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SUSTAINABLE GOVERNANCE IN PUBLIC HEALTHCARE INFRASTRUCTURE: AN INTEGRATED TECHNICAL–FINANCIAL CONTROL APPROACH

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Abstract: Public healthcare infrastructure projects require management approaches that ensure efficiency, transparency, and the sustainable use of public resources. While construction estimate preparation and cost control are traditionally considered administrative or technical procedures, their role in sustainable governance of infrastructure projects remains underexplored. This study analyzes how an integrated methodology for construction estimate preparation and control contributes to sustainable management practices in public hospital infrastructure. Adopting an applied qualitative case-study approach grounded in a socio-technical systems perspective, the research examines the implementation of technical–financial monitoring processes implemented within a real-world institutional context within hospital construction projects commissioned by the Mexican Social Security Institute (IMSS). The methodology integrates digital tools, standardized documentation, and field supervision activities to connect planning, execution, and financial monitoring stages. Results indicate that the integrated approach improves operational coordination, enhances digital traceability, and strengthens transparency in financial management. The systematic alignment between technical documentation and field verification reduced operational inconsistencies and supported evidence-based decision-making processes. Beyond efficiency improvements, the methodology served as a governance mechanism, reinforcing accountability and responsible resource allocation. The study contributes to the sustainable infrastructure management literature by reframing construction estimate control as a socio-technical instrument that supports institutional sustainability in public investment projects. Findings highlight that operational management practices can generate social value by improving transparency and efficiency in the delivery of healthcare infrastructure. The proposed framework offers practical implications for public institutions seeking to strengthen sustainable governance mechanisms in construction management.

Keywords. Sustainable infrastructure management, public governance, healthcare infrastructure, socio-technical systems, construction management sustainability, sustainable governance.

Introduction

Healthcare infrastructure is a critical component of social development systems, as it directly supports public health services, social welfare, and institutional resilience. Hospitals are not only architectural and engineering projects but also socio-technical systems whose planning, construction, and management influence the efficiency, transparency, and sustainability of public resource allocation. In this context, infrastructure management has increasingly been linked to sustainable development objectives, particularly those associated with health (SDG 3), resilient infrastructure (SDG 9), and responsible resource management (SDG 12).

Public hospital projects demand high levels of technical coordination, financial control, and regulatory compliance due to their complexity, multidisciplinary nature, and social relevance. However, cost overruns, documentation inconsistencies, and insufficient integration between administrative and field processes remain recurring challenges in construction management worldwide. These issues not only affect pro-

ject efficiency but also compromise institutional transparency and the sustainable use of public funds.

Recent research in construction management highlights that accurate cost estimation and monitoring systems are essential for reducing uncertainty and improving decision-making processes in large infrastructure projects (Berg et al., 2025; Wang et al., 2025). Likewise, digital tools and integrated documentation systems have demonstrated their capacity to enhance traceability and accountability in public works management (BuildingSMART Spanish Chapter, 2023). Despite these advances, many institutional projects still lack standardized methodologies that link technical execution to financial monitoring and on-site verification within a coherent management framework.

From a sustainability perspective, efficient cost control should not be understood solely as an economic objective but as a mechanism that contributes to responsible resource consumption, reduction of material waste, and improved governance of public infrastructure investments. Particularly in healthcare infrastructure, where projects are financed through public resources, transparent and structured management processes become essential elements of social and institutional sustainability.

Within the Mexican context, hospital infrastructure projects developed under institutional frameworks such as those of the Mexican Social Security Institute (IMSS) require strict compliance with technical, administrative, and regulatory procedures. These characteristics provide an opportunity to analyze how structured methodologies integrating digital tools, technical documentation, and field supervision can strengthen sustainable project management practices.

Therefore, this study addresses the following research question:

Q1. How can an integrated methodology for construction estimate preparation and control contribute to sustainable management and transparency in public hospital infrastructure projects?

The objective of this study is to analyze and systematize the methodological framework applied in professional practice on hospital construction projects, integrating office-based technical processes, digital tools, and field supervision activities. The study proposes that structured estimate control functions as a socio-technical mechanism that enhances administrative efficiency, strengthens accountability, and supports sustainable governance in public infrastructure management.

