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Evidence-to-Decision: Making Informed Decisions in Construction Safety Research

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Abstract: The construction industry remains one of the most hazardous sectors worldwide, contributing disproportionately to occupational injuries and fatalities. This study aims to bridge the persistent gap between academic research and evidence-informed industry practice by evaluating technology-based safety interventions. This study focuses specifically on automated systems for monitoring compliance with personal protective equipment (PPE) as an example case study. To develop the evidence base this study applies the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Evidence to Decision (EtD) framework, adapted from public health research, to assess the quality and applicability of current evidence in the context of practical application. This approach helps identify key enabling factors, limitations, and research gaps, particularly concerning effectiveness, cost, and feasibility. The results show that while automated PPE compliance systems show strong potential, findings reveal that the existing evidence base remains limited, especially regarding their real-world applicability and scalability. The review highlights that while automated PPE compliance systems demonstrate promising accuracy levels (88% to 96%), the existing evidence base is fragmented and incomplete, particularly regarding comparative effectiveness, implementation resource requirements, and scalability across varied construction settings. Therefore, the findings of the review are conditional with further research needed to ensure a complete and accurate assessment. The study concludes that structured research translation frameworks like GRADE EtD has potential to significantly improve evidence-informed decision-making for adopting emerging safety technologies in construction. Moreover, this approach offers a replicable model for accelerating the translation of safety research into practical applications across other construction safety applications.

Keywords: Construction safety, evidence to decision, PPE, research translation, Taiwan.

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1. Introduction

The construction industry is internationally recognised as hazardous and has attracted significant research interest. Making a measured, practical impact on construction safety requires effectively translating the body of research into guidance material that can be adopted into industry practice. For the industry to adopt construction safety research, it must be effectively translated into tangible, evidence-based guidance that can be readily adopted. The ever-changing nature of construction sites and the associated hazards make safety management an ever-moving target. Significant effort is required to consistently update safety management systems to reflect current site conditions (Hallowell et al., 2013). Implementing technology-based safety interventions presents an opportunity to enhance and improve existing practices, ultimately leading to improved safety outcomes. Globally, hazardous sectors such as agriculture, mining, and construction account for over 60% of all fatal occupational injuries, with construction consistently ranked among the top three most dangerous industries worldwide. (International Labour Organization, 2022). This underscores the urgency of implementing innovative approaches that can meaningfully reduce injury risk and protect the health and safety of workers. Therefore, adequate knowledge is essential for guiding the effective integration of health and safety practices with technology. Without this, the full benefits

of new and novel approaches may not be realised and, in the worst-case scenario, could potentially diminish the efficacy of current safety management measures (Purushothaman et al., 2025)

This research discusses adopting public health research translation methods to make recommendations on construction safety practices and identify research gaps regarding practical worker safety measures. A case study on the application of technology-based systems for automating the detection of Personal Protective Equipment (PPE) compliance on construction work sites in Taiwan is presented to illustrate the proposed approach of evidence-based decision-making for construction safety practices. Technology for PPE compliance can take a wide range of forms, including wearable, RFID for pairing, and image analysis to detect compliance (Rasouli et al., 2024) (Rasouli et al., 2024)

To further contextualise the need for such interventions, it is helpful to examine regional safety trends. In Taiwan, the improper use of PPE was the second most frequent unsafe act by workers associated with occupational accidents between 2000 and 2015, where the highest frequency act was improper behaviour (Cheng et al., 2021). Furthermore, PPE compliance is an industry-wide issue for several reasons, including comfort and negative perceptions of need or effectiveness (Haslam et al., 2005). Therefore, efforts to enhance PPE compliance will support improving occupational safety outcomes in Taiwan. Emerging technologies are reshaping the landscape of safety management. While these innovations hold significant promise, their successful implementation depends on overcoming challenges such as workforce adaptation, regulatory alignment, and cost-effectiveness.

Over the past decade, there has been a growing interest in using technology-based interventions to enhance safety systems and improve worker safety outcomes on construction sites (Barata and da Cunha, 2019; Chen et al., 2023; Gao et al., 2022). These interventions aim to enhance workplace safety through various strategies, including hazard identification, promoting safe behaviours, monitoring physical well-being, and advanced training methods. However, transitioning to technology-driven solutions introduces complexities and factors that may affect the successful implementation of such safety systems. These technology-based systems are likely to exhibit failure modes not encountered with conventional safety approaches applied internationally. Nevertheless, by adeptly leveraging these advancements, the construction industry has an opportunity to improve its safety standards significantly.

