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Exploring waste sorting behavior and its antecedents among university students in the UAE using an extended theory of planned behavior

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A B S T R A C T

This study quantitatively examines waste sorting behavior (WSB) and its antecedents among university students in the United Arab Emirates (UAE), a Middle Eastern Gulf country. Using an extended version of the Theory of Planned Behavior, this research investigates the impacts of attitudes, subjective norms and perceived behavioral control on waste sorting intention (WSI), and the impacts of WSI, personal norms, perceived knowledge, trust in the waste management process and convenient infrastructure on WSB. We collected data using a self-administered research questionnaire on a sample of 353 students and used partial least squares structural equation modelling (PLS-SEM) to analyse the data.

The results revealed that attitudes ($\beta = 0.433$, $p < 0.001$), subjective norms ($\beta = 0.163$, $p = 0.002$) and perceived behavioral control ($\beta = 0.137$, $p = 0.017$) significantly positively impacted students' WSI. Moreover, WSI ($\beta = 0.444$, $p < 0.001$), perceived behavioral control ($\beta = 0.153$, $p = 0.001$), perceived knowledge ($\beta = 0.144$, $p = 0.003$) and personal norms ($\beta = 0.182$, $p < 0.001$) significantly positively impacted students' WSB. However, trust in the local waste management system and convenient infrastructure were not significant variables for predicting students' WSB. The R-squared values for WSI and WSB are 0.376 and 0.527, respectively. Practical implications of this study include actionable recommendations for policymakers and educational institutions aimed at enhancing sustainable waste sorting practices.

1. Introduction

Waste sorting behavior (WSB), also called waste separation or waste segregation, is the act of sorting discarded waste into categories to enable recycling and composting (Zhang, 2023). WSB is essential for promoting sustainable waste management, reducing resource depletion and shifting towards a circular economy (Hu et al., 2021). Effective waste sorting (WS) can significantly enhance recycling rates, reduce the volume of waste sent to landfills (Xu et al., 2017) and mitigate environmental impacts (Xiao et al., 2018; Rathore and Sarmah, 2021).

Municipal solid waste generation is predicted to grow from 2.1 billion tonnes in 2023–3.8 billion tonnes by 2050 (United Nations Environment Programme, 2024), underscoring the urgency of adopting comprehensive WS practices. In the UAE, the anticipated growth in waste generation, alongside the country's ambitious sustainability targets, necessitates a thorough understanding of the factors influencing WSB, particularly in the urban areas where waste generation is most prevalent (Abu Jadayil et al., 2022).

We have identified several research gaps related to WSB. First, there is a lack of research on students' WSB and its antecedents. University students, as future leaders and influencers of environmental practices, play a pivotal role in the adoption of sustainable behaviors (Sogari et al., 2017). Investigating their WSBs can provide valuable insights for developing targeted interventions that foster sustainable practices within this demographic Second, WSB has been well researched in Europe (e.g. Stoeva and Alriksson, 2017), Asia (e.g. Loan et al., 2017) and the USA (Kaplowitz et al., 2009), but there remains a significant gap in understanding WSB in the Middle-East North African (MENA) region including the Arabian Gulf countries (Abu Jadayil et al., 2022; Soomro et al., 2022, Nawaz et al., 2025). Third, there is a lack of empirical research on WSB's antecedents (Zhang, 2023).

This study quantitatively examines WSB and its antecedents among university students in the understudied context of the UAE. Our research questions are the following: 1) to what extent do students intend to

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engage in, and actually engage in, WSB? 2) What are the factors that have a significant influence on students' WSB, and which are the most important? Using an extended version of the Theory of Planned Behavior (TPB), we investigate whether attitudes, subjective norms, perceived behavioral control, personal norms, knowledge, trust and convenient infrastructure influence students' WS intentions and behaviors. We used a quantitative approach; data was collected using self-administered questionnaires, and analysed using partial least squares structural equation modelling (PLS-SEM).

The findings of this study offer valuable contributions to the field of environmental and waste management (WM). Insights from this research inform policymakers and university administrators on effective strategies for enhancing WSB. By tailoring educational programs and policy interventions to align with the identified determinants of WSB, stakeholders can foster a culture of sustainability that supports broader environmental objectives.

2. Literature review

2.1. Waste management in the UAE

The United Arab Emirates (UAE) is a federation of seven emirates located on the eastern end of the Arabian Peninsula. It's a constitutional monarchy with a rich history, now known for its modern infrastructure, thriving economy, and prominent role as a global hub for trade and tourism. The UAE is the most competitive economy in the Middle East according to the 2022 Competitiveness Report by the International Institute for Management Development (Bertelsmann Stiftung, 2024). Due to high consumption rates, rapid urbanization and rapid economic expansion, the UAE has one of the highest per capita waste generation rates in the world (Al-Dabbagh, 2021). However, the country wants to become a leader in sustainability in the MENA region through reshaping its vision, strategic objectives and policies (Smida and Waxin, 2026). With its "UAE Centennial Strategy 2071", the UAE plans to become a global leader in sustainability by its centennial anniversary (UAE TDRA, 2023). Moreover, the UAE "Net Zero Mission 2050 Strategy" is a plan to make the UAE net zero in terms of carbon emissions by the year 2050 (MOCCAE, 2022). This includes changes in more than 25 programmes across 6 key sectors, one of which is WM. The "UAE Environmental Policy" comprises eight pillars including integrated WM, and the WM targets include treating 75 % solid waste by 2025 and 85 % by 2035, and reducing waste generation to 1.2 kg per person per day by 2035 (MOCCAE, 2022). The governments of individual emirates are responsible for the delivery of municipal services related to WM, in alignment with national strategies and policies. Each emirate developed plans to increase its recycling efforts in order to divert waste from landfills, aligning with the UAE's goal. For example, the objective of the Emirate of Sharjah is to achieve total landfill waste diversion and net-zero emissions by 2040, in line with national strategies. Recyclables in the UAE account for around 51 % of the municipal solid waste generated, including 25 % paper, 19 % plastic, 4 % glass, and 3 % metal (Abdallah et al., 2019; Elfeky et al. 2021). In the UAE, residents are encouraged to separate their waste into at least two categories: general waste, in one bin, and recyclables (plastic, paper, cardboard, and glass) in the other bin. Some communities also have "recycling centres", designed to collect up to 10 different types of waste. UAE residents' effective WS would facilitate the attainment of the "Net Zero Mission 2050 Strategy".

