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Bridging the Intention–Action Gap in E-Bike Adoption: Behavioral Drivers and Infrastructure Priorities in a Saudi Coastal City

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Abstract

Global transition toward sustainable micro-mobility is an essential aspect of Saudi Vision 2030; however, high car dependency remains a significant barrier to public health and safety targets. In this context, this study explores the factors determining the adoption of electric bicycles (e-bikes) in Al-Qunfudhah, Saudi Arabia. The present research used a convenience sampling strategy through an online survey conducted via social media and texting, utilizing a designed questionnaire of 10 sections delivered to 171 participants, alongside a 5-point Likert scale. Additionally, the scientific validation and analysis were conducted utilizing internal consistency, validity and scale reliability via statistical analysis. The findings indicated a significant intention–action disparity; while respondents demonstrate a strong psychological intention to adopt e-bikes within 12 months (an average of 3.51), real household ownership was relatively low at 11.1%. In addition, a significant 71.9% of participants use private vehicles for short-distance travel (<5 km), influenced by an average bus stop distance of 21.22 km. The hierarchy of barriers indicates infrastructure and security as the main barrier, particularly the absence of dedicated bike lanes, and concerns regarding traffic safety. In contrast, a perception of physical fitness, and interpersonal interaction behave as significant facilitators. Public health data reveals an average weekly activity of 109.77 min, significantly lower than worldwide recommendations; however, 66.7% of individuals believe e-bikes may address the difference. The statistical evaluation acknowledged the questionnaire's robustness, with significant Pearson correlation coefficients ($p < 0.01$) demonstrating internal consistency validity and Cronbach's alpha values between 0.71 and 0.88 indicating high scale reliability, demonstrating a scientifically stable framework for assessing the measured behavioral determinants. The research recommends the establishment of shaded, dedicated micro-mobility networks and the enforcement of safety regulations to promote a healthy, multi-modal urban ecosystem.

Keywords: electric bicycles; micro-mobility; Saudi Vision 2030; statistical analysis; sustainable transportation

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1. Introduction

Global urban transportation landscape has experienced a significant paradigm shift due to the critical requirement to address climate change, decrease urban congestion, and enhance public health [1,2]. Potentially, municipalities globally endeavor to decouple

economic expansion from carbon emissions; particularly, electronic bicycles (e-bikes) have emerged as a revolutionary possibility in the domain of small-scale transportation [3,4]. In contrast to conventional e-bikes deliver motorized support that reduces the physical challenges associated with cycling, providing a feasible option for extended commutes and diverse terrains. Studies have shown that e-bikes can efficiently substitute short- to medium-distance car transportation, hence lowering a city's total carbon emissions and adhering to the World Health Organization's (WHO) global initiative to enhance physical activity [5,6]. Recent worldwide research by Javid et al. [7] indicates that the post-pandemic environment has irrevocably expedited the transition to micro-mobility, with e-bikes being the favored alternative to cars for journeys under 10 km. Recent investigations by Almheiri et al. [8] reveal that in the Gulf Cooperation Council (GCC) region, active transport is fundamental to urban sustainability; however, the intention–action gap is most pronounced in coastal desert cities, where humidity and extreme heat are regarded as formidable physical obstacles.

Despite this, sustainable micro-mobility adoption has become increasingly important due to an unparalleled level of car dependency and its associated economic and environmental impacts in the Kingdom of Saudi Arabia [9]. In this context, official estimates presently indicate around 12 million registered vehicles in a population of 36 million, having a yearly expansion of approximately 5%. By 2030, the number of light cars is expected to reach an unbelievable 25 million [10,11]. Such a reliance is not only a social preference but also an enormous burden on national resources; the transportation industry presently accounts for around 22% of the Kingdom's gross primary energy usage, with road transport, particularly light vehicles, representing 80% of all energy usage [12].

Thus, Saudi Arabia's Public Transportation Authority has lately been authorized by the higher authorities to implement an acceptable limitation on private vehicle ownership per house [13]. This action occurs when the new traffic network currently lacks stated limitations on citizen ownership, but residents are restricted to two licensed cars. National surveys, including the Environmental Household Survey 2019 conducted by the General Authority for Statistics (GASTAT), indicate a nationwide average of 1.38 vehicles per household across the Kingdom [4]. However, regional studies in cities such as Hail reveal quantities as high as 3.15 vehicles per family, highlighting a widespread car culture that recent structural transformation programs aim to diversify [14].

Several studies reported that the substantial economic toll of road traffic crashes (RTCs) underscores the socio-economic consequences of car dependency. Spencer et al. [13] reported that RTCs in Saudi Arabia experienced an economic cost of SAR 137.6 billion (USD 36.7 billion) in 2022, or 3.3% of the national GDP. This study highlights that enhancing interventions such as restricting speed monitoring and seat belt utilization might lead to substantial financial savings; however, a more sustainable prospective solution necessitates transitioning the general population from light motorized vehicles to more secure, active transportation options such as e-bikes [15]. The requirement is further intensified by the societal transformations subsequent to the June 2018 royal decree resuming female driving rights.

According to Al-Garawi et al. [16], this transition has significantly transformed domestic demographics; the proportion of households utilizing private drivers decreased from 45.7% to 27.2% within one year of the decree. Despite women reporting enhanced independence and confidence, the outcomes of the "She Drives KSA" research project reveal that 70% of women remain reliant on personal automobiles as their primary mode of transportation, hence exacerbating the expected shortage of 25 million vehicles by 2030, unless alternative micro-mobility solutions are rendered socially and economically accessible [6].

To the knowledge of the research gap, numerous social and economic motivations for small-scale mobility and significant obstacles persist concerning public awareness and infrastructure. In a real-life survey-based investigation conducted in Hail, Al-fouzan and Almasri [14] revealed that 81.2% of inhabitants recognized that cars may operate on electricity, although 88.7% hadn't ever driven an electric vehicle before, and approximately 44% were unfamiliar to e-bike capabilities. Similarly, Tausif and Haque [17] observed that the Saudi motor vehicle business is very volatile, with consumer satisfaction significantly connected to fuel efficiency and maintenance expenses due to escalating local petrol prices. Previous research indicates an increasing opportunity for e-bikes, which are considerably more economical than cars with internal combustion engines. However, safety continues to be an essential concern.

To date, the majority of transportation studies across the Kingdom have concentrated on significant urban centers such as Riyadh, Jeddah, or Giga-projects associated with Vision 2030 [17,18], but secondary coastal municipalities like Al-Qunfudhah remain mainly neglected. Moreover, the significance of gender in this transition is paramount; subsequent to the 2018 reforms, a substantial corpus of nascent research by Abdelfattah et al. [19] reveals that Saudi women are progressively perceiving e-mobility not merely as a recreational pursuit but as a fundamental instrument for attaining autonomous, multimodal transportation in secondary cities such as Al-Qunfudhah. Currently present, e-bike adoption in Al-Qunfudhah has recently reached its early stages and the region has a significant car reliance rate of 88.3%, but domestic e-bike consumption is at 11.1% [20].

Despite relatively restricted commercialization, e-bikes provide significant comparative benefits beyond either private vehicles or conventional bicycles in the local urban environment. For the 71.9% of local journeys under 5 km, e-bikes provide a cost-effective, flexible, and time-efficient alternative that avoids the cost of fuel, parking, and repair expenses linked to internal combustion engine (ICE) automobiles [21]. Moreover, the fueled support of e-bikes is particularly advantageous in the coastline conditions, facilitating professional, moisture-free journeys by reducing the physical effort needed in elevated humidity and high temperatures that are a significant obstacle to traditional riding [22]. In conjunction with Al-Qunfudhah's largely flat terrain, which removes significant geographic obstacles, e-bikes present themselves as a highly flexible and sustainable mode of active transportation that effectively harmonizes physical health advantages with the Kingdom's overall goals for traffic reduction and low-carbon urban mobility [23].

Thus, this study highlights the national trend, emphasizing a lack of recognized bike lanes and safety anxieties related to traffic accidents as the main obstacles for Al-Qunfudhah citizens. Moreover, the lack of a safety culture is apparent in that most people have not undergone any safety training and also do not wear helmets while cycling, highlighting a substantial research gap in recognizing how a safety strategy bridges the gap between implementation and intention. This study aims to address this gap by delivering a statistically sound analysis of the factors influencing e-bike uptake among residents of Al-Qunfudhah.

This research investigates the relationship between attitudes, social norms, and perceived behavioral controls by ensuring good internal consistency validity (Pearson correlation) and scale reliability. This paper aims to achieve three objectives: (i) to analyze current travel behaviors and awareness in a secondary city context, (ii) to pinpoint specific structural and cultural impediments, such as battery range and social acceptance, that impede the transition from car dependency; and (iii) to recommend evidence-based policies, including solar-powered charging stations and mandatory helmet laws, that correspond with the local needs and the strategic quality of life goals of Vision 2030.

2. Materials and Methods

2.1. Study Area Descriptions

Al-Qunfudhah Governorate is a rapidly growing coastal metropolitan area located in the Tihama plain along the southern Red Sea coastline of Saudi Arabia's Makkah Province (Figure 1). Located roughly 330 km south of Jeddah, the area has a diverse topography with coastal plains, sabkhas, and huge wadi systems, including Wadi Qanunah, which are occasionally vulnerable to rapid flash floods [24,25]. The region has an arid tropical climate characterized by high evaporation rates and considerable hydrological pressure; recent geochemical modeling reveals that groundwater reserves are progressively threatened by saltwater intrusion and salinity due to heavy cultivation extraction and ocean vicinity [26,27]. In the last forty years, remote sensing research has recorded a transition from natural coastal accretion to human-induced erosion, motivated by the rapid emergence of urban facilities, such as ports and corniche roadways [20,21].