Studies indicate that implementation planning can be informed by understanding the interrelationships between enabling and inhibiting factors to ensure investments in smart technologies lead to enhanced safety outcomes (Yap et al., 2025) Nevertheless, there is a paucity of research specifically addressing the practical aspects of implementing these technologies and their applicability across the diverse operational scenarios encountered within Taiwan's construction industry and internationally. Despite the growing academic attention to these technologies, a significant gap remains in research that evaluates their practical application in real-world construction environments, particularly in Taiwan, where unique contextual challenges may affect the effectiveness of such technologies. This research reviews existing literature on current technologies that automate PPE compliance for worker health and safety on construction sites.

This paper discusses how standard research translation methods can be applied to deliver targeted research that links the research and practical implications to improve construction safety outcomes. By applying the GRADE EtD framework, this study aims to contribute academically and provide actionable insights that can inform policy and practical implementation. Ultimately, these findings are intended to support industry and policymakers in making informed, evidence-based decisions that enhance the safety and sustainability of construction practices**.**

2. Methods

The methods applied in this focus on assessing the adoption of technology-based tools for automated PPE compliance on construction sites as an example of using a public health approach for the evidence-based decision-making process for translating current research into industry guidance and identifying current research gaps. The information from a review of literature on the topic of technology for the automated assessment of PPE compliance was reviewed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Evidence to Decision (EtD) adapted from (Moberg et al., 2018). GRADE EtD is a tool commonly applied in the public health field to make evidence-informed decisions for policy and guidance development. The process supports robust decision-making based on collective evidence, reducing reliance on subjective judgment. Furthermore, the methodology provides a structured assessment of the level of certainty in the evaluation made. Fig. 1 illustrates the overview of the evidence review process, which consists of a set of targeted questions, each with an individual assessment and judgement of supporting evidence.

Fig.1. Overview of the evidence to the decision process

For this study the analysis process adopted the interactive Evidence-to-Decision tool (iEtD), an online platform developed by researchers at the Norwegian Knowledge Centre for Health Services. The high-level research workflow is illustrated in Fig 2 below.

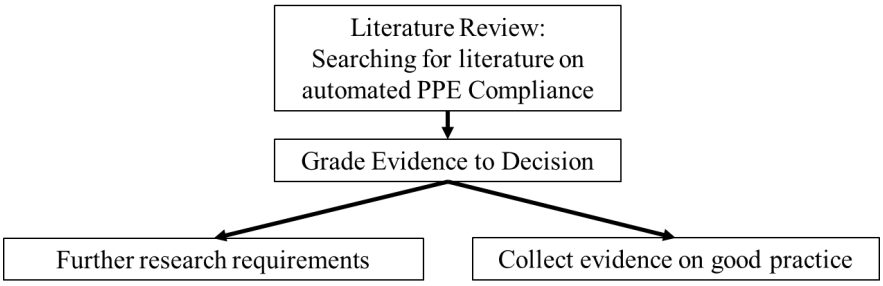

Fig. 2: Flowchart showing the research workflow

A selective literature review in combination with an assessment using iEtD with the health system and public health decision template. This template is intended to assist policymakers in making informed decisions regarding public health interventions aimed at a distinct demographic. Which, in this instance, specifically refers to construction industry workers and targeted measures to improve safety outcomes. In this study, the structured evaluation template is used to assess the strength of the current evidence base in informing decisions and identify limitations of recommendations, as well as highlight knowledge gaps requiring further research. A review of current scientific literature on the topic of automated and conventional PPE compliance measures was used to inform the decision-making process. The literature was selected through a targeted search of peer-reviewed research published over the past 10 years, focusing on safety in the construction industry. The text search was conducted with keywords including 'smart PPE', 'automated PPE compliance', 'PPE compliance', 'PPE compliance assessment' and 'PPE sensor' in addition to 'construction' and 'building'. The search was completed using Google Scholar and Web of Science to limit the literature to peer reviewed scientific publications. Table 1 provides the setting for the evidence review and evaluation for construction workers in Taiwan.

