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CONTENT VALIDITY OF BUILDING INFORMATION MODELLING (BIM) ASSESSMENT CRITERIA FOR FRAMEWORK FORMATION FOR LOCAL GOVERNMENT AUTHORITIES

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ABSTRACT

Assessment of Building Information Modelling (BIM) implementation for local government authorities is defined as a process of managerial evaluation tools that measures the organisation's assessment gap. For assessing the current quality, competence, and repeatability of BIM implementation, assessment criteria are therefore crucial. The construction industry in the country is predominantly reliant on traditional methods, hindering development and global competitiveness. Despite various initiatives to promote BIM, its adoption among construction professionals in Malaysia remains limited. To address this, the research aims to establish BIM assessment criteria tailored for local governance authorities, thereby facilitating smoother BIM implementation. The study employs literature

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review and questionnaire survey methods to assess the content validity of BIM assessment criteria. The data was analysed descriptively in Microsoft Excel using Content Validity Ratio (CVR) and Content Validity Index (CVI) formula. A set of questionnaires has been distributed to six (6) experts in BIM. The literature review proposes 51 items across seven main categories for inclusion in the BIM assessment criteria. The CVR scores indicate that 29 out of the 51 items are considered highly critical by content experts. Additionally, item Level Content Validity Index (I-CVI) and Modified Kappa Coefficient findings reveal that 41 items demonstrate appropriateness and excellence. In conclusion, this study contributes valuable insights for the development of a BIM assessment criteria framework specifically tailored for local governance authorities. The finding of this study is beneficial for further study in developing the BIM assessment criteria framework for local governance authority.

Keywords: *Building Information Modelling (BIM), Content Validity, Assessment Criteria*

INTRODUCTION

Digital technology, notably Building Information Modelling (BIM), is an important component of the Malaysia Construction 4.0 Strategic Plan's Quality, Safety, Sustainability, Productivity, and Competitiveness sub-strategies. To meet the criteria for quality, safety, sustainability, efficiency, and competitiveness in construction projects, digital technology, particularly BIM, plays an important role (CIDB, 2020). The building industry is currently facing a number of new challenges. These challenges include an abundance of 2D project paperwork, the involvement of several construction partners, discrepancies in project design, and slow decision-making. New technologies must be employed to better construction projects from planning to design to construction to building maintenance and operation (Musarat et al., 2023). BIM enables construction and design teams to make the most of their current technical infrastructure. The BIM method simplifies the generation and management of data throughout the whole architecture engineering and construction (AEC) project lifecycle by unifying all essential multidisciplinary construction and design documents into a single repository (Waqar et al., 2023). BIM has many meanings and can be described in many different ways. However, it can be concluded that BIM is a software model that can be used in project planning, design, monitoring and control among construction project group stakeholders in order to ensure project success throughout the project lifecycle (Haron et al., 2017). BIM allows stakeholders to collaborate throughout the project lifespan to input, retrieve, update, or alter information. As a result, it is possible to conclude that BIM facilitates cooperation. This will allow project stakeholders to transition from a fragmented working method to a continuous flow of organised processes (Hadzaman et al., 2018).

PROBLEM STATEMENT

The 2016 Malaysia BIM study states that 17% of the country has adopted BIM. The adoption rate in 2019 is 49%, which is a significant rise from 2016. However, the percentage of BIM adoption rose to 55% in 2021 (Construction Industry Development Board Malaysia (CIDB), 2021). From 2016 to 2021, the implementation of BIM rose steadily. It is evident that different organisation sizes have different BIM adopters. It demonstrates that 30% of big organisations dominated the BIM implementation, with small and medium-to-large organisations coming in second and third, respectively, at 25% and 23%. According to CITP 2016-2020, Local authorities and regulators are not yet outfitted with BIM-ready technology and software to accept designs in BIM and quickly process permits and approvals. This is because local government employees were not properly trained and are generally unaware of the advantages of using BIM. With good planning and selection before construction, BIM is advantageous to the construction sector since it reduces the need for rework and redundancies, which results in cost savings.

