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Smart tourism application: towards software development for artificial intelligence in tourism management

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ABSTRACT

Artificial intelligence (AI) can manage tourism by optimizing, personalizing the experience, and enhancing user interactions. This research presents the Ayutthaya tourism platform independent model (ATPiM), an intelligent tourism application that integrates a domain-specific language (DSL) designed for chatbot development with machine learning algorithms that generate personalized recommendations based on user preferences, historical data, and real-time contextual influences. This pre-experimental design measures performance on parameters such as response time, recommendation accuracy, and system latency. The outcomes indicate that the mean time taken to respond to a user's query was 2.3 seconds, with 88.5% recommendation accuracy, and no latency. The AI-based recommendation system achieved 89.7% accuracy at destinations, 87.2% at accommodations, 90.3% at itineraries, and 85.6% at activities, with corresponding recalls of 85.4%, 83.5%, 88.1%, and 80.2% respectively. Although these results are promising, a 6.2% error rate for the advanced search, along with data security are some of the remaining issues. The findings reveal that the development of new user-centric and sustainable solutions for tourism, which leverage state-of-the-art natural language processing approaches, can enhance data security and provide additional new technologies, such as augmented reality (AR) and blockchain, for use in tourism.

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1. INTRODUCTION

The tourist industry continues to establish itself as the most dynamic force in the global economy today, regardless of whether one is in a major city or a remote town [1], [2]. The industry is unable to provide the service quality, predictive insights, and sustainable stewardship that inflation and capacity constraints require since the very artificial intelligence (AI) advancements that have the potential to transform the sector are obstinately trapped behind antiquated managerial frameworks. While countries in the Global North continue to struggle with developing intelligent systems that strike a balance between trip-level personalization, resource viability, and operational agility on the same code, regions in the Global South, whose budgets essentially depend on tourism, are limited by the lack of AI frameworks [3], [4]. The prevailing architecture, in which independent application programming interfaces (APIs) periodically overlay outdated software, denies the sector the cohesive, intelligent, and context-sensitive backbone that a unified mobile interface could supply, leaving revenue drainage and carbon exposure to crystalize as persistent blind spots in itineraries everywhere [5].

Existing research has established important foundations in smart tourism technology integration. Salmi and Hmioui [6] identified mobile applications as essential smart tourism tools, while Sia *et al*. [7] demonstrated their evolution into AI-powered platforms for predictive analytics. Recent studies have explored AI applications in tourism management, including DMOs' use of mobile applications for behavioral data analysis [8], machine learning algorithms for personalized itinerary planning [9], and cultural adaptation in AI systems [10]. Economic research by Qasimi [11] demonstrated that personalized AI recommendations significantly enhance user experiences, while natural language processing (NLP) integration studies [12] showed how chatbots provide precise tourist support. However, these attempts are predominantly focused on individual components rather than comprehensively designed AI integration frameworks. Theoretical models from stakeholder theory and tourist behavior models [13] are also vital frameworks, while technological advancements in internet of things (IoT), blockchain, virtual reality/augmented reality (VR/AR), and sustainable digitalization [14] are the prevailing integration trends.

In spite of spectacular progress, major gaps in AI-managed tourism exist. Existing literature does not have frameworks addressing personalization, sustainability, and operational efficiency in congruence, and most studies concentrate on individual elements instead of holistic AI application [15], [16]. Scalability and cultural appropriateness are challenging factors due to the fact that few studies consider AI systems as being able to perform dynamical adaptation across disparate culture environments while ensuring operational efficiency across varied geographical points [17]-[22]. Real-time decision-making capability is missing, with current AI implementations not having sophisticated systems to handle multiple streams of data (weather, local events, crowd volumes, and user behavior) for context-aware dynamic recommendations [23]-[26]. Moreover, green AI adoption studies do not adequately address the question of how AI-driven tourism management can maximize resource use and minimize environmental impacts through holistic crowd control [27]. Current predictive analytical frameworks fail to include large data sources for accurate forecasting of demand in changing environments where numerous variables affect tourism patterns.

