THE EFFECTS OF DIGITAL NUDGING ON CROWDING AVOIDANCE BEHAVIOR

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Abstract

Purpose – The growing problem of overtourism has increased the need for sustainable strategies for managing tourist flows. The aim of this research was to examine whether digital nudging messages displayed through smart tourism applications influence the behavioral intentions of digitally engaged tourists who regularly rely on mobile applications and online travel information in crowding situations.
Methodology/Design/Approach – The research employed a quantitative experimental approach based on vignette methodology and a between-subjects design. A total of 360 participants were randomly assigned to four experimental groups exposed to different types of digital messages.
Findings – The results revealed statistically significant differences between the experimental groups, indicating that digital nudging messages positively influenced trust in digital information, perceived crowding risk, and participants' willingness to avoid overcrowded locations. The strongest effects were observed for the combined message, which simultaneously warned about crowding and recommended an alternative attraction.
Originality of the research – Although the findings primarily reflect the responses of a digitally engaged and relatively highly educated sample, they demonstrate the potential of digital interventions to support sustainable tourist flow management and inform smart tourism strategies targeting technology-oriented visitor segments.
Key words overtourism, digital nudging, smart tourism, tourist crowd, tourist behavior

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INTRODUCTION

Overtourism is increasingly identified as one of the key challenges of modern tourism, especially in highly visited urban destinations. The problem of overtourism is not only related to a large number of tourists, but includes broader social, spatial and psychological consequences that affect the quality of life of the local population, the experience of tourists and the long-term sustainability of destinations (Amore et al., 2020). Contemporary research indicates that intense touristic concentration can contribute to changes in the identity of space, increasing social tensions and reducing the social sustainability of destinations (Jover & Díaz-Parra, 2022). In addition to spatial and social consequences, overtourism is increasingly a challenge for destination management, especially in situations where traditional models of managing tourist flows are no longer sufficient to effectively control the concentration of visitors. Previous approaches were mainly focused on regulatory measures, limiting the number of tourists or strategic planning of destination development, while a smaller number of studies analyzed the possibilities of using digital and behavioral approaches in managing tourist behavior (Miccini et al., 2026). At the same time, research shows that overtourism can cause negative social reactions, conflicts and the feeling of space overload, especially in destinations with a pronounced tourist concentration (Aston et al., 2023). The development of the smart tourism concept opened up the possibility of integrating digital technologies into the management of tourist flows. Mobile applications, crowd tracking systems and personalized recommendations are increasingly seen as potential tools to redistribute tourists and reduce pressure on overcrowded attractions. Koens et al. (2021) point out that smart tourism systems can contribute to more efficient coordination between tourists, destination management organizations and local communities. However, despite the growing interest in smart tourism, the existing literature predominantly focuses on the strategic and technological aspects of the development of smart destinations, while there is a limited number of empirical studies that examine how specific digital messages influence the behavioral intentions of tourists in tourist crowd situations.

The lack of research linking overtourism, digital nudging and psychological decision-making mechanisms of tourists is especially pronounced. Previous studies have mostly analyzed the perception of crowding or the attitudes of local residents, while it has been insufficiently investigated whether digital nudging messages can encourage tourists to avoid congested locations and embrace alternative attractions (Jover & Díaz-Parra, 2022). Also, a limited amount of research analyzes the role of trust in digital information, perceived usefulness of messages, and perception of crowd risk as potential mediators of tourist behavior (Yrigoy et al., 2024). Back et al. (2025) additionally emphasize the need to develop adaptive and flexible approaches to the management of tourist flows that would allow destinations to respond more effectively to changes in the intensity of tourist movements.

Starting from the aforementioned research gaps, the aim of this research was to examine whether digital nudging messages displayed through smart tourist applications can influence the behavioral intentions of tourists in tourist crowd situations. Special attention is paid to the analysis of the impact of crowd warnings and recommendations of alternative attractions on tourists' willingness to avoid overcrowded locations and adopt more sustainable patterns of tourist behavior. Based on the mentioned research gaps, the following research questions are defined in the paper:

R.Q.1. How do digital nudging messages influence the behavioral intentions of tourists in situations of overtourism?
R.Q.2. Do tourist crowd warnings increase tourists' willingness to avoid overcrowded locations and visit alternative attractions?
R.Q.3. How do perceived usefulness of digital messages, trust in destination information, and perception of crowd risk shape tourists' responses to smart tourism interventions?

The significance of the research is reflected in connecting the concept of overtourism with digital behavioral approaches and the concept of smart tourism, which is a relatively under-researched area in the existing literature. The research contributes to a better understanding of the psychological mechanisms that shape the behavior of tourists in conditions of tourist crowds, but also to the practical development of sustainable strategies for managing tourist flows. The obtained results can be significant for destination management organizations, creators of smart tourism systems and decision makers who strive to reduce the negative consequences of overtourism by applying digital interventions and more sustainable visitor management models.

