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Smart capital mobilization in shared-use educational facilities: evidence from mega public universities

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ABSTRACT

Although smart capital and shared facilities can improve efficiency in large public universities, many institutions still rely on fragmented paper-based management. This study evaluates how smart capital, integrating facilities, digital systems, and human readiness, drives behavioral change in shared facility management (FM). A survey of 246 staff members across multiple constituent units of a large Vietnamese public university system was conducted. The study integrates constructs from the technology acceptance model (TAM), technology readiness index (TRI), and information system (IS) success model. Partial least squares structural equation modeling (PLS-SEM) was employed to examine structural relationships and role-based differences. The results indicate that perceived ease of use (PEU) and system quality (SQ) significantly influence system use, while TRI affects adoption indirectly through PEU and perceived usefulness (PU). Differences between facility and academic staff highlight the importance of role-sensitive strategies for shared FM. This study provides an integrated framework for mobilizing smart capital in shared-use governance of mega public universities.

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1. INTRODUCTION

Higher education drives social progress and economic mobility in developing countries, where limited resources demand efficient governance. To remain competitive amid labor market shifts and technological change, universities are pursuing reforms to improve efficiency and institutional accountability. In this context, capital extends beyond finance to include educational and infrastructural resources supporting institutional innovation [1], [2]. In large public university systems, multiple constituent units share common facilities and infrastructure. Therefore, coordinating these resources becomes a critical governance challenge. Research on smart campuses shows that integrating advanced technologies with physical infrastructure enhances efficiency, responsiveness, and user experience in higher education [3], [4]. This integration supports intelligent ecosystems for teaching, research, and administration. Building on this perspective, smart capital refers to the integrated capacity of facilities, digital systems, and human readiness to support coordinated infrastructure use in public universities.

In multi-unit university systems, poor coordination of shared laboratories, lecture halls, and specialized equipment creates administrative bottlenecks. It also disrupts teaching continuity, classroom scheduling stability, and students' learning experience [5], [6]. Delays in facility allocation, information asymmetry across units, and fragmented reporting systems may disrupt course delivery. They also limit practical training opportunities and reduce instructional efficiency. Therefore, improving shared-use facility governance is a strategic prerequisite for sustaining teaching quality and learning effectiveness. Fragmented facility management (FM) wastes resources, disrupts teaching schedules, and limits access to shared laboratories.

Existing research on digital transformation and shared facility governance in higher education has produced diverse theoretical and empirical insights. Effective management of physical capital, particularly educational facilities, is fundamental to the functioning of higher education institutions. In this context, FM plays a central role in maintaining safe and supportive environments for teaching and learning [7]. Traditional FM practices often rely on extensive documentation and manual information processing, causing delayed responses and inefficient resource utilization [8]. Smart technologies such as Big Data, quick response (QR) tracking, cloud-based inventory systems, artificial intelligence, and building information modeling are transforming FM practices [8]–[12]. These technologies enable real-time data use, predictive analytics, and better coordination in asset monitoring and management. Their adoption can also influence staff and user behavior, encouraging more proactive and collaborative resource management. Recent studies highlight digital solutions such as platform-based access control systems and real-time monitoring technologies [5], [13]. These tools improve maintenance efficiency and operational oversight and reshape how institutional actors access and use shared resources.

However, most existing studies focus on individual facilities or single-institution settings, providing limited insight into how smart capital operates across decentralized university systems. Spengler *et al.* [14] emphasized policy frameworks and training programs to support shared-use collaborations. However, these works mainly analyze bilateral arrangements between education institutions and external partners. They rarely examine interconnected networks among educational institutions themselves. Existing studies also show that the effectiveness of digital tools is restricted by several challenges. These include poor information quality (IQ), limited functionality, financial constraints, legal ambiguities, communication barriers [6], and data protection concerns [15], [16]. Besides technical problems, human factors are equally critical: low engagement, lack of skills, and resistance to change can undermine initiatives [17]–[21]. To explain these barriers, recent studies increasingly integrate established theoretical frameworks, including the DeLone and McLean information system success model (D&M IS), the technology readiness index (TRI), and the technology acceptance model (TAM). This integrated perspective captures both system-level and user-level determinants of digital transformation [11], [22]–[26].