Figure 1. Geographical location of the study region in Al-Qunfudhah, Saudi Arabia.

This rapid urbanization occurs within a national context where light vehicles account for 80% of energy use in road transport, and road traffic accidents impose an annual economic impact of SAR 137.6 billion, equivalent to 3.3% of the national GDP [28]. Thus, Al-Qunfudhah's largely flat terrain offers a setting ideally suited for electric micro-mobility; however, the convergence of environmental susceptibility, energy-intensive dependence on

desalination, and automobile-focused coastal development highlights the urgent necessity for sustainable transportation diversification in alignment with the quality-of-life goals of Saudi Vision 2030.

2.2. Research Design and Participants

This research utilized a quantitative, cross-sectional descriptive design to assess the perceptions, travel behaviors, and adoption barriers concerning electric bicycles (e-bikes) among the residents of Al-Qunfudhah, Saudi Arabia (Figure 2). Cross-sectional surveys are especially effective at obtaining a snapshot of public opinion at times of major technical or regulatory transition, such as the Kingdom's present shift towards sustainable micro-mobility. The survey design adhered to a three-stage validation process to guarantee the scientific rigor of the study. First, the components conducted a content validity assessment by three specialists in transportation engineering and urban planning to confirm that the questions effectively represented the geographical obstacles to micro-mobility. Second, a pilot test involving fifteen community members was undertaken to resolve any language issues in the Arabic translation. Third, the final data was evaluated for construct validity by Pearson's correlation, confirming that the 10 sections of the questionnaire were logically and statistically interrelated.

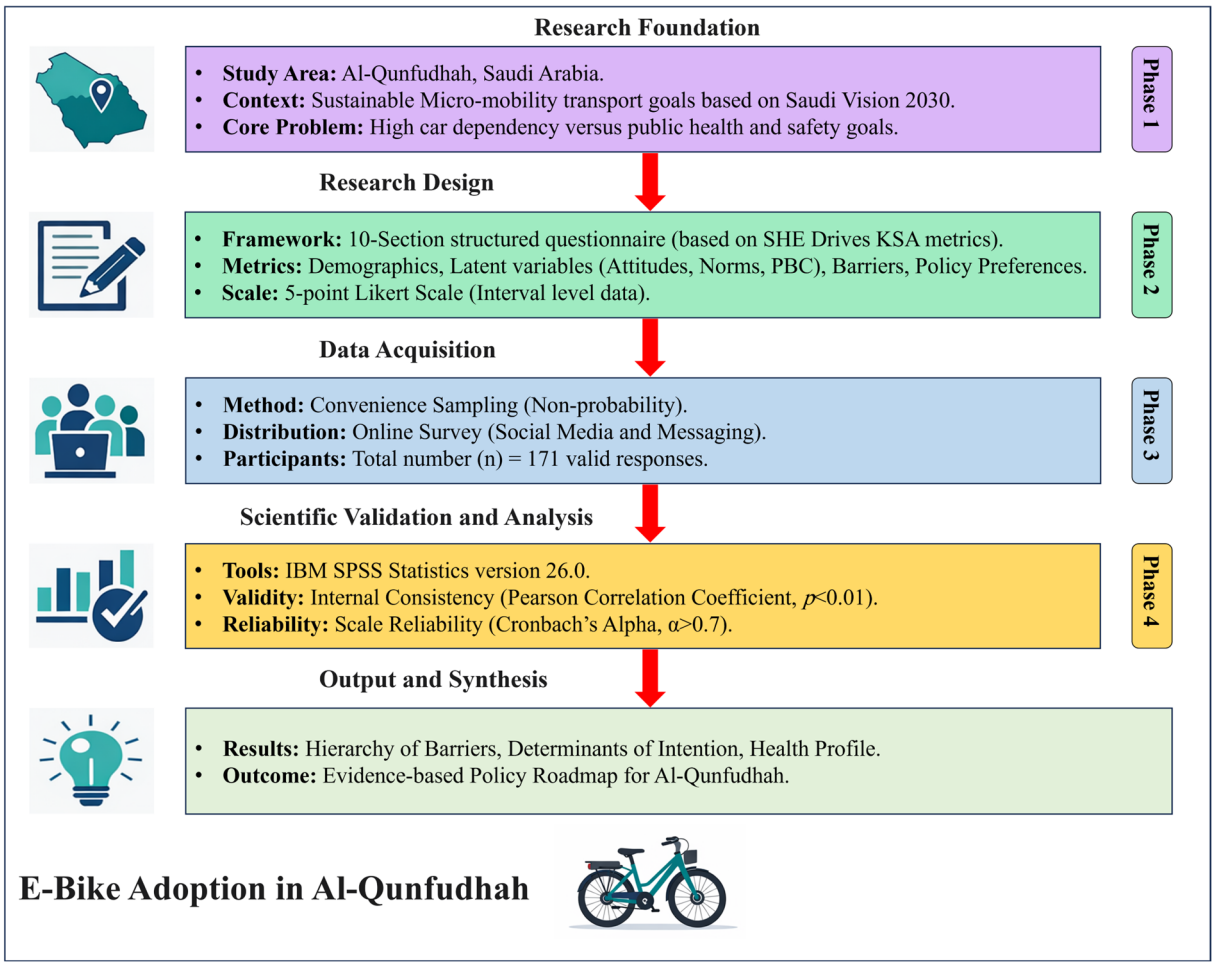

Figure 2. Methodological framework along with research design for assessing the factors influencing electric bicycle adoption in Al-Qunfudhah, Saudi Arabia.

2.2.1. Recruitment and Data Collection

Informed by the methodological framework established by the "She Drives KSA" national program [6], information was obtained through a structured online questionnaire distributed across social networking channels and instant messaging applications. Convenience sampling was utilized as a non-probability method to reach participants within a designated geographical area. The digital dissemination facilitated extensive participation from the Al-Qunfudhah population; however, as demonstrated in previous digital survey research, this approach tends to produce a sample with elevated educational attainment due to the necessary digital competence and access to smartphones. The questionnaire was carried out throughout the course of two weeks, obtaining a total of 171 valid inputs.

This study employed an exploratory cross-sectional design with non-probability convenience sampling; the sample was not intended to provide strict population-level representativeness. Rather, it was designed to identify initial behavioral patterns and perceived barriers in an under-studied secondary-city context. For the analytical procedures used in this study, the final sample of 171 respondents was considered adequate. In particular, for multiple regression models with a small number of predictors, common rules of thumb indicate that the minimum required sample is substantially lower than the achieved sample size. Since the present model included three predictors, the sample exceeded the minimum level generally considered acceptable for regression-based exploratory analysis. The sample size was also adequate for descriptive analysis and internal consistency assessment of the questionnaire scales. Nevertheless, the findings should be interpreted as exploratory rather than fully generalizable, given the use of convenience sampling and the observed gender imbalance.

2.2.2. Cohort Characteristics and Socio-Economic Context

Each participant's demographic profile reflects a varied representation of the Al-Qunfudhah society. The predominant age category comprised young adults aged 20–30 years (32.2%), succeeded by the 41–50 age group (21.1%) and the 31–40 age group (18.7%). The overall gender distribution indicated that 74.9% of the participants were male and 25.1% were female. The sample possessed a significant level of educational achievement, with 56.1% possessing an undergraduate degree and 18.7% having completed postgraduate education. At the time of the research's completion, approximately 49.7% of the respondents were working, 21.1% were students, 16.4% were retirees, and 12.9% were looking for employment.

The socio-economic status of the participants illustrates the highly motorized, automobile-dependent metropolitan landscape characteristic of the Arabian Peninsula. The majority of household monthly revenue was mostly between the SAR 10,000–20,000 level (46.8%). The respondents revealed significant motorization, with 88.3% of families possessing at least one private car; however, 11.1% simply owned an e-bike, and a minimal 0.6% possessed a conventional bicycle. The median number of automobiles per family in this survey was 2.69 (about 3), with ownership reaching a maximum of 11 vehicles. The car ownership rate substantially exceeds the national average of 1.38 automobiles per family, as revealed in the 2019 GASTAT Environmental Household Survey, suggesting that the study population is profoundly engaged in a car-dependent lifestyle. Therefore, 71.9% of participants claimed they usually utilized a car as their main source of transportation, even for relatively short journeys (less than 5 km), underscoring a significant opportunity for micro-mobility intervention.

2.3. Data Acquisition and Conceptual Framework

We obtained the necessary information for this study using an interdisciplinary research tool that aimed to collect measurable travel behaviors (objective data) and subjective behavioral determinants (latent variables). The questionnaire was based on ideas and models that are often used in recent studies about small-scale mobility in Saudi Arabia, particularly the Indicators of Potential Use process from Hail City and the behavioral transition metrics from the "SHE Drives KSA" program. Al-Garawi et al. [16] have pointed to the She Drives KSA framework as a framework for development within the distinctive socio-cultural context of Saudi Arabia, aimed at evaluating the psychological and structural changes subsequent to the 2018 decision on female driving rights (no driving or driving) and the transportation sector (car to e-bike).