The rise in productivity in the construction industry will be immediately impacted by this. BIM governance is crucial in order to support the growth and competitiveness in construction among other countries. The government needs to be strict in enforcing the BIM implementation especially in local governance authority. Therefore, assessment criteria such as company culture, managerial styles, and support for change are necessary for the successful adoption of BIM (Wu et al., 2021). The entire team must comprehend the value of process and system, technology and structure in an organisation's productive working environment for BIM to be successfully implemented.

At the BIM Day 2019 opening ceremony hosted by CIDB, it was announced by Secretary-General of the Ministry of Works that by 2021, roughly 20 local bodies with city status would submit projects using BIM. A recent plan undertaken by the government through four pilot projects for BIM e-Submission progressing with slow uptake. Despite not being specifically included in the strategic plan 4.0, local authorities could stand to gain from its implementation because of their substantial government departments. Given the economic environment at the time of the BIM's creation, an emphasis was placed on leveraging the technology to save costs throughout a project's capital delivery phase. Despite numerous activities that were systematically carried out to embrace the advantages of ICT, the adoption of ICT by Malaysian construction firms is still quite low, especially in BIM (CIDB, 2017, 2019). The implementation process requires thorough strategic planning and an in-depth analysis of numerous factors. Various aspects need to be taken into account, but the organisation's (local authorities') BIM assessment criteria need to be evaluated most of all. For the productivity benefits of BIM deployment to be comprehended, BIM utilisation needs to be quantifiable. Without these metrics, groups and organisations cannot objectively evaluate their own successes and/or failures. (Sinoh et al., 2020).

Prior to making any BIM investments, it is crucial to measure the organisational readiness in terms of people, processes, and IT infrastructure (Harun et al., 2017). BIM deployment requires careful strategic planning and a comprehensive analysis of numerous criteria (Harun et al., 2018). Because of this, it is possible to carry out BIM assessment criteria by evaluating the organisation's present position and comparing it to the implementation needs using the same assessment criteria once the assessment criteria and requirements have been defined (Hashim et al., 2021). Understanding the tools, techniques, level of information, and collaboration that indicate organisational readiness and maturity to deploy BIM is necessary for successful BIM implementation (Al-Ashmori et al., 2020).

LITERATURE REVIEW

BIM governance is described as the process of establishing a building information model that supports a project information management policy across lifecycle and supply chain, taking into account stakeholders' rights and responsibilities for the data and information involved (Rezgui et al., 2013). Within the framework of this study, BIM governance may be characterised as the procedure for formulating a project information policy by gathering both technical and non-technical components while accounting for stakeholders' rights and obligations regarding the data and information related to the project. Collaborative governance has emerged as a novel approach to government in recent times. By uniting several stakeholders on a single platform, this tactic seeks to facilitate consensus-driven decision-making. However, there are still a number of issues that need to be resolved in relation to the creation of BIM governance solutions. For instance, the comprehension of process-oriented socio-organisational, legal, technological, and contractual factors is necessary for efficient BIM governance (Alreshidi et al., 2018).

BIM Maturity is a measurement of the use of BIM inside an organisation and refers to the quality, repeatability, and degree of excellence within a BIM capability (Sinoh et al., 2020). The key benefits of a maturity model are that it makes it possible to identify projects' and organisations' benchmarking data, as well as their strengths and limitations. The available BIM maturity models and BIM guidelines must be studied to determine the necessary standards for BIM performance before developing the readiness criteria (Tong & Phung, 2021). To minimise the gap, this study aims to extract BIM assessment criteria from various maturity models previously developed and construct a new BIM assessment criteria framework for local government authorities. BIM maturity models with context for organisation-wide evaluation include Benchmarking Readiness Assessment for Concurrent Engineering (BEACON) (M. M. A. Khalfan, 2001), Verify End-User (VERDICT) (Ruikar et al., 2006), General Practitioner Information System (GPIS) (Alshawi, 2007), BIM Maturity Matrix (Succar, 2009), BIM QuickScan (Van Berlo et al., 2010), Organisational BIM Assessment Profile (The computer Integrated Construction (CIC) Research Program, 2012), and BIM maturity model for the Dutch construction industry (Siebelink et al., 2018). In order to develop BIM assessment criteria for local governing authorities, all of these models were examined and evaluated. Model description, area of application, category, and assessment criteria were all evaluated. From the BIM maturity model evaluated, the framework formation comprises seven (7) categories namely: technology; process; policy; management strategy; personnel/human resources; data and information structure and project structure. The objective of the paper is to evaluate the content validity of the BIM assessment criteria framework using Content Validity Ratio (CVR), Content Validity Index (CVI) and modified Kappa coefficient which is further explained in the methodology section. The goal of the assessment is to serve as input variables prior to the primary data gathering in order to construct a compelling BIM evaluation criteria framework.