2.2. Theoretical framework: the key antecedents of WSB

The Theory of Planned Behavior (TPB), formulated by Ajzen (1985), is an important model that has been used to predict and explain a wide range of behaviors, including pro-environmental behaviors like recycling or WS (Zhang et al., 2021; Goh et al., 2022; Zhang, 2023). The extended version of our TPB model includes personal norms, trust in the WM system, existence of convenient infrastructure and perceived knowledge towards WS. Below we present the key variables in our research model.

Attitude Towards WS (ATT). Attitude is a psychological construct representing an individual's positive or negative evaluation of a specific behavior (Ajzen, 1985). Positive attitude towards WS is one of the most important antecedents of WSI (Zhang et al., 2021; Zhang, 2023). There is a lack of research on attitudes towards WSB in the Arab world, however.

H1. Students' positive attitude towards WS has a positive influence on WSI.

Perceived Behavioral Control (PBC) explains that individuals are driven by the perceived difficulty or ease of engaging in a particular behavior (Ajzen, 1985). PBC relates to an individual's confidence in their ability to sort waste correctly and access recycling facilities. Several researchers have found that PBC significantly influences WSI (Wan et al., 2017; Hu et al., 2021; Zhang et al. 2021; Soomro et al., 2022), whereas others did not find a significant relationship between PBC and intentions (Kumar, 2019; Coşkun, Özbük, 2020).

H2a. Students' PBC has a positive influence on WSI.

PBC positively influences behavior by enhancing individuals' confidence in their ability to perform tasks (Ho et al., 2022). The study of Terry, O'Leary (1995) evaluated the utility of the theory of planned behavior by employing distinct measures of perceived behavioral control components. These components encompass beliefs related to behavior controllability and efficacy expectancies. Interestingly, the analysis revealed a notable and positive predictor of the actual behavior undertaken. Perceived behavioral control enhances prediction of behavior and this enhancement in prediction supports Ajzen's theory of planned behavior over the traditional theory of reasoned action (Madden et al., 1992). Moreover, Goh et al. (2022) found PBC to be the most influential variable for WSB.

H2b. Students' PBC has a positive influence on WSB.

Subjective Norms (SN) are perceived constraints and pressures from society that influence individuals' decisions on whether to engage in a planned behavior (Fishbein and Ajzen, 1975). In the context of WS, SN encompasses the influence of peers, family and societal expectations on an individual's behavior. Empirical evidence on the role of SN in predicting WSI is mixed. While some studies (Tonglet et al. 2004; Wang et al., 2020; Soomro et al., 2022) found SN to be a significant predictor of WSI, other research reported non-significant results (Knussen et al., 2004; Aguilar-Luzón et al. 2012). Stoeva and Alriksson (2017) found that SN significantly influenced university students' WSI in Sweden, but had a lesser impact in Bulgaria, highlighting the fact that results can vary between different cultures. In collectivist cultures like the UAE, where social approval and conformity are highly valued, subjective norms may play a more prominent role in shaping WSI. Further research is needed to understand the effectiveness of SN in promoting WSI in diverse cultural and social settings.

H3. SN has a positive influence on WSI

Waste Sorting Intention (WSI). Behavioral intention is an individual's readiness to perform a specific behavior (Ajzen, 1985). In our research, it reflects the individual's willingness or readiness to engage in WSB. According to the TPB, behavioral intention is the most immediate predictor of behavior. Numerous studies emphasize the importance of WSI as a predictor of WSB (Klöckner, Oppedal, 2011; Fan et al., 2019; Pivetti et al., 2020; Govindan et al., 2022; Soomro et al., 2022). However, several studies have noted that WSI did not necessarily lead to WSB (Davies et al., 2002; Wang et al., 2020), often attributed to barriers such as limited access to sorting facilities, lack of time, or inadequate knowledge (e.g. Miliute-Plepiene et al., 2016).

H4. Students' WSI has a positive influence on WSB.

Personal Norms (PN) represent an individual's internalized sense of duty to perform environmentally-friendly behaviors like WS. Research by Goh et al. (2022) highlights the importance of PN in motivating pro-environmental behaviors, particularly when external motivators are weak. PN are strongly linked to individuals' values and their understanding of environmental issues, and they are important predictors of WSB (Klöckner, Oppedal, 2011; Fan et al., 2019; Wang et al., 2019). In contexts where recycling infrastructure is underdeveloped, PN often acts as a primary factor of WSB (Nguyen and Watanabe, 2019). Razali et al. (2020) found moral norms as the most significant variable predicting WS in Malaysia.

H5. Students' PN have a positive influence on WSB.

Perceived Knowledge about WS (PKWS). Knowledge in the context of WS behavior refers to individuals' understanding of the consequences of their actions and their specific knowledge of recycling practices and environmental issues (Zhang, 2023). Many studies have highlighted the importance of knowledge in predicting WSB (Kuang and Lin, 2021; Zhang et al., 2021). Specific knowledge about WS or recycling has been found to influence behavior directly and through mediators such as attitude and intention (Pivetti et al., 2020). Bhawal Mukherji et al. (2016) found that increased knowledge led to an increased willingness to participate in WSB, but also observed low levels of participation, indicating a gap between knowledge and practice. While knowledge is recognized as important, it is not always the most influential factor in predicting WSB.

H6. Students' PKWS has a positive influence on WSB.

Trust in Local WM System (DIST). Trust in authorities has been identified as a factor that increases individuals' willingness to contribute to society (De Cremer et al., 2001). However, empirical results on the impact of trust on WSB are inconsistent. Chen et al. (2021) in China, and Loan et al. (2017) in Vietnam, found a positive relation between trust in WM systems and WSB, Pivetti et al. (2020) in Italy, found that trust was a weak predictor of WSB. There is a lack of research on the effect of trust on WSB in the Arab counties. *H7: Students' mistrust in authorities and the WM system negatively impact engagement in WSB.*

Convenient Infrastructure (INFRA) encompasses the availability of recycling infrastructure and its ease of use (Miliute-Plepiene et al., 2016). Several studies have emphasized the importance of convenience in WS practices, including convenient access to recycling bins and clear signage (Miliute-Plepiene et al., 2016; Kuang and Lin, 2021; Zhang et al., 2021). In a systematic literature review, Zhang (2023) concluded that convenience, in terms of time, physical distance to recycling facilities and ease of use, facilitates individual WSB. The UAE has heavily invested in integrated and smart waste management systems, including waste collection and treatment infrastructures (Smida and Waxin, 2026). ***H8:*** *Convenient infrastructure has a positive influence on WSB.*

3. Research methods

3.1. Data collection

We used a self-administered questionnaire, which was digitized using Google Forms for online data collection. Three Professors of Management, HRM and Biology from the same university in the UAE collected data in their classes between Fall 2024 and Spring 2025. Collecting data in class ensured a high response rate (98 %) and also minimized potential biases associated with self-selection, which are often encountered in online-only surveys. Our samples include 353 university students from different academic disciplines. This study was approved by the Institutional Review Board (IRB) in Fall 2024. We adhered to strict ethical guidelines to ensure the confidentiality, anonymity and voluntary participation of respondents.