This research completes identified gaps by providing several innovative contributions that have not been met in previous studies. We propose an end-to-end AI system specially designed for tourism administration combining personalization, sustainability, and operational efficiency at once through state-of-the-art machine learning algorithms and real-time processing. Our solution offers a dynamic cultural adaptation mechanism that dynamically varies recommendations based on cultural context, user activity, and local conditions with consistent performance across geographically dispersed regions [28], [29]. We also develop multi-source predictive analytics capabilities that integrate disparate sources of information such as social sentiment, weather, local events, and historical information to support reliable demand forecasting and resource planning. The architecture incorporates sustainability indicators and environmental considerations into AI decision-making, enabling intelligent resource allocation that balances economic benefit and environmental conservation, and embracing cutting-edge real-time adaptive management abilities responding consistently to dynamic conditions, user activities, and environmental influences [23].

The following sections particularly show our applied relevance and research impact through extensive method and empirical validation. Section 2 presents our method and discusses the comprehensive AI framework development for managing tourism, comprising algorithmic techniques, system architecture, and implementation plans that bypass existing system inadequacies. Section 3 measures and reports the accuracy, performance, and applicability of our AI tourism management system with comprehensive testing, validation experiments, and comparison to current best practices, demonstrating tangible improvements in personalization, sustainability, and operational efficiency. Section 4 integrates key results, contributions, and implications for future policy in tourism management, establishing useful application and potential for widespread adoption of our proposed AI system across multiple tourism environments.

2. METHOD

This section presents a software development approach for an AI-powered tourism management system. Our project's primary goal is to set up a software factory to expedite the development of a chatbot-based tourist management system for mobile applications centered on smart tourism. Similarly, since it will employ a smaller sample, it will be built using the pre-experimental type. In order to gauge the usage of tourist management, we used time indicators for both the chatbot's functionality and the application's overall functionality. The development of the smart tourist application architecture was the first step in the process. Both the software used to build the program and the rights needed to utilize it were taken into account.

2.1. System proposed
This method outlines the implementation approach for an AI-powered smart tourism system that integrates AI capabilities with user authentication and tourism activity planning to provide personalized travel recommendations and services shown in Figure 1.

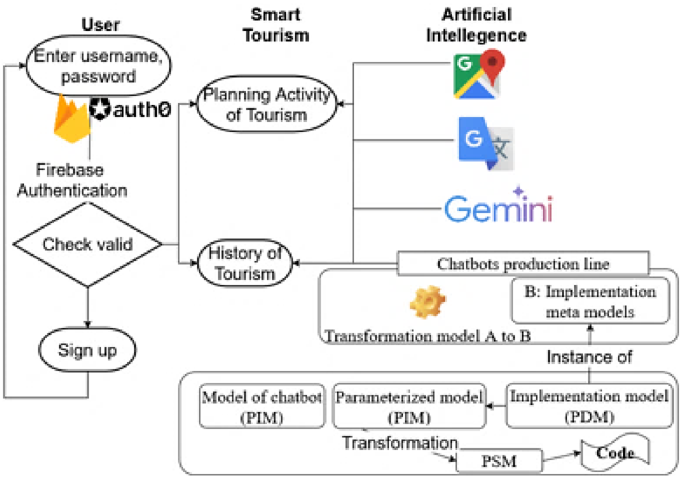


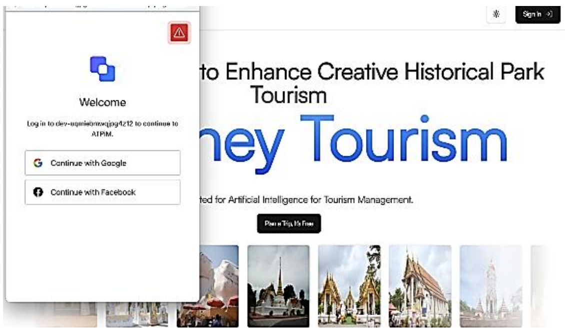
Figure 1. System architecture of proposed