Existing studies on digital FM predominantly examine single-building environments or isolated institutional units [6], [7]. In these settings, governance structures are relatively centralized and coordination mechanisms remain internally bounded. In contrast, mega public universities function as multi-unit ecosystems. Autonomous faculties and administrative divisions share common infrastructure while maintaining distinct operational priorities. Such structural fragmentation increases coordination complexity and inter-unit dependency, highlighting the need for integrated digital governance mechanisms. However, empirical evidence on the interaction between digital system quality (SQ) and user readiness in these large-scale, multi-actor environments remains limited. This study evaluates how smart capital is mobilized through digital FM systems in a multi-unit public university. It also proposes an empirically validated evaluation framework for shared-use governance in higher education.

To address this objective, the study develops and empirically validates an integrated framework combining the TRI, the D&M IS, and the TAM. The framework captures the interplay between psychological predispositions, system-level quality attributes, and cognitive adoption mechanisms in shaping institutional digital engagement. Using partial least squares structural equation modeling (PLS-SEM), the study evaluates both measurement properties and structural relationships. Multi-group analysis (MGA) is then applied to examine role-based differences between facility operators and academic staff.

The study contributes to the literature in two key respects. To the best of our knowledge, this is among the first empirical studies to apply an integrated TAM–TRI–IS success framework to examine smart capital mobilization within a multi-unit public university system. First, it advances technology adoption research by integrating readiness, SQ, and cognitive evaluation into a unified framework suited to large-scale shared governance environments. Second, the study situates the analysis within a mega multi-unit university system rather than a single-building or isolated institutional setting. This perspective extends digital transformation research from individual-level acceptance toward institutional coordination dynamics in higher education. The proposed model is empirically examined at Thai Nguyen University (TNU), one of Vietnam's three national regional university systems, comprising over 80,000 students and 3,600 staff across 12 constituent institutions.

2. THEORETICAL BASIS AND HYPOTHESES DEVELOPMENT
2.1. Technology readiness index
Digital transformation in higher education depends on technological infrastructure and users' psychological readiness to engage with digital systems. The TRI [27] conceptualizes this readiness and is expected to influence how users evaluate SQ and perceive the usefulness and ease of use of digital facility platforms. Hence, the following hypotheses are proposed:
- H1: TRI positively affects information system quality (ISQ).
- H2: TRI positively affects perceived usefulness (PU).
- H3: TRI positively affects perceived ease of use (PEU).

2.2. DeLone and McLean information system success model
The D&M IS success model [28], [29] evaluates IS through dimensions such as IQ, SQ, and service quality (SVQ). In shared-use university environments, high SQ is expected to enhance users' perceptions of usefulness and ease of use. Consequently, the following hypotheses are proposed:
- H4: ISQ positively affects PU.
- H5: ISQ positively affects PEU.

2.3. Technology acceptance model
The TAM explains how cognitive beliefs influence technology usage behavior [30]. PU and PEU determine users' actual system use. In organizational environments, subjective norms (SN) may also influence these cognitive perceptions by reflecting social pressure within institutions. Based on TAM and its extensions, the following hypotheses are proposed:
- H6: SN will significantly affect PU.
- H7: SN will significantly affect intention to use (USE).
- H8: PU will positively affect USE.
- H9: PEU will positively affect PU.
- H10: PEU will positively affect USE.

2.4. Integrated research model
Building on these theoretical perspectives, this study integrates TRI, the D&M IS success model, and TAM into a unified analytical framework for evaluating smart capital mobilization in multi-unit public universities. TRI explains users' psychological readiness to engage with digital technologies, the D&M IS model captures system-level quality attributes, and TAM explains how cognitive beliefs translate into system use. Together, these models form an evaluative chain: readiness (TRI) shapes users' cognitive perceptions of digital systems (TAM), while system quality (D&M IS) conditions how these perceptions translate into effective system use. This integrated perspective enables institutional-level evaluation of digital FM systems in shared-use governance environments. The hypothesized relationships are empirically examined using PLS-SEM in the subsequent section.