3.2. Variables measurement

Sociodemographic factors included age, gender, nationality, field of study, level of study, emirate of residence, type of residence and income category. The key variables in this study were measured using well-established scales from previously published research and adapted to the context of WSB among university students in the UAE.

The quantitative variables in the study were assessed on a 5-point Likert scale, ensuring a structured evaluation process. The scale ranged from 1 to 5, where respondents could indicate their agreement levels (1 = Completely Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Completely Agree). A modified frequency scale based on Fan et al. (2019) was also employed, specifically tailored for measuring WSB. This frequency scale allowed participants to designate the frequency of their WSB on a spectrum from 'Never' to 'Always" (1 =Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always).

To measure WSI, we used Fan et al. (2019)'s measures (4 items). Attitude towards WS (ATT), was measured using Goh et al. (2022)'s 4 items, PBC (3 items) and SN (2 items) were measured by adapting Nguyen and Watanabe (2019)'s measures; PN were measured by adopting the 3 items of Wang et al., (2019). To measure PKWS, we adapted 4 items by Vassanadumrongdee and Kittipongvises (2018). Distrust was measured using the 2 items of Rathore and Sarmah, (2021), and finally, convenient infrastructure was measured by adapting Fan et al. (2019)'s 4 items.

3.3. Data analysis

We used the statistical software packages SPSS 24 and SMARTPLS4 to analyse our data. In predictive research models, Partial Least Squares (PLS) is commonly used for theory development, and it is appropriate for exploratory research (Hair et al., 2019). This study marks the first attempt to construct a theoretical model that examines the antecedents of WSI and WSB in the Arab Gulf.

4. Results

4.1. Demographic profile

The demographic information of the students we surveyed is in Table 1. Respondents were 62.3 % female and 37.7 % male. Most respondents were between 21 and 25 years old (59.8 %), 38.5 % were 16–20 and 1.7 % were above 26. Respondents had a diverse mix of nationalities: the largest groups were the United Arab Emirates (23.8 %) and India (13.6 %). Most students were at the undergraduate level (93.8 %), but we sampled some graduate students as well (6.2 %). Most students earned between 0 and 5000 AED per month (80.2 %), with fewer individuals in higher income ranges. 50.1 % of respondents lived in villas/houses, 31.4 % in flats and 18.4 % in dormitories. Most respondents resided in Sharjah (57.8 %) or Dubai (33.1 %), with smaller percentages in other emirates.

4.2. Common method bias

Podsakoff et al. (2003) and Podsakoff et al. (2024) identified common method bias as a potential concern in research studies using survey instruments to collect data, because data for both independent and dependent variables are often gathered from the same source, using the same measurement tools, at the same time in survey-based research. To assess the presence of common method bias, researchers often utilize Harman's Single-Factor Test (Harman, 1976). In this study, the test results indicated that a single factor accounted for only 32.1 % of the variance, falling below the acceptable threshold of 50 %. Therefore, it can be inferred that common method bias did not have a significant impact on the findings of this study.

Table 1
Profile of respondents.

Gender		N	Percentage
	Female	220	62.3
	Male	133	37.7
Age			
	16–20	136	38.5
	21–25	211	59.8
	> 26	6	1.7
Nationality			
	United Arab Emirates	84	23.8
	India	48	13.6
	Egypt	32	9.1
	Jordan	32	9.1
	Pakistan	27	7.6
	Palestine	27	7.6
	Lebanon	17	4.8
	Other	86	24.4
Level of Education			
	Undergraduate Student	331	93.8
	Graduate Student	22	6.2
Personal Monthly Income (AED)			
	0–5000 AED	283	80.2
	5001–10000 AED	44	12.5
	10001–15000 AED	13	3.7
	15001–20000 AED	8	2.3
	Above 20000 AED	5	1.4
Residence type			
	Villa/House	177	50.1
	Flat	111	31.4
	Dormitory	65	18.4
Emirate of Residence			
	Sharjah	204	57.8
	Dubai	117	33.1
	Ajman	13	3.7
	Abu Dhabi	12	3.4
	Umm Al-Quwain	3	0.8
	Fujairah	2	0.6
	Ras Al-Khaimah	2	0.6

Source: Primary data.

4.3. Measurement model

We examined the mean and standard deviation of each item within the variable, as illustrated in Table 2. This analysis allowed us to gain a deeper understanding of the variability and central tendency exhibited by the data, providing valuable insights for our research. Variance Inflation Factor (VIF) quantifies multicollinearity's impact on regression coefficients (Table 2). A VIF of 1 indicates no multicollinearity, while values above 5 or 10 suggest severe multicollinearity, inflating standard errors and complicating factor analysis interpretation (Kyriazos and Poga, 2023). All the items in Table 2 show no serious multicollinearity problems. Factor loadings were assessed for each item, and the results displayed in Table 2 indicated that all variable items had factor loadings greater than 0.70, except for two items – WSB6 and PERK3– which were excluded from further analysis.

During the measurement model analysis, we considered both internal reliability and validity, including convergent and discriminant validity. To evaluate the internal reliability of each variable, we used Composite Reliability (CR) and Cronbach's alpha. The values of CR and alpha exceeded the recommended threshold of 0.7, as suggested by Hair et al. (2019) (see Table 3), confirming the reliability of the data. Two constructs PBC and SN show an alpha value slightly less than 0.7, however CR value is above 0.7 and hence retained. Convergent validity was assessed through Average Variance Extracted (AVE) and all values (Table 3) for each variable surpassed the threshold of 0.5, as recommended by Henseler et al. (2016), demonstrating successful convergent validity among the variables.

This study applied the Fornell-Larcker criteria to evaluate the divergent validity of the items, aiming to determine the statistical distinction between two supposed different constructs. The square root values of the Average Variance Extracted (AVEs) (Table 4, in bold) exceeded the correlations between constructs. This finding confirms the presence of divergent validity as established by Fornell and Larcker (1981).