The main contribution of this research lies in demonstrating how operational control practices traditionally considered administrative tasks can be reframed as strategic components of sustainable infrastructure management, linking technical precision, financial transparency, and institutional sustainability within public healthcare projects.

Theoretical Framework.

Sustainable management of public infrastructure.

Public infrastructure plays a fundamental role in social development by enabling access to essential services such as healthcare, education, and mobility. In recent decades, infrastructure management has evolved from a purely technical, engineering-oriented activity to an integrated sustainability perspective that incorporates

economic efficiency, social responsibility, and environmental awareness (United Nations, 2015).

Healthcare infrastructure, in particular, represents a strategic component of sustainable development because hospitals operate as critical social assets whose performance directly affects quality of life and institutional resilience. Sustainable infrastructure management involves not only minimizing environmental impacts but also ensuring efficient allocation of public resources, transparency in financial processes, and long-term operational reliability (Hansen & Coenen, 2015).

Within this framework, construction project management becomes a governance mechanism through which institutions translate public investment into social value. Inefficient cost estimation, inadequate monitoring, or fragmented documentation systems may lead to budget overruns, delays, and reduced public trust, underscoring the importance of structured management methodologies.

Cost control as a mechanism for institutional sustainability.

Traditionally, cost estimation and construction estimates have been considered administrative tools focused on financial control. However, contemporary research recognizes cost management as a key component of sustainability because it directly influences resource efficiency, waste reduction, and responsible consumption patterns (Silvius & Schipper, 2014).

Accurate estimation processes enable organizations to optimize material usage, prevent rework, and improve planning reliability. Studies on construction cost estimation emphasize that reducing uncertainty in early project phases significantly improves project outcomes and institutional performance (Berg et al., 2025). Likewise, predictive models and data-driven estimation approaches contribute to more transparent and accountable infrastructure management systems (Alshibani et al., 2025).

From a sustainability perspective, cost control supports:

- Efficient use of financial resources,
- reduction of material waste,
- improved lifecycle management,
- enhanced accountability in public investment.

Therefore, technical-financial monitoring processes can be interpreted as operational instruments that reinforce sustainable governance.

Digitalization and socio-technical integration in construction management.

Digital transformation has significantly reshaped construction management practices by integrating information technologies that improve coordination, traceability, and decision-making. Tools such as Building Information Modeling (BIM), digital budgeting systems, and data management platforms facilitate collaboration across disciplines and enhance project transparency (BuildingSMART Spanish Chapter, 2023).

The adoption of digital tools enables the creation of socio-technical systems in which human decision-making, technical documentation, and technological platforms operate simultaneously. This integration reduces information fragmentation between office planning and field execution, a pri-

mary cause of inefficiencies in construction projects.

Research indicates that digital coordination improves consistency between design documentation and executed quantities, strengthening monitoring processes and reducing operational risks (Cera, 2025). Furthermore, structured data management contributes to institutional learning by enabling organizations to accumulate historical knowledge for future projects (Olowe et al., 2025).

Thus, digitalization becomes not only a productivity enhancer but also a driver of sustainable management practices through improved transparency and accountability.

Governance, transparency, and accountability in public construction projects.

Public infrastructure projects require governance mechanisms capable of ensuring compliance with technical regulations, financial transparency, and social accountability. Governance in construction management refers to the systems, procedures, and institutional arrangements that guide decision-making and ensure responsible use of public resources.

In public healthcare infrastructure, accountability mechanisms are particularly relevant because projects are financed through collective resources and must demonstrate measurable social benefits. Structured documentation, standardized reporting formats, and field verification processes function as control instruments that strengthen institutional legitimacy.

Cost overruns in construction projects have frequently been associated with weak monitoring systems and insufficient integration between planning and execution stages (Tijanić, 2026). Consequently, integrated methodologies that combine administrative control with field supervision improve governance outcomes by enabling early detection of deviations and evidence-based decision-making.

Conceptual integration: Toward sustainable technical-financial control.

Based on the reviewed literature, sustainable infrastructure management emerges as a multidimensional process integrating:

1. Technical precision (engineering execution),
2. Financial control (resource efficiency),
3. Digital coordination (information traceability),
4. Governance mechanisms (institutional accountability),
5. Social value generation (public service improvement).