For the purposes of this research, automated PPE compliance refers to the broad suite of technology that has been developed with the express purpose of assessing if workers are wearing required PPE in the correct time and location. The scope of the assessment included computer vision and machine learning algorithms for analysing video/image streams to detect the use of PPE items such as helmets, vests, and gloves in real time. Also included were IoT (internet of things) devices, RFID (radio frequency identification) enabled devices and wearable sensors, which are placed at site entrances or around construction sites to detect wearing and use of required PPE and GPS-enabled wearables that correlate location data with PPE usage for ensuring workers are appropriately equipped with PPE in designated zones. These sensors are integrated into alerting systems that aggregate information and provide real-time alerting systems that trigger notifications to supervisors and workers that PPE requirements are not being met, enabling swift corrective actions. In comparison, conventional approaches to PPE compliance refer to identification and notification through observations made by supervisors, coworkers or safety compliance inspections.

Table 1. Setting for the review of evidence for automated PPE compliance measures in Taiwan

1. Problem Description	2. Option	3. Comparison	4. Main Outcomes	5. Setting	6. Perspective
PPE is essential for the safety of construction workers; however, PPE is only effective when worn appropriately for the hazards of the task being completed.	Improve worker PPE compliance through technology-based tools for PPE compliance on construction sites	Conventional approaches to construction worker PPE compliance	Improved worker PPE compliance is expected to reduce the rates of worksite injuries and fatalities.	All types of traditional construction sites.	the range of construction site sizes and types.

3. Results and discussion

The GRADE EtD framework regarding automated PPE compliance, informed by current literature, provides valuable insights into the current state of evidence and identifies further research areas. The results are divided into three sections to focus on the different aspects. The first section focuses on understanding the priority of the problem being investigated. The second section focuses on the resourcing associated with the practical implementation of the option if adopted. The third section looks at the practical and policy implications for implementation.

Table 2 shows the first section of the GRADE evidence to decision. The outcomes of the assessment show that, based on the current policy, the problem is likely a priority in Taiwan. In regard to the anticipated effects, the evidence shows that of the automated PPE solution proposed, there is an accuracy range from 88% to 96% (Pisu et al., 2024; Wen et al., 2024). However, there is little evidence of how this compares to conventional measures to PPE compliance. In this assessment, it was assumed that the compliance rates are below the expected performance, given workers' compliance with safety requirements, such as PPE is cited as a causal factor in injury and mortality outcomes (Dodoo and Al-Samarraie, 2023). Overall the desirable effects were considered variable based variation in how data was reported between studies. However, the desirable effects are likely positive based on the ability to perform reliably. As for the undesirable effects there was

insufficient evidence or discussion on potential undesirable impacts to make a judgment. However, there would be expected to be undesirable impacts including false detections with automated systems (Pisu et al., 2024). Overall, on the balance of evidence, the assessment concluded that due to the potential benefits to worker safety and consistency with policy, the assessment favours the automated PPE detection. A definitive evaluation would require substantially more research characterising the potential desirable and undesirable effects of both automated and conventional PPE compliance methodologies.

Table 2. GRADE evidence to decision summary for automated PPE compliance over conventional compliance assessment: problem and effects questions.

Question	Assessment	Judgement	Summary Comments
Problem	Is the problem a priority?	Probably yes	The literature reviewed identifies that technology is needed to overcome the limitations of current approaches. Current government policy in Taiwan encourages states a *"need to implement construction safety and health management, correctly set up occupational safety and health equipment and take measures to prevent occupational hazards"*(Occupational Health and Safety Administration, 2021)
Desirable effects	How substantial are the desirable anticipated effects?	Varies	The desired outcome is to improve compliance with PPE requirements to protect workers from construction site hazards. The studies reviewed stated that the methods applied provided an acceptable level of performance in real-time applications with claimed accuracy range from 88% to 96% (Pisu et al., 2024; Wen et al., 2024). Though improvement is claimed, the magnitude of the performance increase against the conventional approach is difficult to assess consistently across the research provided.
Undesirable effects	How substantial are the undesirable anticipated effects?	Don't Know	The main undesirable effect in this case is the incidence in false positive detections (Pisu et al., 2024). The information on the breadth of possible undesirable effects such as potential negative impacts on safety culture, was insufficient to make an informed judgment.
Certainty of the evidence	What is the overall certainty of the evidence of effects?	Low	While there is some evidence to show potential to realise positive effects in PPE compliance, the overall all evidence base is too limited to be certain of the effects.
Balance of the effects	Does the balance between desirable and undesirable effects favour the comparison?	Probably favours the option	On the balance of the evidence reviewed there is a role for automated PPE compliance. The consistency with policy in Taiwan and the efforts to make the industry to make the construction industry safer. This consistency with objectives of government bodies would suggest that the evidence says the option would be favoured in some scenarios. However, there is significant uncertainty around the applicability of automated PPE compliance across the full spectrum of sites and project types observed in the construction industry.