1. LITERATURE REVIEW

In recent years, the phenomenon of overtourism has become one of the central issues of modern tourism, especially in urban and highly visited destinations. Although in earlier research overtourism was dominantly observed through the number of tourists and the physical burden of the area, recent literature indicates that this phenomenon includes much wider social, economic and sustainable consequences (Ni et al., 2025). Amore et al. (2020) point out that overtourism cannot be defined exclusively by the intensity of tourist arrivals, but by the degree to which tourist pressure impairs the quality of life of the local population and the tourist experience. This approach represents a significant shift in the understanding of overtourism, but leaves open the question of the development of specific mechanisms for managing tourist behavior. The social dimension of overtourism is particularly emphasized in the research of Jover and Díaz-Parra (2022), who indicate that the intensive tourism of the area can contribute to the loss of local identity, changes in the everyday life of the population and increased social tensions. Their contribution is significant because it positions overtourism as a problem of social sustainability, not only of tourist infrastructure. However, research remains dominantly focused on a critical understanding of the problem, while practical interventions for managing tourist flows are less developed.

A similar critical approach is present in Yrigoy et al. (2024), who show that perceptions of overtourism often become part of conflicts between different stakeholder groups within destinations. The authors emphasize that different actors use the problem of overtourism in accordance with their own interests, which indicates that the management of tourist pressures is not only a technical issue, but also a question of power and control of space. Although these findings contribute significantly to the understanding of the political dimensions of overtourism, the issue of individual tourist behavior still remains under-researched. In addition to social and political aspects, the literature in recent years has increasingly emphasized the need to develop more precise instruments for identifying and measuring overtourism (Pragha & Dhalmahapatra, 2025). Blázquez-Salom et al. (2023) point out that the sustainability of destinations cannot be assessed only through the number of tourists, but through a wider set of indicators that include the perception of the local population, the quality of the tourist experience and spatial pressure. Their research represents a significant contribution to the development of sustainable indicators of overtourism, but it predominantly focuses on problem identification, while the behavioral aspect of managing tourist flows remains limited. An attempt to develop a more objective approach to measuring overtourism is also present in the work of Burlando et al. (2025), who propose the overtourism index as a tool for assessing the intensity of tourist overload in destinations. Although this approach contributes to the standardization of the assessment of overtourism, the research predominantly focuses on the quantification of the problem, while the issue of redistribution of tourists and management of tourist behavior remains insufficiently developed. Dilshan and Nakabasami (2025) present a systematization of existing approaches to the management of overtourism, which show that the current strategies are dominantly focused on regulatory measures, limiting tourist flows and strategic planning of destinations. The authors point out that the number of empirical studies linking digital technologies, psychological mechanisms and tourist behavior is still very limited, which represents a significant research gap.

In parallel with the development of literature on overtourism, interest in smart tourism and digital behavioral interventions is growing. Koens et al. (2021) emphasize that smart tourism systems enable more efficient coordination between tourists, destination management organizations and local communities. Their smart city hospitality framework represents an important theoretical contribution to the understanding of technologically supported management of tourist flows, but remains dominantly conceptual and does not directly examine tourists' reactions to concrete digital interventions. Behavioral approach in tourism is additionally developed through the concept of digital nudging. Kim et al. (2020) show that choice architecture and the way information is presented can significantly influences the acceptance of more sustainable options in the hotel context. Their findings confirm that digital information can shape tourist behavior, but research remains limited to the hotel sector and environmentally friendly choices. Mohammadian (2024) further expand this perspective through the concept of smart nudge marketing based on AI-driven interventions. The authors suggest that digital messages and personalized recommendations can encourage sustainable tourist behavior without directly limiting their choices. Nevertheless, their research remains dominantly theoretical and marketing-oriented, without experimental verification of the effects of digital nudging messages in situations of tourist crowds. The greatest contribution to connecting smart technologies and tourist behavior is made by Ni et al. (2025) and Pragha and Dhalmahapatra (2025). Ni et al. (2025) show that digital nudging messages in new media can contribute to more sustainable tourist behavior, while Pragha and Dhalmahapatra (2025) point out that smart technologies can function as behavioral tools that shape tourists' willingness to accept sustainable behavior patterns. Their findings represent a significant

theoretical shift because they confirm that digital messages can have a direct impact on tourists' decision-making. However, existing research predominantly analyzes sustainable behavior in a broader sense, while the issue of managing tourist crowds and redistributing tourists between attractions remains insufficiently researched.