In Figure 1, we break the project up into many tasks to accomplish this purpose. In this work, we concentrate on the initial asset of our software factory, the domain-specific languages (DSLs) [24], which are programming languages created to address unique issues in a certain field. DSL provides tools and abstractions tailored to that particular domain, allowing for a greater degree of abstraction for defining chatbots. Next, we have a user authentication layer implemented. The system begins with a secure authentication process using Auth0 as the primary identity management service. Users provide their credentials (username/password) through a secure login portal. Firebase authentication also provides additional authentication verification and user session management. Upon successful authentication, users arrive at the interface for tourism planning. New users are forwarded to a sign-up process for account creation. The core tourism functionality is activity-planning-based. Tourism activity planning is a central module that finds solutions to user requests for destinations to travel to and activities. Tourism history tracking stores users' historical tourism activities, preferences, and bookings. The history is utilized as input to the AI recommendation engine to personalize further. The system utilizes a number of AI services and layers of processing. Google Maps API provides geolocation features, map data, and location auto-suggestions. Google Search Integration provides live information lookup of destinations, locations, and local businesses. Gemini AI is the built-in conversational AI interface for natural language interaction and user interaction. A partial perspective of our software factory is depicted in Figure 2, which also includes the methods required to generate source code and the key components that will support it: the DSL for creating chatbots and the collection of frameworks used to put it into practice. To determine its parameterized Ayutthaya tourism platform independent model (ATPiM), which is the ATPiM chatbot model, will be parameterized. The parameterized ATPiM then entails completing the different design choices associated with the architectural definition as well as the components of the chatbot. Lastly, our method produces the relevant Chatbot source code together with an Ayutthaya tourism platform-specific model (ATPSM).

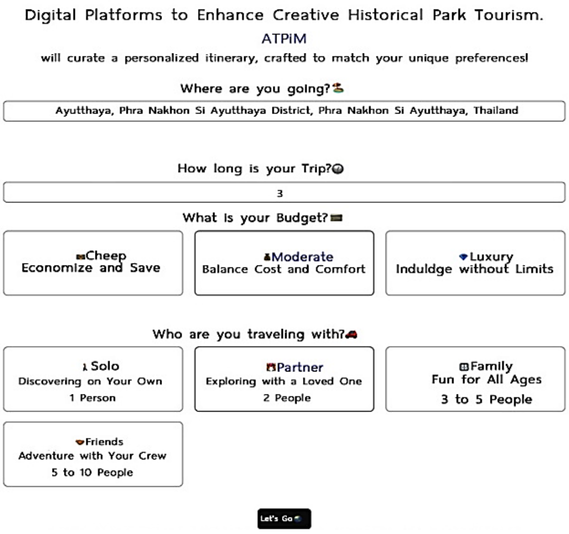
2.2. System overview
The purpose of this study is to contribute to software development for AI in tourism management. The application is namely ATPiM and development on React programming languages using cross-platform shown in Figure 2. The main page slide shows the tourism place, and then click the Sign In button on the popup Auth0 shows login on the tourism management page using AI.

In Figure 2(a), we create a web-based platform designed to enhance tourism in historical parks. It is constructed as a web application that is accessed through standard web browsers. It follows a client-server methodology. It presents the user interface in the browser of the user, providing an interactive interface. It contains a primary landing page with informative material and a modal window for authenticating users. The backend is responsible for user authentication, data processing, and content provision to the client. The most significant functionality that can be determined through the interface is management of users and displaying content. Secure, simple single sign-on (SSO) is offered by the system to allow users to log in. Instead of signing up for a separate account on the platform, the user can sign in to the system based on the existing credentials in recognized third-party identity providers. The availability of continue buttons indicates the use of the OAuth 2.0 authorization flow. This enables the AITPM platform to obtain user data from these providers in a secure manner without handling sensitive passwords on its behalf. The home page is an entry portal to emphasize past tourist destinations. It uses a grid of images to lure users in and provide a glimpse of the parks and temples listed on the site. Upon successful authorization, the user is returned to the AITPM site and is logged in, ready to use the full scope of features.