Table 1 describes the seven (7) categories of each construct; 1) Technology; 2) Process; 3) Policy; 4) Management Strategy; 5) Personnel/ Human Resources; 6) Data and Information Structure; 7) Project Structure according to the evaluated BIM maturity model. Each component consists of a few items that will be tested for content validity; Technology – 6 items; Process – 7 Items; Policy – 3 Items; Management Strategy – 11 Items; Personnel/Human Resources – 11 Items; Data and Information Structure – 10 Items; Project Structure – 3 Items. The total of items that will be tested are 51 items which have been extracted from previous instrument mentioned.

Table 1. Component of BIM Assessment Criteria

No.	Category	Criteria	No. of Items
1	Technology	-Software/Application -Hardware -Network server -Advance BIM tools -BIM facilities/Infrastructure -Technical support	6
2	Process	-Physical and knowledge infrastructure -Clear job instruction -Organisational process -Management system -Strategy deployment -Agility -Business ethic	7

3	Policy	-Preparatory -Regulatory -Contractual	3
4	Management Strategy	-Organisation vision and strategy -Distribution of roles and task -Organisation structure -Quality assurance -Financial resources -Partnership on corporate and project level -Management support -BIM champion -BIM planning committee -Business strategies -Change management	11
5	Personnel / Human Resources	-Mentality and culture -Group and individual motivation -Influence of BIM coordinator / internal expert -Knowledge and skills -Knowledge management -BIM training and support -Willingness to change -Collaboratives attitude -Discipline Team -Leadership & management -Work environment	11
6	Data and Information Structure	-Information structures and flow -Uses of modelling -ICT standards -Data libraries -Internal and external information flow -Type of data -Object structure and decomposition -Model element breakdown -Level of development -Facility data (BIM uses, project uses, operational uses)	10
7	Project Structure	-Facility design -Quality assurance -Client focus	3
		Total Items	51

Sources: Researcher, 2023

SCOPE AND LIMITATION

The main goal of this study is to develop a framework for implementation of BIM assessment criteria for local government authorities. This is in line with the Ministry of Work's goal that by 2021, all 20 local authorities in Malaysia with city status will use Building Information Modelling (BIM) technology in their first project submissions, which will be overseen by the Construction Industry Development Board (CIDB). Despite this, the research scope and limitations are divided into several main points as illustrated in Table 2.

Table 2: Overview of Scope of Study

KEY POINTS	SCOPE
Area of Study	Focuses on Malaysia Local Government Authorities
Area of Exploration	Building Information Modelling (BIM) for an electronic plan submission
	Building Information Modelling (BIM) assessment criteria
Organisation Involved	Local Government Authorities with city council status in Malaysia
Respondent for Questionnaire Survey	Minimum of 5 BIM expertise (Akmal et al., 2022) in Malaysian construction industry sector which is academician, developer, contractor and local governance authority

Sources: Researcher, 2023

METHODOLOGY

This study adopted the quantitative analysis approach. Hence, this study data collection is questionnaire survey form which was distributed to respondents. The choice of respondent for the study involves selection using proposed sampling where the respondents are selected according to their expertise in BIM. In a figurative sense, this study examined the BIM assessment criteria instrument for local governance authority, which aids in the effective deployment of BIM. The primary purpose of the research is to evaluate the content validity of the BIM assessment instrument. The analysis' findings were assessed using the Content Validity Ratio (CVR), Content Validity Index (CVI), and Modified Kappa Coefficient (K*). In analysing and evaluating the results of this study, quantitative approaches were used involving data and information analysed through perception survey method. Quantitative data obtained through structural questions involving Likert scale type questions contained in structured questionnaire forms were analysed by using the Microsoft Excel Software. CVR, CVI and K* formula was inserted into the software and the data were presented in table form. The details of every step of methodology are explained in order.