This study adopts a socio-technical perspective, in which construction estimate control is conceptualized as an integrated management system that links administrative processes with field verification. Rather than being limited to accounting functions, estimate preparation and quantity takeoffs operate as instruments that support sustainable governance by improving transparency, reducing uncertainty, and enhancing decision-making within public hospital infrastructure projects.

Based on the conceptual integration developed in this study, the Integrated Technical–Financial Governance Framework (ITFG Framework) is proposed as a

socio-technical model explaining how operational control processes contribute to sustainable governance in public infrastructure projects (**Figure 1**).

The framework illustrates the interaction among planning, digital coordination, field supervision, and technical–financial monitoring processes, which collectively generate transparency, accountability, and sustainability outcomes in public healthcare infrastructure projects. Conceptual diagram developed by the authors with the assistance of artificial intelligence tools for visual design.

Methodology

Research design.

This study adopts an applied qualitative case-study approach, informed by a socio-technical systems perspective, to analyze how integrated technical–financial control processes contribute to sustainable management in public healthcare infrastructure projects.

Case study methodology is particularly appropriate for examining complex organizational processes occurring within real institutional contexts, where technical practices, administrative procedures, and human decision-making interact simultaneously. In infrastructure management research, applied case studies allow the systematic examination of operational practices that cannot be isolated experimentally but generate relevant organizational knowledge.

The research analyzes the implementation of a structured methodology for construction estimate preparation and control developed during professional practice within a construction company responsible for projects commissioned by the Mexican Social Security Institute (IMSS). The hospital

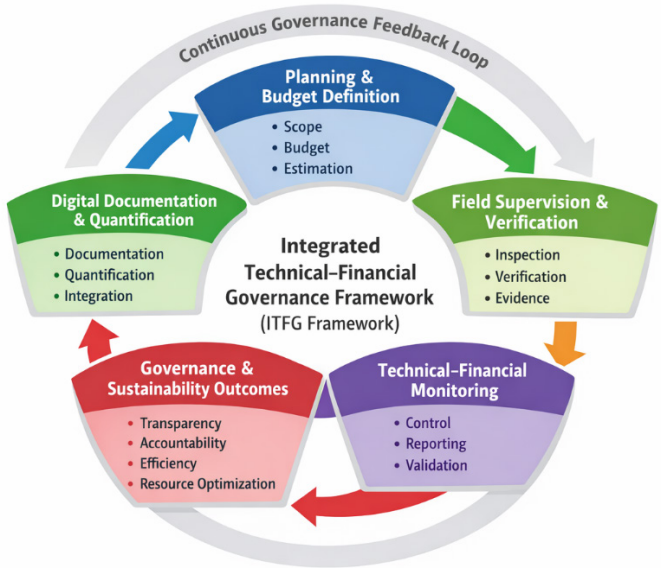

Figure 1. Integrated Technical–Financial Control Framework (ITFG).

Source: Authors' elaboration.

infrastructure project served as the empirical unit of analysis due to its high technical complexity and strict institutional control requirements.

Rather than evaluating individual construction activities, the study focuses on understanding how integrated administrative and field processes function collectively as a management system that enhances transparency, efficiency, and sustainability.

Socio-technical analytical framework.

The methodological approach is grounded in a socio-technical perspective, which considers organizational outcomes as the result of interactions between:

- Technical tools,
- administrative procedures,
- human supervision,
- institutional regulations, and
- operational environments.

Within this framework, construction estimate control is analyzed not merely as a financial activity but as an integrated governance mechanism that links technical execution to accountability processes.

The analytical framework evaluates three interconnected dimensions:

1. **Technical dimension** – preparation of estimates, quantity takeoffs, and documentation.
2. **Administrative dimension** – cost monitoring, reporting systems, and budget control.
3. **Operational dimension** – field supervision, verification processes, and regulatory compliance.

The integration of these dimensions enables assessment of how structured control practices support sustainable infrastructure management.

Case context and data sources.

The empirical study was conducted during a professional internship period (August–November), involving daily participation in technical and administrative activities related to hospital construction management. The research combined office-based work with periodic on-site supervision across multiple project locations within an urban environment.

Data sources included:

- Unit price analysis documents,
- work item catalogs,
- quantity takeoff sheets,
- construction estimates,
- photographic records,
- technical inspection reports,
- integrated project monitoring reports.