Additionally, the study utilized the Heterotrait-Monotrait Ratio (HTMT) criterion to assess discriminant validity. According to this criterion, the value for discriminant validity should be below 0.90 to demonstrate adequate discriminant validity. The analysis indicated the presence of discriminant validity between the reflective constructs (see values in brackets), as depicted in Table 4 (Hair and Alamer, 2022).

4.4. Empirical results

The Pearson correlation matrix in Table 5 (in italics) reveals significant relationships between WSI, WSB, ATT, PBC, SN, PN, INFRA, DIST, and PKWS. Notably, WSI and WSB exhibit a strong positive correlation, indicating that WSI is a good predictor of WSB. Similarly, ATT, PBC, SN, and PN all show positive correlations with WSB, highlighting their importance in promoting WS. Infrastructure also positively correlates with most constructs, suggesting its supportive role. Conversely, DIST consistently displays negative correlations with all other constructs, implying that high distrust in the sorting processes of the local municipality hinders WS efforts. Overall, the matrix underscores the complex interplay of psychological, social, and infrastructural factors in influencing WSB.

We conducted an ANOVA test on the gender and nationality/regions of the respondents (See Appendix A). First, the analysis of WS factors reveals significant differences based on gender. Females exhibit higher mean scores than males across most constructs, including WSI, WSB, ATT, PBC, SN, PN, INFRA, and PKWS, suggesting a greater inclination and capacity for WS. Conversely, males reported higher mean scores for distrust. These findings highlight the importance of considering gender-specific approaches in designing effective WM strategies.

Second, national/regional variations also play a crucial role, with statistically significant differences observed across all constructs. Participants from the Emirates (Region 1) generally displayed the most favorable scores for WSB factors, while 'Arab nations excluding the Emirates' (Region 2) tended to have the lowest. The Indian Subcontinent region (Region 3) showed relatively high distrust scores, and the "Others" region (Region 4) exhibited higher WSI and WSB. These regional disparities underscore the need for tailored interventions that address the unique socio-cultural contexts and infrastructure challenges of each region to promote effective WS practices. However, when entered into the regressions, gender and nationalities/regions were not significant.

4.5. Results of hypotheses

The hypothesis testing results, as shown in Table 6, provide insights into the factors influencing WSI and WSB. The analysis reveals that attitude ($\beta = 0.433$, $p < 0.001$), SN ($\beta = 0.163$, $p = 0.002$) and PBC ($\beta = 0.137$, $p = 0.017$) all have a significant positive impact on WSI, thus supporting hypotheses H1, H2a, and H3.

Furthermore, WSI strongly and positively affects WSB ($\beta = 0.444$, $p < 0.001$), confirming hypothesis H4. PBC also positively influence WSB ($\beta = 0.153$, $p = 0.001$), supporting hypothesis H2b. PKWS ($\beta = 0.144$, $p = 0.003$) and PN ($\beta = 0.182$, $p < 0.001$) also demonstrate significant positive relationships with WSB, leading to the acceptance of H5 and H6.

However, the analysis indicates that not all hypothesized relationships are supported. Specifically, DIST ($\beta = -0.066$, $p = 0.106$) and INFRA ($\beta = -0.015$, p = 0.-748) did not have a significant impact on WSB, resulting in the rejection of hypotheses H7 and H8.

The R-squared values for WSI and WSB at 0.376 and 0.527 respectively (see Fig. 2) demonstrated that a substantial portion of the variability in WSIs and WSBs can be explained by the factors considered in

Table 2
Research items and quantitative measurements.

Construct	Item Code	Item	Mean	SD	Factor loading ($p < 0.05$)	VIF
WSI (Fan et al., 2019)	WSI1	I plan to sort out all the household waste at home.	2.83	1.125	0.879	2.572
	WSI2	I think I will do waste sorting soon.	2.93	1.113	0.889	2.877
	WSI3	I will sort all household waste more frequently.	2.87	1.118	0.910	3.381
	WSI4	I will sort all household waste in a more effective way.	3.09	1.123	0.895	2.572
WSB (Fan et al., 2019)	WSB1	I sort out plastic bottles at home.	2.54	1.363	0.814	3.128
	WSB2	I sort out other plastic waste at home.	2.21	1.181	0.838	3.181
	WSB3	I sort out newspapers, magazines and cardboard boxes at home.	2.41	1.365	0.809	2.013
	WSB4	I sort out metal waste (like beverage cans) at home.	2.15	1.299	0.833	2.257
	WSB5	I sort out kitchen garbage (wet garbage) at home.	2.46	1.507	0.720	2.034
	WSB6**	I sort out toxic substances (like batteries and bulbs) waste at home.	2.47	1.507	0.646	1.734
Attitude (Goh et al., 2022)	ATT1	Sorting household waste is useful.	3.93	1.069	0.798	1.936
	ATT2	It is necessary to carry out waste sorting at home.	3.71	1.017	0.855	2.296
	ATT3	I am interested in carrying out waste sorting at home.	3.27	1.198	0.881	2.447
	ATT4	I feel good about myself when I sort my household waste.	3.57	1.144	0.865	2.293
PBC (Nguyen and Watanabe, 2019)	PBC1	For me, sorting waste at home is easy to do with the three-bin system.	3.51	1.168	0.800	1.506
	PBC2	The three bins provided for household waste separation are sufficient for all my waste sorting.	3.34	1.169	0.757	1.428
	PBC3	Sorting my household waste does not take too much time.	2.93	1.107	0.795	1.236
SN (Nguyen and Watanabe, 2019)	SN1	Most people who are important to me think that I should recycle my household waste.	2.64	1.132	0.868	1.224
	SN2	Most people who are important to me would approve of me recycling my household waste.	3.64	1.052	0.820	1.224
PN (Wang et al., 2019)	PN1	I think I have the duty to sort the household waste.	3.21	1.179	0.852	1.522
	PN2	I think I have an obligation to protect the environment.	3.88	1.096	0.866	2.417
	PN3	I think I have an obligation to conserve resources.	3.82	0.969	0.861	2.445
INFRA (Fan et al., 2019)	INFRA1	The number of litter bins for recyclables is sufficient and no waste will be overfilled.	3.07	1.053	0.801	1.480
	INFRA 2	Recycling bins are well managed.	3.13	1.127	0.736	1.510
	INFRA 3	Recycling bins are well marked so that I know which one to use.	3.69	1.071	0.723	1.517
	INFRA 4	Guidance was available to me in waste sorting.	3.16	1.115	0.756	1.507
DIST (Rathore and Sarmah, 2021)	TWM1	Local authorities mix the collected waste.	3.08	1.102	0.910	2.073
	TWM2	Collected waste is ultimately sent to a landfill.	3.31	1.073	0.942	2.073
PKWS (Vassanadumrongdee and Kittipongvises, 2018)	PERK0	I know what household waste items can be sorted into the different bins.	3.53	1.148	0.705	1.365
	PERK1	I know how to do source separation	2.85	1.059	0.842	1.761
	PERK2	I have knowledge on source separation from my school/univ.	3.25	1.086	0.851	1.792
	PERK3**	I have received information on source separation from the local municipal office/authorities.	1.91	1.119	0.502	1.210

** excluded from further analysis.
Source: Primary data.

Table 3
Model measurement.