Questionnaire Formation

The first method is through literature review of seven (7) existing BIM maturity models in order to identify the critical components in BIM assessment criteria for local governance authority and the impact on BIM implementation. The seven (7) BIM maturity models are; 1) Benchmarking Readiness Assessment for Concurrent Engineering (BEACON) (M. M. Khalfan et al., 2001); 2) Verify End-User (VERDICT) (Ruikar et al., 2006); 3) General Practitioner Information System (GPIS) (Alshawi, 2007); 4) BIM Maturity Matrix (Succar, 2009a); 5) BIM QuickScan (Sebastian & Van Berlo, 2010); 6) Organisational BIM Assessment Profile (The computer Integrated Construction (CIC) Research Program, 2012) and 7) BIM maturity model for the Dutch construction industry (Siebelink et al., 2018). The purpose of literature review is to develop BIM assessment criteria consisting of 51 items with seven (7) main categories in the form of questionnaire survey.

Questionnaire Survey

Classification of Respondents

Based on earlier research, Akmal et al., (2022), recommend using a minimum of five (5) experts since they can at least offer a sufficient level of control to account for chance agreement. Ideally, there should be at least six (6) content-validation experts but should not be more than ten (10) (Akmal et al., 2022). Therefore, considering this recommendation, this study has used six (6) experts as reviewers for the purposes of this study. As a result, the number of BIM experts participating in the research may be seen as acceptable. The six (6) respondents that were chosen as content experts are described in Table 3. The selected panel of experts to be involved and who are experienced in the same domain and have expertise in the development of the instrument whether from academic or professional. It is plausible to infer from the respondents' positions, professional backgrounds, and

BIM-related experience that they have solid understanding of BIM-based projects and are well-known for doing so, particularly related to the BIM assessment criteria (Alias et al., 2019). The selected experts consist of academics, experienced professionals in the area of BIM and consultants from industry sectors and Public Sector agencies. Table 3 indicates the profiles of experts. Selection criteria are based on panel experience and involvement in relevant BIM areas.

Table 3. Sample and Respondents of the Content Validity

No.	Respondent	Working Industry	Experience in Industry (Years)	Experience in BIM (Years)
1.	Senior Lecturer (researcher)	Academician (Public Sector)	15	7
2.	BIM Executive	Industry (Private Sector)	8	5
3.	BIM Manager	Industry (Private Sector)	12	8
4.	BIM Modeller / Coordinator	Industry (Private Sector)	13	8
5.	Senior Quantity Surveyor	Industry (Private Sector)	12	7
6.	Executive Engineer	Industry (Public Sector)	7	5

Sources: Researcher, 2023

Content Validity Ratio (CVR)

The Content Validity Ratio (CVR) is a linear transformation of a proportionate degree of agreement on how many "experts" in a panel rank an item "essential." (Kipli & Khairani, 2020). In CVR, experts are asked to identify whether or not a certain item is necessary to operate a construct in a group of items. In order to do this, they are asked to rate each item on a scale of "1= not necessary, 2= useful but not essential, 3= essential" (Ibiyemi et al., 2019). The final instrument only contains elements that have been determined to be "essential" by an adequate number of; all other items are removed. The value of CVR will be compared to the CVR critical table (Ayre & Scally, 2014). This is done in order to evaluate the item as very important.

$$\textbf{Content Validity Ratio } (\boldsymbol{CVR}) = \frac{\left(ne-\left(\frac{N}{2}\right)\right)}{\left(\frac{N}{2}\right)}$$

ne: number of expert's panel members indicating an item 'essential'
N: number of expert's panel members
Sources: Lawshe, 1975., Akmal et al., 2022

Content Validity Index (CVI)

The CVR is an item statistic that may be used to determine whether an item should be rejected or retained. The content validity index (CVI) for the entire test is computed once items have been identified for inclusion in the final form. The CVI is just the average of the retained items' CVR values (Obilor & Miwari, 2022). A panel of content experts is asked to rate each instrument item on a 4-point ordinal scale in terms of clarity and relevance to the construct underlying the study as defined by the theoretical definitions of the construct itself and its dimensions (1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = highly relevant) (Akmal et al., 2022). CVI values may be calculated for both the overall scale (which we call an S-CVI) and each item on the scale (which we call an I-CVI). The Item Level Content Validity Index (I-CVI) is calculated as the proportion of experts who rated the item's relevance as 3 or 4 when divided by the total number of experts. Likewise, the Scale Level subject Validity Index (S-CVI), which measures the percentage of questions on a test that received a 3 or 4 rating from all content experts (Sidek, 2022).