Table 3 outlines the findings from the second section of the assessment focused on the resourcing aspects. While there were no direct discussion costings for the research reviewed, there was some discussion of systems being low-cost or cost-effective (Yang et al., 2020; Yousif et al., 2024). The evidence review identifies the need for further research on the cost of these types of automated safety systems. Currently, costing information is limited due to the emerging nature of the technology and limited commercialisation (Calvetti et al., 2024). The body of literature suggests that while the initial capital expenditure for automated PPE compliance systems may be higher than that of conventional methods, the overall cost-effectiveness is realised through continuous monitoring, lower labour costs, and a reduction in incident-related expenses. Overall, the assessment shows that there is insufficient evidence to make an informed decision on the resourcing required for recommending automated PPE compliance over conventional PPE compliance measures. An understanding of the resourcing requirements is an important area of research, given the need to make financial decisions on safety management practices.

Table 4 summarises the results from the acceptability and feasibility components of the automated PPE compliance monitoring. The results show there is significant uncertainty around the applicability of automated PPE compliance across the full spectrum of sites and project types observed in the construction industry. The question of equity is very challenging as in Taiwan most accidents are associated with smaller enterprises (Cheng et al., 2021). In these cases, it is unclear whether automated PPE compliance systems. However, given the over-representation of construction workers in terms of workplace accidents resulting in injury, disability and death, an improvement in PPE compliance could improve equity with other industries.

Table 3. GRADE evidence to decision summary for automated PPE compliance over conventional compliance assessment: Resourcing and cost questions.

Question	Assessment	Judgement	Summary Comments
Resources required	How large are the resource requirements (costs)?	Don't know	Of the literature reviewed, there were no figures provided for automated PPE compliance systems. However, some research stated that the components and systems were low-cost or cost-effective (Yang et al., 2020; Yousif et al.,2024). Further research on the cost of these types of automated safety systems (Calvetti et al., 2024).
Certainty of evidence of required resources	What is the certainty of the evidence of resource requirements (costs)?	No included studies	Insufficient evidence was available to reliably assess the resourcing costs for automated PPE compliance systems or compare them effectively with conventional PPE compliance costs. The literature suggests that automated PPE compliance systems would have a higher initial cost but could be offset by the savings made through improved safety performance.
Cost-effectiveness	Does the cost-effectiveness of the option favour the option or the comparison?	Don't know	There is an absence of any quantification of the costs associated with both the automated and conventional PPE compliance approaches. The body of literature suggests that while the initial capital expenditure for automated PPE compliance systems may be higher than conventional methods, the overall cost-effectiveness is realised through continuous monitoring, lower labour costs, and a reduction in incident-related expenses. For companies managing large or multiple construction sites, especially those in high-risk environments, the long-term economic benefits and improved safety outcomes often justify the initial investment. However, these assertions have not been tested in any robust manner and warrant further investigation.