The adoption of e-bikes signifies a comparable disruptive shift from automobile dependency to active micro-mobility; hence, the locally validated psychometric indicators, derived from the She Drives KSA model, which assess social support, social norms, perceived risk, safety concerns, and challenges to autonomy, are readily applicable to the e-bike context. This information pertains to the calibration for the linguistic and cultural details of the Saudi population, hence enhancing the credibility of our findings. This study elucidated that we modified the 10-section survey framework and the Likert-scale metrics from this program to ensure that our research conforms to the data-collection criteria of the Saudi Ministry of Transport and Vision 2030 targets. By applying a methodology previously validated on the Saudi population, we guaranteed that the questionnaire was culturally appropriate and linguistically precise, thereby minimizing response bias. This research specifically employed a multi-dimensional category framework to assess the interaction between personal demographics, structural impediments, and policy preferences.

2.3.1. Quantification and Scaling

All behavioral and attitudinal data points were assessed on a 5-point Likert scale using Cronbach's alpha coefficient (α) (ranging from 1, which refers to strongly disagree/not important, to 5, which indicates strongly agree/very important). The findings will indicate high internal consistency, confirming that the questionnaire is a scientifically stable instrument for measuring behavioral determinants in the Saudi coastal context. This interval-level measurement is the global standard for psychometric transport research, allowing for the calculation of weighted means and standard deviations to identify central tendencies in behavior.

2.3.2. Design of the Survey Procedure

The selection of these 10 specific parameters was facilitated by a literature search on sustainable mobility adoption in developing countries, employing a hybrid methodology that specifically utilized the Theory of Planned Behavior (TPB) framework [29]. This TPB is pivotal research concerning the prediction of transportation mode changes based on localized indicators from the SHE Drives KSA [5] and Indicators of Potential Use [10] frameworks. The 10 particular factors were chosen to encompass the psychological drivers (attitudes, social norms, and perceived behavioral control) and the practical/contextual variables (infrastructure, climate, and policy) pertinent to the urban setting of Saudi Arabia. Moreover, comparable research in Saudi Arabia conducted by Al-Garawi et al. [6] and Almubarak 2024 [5] underscores that individual decision is not just dependent on demography but rather a multifaceted interplay of internal attitudes and external social obstacles. Although all 10 sections are essential for a comprehensive perspective, they do not hold equal significance statistically regarding the variables pertaining to the TBP, whereas the sections d, e, f, and g serve as the principal explanatory factors, and the remaining sec-

tions (Demographics, Health, and Policy) supply the contextual evidence requisite for the local suggestions.

Consequently, categories (d) to (g) were selected to assess the fundamental psychological notions of the TPB, whereas categories (h) and (i) were incorporated to tackle the action aspect of the intention–action gap by recognizing physical and regulatory obstacles. Although demographics and public health categories offer vital descriptive background, the factors concerning obstacles and safety were revealed to be the most consequential determinants in the statistical analysis, signifying their larger significance in the local setting of Al-Qunfudhah. The questionnaire was meticulously crafted to elucidate the relationship between psychological motivators (health perception) and structural barriers (infrastructural deficiencies) to understand why heightened intention does not invariably lead to ownership. The questionnaire comprised 10 key concerns, designed to provide a holistic perspective on the transition from internal combustion engine (ICE) light vehicles to electric micro-mobility:

(a) Demographic Profile and Socio-Economic Characteristics: This section has been categorized into eight variables, such as age, gender, education, employment, income, household composition, and vehicle ownership metrics.
(b) Travel Context and Current E-bike Usage Metrics: This section has been categorized into five items, such as living area, short-trip modes, e-bike access, usage frequency, and purpose.
(c) Public Awareness and Technological Knowledge: This section has been categorized into three parts: prior awareness, market availability knowledge, and familiarity with technical features.
(d) Attitudes and Perceptions Trends: Five categories evaluating the perceived benefits associated with fitness, community acceptance, commuting ease, time-savings, and environmental impact.
(e) Social Norms: Two concerns reflecting the perceived encouragement provided by interpersonal family support and perceived societal contribution.
(f) Perceived Behavioral Regulation and Protection: Five measures assessing financial affordability, infrastructure availability, maintenance knowledge, traffic safety, and vehicle security.
(g) Adoption Intentions: Three concerns evaluating short-term usage plans, sharing interest, and car-replacement propensity.
(h) Barriers and Facilitators: Eleven categories describing purchase price, infrastructure gaps, battery limits, safety anxieties, weather impact, social acceptance, and other emerging factors.
(i) Public Policy Preferences: Seven issues assessing financial grants, tax incentives, sharing subsidies, dedicated infrastructure, renewable energy charging, safety regulations, and awareness initiatives.
(j) Public Health and Personal Safety Profile: This section recorded metrics such as weekly activity levels, compliance with WHO recommendations, perception of health benefits, helmet behavior, accident history, and safety training.

2.4. Validity and Reliability Testing Using Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participant characteristics and responses. In order to ensure the rigorous scientific validity of the method, the following assessments of its internal consistency and dependability were conducted.

(a) *Internal Consistency Validity:* Pearson correlation coefficients were calculated to evaluate the relationship between every component and the overall score of its corresponding scale. Every variable possessed statistically significant correlations ($p < 0.01$), demonstrating strong internal consistency.

(b) *Reliability:* The coefficients of Cronbach's alpha (α) were calculated for each subscale. All scales exceeded the recommended threshold of 0.70, with values ranging from 0.713 (Intentions) to 0.883 (Policy Preferences), confirming the reliability of the instrument.

The sample size of n = 171, however, focused on a peripheral city such as Al-Qunfudhah, exceeds the minimal criteria for the statistical tests utilized (ANOVA/t-tests) and provides a 95% confidence level with a ±7.5% margin of error for this specific urban demographic. The content validity was adjusted according to established international scales (TPB) and the She Drives KSA national paradigm to ensure cultural appropriateness within the local environment. A pilot study was performed with a limited cohort of residents (n = 15) to verify the clarity of language and technical terminology prior to the comprehensive rollout. This study employed Pearson correlation coefficients to determine internal consistency validity and utilized Cronbach's alpha (varying from 0.71 to 0.88) to affirm strong scale reliability. These enhancements fortify the methodological framework of our research.

3. Results

The results of this study are derived from the final representative sample of 171 participants. To establish the stability of the outcomes, the survey instrument was subjected to psychometric validation, confirming that all scales used, ranging from attitudes to policy preferences, have been internally consistent and reliable in assessing behavioral determinants. This study demonstrated the validity and reliability of the data to establish its reliability ahead of presenting its conclusions. The following parts have been adequately addressed.

3.1. Demographic Profile and Socio-Economic Characteristics

This section provides an in-depth study of the demographic profile and socio-economic characteristics associated with the participant population in Al-Qunfudhah. Figure 3 explicitly consolidates the information into eight panels (A–H) that depict various socio-economic factors and car ownership metrics.

Figure 3A illustrates the age distribution, highlighting a demographic profile towards younger and working-age adults, which is essential for the viability of micro-mobility. The main demographic consists of persons aged 20 to 30 years, representing 32.2% of the total sample. The age ranges 41–50 and 31–40 account for 21.1% and 18.7%, respectively. In contrast, the demographics among the under 20 years (8.8%) and over 60 years (5.8%) represent the smallest amounts, suggesting that the findings reflect the active population most inclined to adopt e-bike usage. Figure 3B illustrates the gender distribution, revealing a substantial male predominance (74.9%), while females account for 25.1%. It suggests higher response rates among males, although the female representation is statistically sufficient to offer critical insights on specific gender mobility needs after recent legislative changes in the Kingdom.

Figure 3C illustrates the degree of education achieved, revealing a highly read and advanced group. A substantial majority of the participants (56.1%) possess a university bachelor's degree, while individuals with a high school education account for 25.1%. Furthermore, 18.7% reported having obtained postgraduate degrees. The significant incidence of higher education indicates that the populace has the digital and technical proficiency

necessary to handle e-bike maintenance and charging systems. Figure 3D depicts the job status, characterized by a significant degree of economic engagement. Currently, around 49.7% of respondents are employed, while students constitute 21.1%. Former employees and job seekers represent 16.4% and 12.9% of the sample, respectively. This implies that the research includes perspectives from diverse professional and academic sectors.