Modified Kappa Coefficient (K*)

Although researchers frequently use the CVI to measure content validity, this index does not take the risk of inflated values due to chance agreement into account. As a result, CVI and the Kappa coefficient of agreement can offer measurable ways to assess content experts' opinions. Because it eliminates random chance agreement, kappa provides extra information beyond proportion agreement. The Kappa statistic is a consensus indicator of interrater agreement that accounts for chance agreement. It is a useful addition to CVI since it offers information about the degree of agreement that goes beyond chance (Sidek, 2022). The probability of chance agreement was initially calculated for each item before calculating the modified Kappa statistic. Finally, Kappa was computed by inserting the numerical values of probability of chance agreement (PC) and CVI of each item (I-CVI) following the calculation of I-CVI for all instrument items using the formula below:

$$Probability\ of\ chance\ agreement\ (Pc) = \frac{(N!)}{(A!(N-A)!)}\ X\ 0.5^{N}$$

$$Modified\ Kappa\ Coefficient\ (K*) = \frac{(I-CVI-Pc)}{\left(\frac{1}{Pc}\right)}$$

N: number of expert's panel members

A: number of expert's panel members indicating an item 'relevant'

Sources: Akmal et al., 2022

FINDINGS AND DISCUSSION

The key findings from the questionnaire survey were presented in terms of analysis of Content Validity Ratio (CVR), Content Validity Index (CVI), and Modified Kappa Coefficient (K*).

Result of Content Validity Ratio (CVR) Content Validity Index (CVI) and Modified Kappa Coefficient (K*)

Table 3 below shows the summary results of CVR, I-CVI and K*. Firstly, the results of CVR method indicate 29 out of 51 items for CVR have been addressed by the content experts as utmost critical item: Technology - 4 items; Process - 3 items; Policy - 3 items; Management Strategy – 4 items; Personnel/Human Resources - 7 items; Data and Information Structure - 6 items; and Project Structure - 2 items. Based on Sidek, (2022), CVR critical table, the item score CVR=1.00 for eight number of experts (N = 6) will be classified as critical. In conclusion, 29 out of 51 items tested is considered as critical by all respondents as described in Table 3. However, the remaining 22 items are not officially eliminated as the remaining item will be tested in further method which is CVI and K* testing (Table 4).

Table 4. Result of Content Validity Ratio (CVR), Content Validity Index (CVI) and Modified Kappa Coefficient (K*)

NO.	CATEGORY	ITEMS	Content Ratio Validity (CVR)	Content Validity Index (CVI)	Modified Kappa Coefficient (K*)

1.	Technology	Software/application	/	/	/
		Hardware	/	/	/
		Network server	Eliminated	Eliminated	Eliminated
		Advance BIM tools	/	/	/
		BIM facilities/ infrastructure	/	/	/
		Technical support	Eliminated	/	/
2	Process	Physical and knowledge infrastructure	/	/	/
		Clear job instruction	/	/	/
		Organisational process	Eliminated	/	/
		Management system	Eliminated	/	/
		Strategy deployment	/	/	/
		Agility	Eliminated	Eliminated	Eliminated
		Business ethic	Eliminated	Eliminated	Eliminated
3.	Policy	Preparatory	/	/	/
		Regulatory	/	/	/
		Contractual	/	/	/
4.	Management Strategy	Organization vision and strategy	/	/	/
		Distribution of roles and task	Eliminated	/	/
		Organization structure	Eliminated	Eliminated	Eliminated
		Quality assurance	/	/	/
		Financial resources	Eliminated	/	/
		Partnership on corporate and project level	Eliminated	/	/
		Management support	Eliminated	Eliminated	Eliminated
		BIM champion	/	/	/
		BIM planning committee	Eliminated	/	/
		Business strategies	Eliminated	/	/
		Change management	/	/	/