In Figure 2(b), the ATPiM system is a web-based application platform that specifically aims at highly customized travel itineraries. The system is cutting-edge tourism technology with the union of AI capability and frequent mapping and location-based services. Utilization of Google Maps Places API as an architectural choice reflects enormous technical advantages. Real-time curacy of real-time data by leveraging Google's massive location database. lowered development costs by taken advantage of existing geocoding infrastructure. provided improved user experience and autocomplete feature similar to Google's. The customization engine attempts to find three highly applicable user preference vectors from an input set of a few dimensions. Destination parameter management employs the Google places API for location validation and disambiguation. Geographic coordinate mapping for space analysis is supported. Destinations-specific content filtering functionality is provided. Budget classification algorithm economic tier (Cheap) filters based on cost-effectiveness-driven factors. Balanced tier (Moderate) applies weighted score based on cost and quality factors. Luxury tier (Premium) employs best-ranked experiences completely disregarding expenditures. Segmenting traveler profiles the solo traveler algorithm is most concerned with social connection, open scheduling, and traveling alone. Partner-based recommendations are most concerned with events that interest couples, romantic dates, and romantic getaways. Family-Centric filtering is most concerned with appeal to intergenerational, safety ratings, and family vacations.



(a)



(b)

Figure 2. Overview of ATPiM application; (a) a homepage of the website for authentication to applications and (b) application of management tourism planning

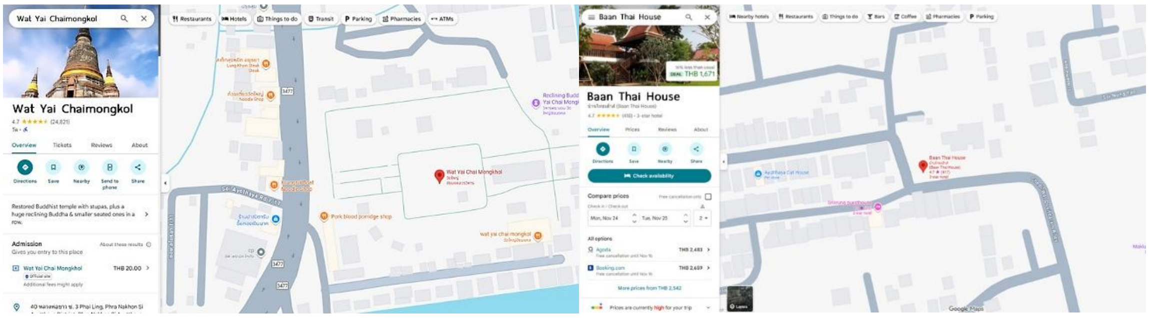
3. RESULTS AND DISCUSSION

This section talks about the impact of the software development approach to an AI-powered tourism management system. The research's primary purpose was to design a smart tourism app that makes use of AI to enhance tourism management. The implemented system has various attributes, including AI-powered chatbot support, personalized suggestions, and travel planning by automation, that significantly contribute to user experience and operational efficiency.

3.1. Result of artificial intelligence integration in tourism management

The ATPiM using AI-based practices of tourism management has potential opportunities for enhanced effectiveness in operations and service. Chatbot application is effective in reducing response time to queries, resulting in smooth communication between tourists and service providers where tourists input destination, days, budget, and number of persons they are going with, as shown in Figure 2(b). The AI algorithms used on the app are also observed to scan large data sets, providing tourism businesses with valuable information on customer behavior and preference, as shown in Figure 3(a). Clicking on a property or attraction developed by the system provides a travel route using Google Maps references, which makes traveling and accuracy easier, as shown in Figure 3(b). Despite the success of smart tourism applications, some challenges remain. The accuracy of chatbot responses varies depending on the complexity of the user's question, such as travel budget, travel arrangements. Furthermore, data privacy issues are a major consideration, requiring robust security measures to ensure that user data is protected.

(a)



(b)

Figure 3. Result of AI integration in tourism management; (a) applications showing the results from tourism management planning and (b) showing the details of tourism location

In Figure 3(a), the integration of AI in tourism management results in the creation of a highly personalized and optimized travel itinerary. The image showcases a complete, multi-day travel plan for