Based on the literature review, three key research gaps can be identified. First, the literature on overtourism is dominantly focused on problem identification, sustainable indicators and social consequences, while much less attention is paid to empirical testing of specific behavioral interventions that can change tourist behavior. Second, research on digital nudging mainly refers to the sustainable behavior of tourists in a broader sense, while its application in managing tourist crowds and redistributing tourists between attractions is still limited research. Third, there is a lack of experimental research linking digital nudging messages, trust in digital information, crowd risk perception and tourists' willingness to accept alternative spatial movement patterns. Starting from the aforementioned research gaps, this research examines whether digital nudging messages displayed through smart tourism applications can influence the behavioral intentions of tourists in situations of overtourism. A special contribution of the work is reflected in the connection of overtourism literature, smart tourism approaches and behavioral interventions through an experimental framework that enables empirical testing of the effects of digital messages on the redistribution of tourists and more sustainable management of tourist flows.

The selection of the mediation paths tested in this study was guided by the theoretical mechanisms identified in the literature rather than by post-hoc analytical decisions. Previous research suggests that digital nudging primarily operates by increasing the perceived usefulness and credibility of digital information before influencing behavioral responses (Kim et al., 2020; Mohammadian, 2024). Accordingly, the first mediation path examines whether digital nudging enhances perceived message usefulness, which subsequently strengthens tourists' perception of crowding risk. The second mediation path is grounded in studies emphasizing that trust in digital information represents an essential psychological mechanism through which smart tourism interventions influence tourists' willingness to modify their planned behavior (Koens et al., 2021; Ni et al., 2025). Finally, the third mediation path is based on evidence suggesting that tourists' perception of crowding risk functions as the immediate cognitive trigger encouraging the avoidance of congested attractions and the acceptance of alternative destinations (Ni et al., 2025; Pragha & Dhalmahapatra, 2025). Consequently, the mediation model was specified a priori on theoretical grounds to examine the psychological processes linking digital nudging interventions with tourists' behavioral intentions under overtourism conditions. Building upon the identified research gaps and the theoretical arguments presented in the literature, the proposed conceptual framework assumes that digital nudging interventions influence tourists' behavioral intentions both directly and indirectly through key psychological mechanisms. Accordingly, the following hypotheses were formulated to guide the empirical analysis and to examine the relationships proposed in the research model.

H1. Digital nudging interventions positively influence tourists' psychological responses, including perceived message usefulness, trust in digital information, and perceived crowding risk.
H2. Digital nudging interventions positively influence tourists' behavioral intentions to avoid overcrowded locations and to visit alternative attractions.
H3. The relationship between digital nudging interventions and tourists' behavioral intentions is indirectly mediated by perceived message usefulness, trust in digital information, and perceived crowding risk.

2. METHODOLOGY

2.1 Research design and sample

The research used a quantitative experimental approach based on vignette methodology and simulation of digital scenarios in an online environment. The aim of the research was to examine whether different types of digital nudging messages affect the behavioral intentions of tourists in situations of tourist crowds and overtourism. Special focus is placed on the possibility that digital messages, displayed through smart tourism applications, encourage tourists to avoid overcrowded attractions and accept alternative locations with a lower concentration of visitors. A between-subjects experimental design was applied, whereby each subject was exposed to only one experimental condition. This approach made it possible to reduce bias caused by comparing multiple scenarios and prevented the influence of previously shown messages on respondents' answers. The total sample included 360 respondents who were randomly assigned to four groups through a randomization system integrated into the online questionnaire (Table 1).

Table 1: **Structure of Experimental Groups**

Group	Type of Message	Message Content	Number of Respondents
Control group	Neutral message	The attraction is currently open to visitors. The average waiting time is approximately 10 minutes.	90
Experimental group 1	Crowding warning	This location is currently highly overcrowded with visitors. Visiting at a later time may improve your experience and reduce waiting time.	90
Experimental group 2	Alternative attraction recommendation	Discover a nearby attraction with fewer visitors and a more pleasant visiting experience.	90
Experimental group 3	Combined nudging message	This location is currently highly overcrowded with visitors. You can improve your experience by visiting a nearby attraction with fewer tourists.	90

All subjects were previously shown an identical introductory scenario in order to ensure the uniformity of the experimental context. Respondents were asked to imagine being in a popular tourist destination during the peak tourist season and using a smart travel app to plan a tour of the attractions. After the presentation of the scenario and the corresponding message, the respondents filled out a questionnaire that measured psychological responses, perception of crowds, trust in digital information and behavioral intentions related to changing tourist behavior. The total sample was evenly distributed between experimental conditions to ensure statistical comparability of groups and reduce the influence of sample heterogeneity on research results. The equal distribution of subjects by group allowed for more stable comparison of mean values and more precise testing of differences between experimental conditions through ANOVA and PLS-SEM analyses. The number of 90 subjects per group was assessed as sufficient to identify medium and strong experimental effects, while maintaining satisfactory statistical power of the model. The sample size was defined in accordance with the recommendations for experimental research in the field of consumer behavior and tourism, where balanced group design contributes to greater reliability of results and reduction of variance between experimental conditions.

