Pol. J. Environ. Stud. Vol. XX, No. X (XXXX), 1–9
DOI:*10.15244/pjoes/194577* ONLINE PUBLICATION DATE:

Short Communication

Perceptions and Practices of Low-Carbon Travel Adoption: A Comparative Analysis of Faculty and Students in Chinese Institutions

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Received: 24 April 2024
Accepted: 13 October 2024

Abstract

This study investigates the factors influencing the adoption of low-carbon travel options among students and faculty at vocational colleges in China. As part of China's broader commitment to sustainable urban development, the promotion of sustainable transportation modes such as public transit, biking, car-sharing, and electric vehicles is crucial. Given the strategic role of educational institutions in shaping sustainable behaviors, this research targets students and teachers to assess their awareness, willingness, and actual behaviors related to low-carbon travel. The study employs a quantitative methodology guided by the Theory of Planned Behavior (TPB), utilizing descriptive analysis and logistic regression models to examine the data. The results reveal significant differences in the effectiveness of low-carbon travel strategies across the two demographic groups, driven by distinct socio-economic, cultural, and infrastructural factors. Specific examples include the influence of carpooling on students' awareness and the impact of educational level on faculty's willingness to adopt low-carbon travel. These findings offer nuanced insights into the barriers and opportunities for promoting low-carbon travel and contribute to the discourse on sustainable urban transportation planning. The research highlights the importance of localized, targeted interventions tailored to the specific needs and preferences of different demographic groups to foster a shift toward more sustainable urban environments.

Keywords: low-carbon travel, cognition, willingness, behavioral differences

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Introduction

In the face of escalating global environmental challenges, urban centers are increasingly at the forefront of adopting and implementing strategies aimed at mitigating climate change effects, particularly those caused by transportation emissions [1]. Urban transportation is a significant contributor to global carbon emissions, with private vehicles alone responsible for a substantial share. As such, the transition to low-carbon travel options is crucial for reducing urban carbon footprints and fostering sustainable urban environments. Low-carbon travel encompasses a range of transportation modes that minimize environmental impact by reducing carbon dioxide emissions and other pollutants [2–4]. These modes include public transportation, cycling, walking, car-sharing, and the use of electric or hybrid vehicles. The transition to these sustainable modes is supported by both technological advancements and policy measures that encourage their adoption [5]. However, the effectiveness of these strategies varies widely across different urban contexts due to differences in infrastructure, cultural attitudes, economic conditions, and public awareness [6, 7]. The importance of adopting low-carbon travel is underpinned by its potential to address multiple urban challenges simultaneously. Beyond reducing emissions, sustainable travel modes can alleviate traffic congestion, lower noise pollution, improve air quality, and enhance public health. Additionally, they contribute to energy security and economic sustainability by reducing dependence on fossil fuels and promoting technological innovation and green jobs.

However, despite the clear benefits, the rate of adoption of low-carbon travel options remains uneven across and within urban populations. This discrepancy can be attributed to a variety of factors, including socio-economic status, geographic location, access to infrastructure, and individual attitudes towards sustainability [8–10]. To effectively encourage a shift toward low-carbon travel, it is essential to understand these factors in specific demographic contexts. The city of Hangzhou provides a unique case study for examining low-carbon travel adoption. Known for its rich cultural heritage and rapid modernization, Hangzhou has been at the forefront of China's push towards sustainability. The city has implemented a range of initiatives aimed at promoting low-carbon transportation, including expanding public transit networks, developing bicycle-sharing programs, and incentivizing electric vehicle use. These efforts reflect a broader commitment to creating a sustainable urban environment that balances economic growth with environmental stewardship. Focusing on students and teachers as specific demographic groups within Hangzhou is particularly pertinent. Educational institutions are vital in shaping future generations' attitudes and behaviors regarding sustainability. Students often represent a more flexible and adaptable demographic, potentially more open to adopting new behaviors such as low-carbon travel. Teachers, on the other hand, not only make their own transportation choices but also influence the attitudes and behaviors of their students, making them key players in the promotion of sustainable practices.