3. METHOD
3.1. Research design
This study employs a quantitative research design to test the proposed integrated model combining the TRI, the TAM, and the D&M IS model. All measurement items were assessed using a 5-point Likert scale (1=strongly disagree; 5=strongly agree). The survey instrument comprised 50 items adapted from previously validated scales.

Survey items were adapted from previously validated scales in TAM, TRI, and the D&M IS success model. Prior to full deployment, the questionnaire was pilot-tested with 20 staff members from different units to ensure clarity, contextual relevance, and linguistic appropriateness. Minor wording adjustments were made based on feedback to improve comprehension while preserving theoretical meaning.

3.2. Participants and data collection
The empirical investigation was conducted at TNU, selected as a representative case of public sector digital transformation in a developing-country context, particularly in relation to shared mega-facility governance. A structured questionnaire was distributed to academic and administrative staff through both online and offline channels. Purposive sampling was employed to target individuals directly involved in shared facility usage and management, ensuring that respondents possessed practical experience with the institutional digital systems under study. This approach strengthens contextual relevance and construct validity, although it may limit statistical generalizability beyond similar mega-university settings.

Of the 260 distributed questionnaires, 252 responses were received. After data screening and removal of incomplete or invalid responses, 246 valid responses were retained for analysis. Participation was voluntary and responses were collected anonymously to reduce potential social desirability bias and institutional pressure effects. Respondents were informed that data would be used solely for research purposes and reported in aggregate form.

3.3. Data analysis procedure

Data analysis was conducted using SmartPLS software. The sample size satisfies the minimum requirement for PLS-SEM based on the ten-times rule for structural paths directed at endogenous constructs. PLS-SEM was selected due to its suitability for exploratory and prediction-oriented research models incorporating higher-order constructs. Compared to covariance-based SEM, PLS-SEM accommodates complex structural relationships with relatively moderate sample sizes and emphasizes variance explanation, aligning with the study's objective of examining institutional-scale adoption dynamics.

The analytical procedure consisted of four stages: i) assessment of the measurement model; ii) evaluation of discriminant validity; iii) structural model testing using bootstrapping with 5,000 resamples; and iv) MGA. TRI and ISQ were specified as higher-order constructs comprising theoretically grounded first-order dimensions. A two-stage approach was applied to estimate higher-order structural relationships, thereby minimizing indicator redundancy and ensuring stable path estimation. The high R^2 values for TRI and ISQ are attributable to their specification as higher-order reflective constructs composed of strongly correlated first-order dimensions, a known characteristic in PLS-SEM that can inflate explained variance without indicating model overfitting. Variance inflation factors (VIF) were examined to confirm that multicollinearity among predictor constructs remained within acceptable thresholds.

4. RESULTS AND DISCUSSION

4.1. Descriptive analysis

The sample consisted of 58.1% female and 41.9% male respondents. Most participants were aged between 30–40 years (43.1%) and 41–50 years (33.2%), indicating a predominantly mid-career profile. Regarding job roles, 44.3% of respondents were facility staff, while 55.7% were lecturers and managers classified as academic staff. This distribution provides balanced representation of operational and academic actors involved in shared facility governance.

4.2. Assessment of the measurement model

Before performing the structural analysis, the measurement model was evaluated to assess construct reliability and validity. Most outer loadings exceed the recommended threshold of 0.70, indicating acceptable indicator reliability. A small number of indicators fall slightly below this threshold but remain within acceptable limits for exploratory research when supported by theoretical relevance and overall construct reliability.

All constructs demonstrate satisfactory internal consistency, with Cronbach's alpha and composite reliability values exceeding recommended thresholds. In addition, the average variance extracted (AVE) values meet the commonly accepted benchmark, indicating adequate convergent validity across constructs. The TRI and ISQ constructs also exhibit strong reliability and validity, while SN, PU, PEU, and USE all meet the recommended measurement criteria. USE, in particular, shows high internal consistency, suggesting strong alignment between measurement items and the underlying construct. Discriminant validity was assessed using the heterotrait–monotrait (HTMT) ratio of correlations. The HTMT values are below the recommended threshold of 0.85, indicating adequate discriminant validity among the constructs. In addition, the bootstrapped confidence intervals obtained from 5,000 resamples do not include the value 1.0, further supporting construct distinctiveness. Some construct pairs (e.g., PU–PEU, optimist-innovativeness (OPT–INN), IQ–SQ) exhibit relatively higher HTMT values compared to others, but all remain within acceptable limits, suggesting conceptual proximity without compromising discriminant validity. Overall, the results indicate that the measurement model demonstrates satisfactory reliability, convergent validity, and discriminant validity. These findings provide a sound basis for the subsequent structural model analysis of smart capital mobilization in shared digital facility environments.

