robotics. Moreover, cracking complex data sets using analytics could protect multimillion dollars (Metricstream, 2020).

Access is the second critical attribute for the effective utilization of AI in the IAF. Internal auditors face many difficulties, and one of the main challenges is related to access; this is because, in some periods, the process holders are open to allowing them in, and in others, they are not. This practice is a custom or association matter rather than a technological issue; however, it is very relevant for using AI in IAF (Seethamraju & Hecimovic, 2022). Access to the operating system that processes and analyses owners is undoubtedly an obstacle to internal auditors, which
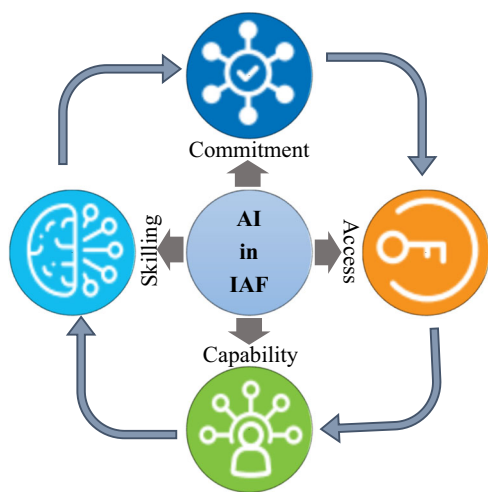
they have to pass before they begin the path to utilize intelligent technology, which is for monitoring continuously (Metricstream, 2020).

The other critical attribute essential for any IAF to utilize AI is system capabilities, as it is where the data reliability initiative commences. The exclusive feature of data storage and analysis begins with knowing the system's capability (Rehmanand & Hashim, 2022). In addition to AI's assessment of the performance of control systems and examination of financial or information systems in the IAF, the essential point is understanding how big data will be handled and processed in the system. For having and telling a material story, there should be the capability of IAF to join the data spots (Metricstream, 2020).

Finally, the successful utilization of AI in the IAF of a company is highly dependent on skilling. Providing training and development for internal auditors is critical since, from a firm viewpoint, it is essential to discover where employees with the necessary skills are seated in the internal audit team and then put them together for fair resource allocation (Nonnenmacher et al., 2021). In time, this could be a challenge since there might be associates in the audit group or team who started working when the technology was less used in their tasks. Making them acquire a technological mindset or training them might be difficult. The key is optional to hire new staff but rather leverage the prevailing talent (Metricstream, 2020). In general, the four attributes are essential for implementing and utilizing AI in the IAF of an organization. One of the targets of this paper is to provide the practical implication and applicability of the subject matter. Thus, companies need to use those attributes in the framework to quickly implement and utilize AI in their IAF.

Conclusion and practical implication

A strong structure of internal audit functions, policies, and guidelines is necessary to gain the opportunities of AI. AI can support the company's internal audit function by delivering substantial strategic oversight, minimizing analysis based on manual procedures, and offering additional wide-ranging audits. The way of doing business is getting more complex than earlier, and it is because of the advances in technology and instant improvements in the manner of operations; hence, companies need to employ AI and update themselves continuously.

The present research on the use of AI in the IAF is in its emerging state. This review finds that many researchers tried to study the topic by introducing new models. The efforts of those researchers encouraged other scholars to contribute new insights into the theoretical frameworks in the field. However, there is a shortage of comprehensive frameworks for the use of AI in the IAF. In addition, it was found that measuring the use of AI in the IAF was not complex. Most studies in this review applied the survey method, indicating that quantitative approaches are the most utilized. However, the limited publications made as conceptual work indicate that AI use in the IAF still needs more theory development and shared views (in definitions). Besides, the review found that no study was undertaken considering two country cases (comparative analysis). Moreover, it was found that most studies undertaken on the topic are based in developed countries. Hence, future researchers can contribute by undertaking comparative analysis and covering different locations, especially developing regions (like Africa) and countries.

The findings of this review provide relevant theoretical and practical contributions for different stakeholders, including internal auditors, regulators, organizations, researchers, and the whole business community. Regarding theory, this review offers a comprehensive highlight of the prevailing research, contributing to formulating and arranging knowledge on the deeper

Fig. 8 CACS framework for artificial intelligence utilization in IAF. The figure shows the commitment, access, capability, and skilling (CACS) framework for AI utilization in the IAF. Source: as suggested by MetricStream (2020).

understanding of how AI affects the IAF. Besides, it highlights the research areas that lack investigations (research gaps), guiding future research directions and theoretical foundations. Moreover, this review contributes to developing a theoretical framework (CACS), assisting stakeholders to understand and conceptualize the use of AI in the IAF, and can be a basis for future investigations.

Regarding practice, this review helps internal auditors assess and understand the potential advantages and risks of implementing AI in their organization's IAF. It also helps internal auditors identify the new skills required to adopt and effectively use AI in their audit tasks, highlighting training and skill development areas. Besides, this review is helpful to regulators in updating regulations on internal auditing in the context of using advanced technology such as AI, ensuring the compliance of internal auditing practices to the evolving technology. Finally, organizations can benefit from this review to decide whether AI investments for their IAFs are justified. Considering the value of utilizing AI in the IAF of an organization, companies need to utilize AI and make it work in the IAF efficiently. For this reason, the recently introduced CACS framework with four attributes was recommended for implementing AI in the IAF. Thus, organizations can benefit from the framework to quickly implement and utilize AI in their IAF.

This review has some limitations, such as the data set used in the database (Web of Science), is limited to the selected keywords, and only includes research articles and conference papers. Although the researcher was aware of this limitation, it was believed that the Web of Science lets more replicable inquiries (a vital aspect of a systematic literature review). Moreover, the results are limited to the extent and depth of the data analyzed. Nevertheless, the reliability of the findings is ensured by the systematic literature review approach, yet the interpretations of the results are contingent on the beliefs and understanding of the researcher.

Data availability
Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

Notes
1 The refined Web of Science research string is documented as follows: *Artificial intelligence* (Topic) and *internal audit* (Topic) and *Preprint Citation Index* (Exclude – Database) and *2019 or 2020 or 2021 or 2022 or 2023* (Publication Years).
2 The refined Web of Science research string is documented as follows: *Artificial intelligence* (Topic) and *internal audit* (Topic) and *Preprint Citation Index* (Exclude – Database) and *2019 or 2020 or 2021 or 2022 or 2023* (Publication Years) and *Article or Early Access* (Document Types) and *Business Economics* (Research Areas).
3 For additional information: https://www.sciencedirect.com/journal/international-journal-of-accounting-information-systems.
4 Web of Science journal citation report 2023, for additional information: https://www.webofscience.com/wos/alldb/full-record/WOS:000714864800001.

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Author contributions

LLP contributed to the initial idea and design of the study; FAW contributed to the data collection, performed the data analysis, and wrote the first draft of the review manuscript; FAW and LLP contributed to the manuscript revision, reading, and approving the submitted versions.

Funding

Competing interests

The authors declare no competing interests.

Ethical approval

This article contains no studies with human participants performed by any author.

Informed consent

Not applicable to this study.

Additional information

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