This study aims to address the research gap by investigating the specific factors that influence the awareness, willingness, and actual behaviors related to low-carbon travel among students and faculty in Hangzhou's vocational colleges. The city of Hangzhou, known for its innovative approaches to sustainability, provides a unique context for examining these dynamics. The research seeks to identify the barriers and opportunities for enhancing the adoption of low-carbon travel within these two distinct demographic groups. By clearly articulating the research questions and hypotheses — such as how socio-economic, cultural, and infrastructural factors differently impact students and faculty — the study aims to contribute significantly to the literature on sustainable transportation. The findings will offer practical insights for policymakers, urban planners, and educational leaders in designing targeted, demographic-specific interventions that promote low-carbon travel. Furthermore, this research not only aligns with global sustainability goals but also addresses the specific local needs of Hangzhou's urban development. By focusing on the comparative analysis between students and teachers, the study highlights both unique and shared factors influencing each group, providing a nuanced understanding of how different segments of the population engage with low-carbon travel options and illustrating how these insights can inform scalable and adaptable localized interventions.

Literature Review

The Theory of Planned Behavior (TPB), developed by Ajzen, posits that an individual's behavior is determined by their intention, which in turn is influenced by their attitudes towards the behavior, subjective norms, and perceived behavioral control [11]. This framework is particularly relevant in exploring the environmental behaviors of different demographic groups, as it highlights how individual perceptions and social pressures shape environmental decision-making. Environmental awareness and behaviors significantly vary across different demographic backgrounds, reflecting a complex interplay of cultural, educational, and economic factors. Research has shown that demographic variables can influence the cognitive awareness of environmental issues and the willingness to engage in environmentally friendly practices. For instance, studies like those by Chao and Yang [12] have investigated such variations among farmers in Xinjiang, revealing that willingness and actual behaviors towards sustainable practices like agricultural insurance are heavily influenced by specific local conditions and personal circumstances. This finding directly informs our hypotheses by highlighting the importance of context-specific factors in shaping environmental behaviors. In our study, we hypothesize that similar localized factors — such as socio-economic conditions, cultural norms, and infrastructural availability — will play a crucial role in influencing the awareness, willingness, and actual

behaviors related to low-carbon travel among students and faculty in Hangzhou.

Similarly, Yu and Hu [13] explored cognitive awareness and behaviors toward clean production on pig farms in Shandong Province through a structural equation model. Their findings highlight how farm scale affects the relationship between awareness and behavior, suggesting that demographic factors such as the size and type of farming operations can influence environmental behaviors. This study emphasizes the need for tailored strategies that consider demographic specifics to effectively promote sustainable practices. In another study, Kuang et al. [14] used an enhanced regression tree model to analyze differences in ecological environment cognition and protection behavior among households in Jiangxi Province. The research indicated that while there might be a high level of environmental awareness, this does not necessarily translate into protective behavior, pointing to a gap that often exists between knowledge and action.

These examples underscore the importance of understanding demographic differences in environmental awareness and behavior. Such understanding is crucial for designing effective interventions that are sensitive to the specific needs and characteristics of different groups. This approach is particularly relevant in the context of low-carbon travel, where demographic characteristics can greatly influence the adoption of sustainable transportation methods [15–18]. Despite the growing body of research on low-carbon travel, particularly in the early 21st century when China began to intensify its focus on sustainable transportation strategies [19, 20], there remains a gap in the literature concerning the specific influences of demographic factors on low-carbon travel behavior. Most existing studies have tended to focus more broadly on urban populations without dissecting the subtleties that different groups exhibit. This paper aims to delve deeper into these demographic nuances by conducting a quantitative analysis of survey data from students and faculties in colleges, examining their cognitive levels, willingness, and actual behaviors toward low-carbon travel. By focusing on these specific groups, the study seeks to provide insights that could guide more targeted and effective policymaking in the field of sustainable transportation [21].

Experimental

Formulation of Research Hypotheses

The foundation of our methodology is built upon clearly defined hypotheses that guide the analysis of survey responses to uncover the nuanced dynamics of low-carbon travel behavior among different demographic groups. Our hypotheses are rooted in the Theory of Planned Behavior, which posits that an individual's behavior is influenced by their intentions, which in turn are shaped by attitudes, subjective norms, and perceived behavioral control. The primary hypotheses for our study are:

Hypothesis 1 (H1): There will be significant differences in the awareness of low-carbon travel between students and faculties, influenced by distinct factors unique to each group. This hypothesis is based on the premise that the professional and educational experiences of these groups shape their environmental cognizance differently.