Table 4. GRADE evidence to decision (EtD) summary for automated PPE compliance over conventional compliance assessment: acceptability and feasibility

Question	Assessment	Judgement	Summary Comments
Values	Is there important uncertainty about, how much people value the main outcomes?	Possibly important uncertainty	The consistency with policy in Taiwan and the efforts to make the industry to make the construction industry safer. The adoption by government bodies would suggest that the evidence says the option would be favoured in some scenarios. There is significant uncertainty around the applicability of automated PPE compliance across the full spectrum of sites and project types observed in the construction industry.
Equity	What would be the impact on health equity?	Probably increased	Construction workers in Taiwan are significantly overrepresented in workplace injury and death. In general, the initiatives should improve health equity related to workplace safety. However, there is a significant difference in the safety outcomes between large and small organisations, with smaller enterprises being significantly overrepresented. It is unclear if automated PPE compliance would be feasible in such scenarios due to the highly transient work and resource constraints.
Acceptability	Is the option acceptable to key stakeholders?	Probably yes	There is evidence sufficient to suggest acceptability from both a worker perspective. In the US the willingness to use wearables is approximately 55% of workers, including a proportion of construction workers (Jacobs et al., 2019). (Habbal et al., 2019) explored obtaining legalisation of PPE compliance based on automatic monitoring with image analysis UAE.
Feasibility	Is the option feasible to implement?	Probably Yes	Many of the studies reviewed have installed and tested the various approaches to automated PPE compliance under real-world conditions. This would suggest that the option would be feasible to implement on construction sites. However, there is no information on the type of sites which would be a viable candidate for automated PPE compliance.

In summary, the review shows that with the emerging nature of technology for the automation of PPE compliance, there are significant information gaps that prevent a full assessment of the evidence supporting the adoption of automated PPE compliance from being made. While the review reveals that the overall evidence is extremely limited, on the balance of evidence, it is likely that automation of PPE compliance is a promising measure for improving worker safety. However, this recommendation is conditional as substantial research across several areas regarding desirable and undesirable benefits, financial resourcing and acceptability is required to further progress practical implementation. In making a final judgment for the GRADE EtD the use of a conditional recommendation is for when there is weak evidence due to significant evidence gaps, but there is reason to support the intervention (Alonso-Coello et al., 2016). In this case, the reason for conditional support is the promising nature of technology to support automated PPE compliance for improved safety outcomes and the aspirations of the construction industry to improve safety performance. This conditional recommendation means that further research is needed to develop the information to address the gaps required to develop a full evidence review.

The outcomes of this research are likely to have broad implications for supporting emerging research on the practical applications of technology-based solutions for worker safety on construction sites. To ensure the greatest practical value of research on technology-based safety solutions, there is a clear opportunity to develop the necessary knowledge base for practical implementation, particularly through integration with research translation processes. The EtD review provides clarity on where those limitations are in the path to developing reliable and effective technology-based systems. Fig. 3 presents a logic model illustrating how GRADE EtD can be applied to the broader research on the use of automated PPE compliance and other technology-based solutions for construction safety.

There are frameworks that can support the research translation process for practical safety interventions. Schulte et al., (2017) proposes a four-stage framework for translating research for OSH interventions, which includes development, testing, institutionalisation, and evaluation. The results show that in the case of technology for PPE compliance, the research is very much at the development stage of the research translation journey, where the focus of the research is at the proof-of-concept stage. To progress the research translation journey for automated PPE compliance measures, there is a clear need for research to progress through to the final evaluation phase, where the positive impacts can be verified and validated. However, as shown in the EtD assessment, the evidence base to guide the practical implementation is extremely limited, particularly regarding resourcing and funding.