5.	Personnel / Human Resources	Mentality and culture	/	/	/
		Group and individual motivation	Eliminated	Eliminated	Eliminated
		Influence of BIM coordinator / internal expert	/	/	/
		Knowledge and skills	/	/	/
		Knowledge management	Eliminated	Eliminated	Eliminated
		BIM training and support	/	/	/
		Willingness to change	/	/	/
		Collaboratives attitude	Eliminated	Eliminated	Eliminated
		Discipline team	Eliminated	Eliminated	Eliminated
		Leadership & management	/	/	/
		Work environment	/	/	/
6.	Data and Information Structure	Information structures and flow	/	/	/
		Uses of modelling	/	/	/
		ICT standards	/	/	/
		Data libraries	/	/	/
		Internal and external information flow	Eliminated	/	/
		Type of data	Eliminated	/	/
		Object structure and decomposition	Eliminated	Eliminated	Eliminated
		Model element breakdown	/	/	/
		Level of development	Eliminated	/	/
		Facility data (BIM uses, project uses, operational uses)	/	/	/
7.	Project Structure	Facility design	/	/	/
		Quality assurance	/	/	/
		Client focus	Eliminated	/	/
TOTAL CRITERIA CONSIDERED AS CRITICAL ITEMS			29	41	41

Sources: Researcher, 2023

Second method in Table 3 above also shows the results of analysis for I-CVI and K* (Polit et al., 2007; Hadzaman et al., 2018). Based on the I-CVI scores analysis details in Table 4 below, 41 items ranging from 0.80 to 1.00 are classified as appropriate to be incorporated in the BIM assessment criteria for local governance authority. The remaining 10 items score below 0.70 can be deduced that it should be eliminated. Despite the elimination of criteria using I-CVI, all the items also been evaluated with K* (Table 5) where 41 items are considered as excellent since the score is above 0.75. Meanwhile, four (4) items are categorised as fair as the score is between 0.40 to 0.59 and six (6) items are considered poor as the score is below 0.40. 10 items which score fair and poor are eliminated. The 10 items that were eliminated derived from the consistency results showing a low value from both analysis of I-CVI (<0.70) and K* (<0.40 and 0.40 – 0.59). Hence, from 51 items of BIM assessment criteria, 41 items are believed to have sufficient content validity after the test. The final findings of 41 items remain and will be included for further study.

Table 5. Evaluation of I-CVI and K* (Akmal et al., 2022)

I-CVI Classification	No. of Items	Score	Modified Kappa Coefficient (K*)	No. of Items	Score
> 0.80	41	Appropriate	> 0.75	41	Excellent
0.70 - 0.79	-	Needs revision	0.60 - 0.74	-	Good
< 0.70	10	Eliminate	0.40 - 0.59	4	Fair
			<0.40	6	Poor

Sources: Researcher, 2023

CONCLUSION

In conclusion, this study has undertaken a rigorous process to validate the content of the research instrument, focusing on the BIM assessment criteria for local government authorities. The assessment of content validity through CVR, CVI, and Kappa coefficient has provided valuable insights into the strengths and weaknesses of the instrument. While 29 out of 51 items were identified as critical by experts based on CVR scores, a further examination through I-CVI and K* testing revealed that 41 items demonstrated appropriateness according to content experts. However, 10 items were suggested for elimination, contributing to a more refined and robust set of 41 BIM assessment criteria items selected for further study. This paper contributes a methodological approach that not only identifies problematic areas in the instrument but also systematically refines it through expert evaluation. The use of CVR, CVI, and Kappa coefficients have been proven effective in clearly differentiating expert opinions, ensuring a high level of validity for the retained items. Looking ahead, it is recommended that future research delve into the dependability of the instrument to enhance its overall utility. Assessing the reliability of the evaluation tool will provide a comprehensive understanding of its consistency and accuracy in measuring BIM assessment criteria for local governance authorities. The outcomes of this study hold significant promise, providing a more accurate and reliable approach to evaluating BIM assessment criteria, ultimately influencing the future trajectory of the original research. In essence, the content validation undertaken in this study not only addresses the identified issues but also serves as a crucial foundation for achieving the broader research goals. Through continuous refinement and validation, the BIM assessment criteria framework aims to make a substantial impact on local governance authorities, contributing to advancements in the field of Built Environment research.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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