Hypothesis 2 (H2): The willingness to adopt low-carbon travel practices will vary between students and faculties, with distinct influences shaping each group's willingness. This reflects an assumption that personal and professional responsibilities may impact the perceived feasibility and desirability of low-carbon travel options.

Hypothesis 3 (H3): The actual behaviors related to low-carbon travel will show a discrepancy from stated willingness among both students and faculties, indicating a gap between intention and action. This hypothesis addresses the common phenomenon where positive attitudes towards environmentally friendly practices do not always translate into consistent behaviors.

Questionnaire Distribution and Collection

The survey was conducted over September and October 2023, with 400 questionnaires distributed to students and faculty members at five vocational colleges in Hangzhou. These educational institutions were specifically selected, rather than commercial districts, to target distinct demographic groups — students and faculty — whose perspectives are crucial for understanding low-carbon travel behaviors. The choice of vocational colleges was strategic, as these institutions represent environments where future professionals are being trained, individuals who are likely to influence or directly participate in sectors such as urban planning and sustainability. By focusing on this demographic, the study aims to capture insights into how these future professionals perceive and engage with low-carbon travel options, providing valuable data that can inform policies and practices as they transition into the workforce. The controlled educational setting allowed for the collection of data from respondents with relatively homogeneous educational backgrounds but potentially diverse attitudes toward sustainability. Face-to-face interviews were conducted to enhance engagement and ensure a comprehensive understanding of respondents' perspectives, resulting in the collection of 385 valid questionnaires with a high response rate of 96.25%.

Statistical Characteristics of the Respondent Groups

Based on the statistical analysis of the 385 valid questionnaires, respondents were divided into two different groups: student and faculty groups. The rationale behind this division is that we consider factors such as the potential influence of education on awareness and attitudes towards low-carbon travel and the contrasting lifestyle patterns between students and faculties. The first group consists of students, including those aged 17 and above, with over 75% being university students, totaling 210 respondents. The second group comprises college faculty members such

Table 1. Statistical Characteristics of the Awareness and Willingness toward the Low-Carbon Concept among Vocational College Teachers and Students.

Category	Awareness and Willingness	Student Group		Faculty Group	
		Individuals	Percentage	Individuals	Percentage
Low-carbon Environmental Awareness	Familiar	171	81.40%	83	47.62%
	Moderate	34	16.28%	35	20.24%
	Unfamiliar	5	2.33%	56	32.14%
Understanding of CO_2	Understanding	95	45.12%	79	44.94%
	Moderate	59	28.05%	52	29.55%
	Unaware	56	26.83%	45	25.51%
Awareness of Summit	Understanding	100	47.77%	58	33.33%
	Moderate	50	23.89%	78	44.44%
	Unaware	60	28.34%	39	22.22%
Opinion on Low-carbon Travel	Support	16	7.41%	54	30.58%
	Neutral	128	61.11%	88	50.00%
	Oppose	66	31.48%	34	19.42%
Understanding of Low-carbon Travel	Understanding	53	25.00%	26	14.78%
	Moderate	131	62.50%	110	63.00%
	Unaware	26	12.50%	39	22.22%
Interest in Low-carbon Travel	Interested	62	29.73%	49	28.13%
	Moderate	68	32.43%	55	31.25%
	Not Interested	79	37.84%	71	40.63%
Opinion on Local City's Low-carbon Travel Development	Support	84	40.20%	69	39.60%
	Neutral	63	29.90%	61	34.65%
	Oppose	63	29.90%	45	25.74%
Willingness to Practice	Willing	180	85.71%	170	97.14%
	Unwilling	30	14.29%	5	2.86%
Observations		210	100%	175	100%

as lecturers, associate professors, and professors, with over 65% representing this category and a total of 175 respondents. The statistical characteristics of the two groups regarding their awareness and willingness towards the low-carbon concept are detailed in Table 1.

After conducting a comparative analysis of the two groups in Table 1, we can draw the following conclusions: Firstly, among the student group, there is little difference in the awareness of the low-carbon concept, attitudes toward developing low-carbon travel, and willingness to practice low-carbon travel; these aspects are generally consistent. Secondly, in both groups of respondents, over 50% of individuals have an awareness level categorized as "understanding" or "familiar," while approximately 20% of respondents have a level of "somewhat understanding" or "basically unaware." However, in terms of developing low-carbon travel, especially in the attitudes toward and willingness to practice low-carbon travel in Hangzhou, both groups show high levels of support and willingness, with proportions ranging between 80% and 95%.