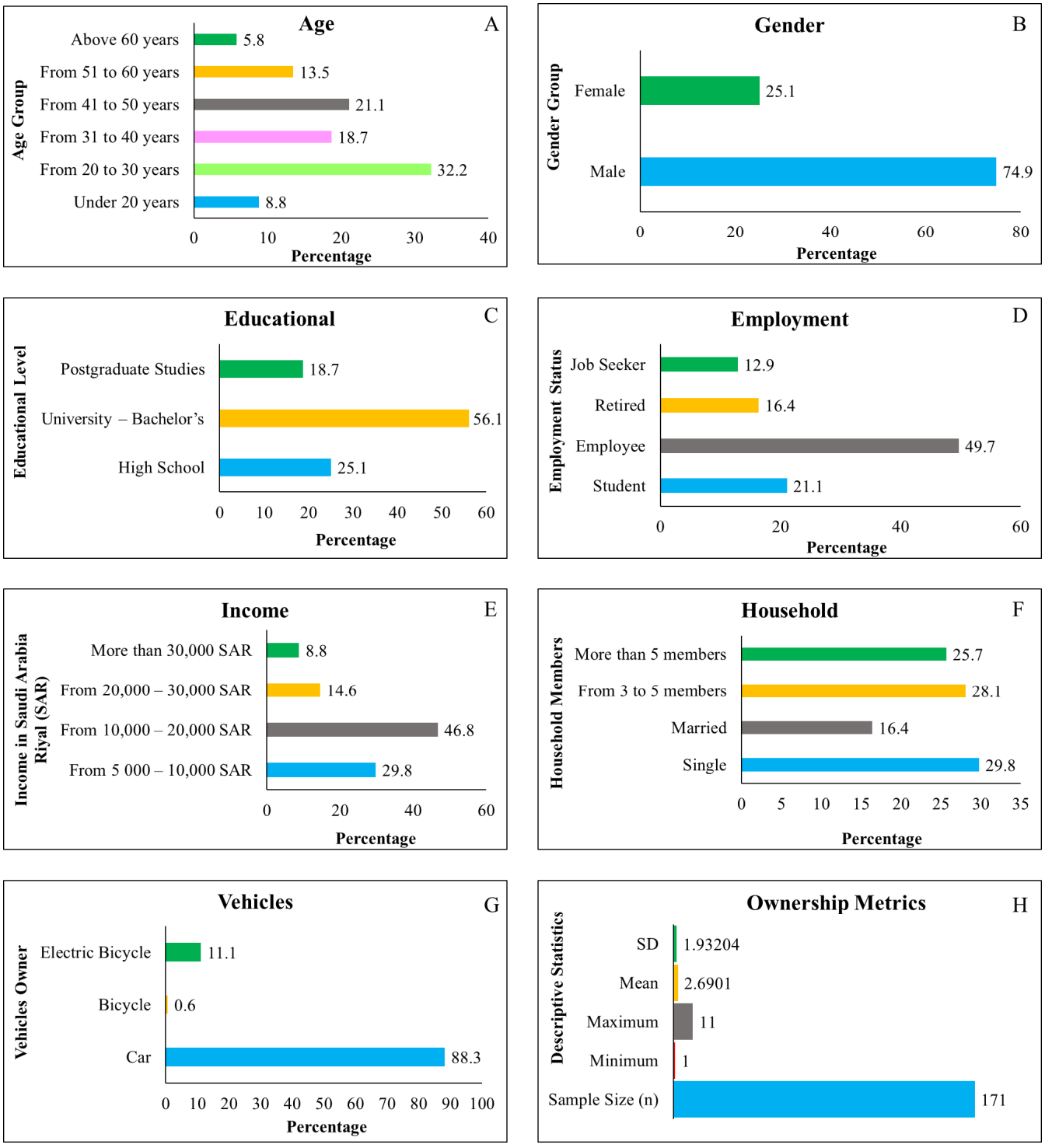

Figure 3. Comprehensive demographic and socio-economic profile of participants in Al-Qunfudhah: (**A**) age distribution; (**B**) gender composition; (**C**) educational attainment; (**D**) employment status; (**E**) monthly household income in SAR; (**F**) household size and marital status; (**G**) distribution of current vehicle ownership; (**H**) descriptive statistics for total vehicle counts per family.

Figure 3E illustrates the projected monthly family income, a fundamental factor influencing purchasing power. The results demonstrate that the majority of the population (46.8%) falls into the middle-income bracket of 10,000 to 20,000 SAR. A significant proportion (29.8%) earns between 5000 and 10,000 SAR, while higher-income categories over 20,000 SAR account for the remaining 23.4%. These parameters are essential for evaluating the financial viability of shifting to e-bikes. Figure 3F illustrates household size, indicating a majority of multi-member living arrangements. Singles constitute 29.8% of the sample, followed closely by households of 3 to 5 individuals at 28.1%. Households consisting of more than five people constitute 25.7%, whilst married couples without children or other dependents constitute 16.4%. The frequency of large households indicates that e-bikes should be promoted as a supplementary vehicle for short errands rather than a complete substitute for the family automobile.

Figure 3G depicts the existing classifications of household car ownership, highlighting a significant imbalance in modal distribution. Automobiles are prevalent, with 88.3% of families owning at least one private car. Conversely, e-bike ownership is at 11.1%, while traditional bicycles constitute a scant 0.6%. This disparity underscores the automobile-oriented nature of the metropolitan environment. Figure 3H displays quantitative ownership data, revealing a mean vehicle ownership rate of 2.69, indicating that the average family possesses approximately three cars. The ownership range extends from a minimum of 1 automobile to a maximum of 11, with a standard deviation of 1.93, illustrating the exceptionally high level of motorization in the research region. Despite the baseline data indicating a significant level of motorization (average corresponding to 2.69 cars), it is essential to investigate whether this physical dependence on automobiles correlates with a deficiency in knowledge about alternatives, as discussed in the subsequent section on public awareness.

3.2. Travel Context and Current E-Bike Usage Metrics

This section examines the travel context and current engagement with electric micromobility. Figure 4 provides a visual summary of consumption trends across five distinct panels (A–E). Figure 4A delineates the participants' residential areas, revealing a largely urban population (49.2%), with 45% inhabiting suburban locales. The substantial combined total of 94.2% in these areas is noteworthy, as urban density is essential for the effective implementation of e-bike infrastructure. Figure 4B depicts modal preferences, indicating a continued car-centric inclination for distances below 5 km. A substantial 71.9% utilize an automobile for these brief trips, while other modes, such as walking (8.8%), conventional cycling (1.2%), and e-bike usage (1.2%), are markedly underrepresented. Significantly, 16.4% employ several modes, indicating a growing openness to multi-modal travel.

Figure 4C assesses physical access, which serves as a significant impediment to adoption. Results indicate that 64.9% of participants experienced insufficient access to an electric bicycle, while 35.1% possess access. This gap underscores that market penetration is still in its early stages. Figure 4D depicts the frequency of e-bike utilization among those who have experimented with bicycles. Fifty percent of buyers indicated having used the car just once, and 23.3% employed it twice. A segment (21.7%) utilized the e-bike on more than three occasions. The statistics suggest that for many individuals, e-bike riding is now rare or experimental. Ultimately, Figure 4E delineates the primary goals for use. Shopping represents the primary activity at 34.5%, succeeded by leisure activities at 25.7%. The use of e-bikes for commuting to work is notably low at only 4.7%, indicating that they are now considered "recreational toys" rather than "functional transportation devices." Surmounting this view becomes the primary difficulty for municipal policy.

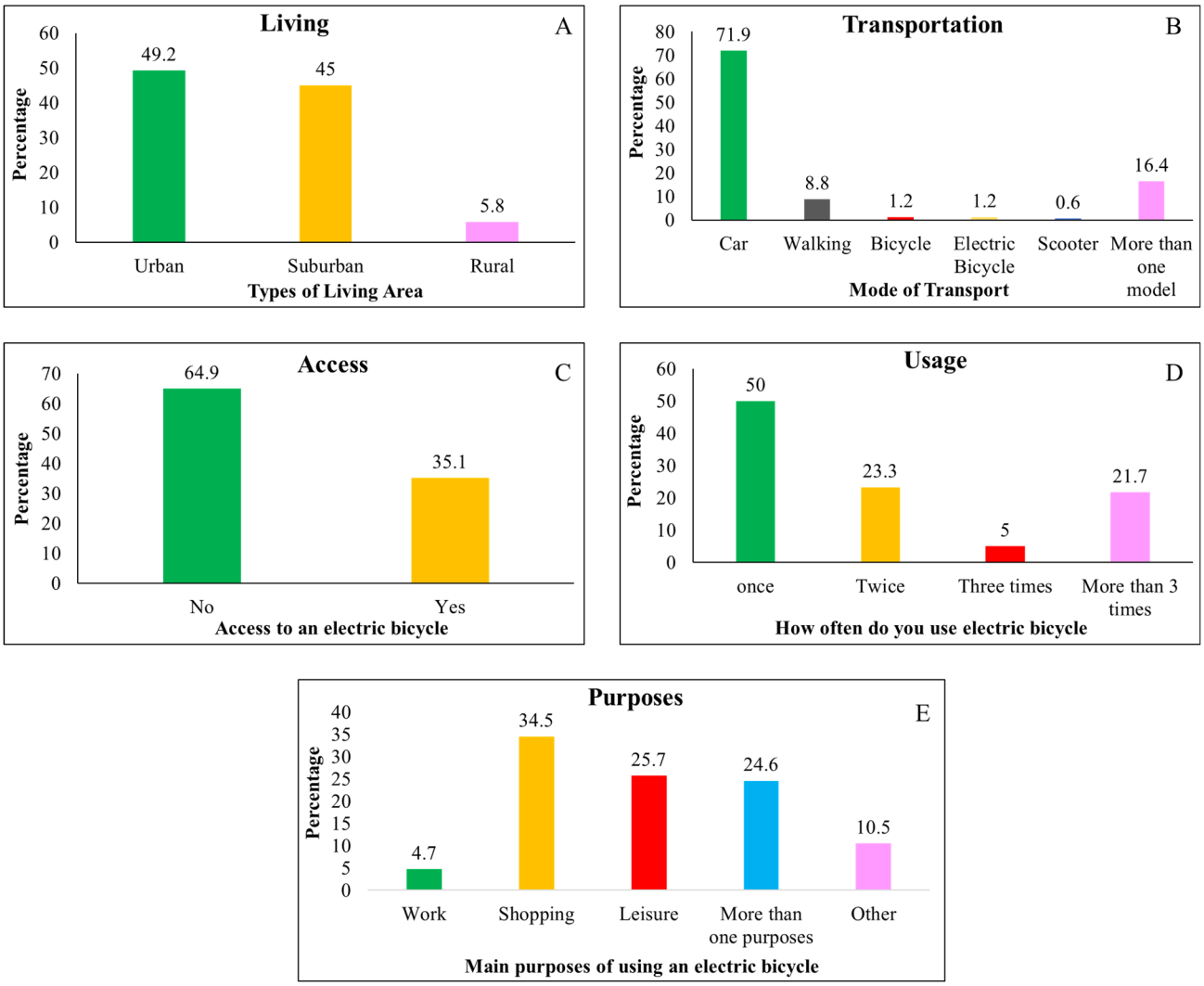

Figure 4. Current travel and e-bike utilization patterns in Al-Qunfudhah: (**A**) residential area classification; (**B**) modal distribution for short-distance; (**C**) current physical access to e-bikes; (**D**) frequency of vehicle usage; (**E**) primary stated purposes for e-bike utilization.