Construct	Mean	SD	Alpha	CR	AVE
WSI	2.93	1.12	0.916	0.940	0.940
WSB	2.37	1.37	0.870	0.902	0.608
Attitude	3.62	1.11	0.873	0.913	0.723
PBC	3.26	1.15	0.692	0.827	0.615
SN	3.14	1.09	0.599	0.832	0.713
PN	3.64	1.08	0.827	0.895	0.739
INFRA	3.26	1.09	0.752	0.841	0.569
DIST	3.19	1.09	0.837	0.924	0.858
PKWS	3.01	1.10	0.717	0.822	0.546

Source: Primary data.

the study. The relatively higher R-squared value for WSB compared to the WSI indicates the importance of including PN and PKWS variables in the model.

5. Discussion and conclusions

5.1. Discussion of results

This study analysed individual WSB and its antecedents among university students in the UAE, an Arab Gulf country, using an extended version of the TPB. The findings showed that ATT, PBC and SN significantly predict WSI on our UAE sample. WSI, PN and PKWS played a crucial role in predicting WSB. However, DIST and INFRA, as measured in this study, did not significantly influence this behavior.

University students are both impressionable and influential, and this research highlights the crucial role of educational institutions in promoting sustainable WM practices.

We found that females exhibited higher mean scores than males, and that UAE citizens had higher scores than other regional groups, across most constructs. However, gender and nationality were not found to be significant in the regressions. Our results on gender are interesting, because in Saudi Arabia, Soomro et al. (2022), found that males reported a stronger recycling intention and reselling behavior. Socio-demographic variables, usually including age, gender, income, education level and form of dwelling, are the most frequently studied variables (Miafodzyeva and Brandt, 2013) in recycling behavior studies, but there is no consensus on their importance. Ekere et al. (2009) found that gender was an important variable, but it was insignificant in other WSB studies (Hage et al. 2009; Miafodzyeva and Brandt, 2013). Miafodzyeva and Brandt (2013), in their review, concluded that socio-demographic variables were generally poor predictors of WSB, but that these variables were important for ensuring the representativeness of the sample.

Overall, the means on the WSI and WSB were low, 2.93 and 2.37, respectively. Females and UAE nationals scored higher on both WSI and WSB, but their averages for WSB are still lower than 3, indicating room for improvement. WS is not yet a generally practiced behavior in the UAE. WSB was below WSI, which is consistent with previous research

Table 4
Fornell-larcker criteria and HTMT ratio.

Constructs	WSI	WSB	ATT	PBC	SN	PN	INFRA	DIST	PKWS
WSI	**0.893**								
WSB	0.644	**0.780**							
	(0.715)								
ATT	0.569	0.596	**0.850**						
	(0.626)	(0.676)							
PBC	0.380	0.459	0.390	**0.784**					
	(0.470)	(0.574)	(0.487)						
SN	0.462	0.535	0.546	0.459	**0.844**				
	(0.620)	(0.734)	(0.755)	(0.707)					
PN	0.412	0.508	0.597	0.386	0.505	**0.860**			
	(0.458)	(0.581)	(0.682)	(0.490)	(0.712)				
INFRA	0.329	0.369	0.423	0.445	0.421	0.432	**0.755**		
	(0.381)	(0.440)	(0.507)	(0.598)	(0.619)	(0.547)			
DIST	−0.206	−0.216	−0.244	−0.084	−0.124	−0.111	−0.225	**0.926**	
	(0.234)	(0.243)	(0.288)	(0.112)	(0.201)	(0.134)	(0.296)		
PKWS	0.409	0.505	0.499	0.485	0.474	0.473	0.503	−0.255	**0.739**
	(0.490)	(0.614)	(0.593)	(0.696)	(0.715)	(0.585)	(0.698)	(0.310)	

Source: Primary data.

Table 5
Correlation between the constructs.

Constructs	WSB	ATT	PBC	SN	PN	INFRA	DIST	PKWS
WSI	.641**	.565**	.372*	.460**	.405**	.316**	−.204**	.405**
WSB		.586**	.444**	.522**	.486**	.347**	−.217**	.490**
ATT			.376**	.546**	.588**	.410**	−.245**	.505**
PBC				.452**	.369**	.427**	−0.07	.485**
SN					.503**	.415**	−.128*	.468**
PN						.428**	−.111*	.478**
INFRA							−.235**	.494**
DIST								−.248**
PKWS								

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Source: Primary data.

Table 6
Hypotheses results.

	Relationship	β	Standard deviation (STDEV)	t-statistic	p-value	Remarks
H1	ATT → WSI	0.433	0.041	10.675	0.000	Accepted
H2a	PBC → WSI	0.137	0.057	2.396	0.017	Accepted
H2b	PBC → WSB	0.153	0.046	3.361	0.001	Accepted
H3	SN → WSI	0.163	0.053	3.089	0.163	Accepted
H4	WSI → WSB	0.444	0.039	11.425	0.000	Accepted
H5	PKWS → WSB	0.144	0.048	3.008	0.003	Accepted
H6	PN→ WSB	0.182	0.046	3.993	0.000	Accepted
H7	DIST→ WSB	−0.066	0.041	1.617	0.106	Rejected
H8	INFRA → WSB	−0.015	0.047	0.321	0.748	Rejected

Source: Primary data.

that has identified various barriers that prevent the translation of good intentions into consistent action (Davies et al., 2002; Wang et al., 2020). It is important to note that the MENA region faces critical WM challenges, due to financial limitations, lack of data, and outdated practices, waste in this region is regarded as mere disposal material rather than a potentially valuable resource (Thabit et al. 2022). Many students in our sample come from MENA countries, where residents are not used to separating their waste, and where poor WSB remains a significant issue, leading to inefficiencies in recycling processes (Noufal et al., 2020; Al-Dabbagh, 2021). Many MENA regions report low community engagement and awareness about proper WM practices (Noufal et al., 2020).