Looking at the aforementioned awareness, support, and willingness proportions, there may be some contradictions. This contradiction can be explained as follows: Firstly, although there are not many people with a comprehensive understanding of low-carbon or low-carbon travel, more than half of the people are aware that this is a meaningful thing. Even those who do not know much about it have some knowledge from national policies or promotional reports, understanding it as an advocated positive behavior. Therefore, on a moral

Table 2. Definition of Relevant Variables.

Variable	Definition
Gender	1=Male; 0=Female
Age	1=Below 18 years old; 2=19–34 years old; 3=35–60 years old; 4=60 years old and above
Education Level	1=High school; 2=College; 3=Bachelor's degree; 4=Graduate degree
Awareness of Low-carbon	1=Very familiar; 2=Somewhat familiar; 3=Not familiar
Understanding of CO_2	1=Very understanding; 2=Somewhat understanding; 3=Not understanding
Awareness of Low-carbon Travel	1=Very aware; 2=Somewhat aware; 3=Not aware
Choice of Travel Mode - High-speed Rail	1=Choose high-speed rail; 0=Do not choose high-speed rail
Choice of Travel Mode - Airplane	1=Choose airplane; 0=Do not choose airplane
Attitude towards Low-carbon Travel Development	1=Agree; 2=Neutral; 3=Disagree
Interest in Low-carbon Travel	1=Interested; 2=Somewhat interested; 3=Not interested
Opinion on Local City's Low-carbon Travel Development	1=Agree; 2=Neutral; 3=Disagree
Willingness to Practice	1=Yes; 0=No

level, the majority express support and willingness. Secondly, it may be due to the psychological phenomenon of conformity. Despite a lack of substantial knowledge, most people still recognize it as a positive behavior, and it is predicted that there will be more supporters. Therefore, expressing support or willingness is not seen as a bad thing. Moreover, this can also indicate an individual's noble qualities without being excluded from supporters; finally, the degree of cognitive understanding does not necessarily equate to the degree of support or willingness. This depends on whether the matter is related to the individual's personal interests. If it is less relevant, the proportion expressing approval is usually higher than the proportion expressing opposition.

Results and Discussion

Definition of Relevant Variables

Based on the questionnaire data from the respondents, we intend to construct a logistic function model to analyze the factors influencing awareness and willingness for low-carbon travel. The logistic function model performs well in predicting the probability of the dependent variable occurring for binary or multicategory qualitative variables or numerical variables, making it suitable for explaining the research hypotheses in this study [22]. According to the expression of the logistic function model and the aforementioned research hypotheses, we define all variables. Given the limited space, we will provide definitions only for variables with significant correlations, as specified in Table 2.

Factors Influencing Low-Carbon Travel Awareness

The probability of students and professionals understanding low-carbon travel was taken as the dependent variable in the logistic function model [23]. Personal attribute characteristics, awareness of low-carbon environmental protection, awareness of CO_2, understanding of the "Copenhagen Climate Summit," attitude towards developing low-carbon travel, interest in low-carbon travel, and daily low-carbon behaviors were taken as independent variables. The data were then analyzed using stepwise forward (Wald) regression calculation with SPSS 18.0 statistical software. The results in Table 3 show that there are both common and different factors influencing the awareness of low-carbon travel for student and professional groups. This validates some hypotheses in Hypothesis 2 and Hypothesis 3 while rejecting the hypothesis related to personal attribute characteristics. Common factors include: The awareness of both groups is significantly negatively correlated with an understanding of low-carbon meaning and CO_2 issues. This implies that students and professionals who are not familiar with low-carbon concepts and CO_2 issues also lack awareness of low-carbon travel.

Different factors include: Firstly, the awareness level of students is significantly positively correlated with choosing to carpool, indicating that those who choose to carpool have a higher awareness of low-carbon travel than those who do not. Secondly, the awareness level of students is significantly positively correlated with the attitude towards developing low-carbon travel. In other words, those who hold a favorable attitude have a higher awareness level

Table 3. Presents the regression results of the function models for the awareness level of low-carbon travel in different groups.