These materials constituted documentary evidence that enabled triangulation among planned activities, executed work, and financial monitoring processes.

The institutional context of IMSS projects provided a controlled environment characterized by standardized documentation requirements, regulatory compliance procedures, and formalized reporting structures, enabling systematic observation of management practices.

Tools and digital integration.

Digital tools played a central role in the methodological implementation by enabling coordination between technical and administrative information flows.

The following tools were employed:

- Microsoft Excel for data organization, cost analysis, deviation monitoring, and reporting;
- OPUS software for budget preparation and financial control through comparison between planned and executed costs;
- AutoCAD (2D) for drawing coordination and accurate measurement of construction quantities.

The combined use of these tools facilitated traceability of information and reduced discrepancies between project documentation and field execution, thereby supporting integrated monitoring processes.

Operational procedures.

The methodology integrated office activities and field supervision into a continuous monitoring cycle.

Office activities.

Office-based processes included:

- Unit price analysis,
- development of work item catalogs,
- material quantification,
- preparation of periodic construction estimates,
- preparation of technical reports.

These activities established the technical and financial baseline for project monitoring and enabled structured documentation management.

Field activities.

Field supervision involved:

- Daily site inspections,
- verification of construction procedures,
- regulatory compliance monitoring,
- supervision of work execution,
- photographic documentation.

Site visits enabled validation of executed quantities and alignment between physical progress and financial estimates, strengthening decision-making processes.

Data integration and analysis.

Data analysis followed an interpretative analytical strategy focused on identifying how integrated control practices influenced project management outcomes.

The analysis examined:

- Consistency between technical documentation and executed work,
- alignment between financial monitoring and physical progress,
- identification of deviations and corrective actions,
- improvements in administrative efficiency.

Integrated reports combining technical, financial, and visual evidence served as the primary analytical instruments. These reports enabled cross-verification of information and supported evaluation of the methodology's contribution to transparency and operational efficiency.

Methodological contribution.

The methodological contribution of this study lies in systematizing operational practices commonly treated as administrative routines and reframing them as components of a sustainable management framework for public infrastructure.

By integrating digital tools, standardized documentation, and field verification, the proposed approach demonstrates how technical-financial control processes can function as socio-technical mechanisms that enhance governance, accountability, and resource efficiency in healthcare construction projects.

Results

Operational integration and process efficiency.

The implementation of the integrated methodology enabled the consolidation of a coordinated technical–administrative workflow linking office-based planning activities with field supervision processes. This integration reduced fragmentation between project documentation, financial monitoring, and on-site execution, generating a continuous information flow that improved operational decision-making.

The structured preparation of construction estimates and quantity takeoffs allowed systematic monitoring of project progress, ensuring consistency between planned quantities and executed work. As a result, administrative procedures associated with estimate preparation became more efficient, reducing processing time and improving information reliability.

From a sustainability perspective, process integration improved organizational efficiency by reducing redundant documentation and strengthening coordination among technical personnel, supervisors, and administrative staff.

Digital traceability and financial transparency.

The combined use of Microsoft Excel, OPUS, and AutoCAD established a digital workflow that enhanced traceability throughout the project lifecycle. Information generated during design coordination, material quantification, and budget preparation was systematically connected with financial monitoring and reporting processes.

This digital integration enabled verification of quantities derived from executive drawings, automated comparison of planned and executed costs, real-time identification of deviations, and generation of standardized monitoring reports.

Improved traceability strengthened transparency in financial management by providing verifiable documentation supporting construction estimates and payment validation processes. The availability of structured digital records also facilitated institutional accountability by ensuring that technical decisions were supported by documented evidence.

Reduction of operational errors and resource optimization.

The adoption of standardized formats and verification procedures reduced common inconsistencies typically observed in the preparation of construction estimates. Alignment between technical drawings and field measurements minimized discrepan-

cies in material quantification, contributing to more accurate budgeting and resource allocation.

Field supervision played a critical role in validating completed work and detecting potential deficiencies early, preventing rework and unnecessary material consumption. This preventive monitoring approach contributed to operational sustainability by improving resource efficiency and reducing avoidable waste.

Although quantitative performance indicators were not the primary focus of the study, qualitative evidence obtained from project documentation and supervision reports indicated improved coordination, fewer documentation corrections, and greater precision in estimate preparation.