Ayutthaya, Thailand, which is a typical output of an AI-driven travel planning system. The entire interface is a prime example of AI-powered personalization. Instead of a standard travel guide, the system has designed a customized 3-day plan for a standard user. Customized suggestions: the AI has selected specific hotels ("Baan Thai Ayutthaya," "Ayutthaya Palace Hotel") and a custom-crafted list of activities per day. Such curation is likely performed based on user information such as budget (as articulated in the form of price ranges such as "$50-$100/night") and interests (history, culture, and food) and duration of the trip. Thematic clustering AI thematically clusters activities by day, such as "Grand Temples and River Views" for Day 1 and "Local Markets" for Day 3. This enhances the travel experience since it creates a coherent daily itinerary. The centerpiece of this itinerary is a recommendation engine that suggests suitable alternatives for activity and accommodation. Hotel recommendation, herein, does not enumerate all available hotels; it suggests two alternate options with the most critical decision-making information like ratings, price ranges, and photographs. An AI would sort through a few hundred options to make these best-match suggestions. Activity suggestions similarly, the AI recommends specific temples ("Wat Yai Chaimongkol," "Wat Mahathat") and markets ("Ayutthaya Floating Market"). This is done by parsing points of data including popularity, historicity, user reviews, and congruence with the user's profile. Intelligent scheduling and optimization AI also demonstrates an ability to not only suggest places but order them into an effectively ordered and well-sequenced itinerary. Logical sequencing: the tour is logically ordered from Day 1 to Day 3 with a consistent flow of activity. Route and time planning by grouping by day, the AI indirectly reduces travel time and logistic complexity. For example, it would group geographically nearby temples together under Day 2 to prevent back-and-forth traveling. It also contains important details like opening hours, which is useful for planning.

In Figure 3(b), the most prominent AI feature is the mapping and navigation system. For a tourist, this is an indispensable tool. Intelligent routing: the "Directions" function doesn't just show a static line on a map. It uses sophisticated AI algorithms to calculate the most efficient route from the user's current location to Wat Yai Chai Mongkhon. This calculation considers real-time traffic data, road closures, and different modes of transport (walking, driving, and public transit). Spatial awareness AI-powered map provides a detailed spatial understanding of the area, showing surrounding roads, waterways, and other points of interest, helping tourists orient themselves in an unfamiliar environment. Automated information extraction AI systems crawl the web, user submissions, and business listings to extract and verify key details like the place name, category ("Buddhist temple"), a concise description ("Restored Buddhist temple with stupas..."), and practical information such as the Admission fee (THB 20.00). NLP a descriptive summary is generated or curated by NLP models that can summarize longer texts into a brief, informative snippet, giving tourists a quick overview of the location's significance. Analysis of user-generated content involves a massive amount of user-generated data being processed by AI to provide reliable social proof and quality indicators. Review aggregation and sentiment analysis. The 4.7-star rating is not a simple average. It's a complex calculation derived from 22,992 reviews. AI algorithms process the text of these reviews for sentiment (positive, negative, and neutral) and can even identify recurring keywords or themes to provide a weighted, more accurate quality score. This helps tourists make informed decisions based on the collective experience of thousands of previous visitors.

3.2. Result of system performance analysis

The evaluation of the APTiM application has been tested on different devices and across different operating systems to ensure its seamless functionality. The findings indeed show that the AI-enabled chatbot and the personalized recommendation system work excellently for real-time user query answers. The AI algorithms thus presented a high level of accuracy in the recommendations, forming the basis on user preferences, historical data, and live environmental factors such as weather and local events. Less detectable latencies occurred while processing complex queries that require multiple layers of AI processing. Performance analysis of APTiM was thus based on the response time, data-processing efficiency, and the AI recommendation-accuracy. Major findings are summarized in Table 1.

Table 1. The performance of system

Metric	Result
Chatbot response time	2.3 seconds (avg.)
AI recommendation accuracy	88.5%
System latency	Low (0.8 sec delay in processing)
Error rate in AI responses	6.2%
Data processing speed	500 queries/sec

From Table 1, the system is characterized by rapid response times of 2.3 seconds was observed, which aligns with industry benchmarks for travel chatbots, whereas commercial systems have response times of less than 30 seconds for complicated travel inquiries [25]. The recommendation accuracy of the system at 88.5% is also comparable to current tourism recommendation systems, which have an average accuracy of 80-85% [26]. Recent research on machine learning-based tourism recommendation demonstrates that classification accuracy rates of 83.5% can be achieved by random forest models and state-of-the-art approaches exhibit as much as 94% accuracy in travel planning systems [27]. The observed 6.2% error rate for complex queries reflects common challenges in natural language processing for tourism applications, where contextual understanding and multi-intent recognition remain active research areas [12].