4.3. Assessment of structural model

Hypothesis testing of the structural model was conducted using standardized path coefficients estimated through bootstrapping. The results are summarized in Table 1, where 7 of the 10 hypothesized relationships are supported. Overall, the findings highlight the central role of usability-related perceptions in shaping institutional adoption of digital FM systems. PEU and PU both contribute significantly to system use, reinforcing the core assumptions of the TAM. In addition, ISQ strongly influences users' cognitive evaluations by enhancing both PU and PEU. SN also shows a positive influence on system use, indicating that social and organizational expectations can encourage engagement with shared digital facility platforms.

In contrast, several hypothesized relationships involving TRI are not directly supported. Specifically, TRI does not exert a significant direct influence on SQ or PU. This result suggests that readiness characteristics may operate indirectly through users' cognitive perceptions rather than through direct structural effects.

Despite the absence of a direct TRI–PU relationship, mediation analysis reveals a meaningful indirect pathway through PEU. In this pathway, TRI shapes usability perceptions, which subsequently influence PU and ultimately system use. This finding suggests that psychological readiness contributes to institutional adoption primarily by shaping users' perceptions of system usability.

Table 1. Path coefficient result

Hypothesis	Relationships	Std. Beta	t-value	p-value	f2	Decision
H1	TRI→ISQ	0.029	0.983	0.325	0.026	Not supported
H2	TRI→PU	0.102	0.885	0.376	0.008	Not supported
H3	TRI→PEU	0.414	3.950	0.000	0.145	Supported
H4	ISQ→PU	0.327	3.067	0.002	0.088	Supported
H5	ISQ→PEU	0.456	4.204	0.000	0.176	Supported
H6	SN→PU	0.068	0.731	0.465	0.005	Not supported
H7	SN→USE	0.202	2.521	0.012	0.053	Supported
H8	PU→USE	0.334	4.036	0.000	0.093	Supported
H9	PEU→PU	0.436	4.651	0.000	0.236	Supported
H10	PEU→USE	0.354	3.784	0.000	0.108	Supported

Further analysis of the higher-order constructs indicates that the lower-order dimensions of TRI and ISQ contribute differently to cognitive perceptions. Within TRI, discomfort (DIS) demonstrates the strongest indirect influence on PEU, while OPT and INN also contribute to usability perceptions. Within ISQ, SQ exerts the most prominent influence on both PU and ease of use, highlighting the importance of technical reliability in digital system evaluation.

To evaluate the explanatory and predictive strength of the structural model, R^2 and Q^2 values were examined. The results indicate substantial explanatory power for several endogenous constructs. Complementary blindfolding-based Q^2 values further confirm the predictive relevance of the model. The high R^2 values for TRI and ISQ should be interpreted in light of their specification as higher-order reflective constructs composed of strongly correlated lower-order dimensions, a known characteristic in PLS-SEM that increases explained variance without indicating model overfitting. These results indicate that usability perceptions function as the primary evaluative gateway through which smart capital translates into actual institutional use. Figure 1 illustrates the structural relationships of the proposed model and summarizes the interaction between TRI, SQ, cognitive perceptions, and system use within the shared digital FM environment.