Mobility Connectivity and Trip Intensity

To assess the availability of public transportation and the overall mobility demand of the general population, this study examined the distance to the nearest transportation infrastructure and the average daily travel frequency. The results are presented in Table 1. The analysis indicates a substantial infrastructure deficit. Table 1 indicates that the average distance from a resident's residence to the nearest bus station is 21.22 km. Although certain metropolitan inhabitants indicate proximity under 1 km, the maximum distance of 500 km and the standard deviation of 61.42 underscore a significant deficiency in localized public transit accessibility, especially for individuals in peripheral or rural areas. This physical limitation offers a principal scientific justification for the results presented in Figure 4B, indicating that a predominant 71.9% of participants used private vehicles even for short-distance journeys under 5 km. In an environment where the nearby transportation station is considerably more distant than the trip's destination, public transportation becomes an unfeasible option, thereby establishing car dependency as an essential requirement rather than an easy choice.

Table 1. Quantitative analysis of transportation availability and travel distance of the nearest bus stop from home.

Descriptive Statistics	Sample Size (n)	Minimum	Maximum	Mean	SD
Distance of the Nearest Bus Stop from Home	171	1	500	21.2	61.4
Number of Daily Trips	171	0	8	2.7	1.4

Concerning trip intensity, participants indicate an average of 2.69 daily trips, with a maximum of 8 journeys per day. This indicates a stable need for mobility, influenced by everyday needs related to employment, schooling, and purchasing goods, as previously seen in Figure 4E. The low standard deviation (1.42) for daily travel suggests that this demand is consistent across the demographic range. The correlation between trip frequencies and the 64.9% absence of access to electric bicycles depicted in Figure 4C indicates that the substantial daily mobility is predominantly accommodated by the private car sector. Thus, the transition to e-mobility gives a significant opportunity to transfer these frequent, short-distance daily journeys from the carbon-heavy light vehicle industry to more sustainable micro-mobility alternatives. The transition from broad knowledge of e-bikes to their actual utilization is influenced by more profound psychological issues. Section 3.3 examines the attitudes and social norms that influence these adoption intentions.

3.3. Public Awareness and Technological Knowledge

This section measures the extent of knowledge and market awareness regarding electric micro-mobility in the Al-Qunfudhah governorate. The knowledge concerning previous exposure, market access, and technical knowledge is illustrated in Figure 5, divided into panels A, B, and C.

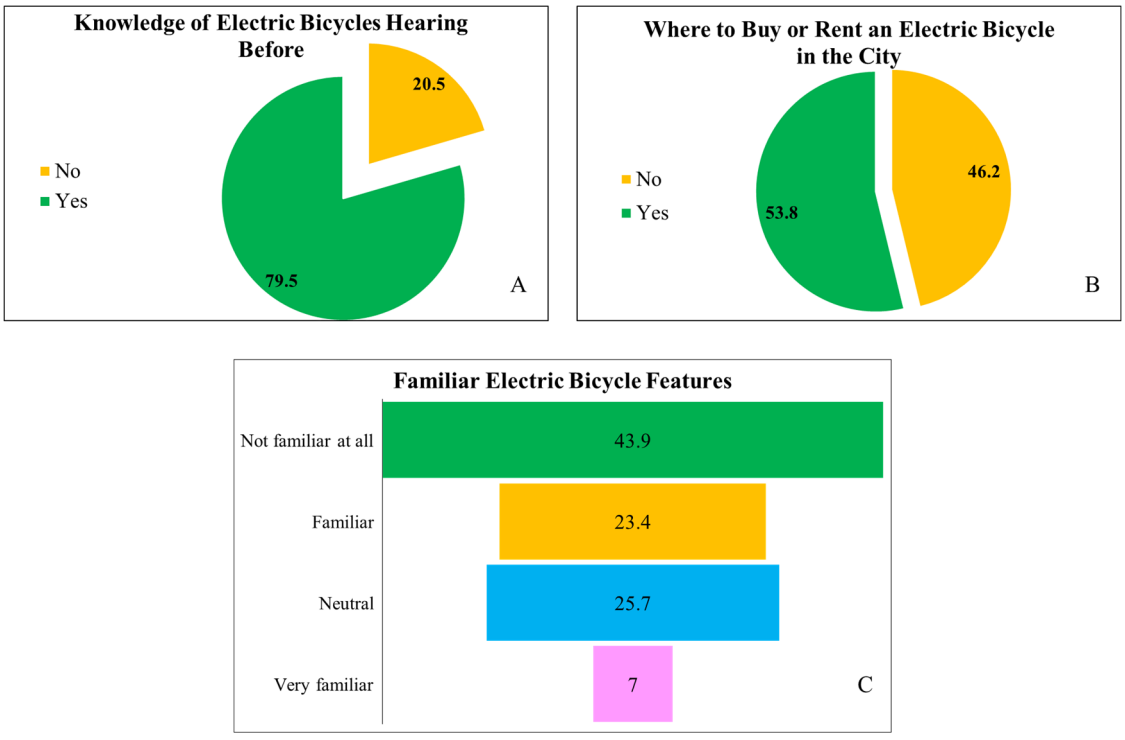

Figure 5. Evaluation of public knowledge and technological Knowledge regarding electric bicycles in Al-Qunfudhah: (**A**) distribution of participants with earlier awareness of e-bikes, (**B**) awareness of local buying and rental options and (**C**) self-assessed knowledge with technical e-bike specifications.

Figure 5A indicates a general level of prior awareness. A significant proportion (79.5%) indicated previous experience hearing about e-bikes. This suggests that although e-bikes are a familiar idea, this superficial understanding has not yet resulted in substantial market ownership. Figure 5B evaluates market availability knowledge. Market information is evenly distributed: 53.8% of participants know where to procure an e-bike, whereas 46.2% do not. This deficiency constitutes an essential information challenge that may impede adoption rates. Figure 5C reviews technical comprehension. The data indicates a significant deficiency in deep familiarity associated with 43.9% reporting they are not familiar at all. Merely 7.0% regard themselves as highly familiar, underscoring a significant lack of comprehensive technological knowledge.

3.4. Attitudes and Perceptions Trends

The following part explores the psychological aspects that affect e-bike adoption by evaluating participants' attitudes and views. The findings, presented in Table 2, employ a 5-point Likert scale to assess agreement across five principal dimensions: commuting convenience, physical fitness, environmental effect, time efficiency, and social acceptability.

Table 2. Quantitative evaluation of respondents' attitudes and perceptions regarding electric bicycles.

Components	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Standard Deviation
	N	%	N	%	N	%	N	%	N	%		
Using an e-bike makes my daily commute easier than using a regular bicycle.	67	39.2	16	9.4	45	26.3	14	8.2	29	17	2.54	1.49
Riding an e-bike improves my fitness.	36	21.1	16	9.4	47	27.5	22	12.9	50	29.2	3.2	1.49
Perceived environmental benefit of e-bikes.	80	46.8	19	11.1	36	21.1	15	8.8	21	12.3	2.29	1.44
E-bikes save time compared to driving or public transportation.	66	38.6	22	12.9	44	25.7	20	11.7	19	11.1	2.44	1.39
E-bikes are stylish and socially acceptable in my community.	42	24.6	27	15.8	58	33.9	17	9.9	27	15.8	2.77	1.35

The analysis indicates that participants usually demonstrate a neutral to cautious disposition regarding e-bike adoption, with mean values fluctuating between 2.29 and 3.20. The most strongly regarded advantage is the prospect of enhanced physical health, as evidenced by the assertion, riding an electric bike enhances my physical condition, which achieved the highest mean score of 3.20. Subsequently, social acceptability has been evaluated at 2.77, while the perceived convenience of commuting relative to conventional cycling is scored at 2.54. Particularly, while e-bikes offer powered assistance, participants were less persuaded by their time-saving potential (2.44) and environmental advantages (2.29), with the latter eliciting the highest proportion of Strongly Disagree reactions (46.8%).

The elevated standard deviations observed across all categories (from 1.35 to 1.49) reflect a considerable level of variability and polarization in popular opinion. For instance, 29.2% of the respondents strongly agree that e-bikes enhance fitness, whereas 21.1% strongly disagree, indicating a lack of consensus regarding the functional significance of e-mobility. This diversity indicates that despite a portion of the Al-Qunfudhah community acknowledging the health-related benefits of the technology, a more substantial proportion continues to adhere to a car-centric perspective, viewing e-bikes as an insignificant time-saving option and an unimportant vehicle for environmental preservation.