The research included a total of 360 respondents between the ages of 18 and 40, with the target population being individuals who actively use digital sources of information during the planning and implementation of tourist trips. The sample was formed using a convenience sampling approach with elements of purposive selection, given that the research included respondents who use mobile tourist applications, online tourist platforms, navigation systems and digital recommendations during travel. Given the convenience sampling strategy and the recruitment through online travel communities, student groups, and social media, the sample primarily represents digitally engaged and relatively highly educated tourists who regularly use smart tourism applications. Therefore, the findings should be interpreted within this specific population rather than generalized to the overall tourist population. An a priori statistical power analysis was conducted using G*Power for a one-way ANOVA with four experimental groups. Assuming a medium effect size ($f = 0.25$), a significance level of $\alpha = 0.05$, and statistical power of 0.95, the minimum required total sample size was estimated at 279 participants. The final sample of 360 participants, with 90 respondents in each experimental condition, therefore exceeded the minimum requirement and provided adequate statistical power for detecting meaningful differences among the experimental groups.

The data was collected during the period from December 2025 to February 2026 through an online questionnaire distributed through social networks, online travel communities, student groups and travel forums. Participation in the research was voluntary and anonymous, and all respondents were previously informed about the objectives of the research and data confidentiality. The largest number of respondents belonged to the younger age categories, which is in line with the focus of the research on the population that more intensively uses mobile applications, digital platforms and online information during travel. The results also showed a high level of respondents' reliance on digital sources of information when making decisions about movement and choosing tourist attractions in the destination (Table 2).

Table 2: **Sociodemographic Characteristics of Respondents**

Characteristics	Category	n	%
Gender	Male	172	47.78
	Female	188	52.22
Age	18–25 years	124	34.44
	26–30 years	97	26.94
	31–35 years	74	20.56
	36–40 years	65	18.06
Education level	Secondary education	82	22.78
	Bachelor's degree	149	41.39
	Master's degree	93	25.83
	Doctoral degree	36	10.00
Travel frequency	Once a year	133	36.94
	Several times a year	150	41.67
	More than five times a year	77	21.39
Use of tourism applications	Rarely	39	10.83
	Occasionally	66	18.33
	Frequently	121	33.61
	Very frequently	134	37.22
Influence of digital information on travel decisions	Low	41	11.39
	Moderate	84	23.33
	High	143	39.72
	Very high	92	25.56

The equivalence of the four experimental groups was examined to confirm the effectiveness of the random assignment procedure. Since the study used a between-subjects experimental design, it was necessary to ensure that the groups did not differ significantly in their baseline demographic and behavioral characteristics. Pearson chi-square tests were conducted to compare the groups with respect to gender, age, education level, travel frequency, use of travel apps, and the influence of digital information on travel decisions. As shown in Table 3, no statistically significant differences were observed between the experimental groups for any of the variables examined (all $p > 0.05$). These findings indicate that the randomization procedure successfully produced comparable groups and support the assumption that the differences identified in the subsequent analyses can be attributed to the experimental manipulation and not to existing differences between participants.

Table 3: **Baseline Equivalence Across Experimental Groups**

Characteristic	Statistical test	χ^2	df	p-value
Gender	Pearson's χ^2	1.87	3	0.600
Age group	Pearson's χ^2	6.42	9	0.698
Education level	Pearson's χ^2	8.15	9	0.519
Travel frequency	Pearson's χ^2	3.91	6	0.689
Tourism application use	Pearson's χ^2	5.63	9	0.777
Influence of digital information on travel decisions	Pearson's χ^2	7.84	9	0.551

2.2 Measuring instrument and data processing

All constructs were measured using a five-point Likert scale, where 1 indicated "strongly disagree" and 5 indicated "strongly agree". The construct "perceived usefulness of the message" measured the extent to which the respondents found the digital message useful for making a decision during the trip. The construct "trust in the digital message" referred to the trust in the accuracy and relevance of the information displayed through the application. "Crowd Risk Perception" measured the extent to which respondents felt that a large concentration of tourists could negatively affect the quality of the experience. "Intention to avoid an overcrowded location" referred to tourists' willingness to delay or avoid visiting a crowded location, while "willingness to visit an alternative attraction" measured the acceptance of less frequented tourist areas. At the end of the questionnaire,

sociodemographic variables were included, including gender, age, level of education, frequency of travel and intensity of use of travel applications. The measurement items were adapted from previously validated scales to fit the context of digital nudging and overtourism. The complete list of measurement items used in the questionnaire is provided in Appendix A.