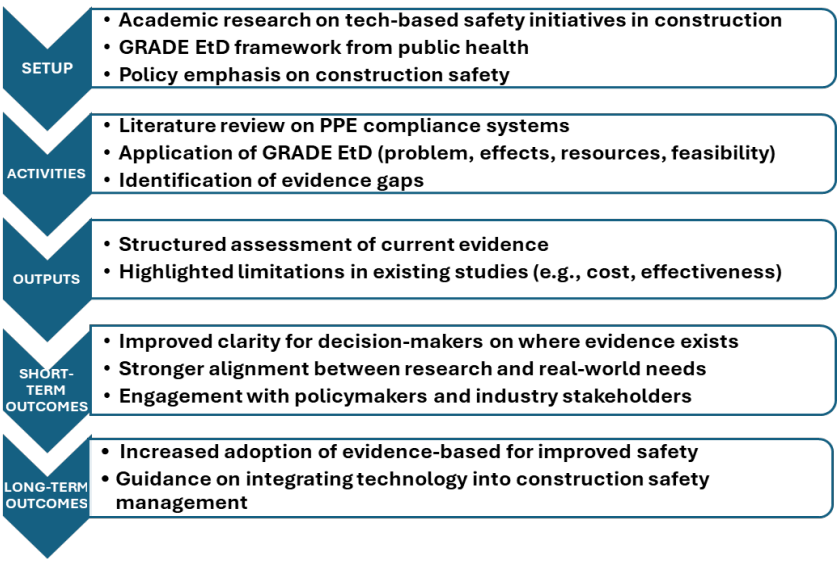

Fig. 3. Logic model for applying EtD to guide short-term and long-term outcomes for the use of technology in construction safety

4. Conclusions

The research presented introduces the application of the GRADE EtD framework within the domain of construction safety practice, supporting the departure from conventional and often intuition-driven risk management approaches to greater reliance on structured evidence. Through systematically translating current construction safety research evidence into a structured decision framework, the study delivers two critical innovations. Firstly, the EtD methodology integrates factors such as stakeholder values, feasibility constraints, and equity considerations into a transparent, replicable process that rapidly identifies research gaps in practical applications. Second, the research demonstrates how multi-criteria EtD assessments can harmonise disparate data sources in construction safety research, enabling the prioritisation of interventions with both empirical rigour and contextual relevance.

Using EtD to assess the automated PPE compliance of construction workers provides an informative case study on the practical application for construction safety research translation. The assessment concluded that while there is potential to improve construction worker safety by ensuring protection from site hazards, there is a clear paucity of information to guide the uptake in a practical setting. This assessment was the product of identifying significant gaps in the practical implementation aspects, particularly in areas of acceptance, resourcing and undesirable effects. Such a result is attributable to the emerging nature of the research areas. Completing the EtD assessment at this stage provides a structured evaluation

of key research gaps that support the rapid development of the knowledge required to effectively implement technology-based safety interventions on construction sites.

Adapting research translation methods from other public-health-focused research fields helps identify practical research implications and research gaps addressing longstanding challenges in delivering meaningful improvements in construction safety practice. Conventional approaches to evidence development often fragment evidence across technical, organisational, and human dimensions, leading to *ad hoc* decisions and missed opportunities for systemic improvement. In contrast, the EtD approach, adapted from public health, fosters holistic appraisal. Such appraisals provided decision-makers with evidence to interrogate the strength and trade-offs of each safety option, in the context of resource effectiveness, stakeholder perceptions, implementation barriers, and potential undesirable consequences.

Addressing gaps in knowledge of successful safety practice, particularly the aspects of effectiveness and resource requirements, will support construction companies in developing robust business cases for appropriately investing in tools for automated PPE compliance. Furthermore, the information can also be used to provide guidance to the construction industry on best practices for technology use in construction safety to ensure optimal implementation for safety outcomes. This information on practice may also have relevance for guiding industry-level safety policy initiatives. Furthermore, this approach can be expanded to include the translation of research relating to other emerging technologies for construction safety.

Limitations of this study are primarily the limited information required to answer the set of GRADE EtD questions in full. Emerging research areas, such as technology in construction safety, are expected to have gaps as the knowledge base evolves. Therefore, research translation is critical in closing the gaps between research and practical improvement to worker safety on construction sites. As the purpose was to use automated PPE compliance on construction sites as a case study to test the methodology, a narrative-based literature review was used. A more systematic review may have yielded additional information to support the evidence assessment; however, the information was considered sufficient to test the utility of EtD in construction safety research. Also, while there is similarity in the research translation approach for public health and construction safety, the Grade EtD was not specifically developed for construction safety applications. Further research is needed to either adopt or adapt methodologies from other research fields or to develop a construction safety-specific methodology.

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Author Contributions

Hew Merrett contributes to conceptualization, methodology, analysis, investigation, draft preparation, and manuscript editing. Dessy Natalia Selly contributes to conceptualization, methodology, analysis, investigation, and draft preparation, manuscript editing. Wei Tong Chen contributes to conceptualization, methodology, analysis, investigation, and manuscript editing

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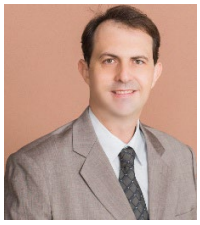

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