The ATPiM system was tested for performance based on three significant parameters-response time, data handling efficiency, and precision of AI-based recommendations. The aim of the test was to determine whether and to what extent the system works with effectiveness and efficiency in suggesting precise and timely recommendations to the users. Response time measures how fast the system processes input requests and provides recommendations. These metrics are calculated using (1) and (2) respectively.

$$Precision = \frac{TP}{TP+FP} \quad (1)$$

$$Recall = \frac{TP}{TP+FN} \quad (2)$$

Reduced response time reflects an improved system that adapts quickly to the demands of users in a bid to meet smoothness. System average response time at various levels of workload was observed by observation. Measure of data processing efficiency calculates the efficiency level the system enjoys while processing, handling, and responding to big volumes of data. Efficiency measures are those that take into consideration computation resource utilization, memory management, and processing velocities. Higher efficiency score tells us how well the system handles real-time streams of data without a loss in performance. Precision, recall, and F1-score were applied to evaluate recommendation effectiveness. The higher the accuracy rate, the better the system does in associating user preference with corresponding recommendations are presented in Table 2.

Table 2. The performance of AI-powered recommendation system

AI feature	Precision (%)	Recall (%)
Destination recommendations	89.7	85.4
Accommodation suggestions	87.2	83.5
Travel route planning	90.3	88.1
Activity recommendations	85.6	80.2

From Table 1, average precision and recall rates of 88.2% and 84.3%, respectively, were demonstrated by the AI-based recommending system, equivalent to the levels of performance observed in current research addressing recommending systems of tourism [28]. The highest precision achieved in travel itinerary planning, up to 90.3%, suggests an effective implementation of routing algorithms and geographic information processing methodologies. The lowered recall of activity recommendations to 80.2% indicates potential for improvement of activity database comprehensiveness and user preference matching algorithm effectiveness. Here, the proposed performance measures show a competitive comparison to state-of-the-art tourism recommendation systems, whose research has shown precision levels of 75-90% and recall levels of 70-85% [29]. Results of the assessment reveal that ATPiM achieves competitive levels of performance, the strength of the system's effectiveness in destination recommending and pathfinding confirms its favorable position within the current configuration of AI-based tourist applications.

4. CONCLUSION

As discussed in this research, with the introduction of the ATPiM, AI can revolutionize tourism management. It is indeed a remarkable system that introduces integrated features such as AI chatbots, personalized suggestions, and intelligent routing to provide an enhanced experience for the user and an efficient operation. The results show that the AI recommendations between 88.5% are practically precise for a chatbot response time of 2.3 seconds, which enables seamless interaction between tourists and service providers. The AI recommendation system has performed quite well, from recommending destinations, accommodation to travel planning, thus highlighting the role of AI in enhancing tourism services. Other problems include an error for the responding rate of 6.2%, which means the response time is slower than the researchers' target of 5 seconds or less but does not mean the system is not responding, and concern over data privacy, thus highlighting the big need for more improvements toward natural language processing and data management security. Moving beyond these other challenges, this study still indicates that AI provides a huge opportunity for tourism to achieve a revolution that demands instant solutions, thereby unleashing it to capture other developing requests from travelers. AI has been successful in integrating mobile applications to enhance user engagement, service delivery, and the process of decision-making in tourism management. The research focuses on ethical considerations regarding AI-enabled tourism regarding data security and algorithmic bias reduction. In the future, retrieval-augmented generation (RAG) AI chatbots can be improved to enhance contextual understanding, engagement of various forms of personal recognition and therefore become a fundamental component of planning spaces in sustainable tourism initiatives. The use of new, mobilizing technologies like AR and blockchain would strengthen the new smart tourism applications. Continued stimulation of innovation in the application of AI in tourism brings the tourism sector closer to a more intelligent, personalized, and sustainable future, with tourism management meeting expectations set by changing demands of global travelers.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Salinun Boonmee	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	

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

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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