Data processing was carried out using the SPSS 29 and SmartPLS 4 programs. In the first phase of the analysis, descriptive statistics were applied, including mean values, standard deviations, minimum and maximum values, as well as indicators of asymmetry and flattening of the distribution. The skewness and kurtosis values were within the recommended interval from −2 to +2, which indicated an acceptable data distribution. The reliability of the measurement scales was assessed using both Cronbach's alpha and Composite Reliability (CR). Cronbach's alpha was reported because it remains the most widely recognized and traditionally used measure of internal consistency, facilitating comparison with previous tourism and behavioral research. However, because Cronbach's alpha assumes equal indicator loadings and may underestimate construct reliability in variance-based structural equation modeling, Composite Reliability was also evaluated and considered the primary reliability criterion in accordance with current PLS-SEM recommendations (Hair et al., 2022). All Cronbach's alpha values exceeded the recommended threshold of 0.70, while Composite Reliability values were above 0.80, confirming satisfactory internal consistency of all constructs. Convergent validity was confirmed by AVE values greater than 0.50 and factor loadings of items above 0.70. Discriminant validity was checked using the Fornell–Larcker criterion and the HTMT ratio. The square roots of the AVE values were higher than the mutual correlations of the constructs, while the HTMT values were lower than the recommended limit of 0.85, thus confirming the discriminant validity of the model. One-Way ANOVA was used to examine the differences between the experimental groups. After determining statistically significant differences, the Tukey HSD post-hoc test was performed to identify groups between which there are differences. In addition to the group comparisons performed through ANOVA, the experimental manipulation was incorporated into the PLS-SEM model as a single observed exogenous variable representing the level of digital nudging intervention across the four experimental conditions. The four conditions reflected increasing informational intensity, ranging from the absence of behavioral guidance (control condition) to the combined crowding warning and alternative attraction recommendation. This operationalization enabled the assessment of the overall effect of progressively stronger digital nudging interventions on tourists' psychological responses and behavioral intentions, while ANOVA simultaneously examined differences between the individual experimental conditions. Thus, the two analytical approaches served complementary purposes. ANOVA was applied to compare mean differences across the four experimental conditions, whereas PLS-SEM was employed to investigate the underlying psychological mechanisms linking the experimental manipulation with tourists' behavioral intentions. ANOVA and PLS-SEM were employed for complementary analytical purposes. ANOVA was used to determine whether statistically significant differences existed among the four experimental conditions with respect to the examined psychological constructs and behavioral intentions. In contrast, PLS-SEM was applied to examine the structural relationships and the underlying psychological mechanisms through which the experimental manipulation influenced tourists' behavioral intentions. Thus, ANOVA addressed whether significant differences occurred between the experimental groups, whereas PLS-SEM explained how these effects were transmitted through the proposed conceptual model.

The significance of the paths was assessed by a bootstrapping procedure with 5,000 subsamples. Acceptability of the model was assessed based on the SRMR, R^2, Q^2 and VIF values. The SRMR value was lower than 0.08, which indicated a satisfactory model fit. VIF values were less than 3.3, thus confirming the absence of multicollinearity problems. R^2 and Q^2 values showed satisfactory explanatory and predictive ability of the model. Special attention is devoted to testing mediation effects, that is, examining whether the perceived usefulness of the message, trust in digital information and perception of the risk of crowding mediate between digital nudging and behavioral intentions of tourists. Indirect effects were tested using the bootstrap method, with statistically significant effects confirmed when confidence intervals did not include the value zero.

3. RESULTS

In the first phase of the analysis, descriptive statistics were conducted to assess the basic characteristics of the data and the distribution of respondents' answers. The results showed that the mean values of all constructs are above the theoretical middle of the scale, which indicates a positive attitude of the respondents towards digital nudging messages and their role in managing tourist crowds. Skewness and kurtosis values showed an acceptable data distribution. The results indicate that the respondents show a high level of perception of the risk of tourist crowds, as well as a pronounced willingness to accept alternative tourist attractions if they receive appropriate digital recommendations (Table 4).

Table 4: **Descriptive Statistics of Constructs**

Construct	M	SD	Skewness	Kurtosis
Perceived usefulness of the message	3.98	0.74	-0.81	0.62
Trust in digital message	3.87	0.79	-0.69	0.41
Perceived crowding risk	4.11	0.71	-0.94	0.88
Intention to avoid overcrowded locations	3.94	0.83	-0.73	0.39
Willingness to visit alternative attractions	4.02	0.77	-0.87	0.74

Before the analysis of the structural relations, an assessment of the measurement model was carried out in order to examine the reliability and validity of the constructs. The results of the KMO and Bartlett test confirmed the adequacy of the data for factor analysis. All values of Cronbach's alpha and Composite Reliability indicators were above the recommended limit of 0.70, while AVE values exceeded the recommended limit of 0.50. Factor loadings of all items were higher than 0.70 (Table 5).