Factors	Student Group (1)		Faculty Group (2)	
	Coefficient	Sig	Coefficient	Sig
Awareness of Low-carbon	-1.752	0.000***	-2.124	0.000***
Understanding of CO_2	-0.852	0.001***	-0.753	0.021**
Choice of Travel Mode - High-speed Rail	1.310	0.017**		
Attitude towards Low-carbon Travel Development	-0.985	0.003***		
Interest in Low-carbon Travel			-0.796	0.009***
Constant	4.921	0.000***	7.198	0.001***
-2Log LIKE	276.381		259.165	
Cox&Snell R^2	0.274		0.323	
H&L test	0.336		0.681	

Note: ***,**,* represent significance levels at 0.001, 0.01, and 0.05, respectively.

than those who do not support it. Thirdly, the awareness level of professionals is significantly negatively correlated with the level of interest in low-carbon travel. This implies that professionals interested in low-carbon tourism have a higher awareness level than those who are not interested. This result indicates that there are differences in the factors influencing the awareness of low-carbon travel for student and professional groups. Based on the regression results, the probability models for awareness are as follows:

$$Y(x_i) = Logit(x_i) = 4.921 - 1.752x_1 - 0.852x_2 + 1.310x_3 - 0.985x_4 \quad (1)$$

$$Y(x_z) = Logit(x_z) = 7.198 - 2.124z_1 - 0.753z_2 - 0.796z_3 \quad (2)$$

Factors Influencing the Willingness for Low-Carbon Travel

The willingness for low-carbon travel is taken as the dependent variable, and other relevant variables are considered independent variables to establish a logistic function model [20]. The SPSS 18.0 statistical software was used to conduct stepwise forward (Wald) regression calculations and the regression results are presented in Table 4. Table 4 indicates significant differences in the factors influencing the willingness for low-carbon travel between the student group and the professional group. These differences not only exist quantitatively but also involve entirely different influencing factors [24]. For the student group, the willingness for low-carbon travel shows a significant negative correlation with age. This implies that older students are more willing to practice low-carbon tourism, while younger students may be less inclined. Additionally, the willingness is significantly positively correlated with choosing high-speed trains and airplanes as modes of travel. In other words, students who choose these two modes of travel are more willing to engage in low-carbon travel. There is also a significant negative correlation with whether they support the development of low-carbon travel and whether they are interested in low-carbon travel. Students who support the development and express interest in low-carbon travel are more willing to practice it, and vice versa. For the professional group, the willingness for low-carbon travel is significantly positively correlated with gender and educational level. This indicates that males are more willing to engage in low-carbon travel, and respondents with higher levels of education are more inclined toward low-carbon travel. Additionally, there is a significant positive correlation with the level of understanding of low-carbon travel. As the understanding level increases, the willingness for low-carbon travel also strengthens. However, there is a significant negative correlation with the attitude toward supporting the development of low-carbon travel in Hangzhou. Professionals who hold a favorable attitude are more willing to practice low-carbon travel, while those with an unfavorable attitude may be less inclined. It is noteworthy that during the regression calculation, removing the constant term for the professional group resulted in an increase in influencing factors, and the Cox & Snell R increased to 0.576. Therefore, the final decision was to exclude the constant term from the function regression model. In this way, the probability models for the willingness for low-carbon travel for the student group and the professional group are, respectively:

$$Y(x_i) = Logit(x_i) = 7529 - 1.961T_1 + 2385T_2 + 1.732T_3 - 1.452T_4 - 1.285T_5 \quad (3)$$

Table 4. Regression Results of Function Models for Different Groups on the Level of Low-Carbon Travel Awareness.