Strengthening of technical–financial governance.

Integrated project reports, combining technical data, financial monitoring, and photographic documentation, served as a comprehensive control mechanism supporting governance processes. These reports enabled simultaneous evaluation of physical progress and financial execution, facilitating evidence-based decision-making.

The incorporation of photographic documentation provided objective validation of executed work, reinforcing transparency and reducing uncertainty during estimate approval processes. This practice strengthened institutional confidence among project stakeholders and supported compliance with regulatory and contractual requirements.

The methodology demonstrated that structured documentation systems can operate as governance instruments by linking accountability mechanisms with operational practices.

Institutional outcomes and project completion.

The project achieved full completion within established contractual parameters, supported by systematic monitoring practices implemented throughout execution. Coordination between office activities and field supervision improved workflow continuity and ensured alignment between administrative processes and construction progress.

The structured control methodology contributed to improved administrative efficiency, enhanced reliability of technical information, compliance with institutional documentation standards, and strengthened monitoring of physical–financial progress.

These outcomes indicate that integrated estimate control practices extend beyond administrative functions and contribute to the sustainable management of public infrastructure projects by improving transparency, efficiency, and institutional coordination.

Discussion

The findings of this study demonstrate that construction estimate preparation and control, traditionally understood as administrative procedures, can function as strategic mechanisms supporting sustainable management in public healthcare infrastructure projects. The integration of technical documentation, digital tools, and field supervision revealed that operational control practices contribute not only to pro-

ject efficiency but also to institutional transparency and governance.

Cost control as a dimension of sustainable infrastructure management.

The results support the growing body of literature that interprets project management practices as components of sustainability rather than purely technical activities (Silvius & Schipper, 2014). In the analyzed case, structured estimate control enabled improved alignment between planned resources and executed work, reducing uncertainty and strengthening financial reliability.

From a sustainability perspective, efficient cost monitoring promotes responsible allocation of public resources by minimizing waste, preventing rework, and improving planning accuracy. These outcomes align with sustainable infrastructure principles emphasizing lifecycle efficiency and resource optimization. Thus, cost control emerges as an operational expression of sustainable management rather than solely a financial monitoring activity.

Beyond governance and financial transparency, the integrated control approach also contributes indirectly to environmental sustainability. Improved accuracy in material quantification and continuous field verification reduce overestimation, prevent rework, and minimize unnecessary material consumption. These operational efficiencies decrease construction waste generation and promote more responsible use of physical resources, demonstrating how administrative control mechanisms can produce environmental benefits within infrastructure projects.

Digitalization and transparency in public infrastructure governance.

The integration of digital tools played a central role in enhancing transparency and accountability. Consistent with previous studies on digital transformation in construction management (BuildingSMART Spanish Chapter, 2023), the coordinated use of Excel, OPUS, and AutoCAD facilitated traceability across planning, execution, and reporting stages.

Digital traceability reduced information asymmetry among stakeholders and enabled verification of decisions through documented evidence. This reinforces the argument that digitalization contributes to sustainability not only through efficiency gains but also through improved governance structures and institutional trust.

In public healthcare projects, where accountability requirements are particularly strict, digital documentation systems become essential governance instruments supporting transparent resource management.

Socio-technical integration and organizational learning.

The study highlights the importance of socio-technical integration in construction management. The interaction between human supervision, technological tools, and standardized procedures created a feedback system that improved coordination between office activities and field execution.

This integration facilitated organizational learning by enabling continuous comparison between planned and actual outcomes. The accumulation of structured documentation contributes to institutional memory, allowing organizations to refine

future projects and strengthen long-term sustainability practices.

These findings reinforce socio-technical perspectives, suggesting that sustainable performance emerges from balanced interaction between technological systems and human decision-making processes.

Governance implications for public healthcare infrastructure.

Public hospital projects represent socially sensitive investments that require strong governance mechanisms. The integrated methodology analyzed in this study functioned as a governance framework by linking accountability processes with operational activities.

Photographic documentation, standardized reports, and continuous supervision reduced uncertainty during estimate validation and strengthened compliance with regulatory requirements. These mechanisms enhanced institutional legitimacy by ensuring that financial expenditures corresponded to verifiable physical progress.