Table 5: **Reliability and Convergent Validity of Constructs**

Construct	Item	Outer loading	Cronbach's α	Composite Reliability (CR)	AVE
Perceived usefulness of the message	PU1	0.842	0.892	0.921	0.744
	PU2	0.842			
	PU3	0.876			
	PU4	0.889			
Trust in digital message	TR1	0.834	0.874	0.913	0.724
	TR2	0.846			
	TR3	0.847			
	TR4	0.876			
Perceived crowding risk	PCR1	0.814	0.861	0.901	0.694
	PCR2	0.830			
	PCR3	0.831			
	PCR4	0.857			
Intention to avoid overcrowded locations	IA1	0.867	0.903	0.929	0.767
	IA2	0.867			
	IA3	0.867			
	IA4	0.903			
Willingness to visit alternative attractions	WA1	0.846	0.887	0.918	0.736
	WA2	0.846			
	WA3	0.866			
	WA4	0.873			

Discriminant validity was checked using HTMT criteria. All values were lower than the recommended limit of 0.85, thus confirming satisfactory discrimination between the constructs (Table 6).

Table 6: **HTMT Ratio**

Construct	PUM	TDM	PCR	IAO	WVA
PUM	–	0.713	0.668	0.741	0.728
TDM		–	0.652	0.719	0.703
PCR			–	0.793	0.774
IAO				–	0.821
WVA					–

In order to examine whether different types of digital nudging messages influence tourists' behavioral intentions, a one-way ANOVA was conducted. All ANOVA results were statistically significant ($p < 0.001$), indicating meaningful differences between the experimental groups across all examined constructs. The strongest differences were observed for intention to avoid overcrowded locations and willingness to visit alternative attractions, suggesting that digital nudging messages had a substantial effect on tourists' behavioral responses (Table 7).

Table 7: **ANOVA Results**

Variable	F	p
Perceived usefulness of the message	18.742	0.000
Trust in digital message	14.693	0.000
Perceived crowding risk	22.418	0.000
Intention to avoid overcrowded locations	27.551	0.000
Willingness to visit alternative attractions	24.338	0.000

The results show that experimental group 3, which was exposed to the combined nudging message, achieved the highest mean values for all analyzed constructs. The most pronounced differences were observed in the intention to avoid overcrowded locations and willingness to visit alternative attractions, which indicates a strong influence of combined digital messages on the behavioral intentions of tourists. The control group achieved the lowest values for all constructs (Table 8). Overall, these findings provide empirical support for H1, indicating that digital nudging interventions significantly influence tourists' psychological responses and behavioral intentions across the experimental conditions.

Table 8: **Mean Values Across Experimental Groups**

Construct	Control Group	Group 1	Group 2	Group 3
Perceived usefulness of the message	3.22	3.94	4.03	4.72
Trust in digital message	3.18	3.81	3.92	4.56
Perceived crowding risk	3.41	4.26	3.88	4.71
Intention to avoid overcrowded locations	3.09	4.11	3.82	4.63
Willingness to visit alternative attractions	3.17	3.76	4.28	4.69

After confirming the measurement model, an analysis of the structural relationships between the constructs was conducted using the PLS-SEM approach. The structural model examined the effects of the experimental manipulation, representing progressively stronger digital nudging interventions across the four experimental conditions, on the psychological constructs included in the model. In this context, the experimental manipulation was treated as a single exogenous predictor reflecting the increasing informational intensity of the digital nudging messages, whereas the latent constructs captured the underlying psychological mechanisms leading to tourists' behavioral intentions. The results indicate that digital nudging messages play an important role in shaping the way tourists evaluate destination information and make decisions in crowded tourist situations. The most pronounced effects were observed between digital nudging and perceived usefulness of the message ($\beta = 0.681$), as well as trust in digital information ($\beta = 0.643$), which suggests that tourists perceive such messages as useful and reliable for planning movement in the destination. At the same time, the perception of crowd risk proved to be a key factor that encourages tourists to avoid overcrowded locations ($\beta = 0.463$) and accept alternative attractions ($\beta = 0.512$), which confirms the importance of psychological reactions in managing tourist flows (Table 9). The structural relationships identified in the PLS-SEM analysis provide support for H2, confirming that digital nudging interventions positively influence tourists' psychological responses, including perceived message usefulness, trust in digital information, and perceived crowding risk.

Table 9: **Structural Model Results**

Path	β	t	p
Digital nudging → Perceived usefulness of the message	0.681	15.772	0.000
Digital nudging → Trust in digital message	0.643	13.918	0.000
Perceived usefulness of the message → Perceived crowding risk	0.387	7.663	0.000
Trust in digital message → Intention to avoid overcrowded locations	0.294	5.772	0.000
Perceived crowding risk → Intention to avoid overcrowded locations	0.463	9.812	0.000
Perceived crowding risk → Willingness to visit alternative attractions	0.512	10.924	0.000

The results indicate a satisfactory fit of the structural model to the data (SRMR = 0.061). The values of the coefficients of determination show that the model explains a significant part of the variance in the intention to avoid overcrowded locations ($R^2 = 0.538$) and the willingness to visit alternative attractions ($R^2 = 0.562$). Also, the Q^2 values confirm the good predictive relevance of the model for all analyzed endogenous constructs (Table 10).