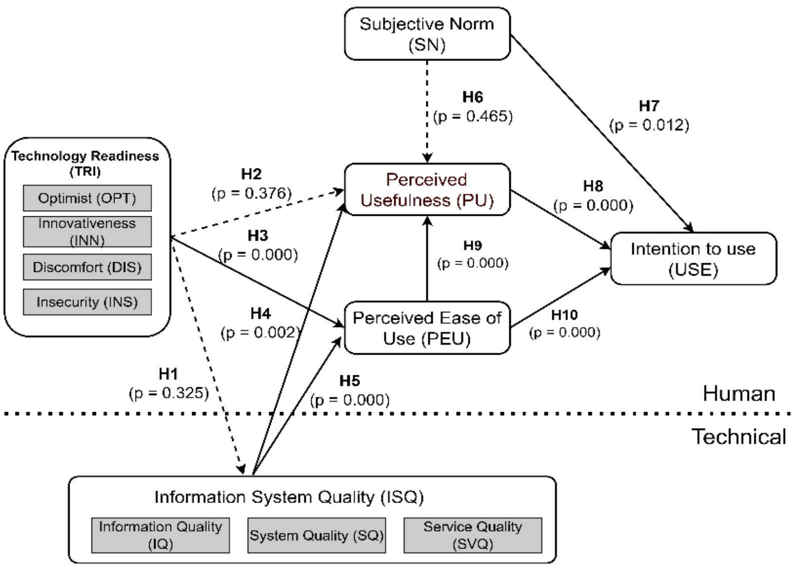

Figure 1. Structural model results

4.4. Multigroup analysis

The MGA results indicate that most structural relationships remain consistent across the two respondent groups, suggesting overall model stability between academic staff and facility staff. Only one structural path shows a significant difference: the relationship between TRI and PU. While this relationship is positive among academic staff, it becomes negative among facility staff. This difference suggests that the influence of TRI on system usefulness perceptions may depend on occupational roles, highlighting the importance of role-sensitive strategies when implementing digital FM systems in multi-unit universities.

4.5. Discussion

The results indicate that 7 of the 10 hypothesized relationships are supported. The prominence of PEU suggests that, in mega public university environments characterized by complex coordination structures and high administrative workload, cognitive effort becomes a decisive adoption barrier. Ease of use emerged as the strongest determinant, suggesting that usability should be prioritized in system design. Systems perceived as difficult to navigate are likely to face resistance regardless of their functional advantages. In this sense, usability operates as a cognitive filter through which system value is interpreted. This mechanism explains both the direct and indirect effects of PEU observed in the model and reinforces the core logic of TAM, where ease of use precedes usefulness and behavioral engagement [30], [31]. In large public universities, where administrative procedures are often layered and time-intensive, staff may prioritize usability over abstract technological readiness, as complex systems can inadvertently amplify operational workload.

System-level quality attributes appear to shape both usability perception and value recognition, suggesting that technical reliability precedes and conditions cognitive acceptance in multi-unit governance environments. The breakdown of ISQ reveals that all three dimensions contribute meaningfully, though SQ had the most pronounced effect, highlighting the centrality of technical reliability and responsiveness. These results affirm that digital engagement hinges not only on what systems deliver, but also on how consistently and effectively they support user needs. This distinction highlights two complementary dimensions of effectiveness: technical performance, represented by ISQ attributes, and behavioral effectiveness, reflected in users' cognitive evaluations and adoption decisions. Similar observations have been reported in studies of digital FM systems and IS success [22], [29].

While the majority of relationships in the proposed model were supported, TRI showed no direct impact on ISQ or PU, consistent with Sidek *et al.* [11], who noted that system-level success factors in public FM are often seen as institutional provisions. Nevertheless, a key insight emerged from the mediating pathways: TRI significantly impacted PEU, which in turn shaped PU and ultimately USE (TRI→PEU→PU→USE). This result suggests that in complex public university settings, readiness does not directly bias evaluations of system performance or utility. Instead, readiness enhances perceptions of ease of use, which then shape usefulness and usage. Such findings are consistent with studies showing that TRI influences adoption primarily through cognitive perceptions rather than direct structural effects [27], [32].

The analysis of TRI sub-dimensions reveals differentiated contributions to PEU. DIS showed the strongest indirect effect on PEU, suggesting that emotional unease can shape cognitive receptivity. INN and OPT also demonstrated meaningful influence, reflecting the value of proactive dispositions in facilitating system engagement. Conversely, insecurity (INS) showed minimal impact, implying that trust-related concerns matter less when institutional systems are perceived as reliable or mandated. These variations affirm that digital readiness is multidimensional, with affective traits playing a more prominent role than anticipated in mega-institutional digitalization. This observation aligns with prior research in shaping technology acceptance [23], [27].