3.5. Social Norms

This section investigates the impact of social pressure and interpersonal support on the utilization of electric bicycles. Social expectations significantly influence transportation behavior, particularly in regions where private vehicle ownership is regarded as a traditional status symbol. Table 3 reflects the opinions of the respondents concerning the degree of support obtained from their immediate social networks and their perceptions of societal attitudes toward e-bike riders.

Table 3. Distribution of sample responses and descriptive data regarding social expectations.

Components	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Standard Deviation
	N	%	N	%	N	%	N	%	N	%		
My family or friends support my use of an e-bike.	29	17.0	20	12	56	32.7	11	6.4	55	32.2	3.25	1.45
People who are important to me believe that e-bike riders contribute positively to society.	34	19.9	16	9.4	66	38.6	20	11.7	35	20.5	3.04	1.35

The data reveals a moderate, yet favorable, social climate for e-bike usage in Al-Qunfudhah, with both assessed variables surpassing the expected neutral midpoint of 3.0. The greatest consistency was observed with immediate social support; the assertion my relatives or close companions support my utilization of an e-bike obtained a mean score of 3.25. Significantly, approximately a third of the respondents (32.2%) Strongly Agreed with this observation, indicating that interpersonal interactions may serve as a crucial catalyst for those contemplating switching to micro-mobility. This internal support is frequently required for behavioral transformation in highly communal societies. Conversely, the perceived societal contribution of e-bike users attained a mean score of 3.04. Although most respondents were indifferent (38.6%) or favorable (32.2% combined Agree/Strongly Agree), over 30% conveyed a negative view. This implies that although familial backing is comparatively robust, the wider community in Al-Qunfudhah may not yet fully acknowledge e-biking as a substantial positive impact on social or environmental welfare. The standard deviations (1.35 to 1.45) indicate a fragmented viewpoint, suggesting social acceptance exists but has not yet attained a cohesive cultural norm.

3.6. Perceived Behavioral Regulation and Protection

The following section analyzes participants' self-efficacy, their perceived capability, and their control concerning the utilization of electric bicycles in the present urban context. Perceived Behavioral Control (PBC) is a crucial indicator, as it assesses whether an individual believes they possess the requisite resources and security to execute their aims. Table 4 illustrates the descriptive statistics for five variables pertaining to affordability, road safety, technical expertise, traffic lights, and security.

Table 4. Quantitative assessment of perceived behavioral control and safety indicators.

Components	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Standard Deviation
	N	%	N	%	N	%	N	%	N	%		
I can afford to buy or rent an e-bike.	50	29.2	23	13.5	47	27.5	23	13.5	28	16.4	2.74	1.43
There are enough safe paths or roads in my area for riding an e-bike.	34	19.9	10	5.8	32	18.7	19	11.1	76	44.4	3.54	1.57
I know how to charge and maintain an e-bike.	41	24	17	9.9	44	25.7	23	13.5	46	26.9	3.09	1.51
I feel safe riding an e-bike in traffic.	26	15.2	9	5.3	39	22.8	22	12.9	75	43.9	3.65	1.46
I worry about theft or damage when I park my e-bike.	65	38	24	14	35	20.5	13	7.6	34	19.9	2.57	1.54

Low High

The data indicates an unexpected optimism over traffic safety, as participants rated I believe safe riding an e-bike in traffic with a mean score of 3.65, the highest on this dimension. The opinion of existing infrastructure (3.54) is closely followed, with 44.4% of respondents strongly asserting that sufficient safe paths are available. Table 4 indicates a mean score of 3.65 for "I feel safe riding an e-bike in traffic," reflecting a significant level of individual self-efficacy. However, this is countered by a barrier score of 4.06 regarding the absence of bike lanes (Table 6), implying that although residents perceive themselves as capable riders, the physical environment constitutes an insurmountable obstacle. However, this study has observed a significant decline in personal technical understanding (3.09) and financial accessibility (2.74). The minimal score (2.57) pertaining to anxiety over theft indicates that security apprehensions represent a negligible psychological burden relative to the vehicle's actual expense. The study indicates that whereas people possess confidence in managing traffic, they are constrained by elevated buying or renting expenses. The elevated standard deviations (reaching 1.57) signify that Perceived Behavioral Control is the more conflicted dimension in the study. For example, 43.9% of respondents express a strong sense of safety in traffic, although an interesting 15.2% strongly disagree, suggesting that perceptions of infrastructure are significantly influenced by the particular neighborhood in Al-Qunfudhah where the respondent lives.

3.7. Adoption Intentions

The completing aspect of the behavioral study assesses adoption intentions, which are considered the most immediate indicator of future utilization. By assessing the probability of users transitioning to e-bikes for short trips or engaging in sharing initiatives, local authorities can evaluate the prospective effect on traffic mitigation. Table 5 indicates the objectives of residents over three actionable timeframes and types of participation. The results indicate a strong inclination toward e-bike adoption because all average scores exceed the neutral threshold. The highest intention was noted for widespread use in the forthcoming 12 months (3.51), with 42.1% of the respondents expressing Strongly Agreed. This substantial commitment indicates considerable market preparedness for e-mobility. Moreover, the overwhelming support for e-bike-sharing plans (3.19) suggests that locals are receptive to alternative ownership arrangements that could mitigate the significant cost.

Table 5. Descriptive information regarding participants' intentions of e-bike adoption.

Components	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Standard Deviation
	N	%	N	%	N	%	N	%	N	%		
I intend to use an e-bike within the next 12 months.	26	15.2	17	9.9	44	25.7	12	7	72	42.1	3.51	1.49
I would consider replacing car trips of less than 5 km with an e-bike.	41	24	21	12.3	38	22.2	16	9.4	55	32.2	3.13	1.57
I would participate in an e-bike-sharing program if available in my city.	40	23.4	12	7	46	26.9	22	12.9	51	29.8	3.19	1.52

The decision to consider substituting car trips of less than 5 km possessed the lowest mean score in this section (3.13). Despite being overwhelmingly positive, the elevated Strongly Disagree percentage (24.0%) underscores the ongoing cultural and environmental challenges in persuading citizens to abandon the convenience of private vehicles. The results indicate that although locals are personally enthusiastic about e-bikes, they remain uncertain regarding their practical utility as a daily substitute for short-distance vehicle transport. The intention scores (3.51) reflect considerable psychological readiness; however, they significantly contrast with the low ownership rates (11.1%), suggesting a behavioral constraint resulting from the elevated barrier scores discussed in the following section.

3.8. Barriers and Facilitators

This section highlights the significant obstacles encountered by the community in comprehending the disparity between their strong intention to embrace e-mobility and their presently low levels of ownership. Table 6 presents a detailed evaluation of 11 potential barriers and facilitators, evaluated according to their perceived significance to the responder.

Table 6. Evaluation of the perceived significance of barriers and facilitators for e-bike adoption.

Components	Not Important at All		Not Important		Neutral		Important		Very Important		Mean	Standard Deviation
	N	%	N	%	N	%	N	%	N	%		
High purchase price.	22	12.9	14	8.2	52	30.4	13	7.6	70	40.9	3.56	1.42
Lack of charging stations.	20	11.7	7	4.1	37	21.6	15	8.8	92	53.8	3.89	1.4
Limited battery range.	19	11.1	10	5.8	34	19.9	25	15	83	48.5	3.84	1.38
Lack of designated bike lanes.	16	9.4	7	4.1	26	15.2	23	14	99	57.9	4.06	1.32
Safety concerns (traffic accidents, injuries)	20	11.7	5	2.9	30	17.5	15	8.8	101	59.1	4.01	1.4
Weather or extreme heat	21	12.3	12	7	29	17	15	8.8	94	55	3.87	1.45
Cultural or social acceptance	42	24.6	21	12.3	33	19.3	19	11	56	32.7	3.15	1.59
Lack of storage space at home	32	18.7	21	12.3	42	24.6	20	12	56	32.7	3.27	1.5
Unfamiliarity with operation or maintenance	24	14	14	8.2	47	27.5	20	12	66	38.6	3.53	1.43
Availability of financial support or incentives	23	13.5	15	8.8	45	26.3	20	12	68	39.8	3.56	1.43
Other emerging factors?	0	0	123	71.9	48	28.1	0	0	0	0	2.28	0.45

Low High

The average scores span from a minimum of 2.28 to a significantly significant 4.06, establishing a distinct hierarchy of structural problems. The research reveals a significant shortfall in infrastructure alongside security as the main obstacle to adoption. The absence of defined bike lanes was identified as the primary obstacle (average corresponds to 4.06), with 57.9% of respondents categorizing it as very important. This statistic is directly succeeded by safety concerns (4.01). In particular, environmental factors such as weather conditions or extreme heat (3.87) and technological constraints including a shortage of electrical charging stations (3.89) and insufficient battery range (3.84) received elevated scores, suggesting that residents are significantly apprehensive concerning the practical characteristics of riding in a coastal desert setting. Conversely, social and cultural variables constitute lesser obstacles. The mean score for cultural or social acceptance was 3.15, whereas lack of storage capacity received a score of 3.27. This indicates that although Al-Qunfudhah is a conventional automobile-oriented community, the inhabitants prioritize physical safety and technological infrastructure over the social stigma associated with cycling. The findings demonstrate that with the provision of secure, shaded pathways and a comprehensive charging infrastructure, cultural resistance would be relatively achievable.