Factors	Student Group (1)		Faculty Group (2)	
	Coefficient	Sig	Coefficient	Sig
Gender			1.215	0.028**
Age	-1.961	0.001***		
Education Level			0.821	0.001***
Attitude towards Low-carbon Travel Development			0.887	0.022**
High-speed Rail	2.385	0.000***		
Airplane	1.732	0.011**		
Attitude towards Low-carbon Travel Development	-1.452	0.021**		
Interest in Low-carbon Travel	-1.285	0.002***		
Attitude towards Local Development of Low-carbon Travel			-2.191	0.003***
Constant	7.529	0.000***		
-2Log LIKE	124.575		1487.54	
Cox&Snell R^2	0.201		0.583	
H&L test	0.515		0.211	

Note: ***,**,* represent significance levels at 0.001, 0.01, and 0.05, respectively.

$$Y(x_z) = Logit(x_z) = 1.215K_1 + 0.821K_2 + 0.887K_3 - 2.191K_3 \quad (4)$$

In Equation (3), $Y(x_i)$ represents the probability of the student group being aware of low-carbon travel. T_1 represents the age variable, T_2 is the variable for the mode of travel "train," T_3 represents the mode of travel "airplane," T_4 represents the attitude variable towards the development of low-carbon travel, T_5 and represents the interest in low-carbon travel.

In Equation (4), $Y(x_z)$ represents the probability of the professional group being willing to practice low-carbon travel. K_1 is the gender variable, K_2 represents the variable for the level of education, and K_3 represents the variable for the degree of understanding of low-carbon travel.

After conducting the Chi-square Hosmer and Lemeshow test, the Sig values (P-values) for Equation (3) and Equation (4) in the logistic regression models are 0.515 and 0.211, respectively. These values are greater than 0.1 and greater than 0.05. Therefore, it can be observed that the goodness of fit for these two regression models is relatively good, indicating their ability to explain the relationship between the dependent and independent variables.

Conclusions

The study identifies four significant factors influencing the awareness of low-carbon travel among students, including understanding low-carbon concepts, awareness of CO_2 issues, the choice of carpooling as a travel option, and attitudes toward the development of low-carbon travel. For the professional group, three factors were identified: understanding low-carbon concepts, awareness of CO_2 issues, and interest in low-carbon travel. While there are distinct differences in the factors affecting awareness between these two groups, commonalities also exist, suggesting that certain educational and environmental themes resonate broadly across demographics. In terms of willingness to adopt low-carbon travel, the influencing factors differ significantly between students and professionals. For students, age, preference for train and airplane travel, attitudes toward the development of low-carbon travel, and interest in low-carbon travel are significant predictors. Among professionals, gender, educational level, understanding of low-carbon travel, and attitudes toward local low-carbon development are the key factors. Notably, there are no shared influencing factors between these two groups, highlighting the need for targeted interventions tailored to the specific characteristics of each demographic.

Despite the high levels of awareness (around 60%) and willingness (nearly 90%) to engage in low-carbon travel, a notable gap exists between expressed willingness and actual behavior. This gap underscores the complexity of translating positive attitudes into consistent low-carbon practices. It suggests that while awareness and willingness are essential precursors to behavior, they alone are insufficient to drive change. To effectively promote

low-carbon behaviors and establish sustainable habits, it is crucial to implement supportive policies and institutional frameworks that encourage and reinforce these behaviors. Additionally, fostering a cultural shift towards habitual low-carbon practices will be essential for achieving long-term sustainability goals.

However, this study has some limitations. It primarily focuses on quantitative analysis, which, while robust, may not fully capture the nuanced motivations and barriers that individuals face in adopting low-carbon travel. The study also does not explore the deeper psychological and socio-cultural mechanisms that might explain the observed differences between student and professional groups [25]. Future research could address these gaps by incorporating qualitative methods, such as interviews or focus groups, to gain deeper insights into the motivations behind low-carbon travel behaviors [26–28]. Moreover, longitudinal studies would be valuable in assessing how awareness, willingness, and behaviors evolve over time, particularly in response to changing policies or environmental conditions. Such research could help identify the long-term impacts of targeted interventions and provide a more comprehensive understanding of how to close the gap between willingness and actual behavior. Exploring the role of external factors, such as infrastructure developments and economic incentives, in shaping low-carbon travel choices could also offer new directions for enhancing the effectiveness of sustainability initiatives. In conclusion, while this study provides valuable insights into the factors influencing low-carbon travel awareness and willingness, there is a clear need for further research to explore the underlying mechanisms and to develop more effective strategies for promoting sustainable travel behaviors across different demographic groups.

Acknowledgements

We appreciate the contributions of the reviewers and editors. Professor Lichen Chou extends thanks to Jing Su, the research assistant for this project, for her diligent efforts in data collection.

Conflict of Interest

The authors declare no conflict of interest.

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