The first hypotheses concerned the antecedents of WSI, and they were all validated. The attitudes displayed by students (mean score of 3.62) provide a promising foundation for interventions aimed at improving WSI and WSB. Students acknowledged the usefulness and necessity of WS at home, and ATT was the strongest antecedent of WSI in our study (H1), which aligns with existing literature suggesting that positive attitudes are critical antecedents of pro-environmental behaviors and WSI (Rathore and Sarmah, 2021, Nawaz et al., 2025). The gap we found between attitudes and behaviors is consistent with prior research, suggesting that favourable attitudes do not always translate into action due to barriers or insufficient motivation (Bamberg and Möser, 2007). Our quantitative research questionnaire only measured positive attitudes towards WS.

SN was the second most important antecedent of WSI on our sample (H3). This result is also consistent with previous research (Tonglet et al., 2004; Wang et al., 2020) that found SN to be a significant predictor of WSI. The Arab and African cultures are considered to be collectivist, where family, leaders, friends and communities have an important

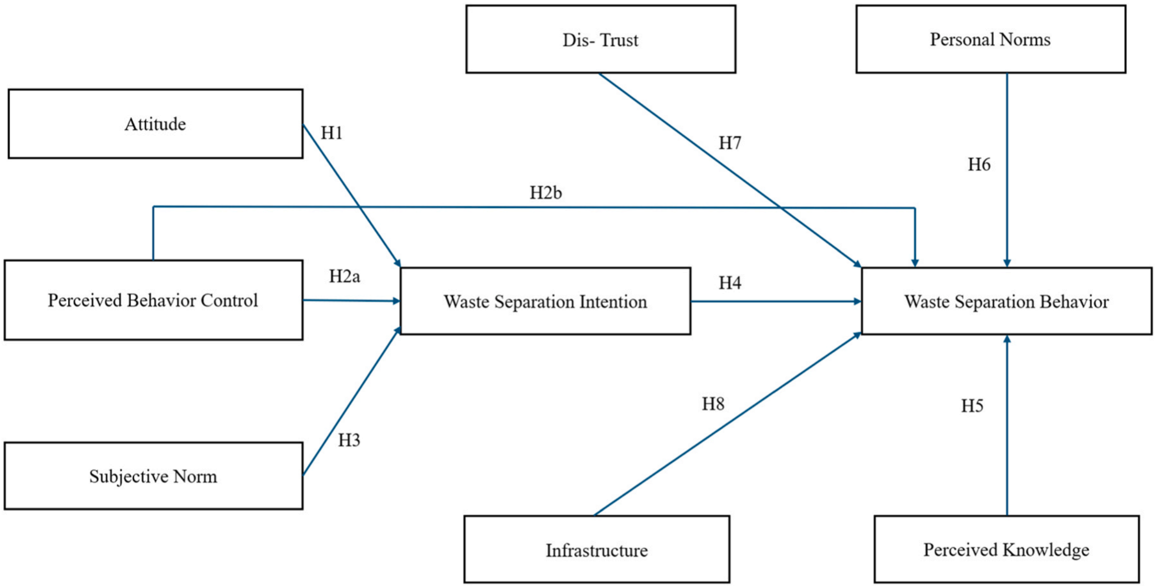

Fig. 1. The research model.

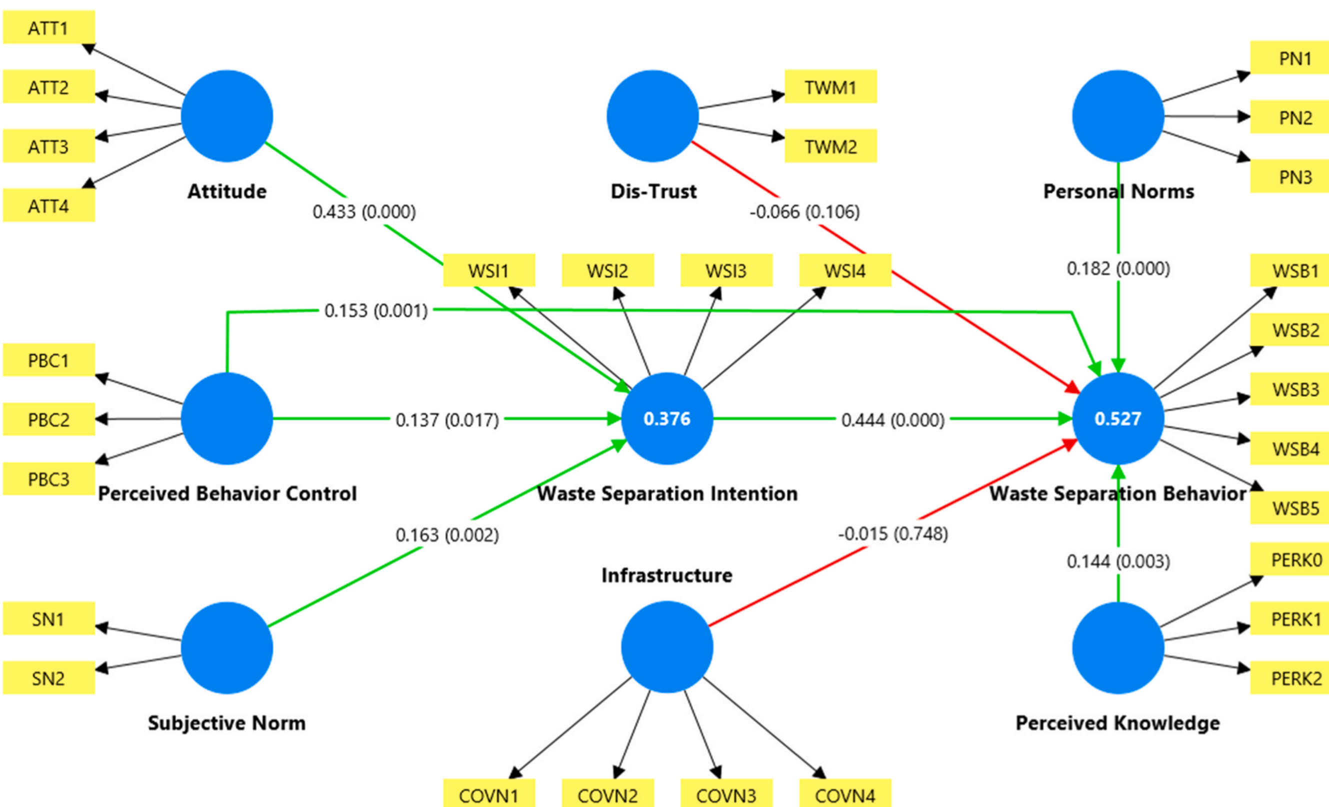

Fig. 2. Relationship estimates. Source: Primary data.