Social influence appears to shape behavioral conformity rather than cognitive evaluations of usefulness, suggesting that peer pressure operates primarily at the behavioral level rather than at the evaluative level, consistent with the findings of Setiyani *et al.* [32]. As digital transformation initiatives become more pervasive and technological processes increasingly institutionalized, individuals are expected to conform and integrate new tools into their workflows. Accordingly, SN may function as a normative enforcement mechanism in contexts where technology adoption is culturally or organizationally endorsed.

Interestingly, MGA results reveal a significant divergence in the TRI–PU relationship across occupational groups. While TRI positively influences PU among academic staff, the effect becomes negative among facility operators. From an evaluative standpoint, the divergent TRI–PU relationship indicates that smart capital effectiveness is role-contingent, requiring differentiated governance strategies. This divergence suggests role-contingent interpretations of digitalization. Academic staff, whose responsibilities often involve planning, coordination, and information processing, may perceive higher readiness as enhancing system utility. In contrast, facility operators, who directly execute operational tasks, may interpret digital systems as monitoring instruments or workflow intensifiers, thereby weakening the readiness–usefulness linkage. This asymmetry highlights the importance of aligning digital transformation strategies with occupational identity and task structure in multi-unit governance environments. This finding suggests that digitalization may be interpreted differently depending on whether systems are perceived as decision-support tools or operational control mechanisms. Similar role-based differences in technology adoption have been observed in organizational digitalization contexts [18], [19].

From a theoretical perspective, the findings suggest that TRI does not directly determine system adoption in large-scale institutional settings. Instead, readiness operates through cognitive mediators such as PEU and PU. This layered mechanism suggests that smart capital mobilization may depend not only on infrastructural deployment but also on alignment between system design and user cognition. Such interpretations are consistent with broader research on digital transformation and organizational technology adoption [13].

From a practical standpoint, the results indicate that improving SQ and usability may be more effective than relying solely on readiness enhancement initiatives. The observed role-based differences further imply that differentiated training and communication strategies are necessary to facilitate effective smart capital utilization in large-scale public universities. For policymakers and university administrators, this means prioritizing system reliability, usability, and service responsiveness when allocating digital infrastructure investments. At the institutional level, governance mechanisms should harmonize inter-unit coordination through standardized access protocols and integrated reporting systems. While academic staff may benefit from readiness-enhancing programs, facility operators may require workflow-sensitive system redesign to prevent perceptions of workload intensification. Collectively, these findings provide actionable, evidence-based guidance for designing role-sensitive digital strategies in large-scale public university ecosystems. These recommendations align with broader research emphasizing the role of digital infrastructure and intelligent facility systems in enhancing institutional coordination and operational efficiency [8].

More broadly, the study highlights that digital transformation in shared FM requires coordinated technical and behavioral interventions. Future research may explore longitudinal adaptation patterns and comparative institutional settings to further validate and generalize the proposed framework. These implications align with broader higher education modernization initiatives in developing countries, where digital governance reforms aim to enhance transparency, efficiency, and collaborative resource utilization at scale [3], [4].

5. CONCLUSION

This study developed and validated an integrated TAM–TRI–IS success framework to examine smart capital mobilization through digital FM systems in a multi-unit public university environment. The results indicate that PEU and ISQ play central roles in shaping system adoption. TRI does not directly influence system use; instead, it operates indirectly through cognitive mediators, particularly PEU and PU. These findings extend the TAM by positioning readiness as an upstream psychological enabler that requires cognitive translation before influencing behavioral engagement in shared-use digital systems. The study therefore provides empirical evidence that digital facility governance in mega public universities depends not only on technological infrastructure but also on the alignment between system design and users' cognitive evaluations.

From a practical perspective, the findings suggest that improving system usability and reliability should be prioritized when implementing digital FM platforms in large public universities. The MGA further indicates that digitalization strategies should account for role-based differences between academic staff and facility operators. In addition, this study contributes to evaluation-oriented perspectives on smart capital governance by demonstrating how digital facility systems function as instruments for coordinating shared institutional resources. Future research should test the proposed framework across different university systems and larger samples.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Derived data supporting the findings of this study are available from the corresponding author [M-ANT] on request.

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