The findings suggest that governance effectiveness in infrastructure projects depends not only on regulatory frameworks but also on the operational practices through which monitoring and verification occur.

Contribution to sustainable development objectives.

The study contributes to discussions on sustainable development by demonstrating how technical management practices support broader societal goals. Improved efficiency and transparency in hospital infrastructure projects indirectly strengthen healthcare service delivery, aligning with Sustainable Development Goal 3 (Good Health and Well-being).

Similarly, the integration of digital monitoring systems and efficient resource management practices supports SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Consumption and Production). By reducing inefficiencies and improving accountability, structured estimate control contributes to sustainable public investment management.

Limitations and future research.

This study is based on a single applied case within a specific institutional context, which limits the generalization of findings. Future research could incorporate comparative analyses across multiple infrastructure projects or include quantitative performance indicators to evaluate sustainability impacts more systematically.

Additionally, future studies may explore the integration of advanced digital technologies, such as BIM and artificial intelligence, to further strengthen sustainable governance mechanisms in public construction management.

Conclusions

This study analyzed the implementation of an integrated methodology for construction estimate preparation and control within a public hospital infrastructure project, demonstrating that technical–financial monitoring processes can operate as strategic mechanisms supporting sustainable infrastructure management.

The findings show that integrating administrative procedures, digital tools, and field supervision improves coordination

between the planning and execution stages, strengthening operational efficiency and reducing inconsistencies in construction documentation. Beyond technical improvements, the methodology enhanced information traceability and reinforced transparency in financial monitoring processes, supporting accountability in the use of public resources.

From a sustainability perspective, the study highlights that cost control practices should not be interpreted solely as financial management activities but as operational instruments that promote responsible resource allocation, prevent material waste, and ensure institutional reliability. In public healthcare infrastructure projects, where investments directly affect social well-being, structured monitoring systems become essential components of sustainable governance.

The socio-technical integration observed in this case demonstrates that sustainability in infrastructure projects emerges from the interaction between technological tools, standardized procedures, and human supervision. The coordinated use of digital platforms enabled continuous verification of physical and financial progress, strengthening decision-making processes and reducing uncertainty throughout project execution.

This research contributes to the literature on sustainable infrastructure management by reframing construction estimate control as a governance mechanism linking technical precision with institutional transparency. The study expands existing discussions on sustainability by showing how operational management practices can generate social value through improved efficiency and accountability in public investment.

In practice, the proposed methodological framework provides public institutions and construction organizations with a replicable approach to improving monitoring processes for healthcare infrastructure projects. The integration of documentation systems and field verification procedures offers a pathway toward more transparent and efficient project management practices.

The study also contributes to discussions on sustainable development by demonstrating alignment with global development objectives, particularly those related to resilient infrastructure, responsible resource management, and improved public service delivery. By strengthening transparency and efficiency, integrated estimate control indirectly supports the long-term sustainability of healthcare systems.

Despite its contributions, this research is limited by its focus on a single case study within a specific institutional context. Future research could expand the analysis through comparative studies across multiple projects, the incorporation of quantitative sustainability indicators, or the evaluation of advanced digital technologies such as BIM-based monitoring or artificial intelligence-supported cost estimation.

Policy implications for developing countries. The findings of this study provide practical insights for public institutions in developing countries facing similar challenges in healthcare infrastructure management. Many emerging economies operate under conditions of limited financial resources, fragmented administrative systems, and high accountability demands. The integrated technical–financial control approach presented here demonstrates that improvements in governance do not necessarily require advanced technological infrastructures

but can emerge from structured coordination between documentation practices, digital tools, and field supervision.

Policymakers may strengthen infrastructure sustainability by promoting standardized monitoring procedures, integrating digital traceability into public procurement processes, and encouraging institutional training focused on technical–financial transparency. These measures can enhance public trust while improving efficiency in infrastructure delivery across diverse institutional contexts.

In conclusion, the study demonstrates that structured technical–financial control systems can transcend administrative functions and become key instruments for sustainable governance in public infrastructure projects, reinforcing transparency, efficiency, and institutional sustainability in healthcare construction management.

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Declaration / Author contributions

Use of artificial intelligence tools. Artificial intelligence tools were used exclusively to assist in the visual design of Figure 1. The conceptual content, analytical framework, and scientific interpretation were fully developed and validated by the authors.

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