impact on people's behavior. Shen et al. (2019) noted that social influence was particularly important for younger individuals, who are more likely to be influenced by the behaviors and expectations of their peers. Our results for SN is 3.14, barely over "neutral", indicating that students do not perceive strong social pressure to engage in WS. This weak normative influence may stem from a lack of family and visible peer engagement in recycling activities, as Shen et al. (2019) suggest that social visibility is crucial for strengthening normative behaviors. Educational institutions in the UAE have a major role to play in improving WSB, as educators can promote and offer clear guidance on WS.

PBC, which reflects students' confidence in their ability to perform WS, had a mean score of 3.26 in this study. The findings of this study demonstrate that PBC plays a significant role in influencing WSI as well as WSB among students, thus providing strong support for hypotheses H2a and H2b. This indicates that students' perception of control over their WS actions has a notable impact on their intention and actual behavior. It underscores the importance of considering PBC as a key factor in promoting sustainable WM practices among student populations. These findings are consistent with earlier studies (Xu et al., 2017; Zhang et al., 2021, Goh et al. (2022). The moderate level of PBC we observed indicates that while many students feel capable of engaging in recycling, significant challenges remain. WS is not an easy task, and may take too much time for our respondents. Inconvenience, and confusion about WS guidelines, could be possible constraints on WSI. Hu et al. (2021) suggest that active community management, at educational institutions for example, could increase students' confidence and abilities in performing WS.

The next five hypotheses concerned the antecedents of WSB, and three of them were validated. The strong positive effect of WSI on WSB (H4) was supported in this study and consistent with past studies (Elhoushy and Lanzini, 2021). PN significantly predicted WSB (H5), which confirms previous findings (Loan et al., 2017; Nguyen et al., 2017; Wang et al., 2020; Goh et al., 2022; Zhang, 2023), that PN enhanced the TPB's predictive power to explain WSB. PN had a bigger effect than SN in our study, maybe because the students are more educated or more aware about sustainability issues than the general community.

PKWS significantly predicted WSB (H6), which is consistent with previous literature results on the significant impact of knowledge on WSB (Kuang and Lin, 2021; Zhang et al., 2021). The mean score for PKWS was about 3, which demonstrates that many students do not understand the WS practices. Overall, PKWS, PN and WSI explained around 51 % of the variance in WSB, which is consistent with previous literature results.

Our study measured distrust (DIST), and the mean was 3.19, which indicated a moderate lack of trust amongst our respondents in the local WM system. This variable was not significantly related to WSB, however. Emirati respondents were the only national group with an average score lower than 3 on this variable, indicating higher levels of trust. The UAE is now considered to be a regional leader in integrated waste management (Smida and Waxin, 2026). For example, in 2023 the Emirate of Sharjah achieved a 90 % landfill diversion rate (BEEAH group, 2023). Unlike the UAE, which has implemented sophisticated integrated WM systems, most of the other MENA countries operate conventional WM systems (Negm and Shareef, 2019). Our non-Emirati respondents may not be fully aware of the modern WM systems implemented in their host country, the UAE, which could explain their relative lack of trust in the UAE WM system.

Finally, our hypothesis on convenient infrastructure has not been validated. The average score was slightly above 3, with women and Emirati respondents generally scoring higher. Some respondents reported benefitting from convenient and available infrastructures, but not enough to make it significant. Expanding the availability of labelled bins and improving the accessibility of facilities generally support better WSB. Our results did not align with other studies' findings that perceived convenient infrastructure had a positive impact on WSB and recycling in different contexts (Zhang, 2023; Nawaz et al., 2025). Our results may have been insignificant due to high variation in the availability of WS infrastructures in the UAE. After taking the survey, students commented in class about their access to WS infrastructures: some reported that they did not have access to WS bins in their neighbourhood, others did not know where the WS bins were located, some said that their parents were taking the recyclable waste to work, where there was a WS facility, whereas others enjoyed regular and convenient WS and collection at home.

5.2. Contributions

Theoretically, this research contributes to the existing literature in several important ways. Firstly, this study provides a comprehensive theoretical framework based on an extended version of the TPB. In addition to well established and well-tested variables (ATT, SN and PBC) predicting WSI, this study included two variables (PN and PK) that significantly influenced individuals' WSB. Secondly, our research model has been tested in the under-researched context of the UAE, a high income Middle-Eastern country and an Arab Gulf State. This research demonstrates that TPB constructs are useful in measuring the factors that contribute to WSI and WSB in the UAE, a wealthy country with centralized WM systems. Thirdly, this study did not find significant effects for trust and infrastructure, in the UAE context. This might suggest possible contextual limitations of the extended TPB model. Our results might indicate that in highly developed and centralized WM contexts, determinants like trust and infrastructure may have diminished explanatory roles. Other factors such as personal norms, attitudes or cultural values may be more relevant in these contexts. This underlines the importance of contextual tailoring when applying behavioral theories, and suggests that future research should consider the unique institutional, cultural and infrastructural landscapes of high-income rentier states to better understand and predict WSB within them.