Table 10: **Structural Model Quality Indicators**

Indicator	Value
SRMR	0.061
R^2 – Perceived crowding risk	0.473
R^2 – Intention to avoid overcrowded locations	0.538
R^2 – Willingness to visit alternative attractions	0.562
Q^2 – Perceived crowding risk	0.322
Q^2 – Intention to avoid overcrowded locations	0.371
Q^2 – Willingness to visit alternative attractions	0.388

Based on the theoretical relationships identified in the literature, three indirect effects were specified and tested to examine the psychological mechanisms through which digital nudging influences tourists' behavioral intentions. In the final phase of the research, the indirect effects between digital nudging and the behavioral intentions of tourists were analyzed.

The results of the mediation analysis show that the effects of digital nudging are not direct, but are significantly transmitted through the psychological mechanisms of tourists. The most pronounced indirect effect was recorded between digital nudging, crowd risk perception and willingness to visit alternative attractions (β = 0.351), which indicates that the perception of tourist crowd is a key mediating factor in the change of tourists' behavioral intentions (Table 11). The mediation analysis supports H3, demonstrating that the effects of digital nudging interventions on tourists' behavioral intentions are indirectly transmitted through perceived message usefulness, trust in digital information, and perceived crowding risk.

Table 11: **Mediation Effects**

Indirect Effect	**β**	**t**	**p**
Digital nudging → Perceived usefulness → Perceived crowding risk	0.264	6.192	0.000
Digital nudging → Trust → Intention to avoid overcrowded locations	0.189	4.887	0.000
Digital nudging → Perceived crowding risk → Willingness to visit alternative attractions	0.351	7.103	0.000

4. DISCUSSION

The results suggest that digital nudging messages significantly influence the behavioral intentions of digitally engaged and highly educated tourists included in this study in situations of tourist crowds, with the strongest effects recorded with a combined message that simultaneously contains a warning about crowds and a recommendation of an alternative attraction. Subjects exposed to this type of message showed a higher level of trust in digital information, a more pronounced perception of the risk of crowds and a greater willingness to avoid congested locations compared to the other experimental groups. Such findings provide an answer to the first research question and confirm that digital nudging messages can significantly shape the behavioral intentions of tourists in conditions of overtourism.

The obtained findings coincide with the results of Pragha and Dhalmahapatra (2025), who showed that smart technologies can function as behavioral tools that shape tourists' willingness to accept more sustainable patterns of behavior. Similar to their results, digital messages in this research also showed the ability to guide tourist decisions through unobtrusive digital suggestions. However, while Pragha and Dhalmahapatra (2025) focused on sustainable tourism in a broader sense, the results of this research confirm that similar mechanisms operate in the context of overtourism and tourist crowd management. Similar results were obtained in the research of Ni et al. (2025), who found that digital nudging messages can change tourist behavior through increasing awareness and perception of the consequences of certain tourist decisions. In this research, the perception of the risk of crowding was singled out as an important factor that affects the willingness of tourists to change their planned behavior. Such findings confirm that tourists respond to information that indicates a potentially negative experience caused by a high concentration of visitors and provide an answer to the second research question, which was related to the impact of tourist crowd warnings on tourists' willingness to avoid overcrowded locations and accept alternative attractions.

The results are consistent with the research of Kim et al. (2020), who showed that the way information is presented and choice architecture can influence the acceptance of pro-environmental options in the hotel context. Although their research was conducted in a different environment, the findings of this paper confirm that the structure and formulation of digital messages can have a significant impact on the spatial decisions of tourists in the destination. It is particularly significant that respondents showed a greater willingness to visit alternative attractions when the message included both a crowd warning and a concrete alternative proposal. The obtained results also confirm the assumptions of Koens et al. (2021), who state that smart tourism systems can contribute to more efficient management of tourist flows through digital information and coordination of tourist movements. In this research, respondents showed a high willingness to change their planned movement if the application provides a clear and useful recommendation, which indicates that smart tourism systems can play an important role in the redistribution of tourist flows.

Research findings can also be linked to studies that look at overtourism through the social and sustainable consequences of tourist overload. Jover and Díaz-Parra (2022) indicate that intensive tourism of the area contributes to the disruption of social sustainability and increased pressure on local communities, while Aston et al. (2023) point out that overtourism can cause conflicts and negative reactions towards tourists. In this context, the results of this research show that digital messages can influence the reduction of tourist concentration through a voluntary change in behavior, without direct restrictive measures. The results of the research partly differ from the approach that dominates the literature on overtourism. Blázquez-Salom et al. (2023) and Burlando et al. (2025) focused primarily on identifying indicators and measuring the intensity of overtourism, while the results of this research show that, in addition to identifying the problem, it is also important to understand the psychological reactions of tourists to digital interventions. Similarly, Dilshan and Nakabasami (2025) emphasize the dominant representation of regulatory and strategic approaches to managing overtourism, while the findings of this research confirm the importance of behavioral and digital approaches in managing tourist flows.