The quantitative evaluation of the weather barrier indicates a purpose as a principal impediment to active transport. Extreme heat is statistically classified as a primary obstacle, with an average significance value of 3.87 (Table 6). Al-Qunfudhah's coastal climate frequently results in a heat index over 45 °C in the summer, rendering this subjective anxiety based on factual environmental risk. A further in-depth study of the results reveals a comparative benefit for e-bikes: although 46.8% of respondents strongly disagree

that traditional riding is feasible in hot conditions, this opposition markedly diminishes for e-bikes. The finding is ascribed to the pedal-assist system, which facilitates cooling airflow with minimum physical exertion. The findings suggest that e-bikes have a higher temperature threshold for acceptance than conventional bicycles in the Tihama region. To mitigate this 3.87-rated obstacle, our research proposes the incorporation of bioclimatic urban design, especially the implementation of solar-responsive protection and high-albedo paving materials for the planned 21.22 km micro-mobility network.

3.9. Public Policy Preferences

This section assesses popular support for diverse governmental and municipal initiatives aimed at promoting an e-bike ecosystem. Determining public policy preferences is crucial for urban planners to decide on budget expenditures. Table 7 outlines the levels of support for seven distinct policy measures, encompassing financial assistance and safety rules. The outcomes indicate strong approval for measures focused on infrastructure and safety. Both enforcing compulsory helmet regulations and creating designated urban bike lanes obtained the highest degree of support (mean = 3.53), with the second one achieving the highest individual very supportive percentage at 71.3%.

Table 7. Distribution of preliminary responses regarding planned transportation policy choices.

Components	Not Supportive		Somewhat Supportive		Neutral		Very Supportive		Mean	Standard Deviation
	N	%	N	%	N	%	N	%		
Government grants or financial support for purchasing e-bikes	14	8.2	43	25.1	68	39.8	46	26.9	2.85	0.91
Reduced excise duties or taxes on e-bikes	10	5.8	37	21.6	48	28.1	76	44.4	3.11	0.94
Low-cost e-bike rental or sharing programs	9	5.3	37	21.6	50	29.2	75	43.9	3.12	0.93
Creating dedicated city bike lanes	6	3.5	19	11.1	24	14	122	71.3	3.53	0.83
Installing solar-powered charging stations	3	1.8	24	14	26	15.2	118	69	3.51	0.8
Enforcing mandatory helmet laws	2	1.2	22	12.9	30	17.5	117	68.4	3.53	0.76
Awareness campaigns about the benefits of e-bikes	5	2.9	21	12.3	39	22.8	106	62	3.44	0.82

This result highlights the issues highlighted in Section 3.8 pertaining to safety and infrastructure. Moreover, the public has a distinct inclination toward sustainable energy integration, as seen by the high mean score of 3.51 for installing solar-electric charging facilities. Significantly, direct financial help through government subsidies garnered the least support (mean = 2.85), much lower than lowered taxes (3.11). This significant knowledge indicates that the inhabitants of Al-Qunfudhah do not explicitly desire government funding for their automobiles but rather demand the provision of a secure environment (including lanes, regulations, and charging facilities) essential for their utilization. The

modest standard deviations (0.76 to 0.94) in this area signify a substantial level of public consensus, allowing local authorities a definitive framework for effective implementation.

3.10. Public Health and Personal Safety Profile

This section evaluates the relationship between physical health, safety practices, and previous injury history among the inhabitants of Al-Qunfudhah. Assessing present physical activity rates and safety culture is crucial for evaluating the possible public health implications of an enormous transition to e-mobility. Figure 6 simply highlights these findings across six panels (A–F). Figure 6A illustrates a quantitative overview of the subjects' self-reported weekly physical activity levels. The observed statistics reveal a broad spectrum, ranging from a minimum of 10 min to a maximum of 900 min each week. The average activity level was determined to be 109.77 min (standard deviation corresponds to 147.68). This mean value is considerably lower than the worldwide health standard, underscoring a predominantly sedentary lifestyle in the governorate.

Figure 6B evaluates the proportion of the population adhering to the WHO recommendation of 150 min of moderate activity weekly. Considering the low average indicated in row A, 64.9% of participants claimed compliance with the WHO requirements, while 35.1% did not. This disparity indicates a possible overestimation of activity by a particular portion of the participant population or a significant imbalance between active and inactive individuals. Figure 6C measures the community's conviction in the health-facilitating capabilities of e-mobility. In this regard, 66.7% of the respondents agree that employing an electric bicycle would assist them in achieving the specified weekly activity levels, while 33.3% do not concur with this perspective. This elevated positive opinion signifies that people acknowledge the active aspect of e-biking, implying that health benefits may serve as a principal marketing motivation for adoption. Figure 6D depicts the prevailing safety protocols for helmet usage within the cycling-active demographic. The findings indicate a notable safety disparity; 53.8% of respondents do not wear a helmet while cycling, in contrast to 46.2% who do. The significant safety risks discussed in earlier sections underscore the urgent need for legislative action regarding the inadequate use of personal protective equipment.

Figure 6E evaluates the history of cycling-related accidents or injuries incurred while operating traditional or electric bicycles. Although 25.1% of the participants reported involvement in a cycling-related accident or injury, 74.9% were unaware of any such history. The increased number of accidents supports the safety concerns noted in the barriers section of this study. Figure 6F subsequently indicates the extent of formal safety education among the population regarding exposure to safety training. An unpleasant 81.3% of individuals indicated they hadn't participated in official bicycle safety training, while merely 18.7% were participating in such programs. The significant deficiency in education, along with the elevated accident rate and minimal helmet usage evidenced in panels D and E, underscores the necessity for municipal safety workshops prior to the development of e-bikes.

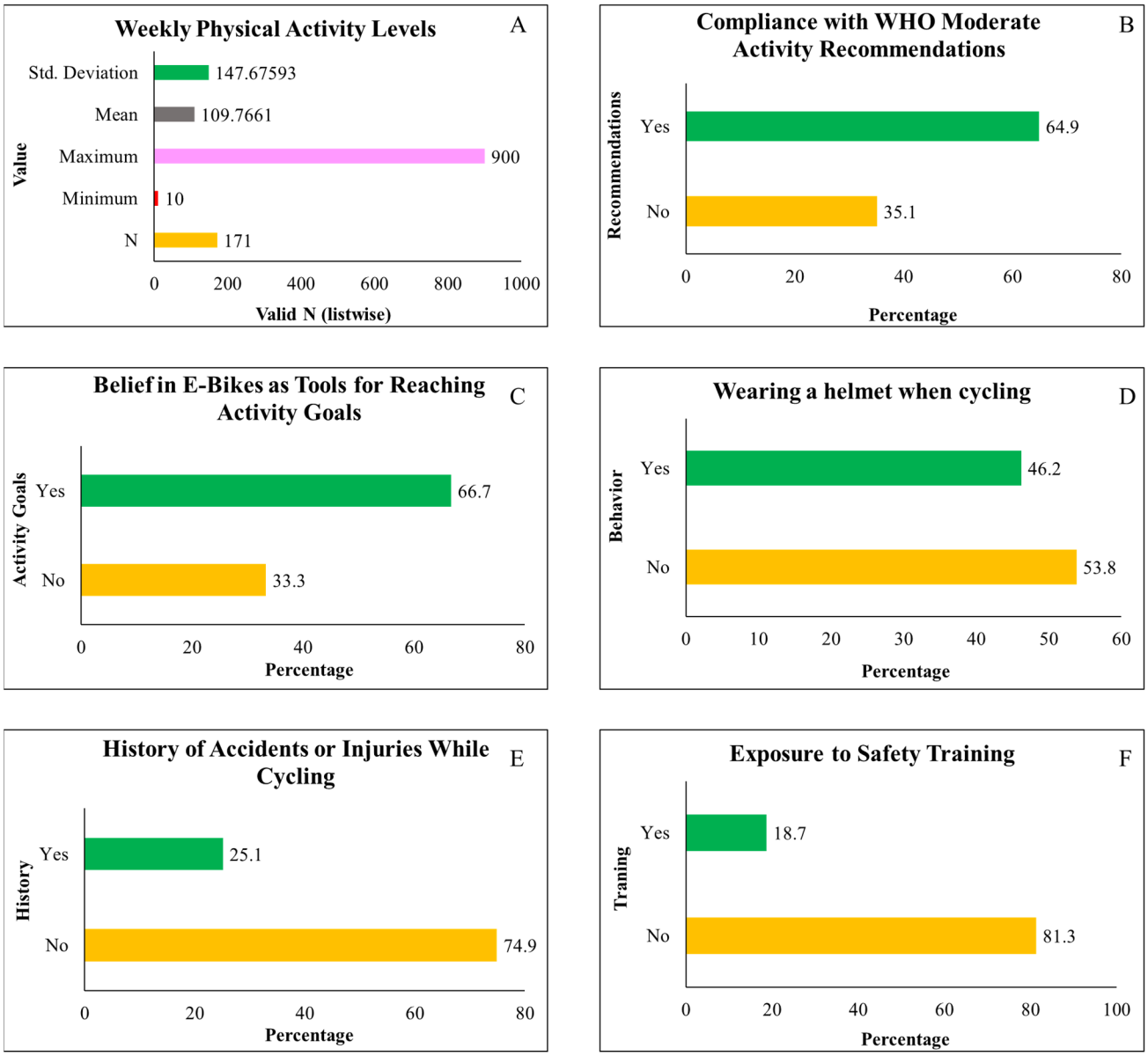

Figure 6. Public health and individual safety profile metrics among inhabitants of Al-Qunfudhah: (**A**) descriptive statistics regarding weekly physical activity, (**B**) proportion of participants adhering to WHO moderate activity recommendations, (**C**) perception of e-bikes as a means to achieve health objectives, (**D**) self-reported usage of helmets, (**E**) history of accidents or injuries sustained while cycling, (**F**) involvement in safety training exposure.