Practically, beyond promoting sustainable WM practices and environmental awareness among UAE students, this study provides insights for targeted interventions and policy measures. Firstly, implementing awareness campaigns among students that promote the benefits of WSB, supported by social media campaigns and offering opportunities for participation, could improve attitudes towards WSB, WSI and WSB (Zhang, 2023). Secondly, implementing formal sustainability education could help students improve their WSB. Educational institutions could include specific information about the importance of WS and how to efficiently sort waste. Integrating WS education into academic curricula and extracurricular activities can increase students' PKWS and PBC. Workshops, interactive resources and digital tools can equip students with the skills and confidence needed to engage in WS practices. Our results also highlight the need for government agencies and educational institutions to do a better job of educating UAE residents about why and how to engage in WSB, including what can and cannot be recycled and where to put different types of waste. Further studies could examine the effectiveness of environmental education in schools and universities in the Gulf and other MENA countries. Future research could also explore how different educational approaches impact long-term WSB. Thirdly, the relatively weak effect of social pressure highlighted an opportunity for intervention. Enhancing the visibility of recycling initiatives and fostering a sense of collective responsibility could help establish WS as a common, expected behavior. Peer-led campaigns, student competitions and university-wide events that celebrate environmental achievements could increase the influence of subjective norms. Faculty involvement and visible leadership in recycling efforts could further reinforce these social influences, creating a culture where WS is viewed as a shared responsibility. These efforts could mobilize communities and create widespread behavioral shifts. Fourthly, providing accurate and accessible information could indirectly build trust and improve WSB in the UAE. In the European Union, it was found that trust in the effectiveness of WM systems could encourage WSB (Minelgaitė and Liobikienė, 2019). Communicating about the UAE's sophisticated WM system could improve the students' perception of its effectiveness, and might boost participation in WSB. In our study, knowledge about WS was negatively related to distrust in local WM. Educational campaigns and transparent communication about existing WM processes could foster trust and improve WSB (Phong and Loan, 2024). Finally, universities could adopt policies and measures to enhance attitudes and awareness about environmentally friendly behavior to encourage WSB, and provide incentives for recycling. Another intervention could be increasing the availability of well-labelled and conveniently located recycling bins. Easy-to-understand explanations of proper WSB could be posted on recycling collection bins, which would address students' concerns about the perceived complexity of recycling systems. By reducing logistical challenges, institutions could empower students to align their attitudes with their actions.

5.3. Limitations and future research

This study has limitations related to generalizability and comprehensiveness of the findings. The first limitation concerns the sample. This study's sample was drawn exclusively from students in a single university, and only three professors (of HRM, Management and Biology) from this university collected data. So, our sample does not represent the whole population of the concerned university, nor the university student population across the UAE. Other universities would exhibit different student profiles, influenced by variations in environmental education programs, campus sustainability initiatives and socio-demographic factors. The single university background might unintentionally introduce some biases, potentially skewing the results. Further studies could collect data in multiple universities in the UAE and other Gulf countries. Moreover, this study primarily included students born between 1996 and 2005, a group often characterized by higher environmental awareness and a greater propensity for adopting sustainable practices. However, this focus introduces age-related bias, as the findings may not reflect the behaviors and attitudes of younger and older UAE residents. Generational differences in environmental values, motivations and access to resources may significantly influence WSBs. Finally, our sample includes more female (62 %) than male students, and some nationalities are more represented than other. Future research could analyse the impact of gender and region/nationality on WSB and its antecedents, in the UAE, on a larger, balanced sample.

Other limitations relate to our research design. Firstly, this study could not examine changes in WSB changes over time, since we collected data only once. Longitudinal data collection is essential for understanding dynamic behavioral patterns and the long-term impact of interventions. Secondly, the study relied on self-reported data to assess WSBs, which may be subject to social desirability bias. More objective methods, such as observational studies or waste audits could provide a more accurate assessment of WSB. Thirdly, our study only includes nine variables. Future research could examine the impact of contextual variables such as the amount of local governmental support and emirate of residence on WSB, for example. Future studies could also measure trust and convenient infrastructure differently, or qualitatively examine why this variable was not significant in the UAE context. Fourthly, qualitative studies could help refine our understanding of WSB in the UAE, and answer questions such as: why do many UAE residents not sort their wastes, despite benefitting from sophisticated WM infrastructure? What are the students' negative attitudes towards WS? What barriers prevent students' from engaging in WS in the UAE? Finally, it would also be interesting to examine UAE organisations' WSB (Dragomir and Dumitru, 2022) in the future.

CRediT authorship contribution statement

Waxin Marie-France Judith: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Data curation, Conceptualization. **Aaron Bartholomew:** Writing – original draft. **Baber Hasnan:** Formal analysis. **Aaliya Ahammed:** Investigation.

Declaration of Competing Interest

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.

Appendix A

	Gender	Mean	Std. Dev	F	P- Value	Regions*	Mean	Std. Dev	F	P- Value
WSI	Male (n = 133)	2.65	0.96	17.682	0.000	1	3.16	1.01	2.897	0.035
	Female (n = 220)	3.10	0.99			2	2.79	0.94		
						3	2.91	1.03		
						4	3.11	1.17		
WSB	Male	2.09	1.11	13.400	0.000	1	2.49	0.97	3.926	0.009
	Female	2.52	1.04			2	2.15	1.01		
						3	2.56	1.24		
						4	2.62	1.21		
ATT	Male	3.31	1.01	24.758	0.000	1	3.85	0.82	2.686	0.046
	Female	3.81	0.85			2	3.53	0.84		
						3	3.52	1.23		
						4	3.75	0.91		
PBC	Male	3.10	0.90	6.375	0.012	1	3.25	0.87	2.746	0.043
	Female	3.35	0.89			2	3.16	0.93		
						3	3.51	0.75		
						4	3.19	1.12		
SN	Male	2.99	0.91	5.540	0.019	1	3.49	0.77	9.189	0.000
	Female	3.23	0.92			2	2.89	0.96		
						3	3.27	0.81		
						4	3.22	0.99		
PN	Male	3.46	0.89	7.420	0.007	1	3.75	0.98	3.575	0.014
	Female	3.74	0.94			2	3.48	0.89		
						3	3.86	0.89		
						4	3.64	1.00		
INFRA	Male	3.10	0.78	8.214	0.004	1	3.47	0.87	2.563	0.055
	Female	3.36	0.84			2	3.18	0.79		
						3	3.20	0.80		
						4	3.29	0.87		
DIST	Male	3.34	1.11	4.739	0.030	1	2.90	1.04	3.484	0.016
	Female	3.10	0.93			2	3.24	0.95		
						3	3.37	1.07		
						4	3.30	0.97		
PKW	Male	2.88	0.86	32.929	0.000	1	3.46	0.84	6.823	0.000
	Female	3.41	0.85			2	3.01	0.88		
						3	3.41	0.80		
						4	3.10	1.08		

*Regions: 1)All Emirates, 2) All Middle East North-Africa nations except the UAE; 3) Subcontinent including Indians, Pakistan, Bangladesh, Sri Lanka, Nepal, 4) Others including America, Canada, Russia, and so on.

Data Availability

Data will be made available on request.

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