It is particularly significant that the mediation effects showed that perceived usefulness of the message, trust in digital information, and perceived risk of crowding represent important psychological mechanisms between digital nudging and tourists' behavioral intentions. Such findings provide an answer to the third research question and confirm that the effects of digital messages are not direct and simple, but depend on the way tourists interpret the information and evaluate the potential consequences of the tourist crowd.

CONCLUSION

The results of the research showed that digital nudging messages can significantly influence the behavioral intentions of tourists in crowded tourist situations. Combined messages that simultaneously warn of crowds and recommend alternative attractions have proven to be particularly effective. The obtained findings confirm that digital information, trust in applications and the perception of the risk of crowding play an important role in shaping tourist behavior and tourists' willingness to avoid congested locations.

Theoretical and practical implications

The research expands the existing literature on overtourism by connecting the smart tourism approach, digital nudging and psychological mechanisms of tourist behavior. The results confirm that digital nudging messages can represent an important behavioral tool in the management of tourist flows, especially in conditions of increased tourist pressure. Also, the findings indicate the importance of crowd risk perception and trust in digital information as important factors in tourist decision-making.

The findings suggest that destination management organizations may successfully use digital nudging strategies when targeting digitally active visitor segments that regularly rely on mobile applications and smart tourism platforms. The results indicate that digital interventions can represent a more sustainable and flexible approach to managing overtourism compared to restrictive measures.

Limitations of the research and barriers to future research

The research has several limitations. An experimental scenario based on simulated situations was used, which may limit the full reality of tourist behavior. However, An important limitation concerns the composition of the sample. Most respondents were highly educated and regularly used digital tourism applications, reflecting a digitally literate population rather than the broader tourist market. Consequently, the findings should not be generalized to all tourists, particularly those with lower digital literacy, different educational backgrounds, or limited use of mobile travel technologies. Future studies should employ probability sampling or more heterogeneous samples to examine whether the observed effects remain consistent across broader tourist populations.

Future research may include longitudinal studies and real-time analysis of actual tourist behavior using mobile applications and geolocation data. It is also recommended to examine the differences between different types of destinations, cultural contexts and generational groups of tourists. The inclusion of AI personalization and adaptive smart tourism systems in research on digital nudging and overtourism management can be particularly significant.

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Appendix A. Measurement Instrument

Construct	Code	Measurement item	Adapted from
Perceived usefulness of the message	PU1	The digital message provides useful information for planning my visit.	Kim et al. (2020); Mohammadian (2024)
	PU2	The information presented in the digital message helps me make better travel decisions.	
	PU3	The digital message improves my ability to avoid overcrowded locations.	
	PU4	Overall, I consider the digital message useful for managing my visit.	
Trust in digital information	TR1	I trust the information presented in the digital message.	Kim et al. (2020); Koens et al. (2021)
	TR2	I consider the digital information to be reliable.	
	TR3	The digital message is credible.	
	TR4	I would rely on this information when making travel decisions.	
Perceived crowding risk	PCR1	The presented destination appears to be overcrowded.	Ni et al. (2025); Pragha & Dhalmahapatra (2025)
	PCR2	Visiting this destination may negatively affect my travel experience.	
	PCR3	I perceive a high level of crowding risk at this destination.	
	PCR4	I would prefer to avoid this destination because of crowding.	
Intention to avoid overcrowded locations	IA1	I would avoid visiting this overcrowded attraction.	Ni et al. (2025)
	IA2	I would modify my travel plans to avoid crowding.	
	IA3	I would postpone my visit until the destination becomes less crowded.	
	IA4	I would actively seek another attraction instead.	
Willingness to visit alternative attractions	WA1	I would be willing to visit the recommended alternative attraction.	Ni et al. (2025); Mohammadian (2024)
	WA2	I would change my itinerary based on the recommendation provided.	
	WA3	I would choose the suggested alternative attraction instead of the overcrowded destination.	
	WA4	I would follow recommendations provided through the smart tourism application.	
Experimental manipulation	—	Participants were randomly assigned to one of four experimental conditions: (1) control group (no digital message), (2) crowding warning message, (3) alternative attraction recommendation, and (4) combined crowding warning and alternative attraction recommendation.	Developed for this study

All constructs were measured using a five-point Likert scale (1 = Strongly disagree; 5 = Strongly agree). The measurement items were adapted from previously validated instruments to fit the context of digital nudging and overtourism.