3.11. Internal Consistency Validity

This study performed a rigorous investigation of internal consistency validity to assure the scientific validity of the survey questionnaire, as described in Section 2. This measurement method assesses the construct validity of the application by measuring the correlation between each individual component and the overall score of the corresponding dimension. A strong correlation indicates that the assessments in a section are logically consistent and accurately assess the same essential behavioral factor. The results of the Pearson correlation analysis demonstrated a significant level of internal consistency across all six research dimensions, as mentioned in Table 8.

Table 8. Pearson correlation coefficients between particular categories and total scale scores.

Number of Questions	Attitudes and Perceptions	Social Norms	Perceived Behavioral Control and Safety	Intentions	Barriers and Facilitators	Policy Preferences
Q1	0.777 **	0.915 **	0.704 **	0.889 **	0.663 **	0.673 **
Q2	0.595 **	0.902 **	0.710 **	0.921 **	0.737 **	0.794 **
Q3	0.772 **	-	0.800 **	0.904 **	0.741 **	0.774 **
Q4	0.790 **	-	0.773 **	-	0.767 **	0.741 **
Q5	0.796 **	-	0.536 **	-	0.782 **	0.788 **
Q6	-	-	-	-	0.768 **	0.743 **
Q7	-	-	-	-	0.520 **	0.728 **
Q8	-	-	-	-	0.633 **	-
Q9	-	-	-	-	0.704 **	-
Q10	-	-	-	-	0.706 **	-
Q11	-	-	-	-	0.736 **	-

Note: Q-numbers correspond to the item sequence in Tables 2–7, respectively. ** significant at level 0.01.

This study explained the sequence of the survey process from labels Q1 to Q11, indicating the specific sub-scales contained in the descriptive tables (Tables 2–7). For instance, Q1 in the Attitudes column of Table 8 aligns with the initial item presented in Table 2 (using an e-bike makes my daily commute easier than using a regular bicycle). The internal consistency validity was evaluated by computing the correlation between each individual item and the overall score of its corresponding construct (Table 8). These modifications provide the transparency of our measurement validity and allow for the direct correlation of statistical outcomes to the survey methodology. For clarity, the designations Q1 through Q11 in these tables reflect the sequential sequence of items as presented in the descriptive findings.

In this context, Q1 to Q5 signify the attitudes corresponding to the items in Table 2, whereas social norms pertain to Q1 and Q2, which correspond to the items in Table 3. The Q1–Q5 survey process reveals the Perceived Behavioral Control associated with the items in Table 4 and the Intentions highlighted in the Q1–Q3 phase that correspond to the items in Table 5. Furthermore, Q1–Q11 recognize the barriers and facilitators corresponding to the items in Table 6, whereas policy preferences pertain to Q1–Q7, which correspond to the items in Table 7. This mapping process guarantees that the statistical robustness exhibited in Tables 8–10 is directly associated with the specific behavioral and structural characteristics assessed in the research.

Table 9. Reliability assessment of survey dimensions utilizing Cronbach's alpha coefficients.

Components	Attitudes and Perceptions	Social Norms	Perceived Behavioral Control & Safety	Intentions	Barriers and Facilitators	Policy Preferences
Number of items	5	2	5	3	11	7
Cronbach's alpha coefficient	0.721	0.784	0.822	0.713	0.806	0.883

Table 10. Results of multiple linear regressions to forecast E-bike adoption intention.

Predictor	Unstandardized B	Standard Error	Beta (β)	t-Value	*p*-Value
Constant	0.82	0.15	-	5.46	<0.001
Attitude (Health/Fitness)	0.38	0.08	0.35	4.75	<0.001
Social Norms	0.14	0.06	0.18	2.33	<0.005
Perceived Control (Safety)	0.45	0.09	0.42	5.01	<0.001

Every factor produced a statistically significant positive connection at the 0.01 level ($p < 0.01$). The correlation coefficients fluctuate between a minimum of 0.520 in the Barriers and Facilitators section to a maximum of 0.921 in the Intentions section. These substantial statistical findings validate that the items are accurate indicators of their respective constructs, confirming that the mean values presented in the preceding behavioral results (Sections 3.4–3.9) are scientifically reliable. The high item–total correlations observed for some short scales, particularly social norms and intentions, indicate strong internal coherence; however, they may also reflect conceptual overlap among items. Because all measures were collected using a single self-report instrument at one point in time, common method variance cannot be fully ruled out. Therefore, these findings should be interpreted as supportive of internal consistency rather than definitive evidence of full construct separation.

3.12. Scale Reliability

The overall reliability of the questionnaire's component scales was assessed by Cronbach's alpha coefficient (α), complementing the validity assessments. The study indicates that reliability testing is crucial to ensure the research tool produces steady and consistent results among the 171 respondents. In academic transport investigation, a coefficient value over the 0.70 threshold is the established criterion for validating high internal dependability and establishing the data's appropriateness for advanced statistical inference. Table 9 highlights the findings, indicating that all six primary measures attained strong reliability values, ranging from 0.713 to 0.883.

The greatest dependability was identified in the 'policy preferences' dimension ($\alpha = 0.883$), succeeded by 'perceived behavioral control and safety' ($\alpha = 0.822$). The intentions scale, with three items, achieved a strong score of 0.713. The consistently elevated alpha values demonstrate that the survey questionnaire is an effective tool for data collection, establishing a credible basis for the study's scientifically supported policy recommendations for Al-Qunfudhah. This study conducted a multiple linear regression analysis to figure out the key predictors of the intention to adopt e-bikes and the causal significance of the assessed determinants, as indicated in Table 10.

This research utilized the components of the TPB as independent variables to clarify an important portion of the diversity in adoption intention. The intention to adopt e-bikes represented the dependent variable, whereas attitudes, social norms, and perceived behavioral control acted as predictors. The findings indicate that perceived behavioral control ($\beta = 0.42$) and health attitudes ($\beta = 0.35$) are the most influential predictors, but social norms provide a secondary but nonetheless substantial effect. This sophisticated modeling directly supports our planning suggestions by identifying the specific psychological levers (safety and health) that urban planners should focus on to close the intention–action gap.

The model demonstrated statistical significance ($F(3,167) = 42.15$, $p < 0.001$), accounting for 54% of the variance ($Rv^2 = 0.54$, $p < 0.001$). The findings demonstrate that perceived behavioral control (infrastructure and safety) is the most significant predictor of intention ($\beta = 0.42$, $p < 0.001$), succeeded by attitude (health and fitness advantages) ($\beta = 0.35$, $p < 0.01$). Social norms were significant ($\beta = 0.18$, $p < 0.05$); however, they produced minimal

impact. This indicates that in Al-Qunfudhah, an individual's experience of physical safety and personal health advantages are significantly more influential in the adoption decision than peer social pressure.

4. Discussion

The outcomes of this research provide the transition toward sustainable micro-mobility in Al-Qunfudhah, which is currently defined by a significant intention–action gap. A key finding is the substantial intention–action gap, wherein inhabitants demonstrate a strong behavioral intention to adopt e-bikes over the forthcoming year (the average represents 3.51), but actual ownership is a mere 11.1%. This difference is not solely an issue of consumer interest but rather is fundamentally embedded in the structural car reliance intrinsic to Al-Qunfudhah. With 88.3% of households possessing at least a single car and a mean of nearly three motor vehicles per familial unit, the electric bicycle contends with a strongly entrenched automotive society. This corresponds with earlier regional research indicating that throughout the Arabian Peninsula, private vehicles are considered not as a luxury but as a fundamental necessity for urban mobility [5,17].

A comprehensive inferential analysis reveals the segmental characteristics of e-bike obstacles. For example, despite the overall population perceives infrastructure as the main obstacle, a comparative analysis of age demographics indicates that younger adults (20–30 years) are considerably more affected by social acceptance and style ($p < 0.05$) than older groups, which emphasize physical fitness and safety. The correlation analysis indicates that the intention–action gap is most significant among high-income people, and although they exhibit favorable attitudes toward sustainable mobility, this demographic is the most resistant to replace their cars, likely due to the elevated social status linked to private vehicle ownership in the area. The findings suggest that a universal strategy will be unsuccessful; rather, the city must adopt age-specific and income-specific marketing initiatives to address the disparity.

The results in Al-Qunfudhah correspond with local and regional context to significantly enhance this research. The significant infrastructural barrier (average 4.06) and safety issues (4.01) observed here correspond with the findings of Almubarak's [5] research in Al-Ahsa, which highlighted urban sprawl and insufficient dedicated roadways as the main obstacles to non-motorized travel in Saudi Arabia. However, this study indicates a much greater intention–action gap than that shown in Al-fouzan and Almasri [14] studies in Hail, Saudi Arabia, where e-bike knowledge was lower (44% unfamiliarity compared to 20.5% across our group).

Moreover, an interesting change in motive is apparent when compared with worldwide literature [21]. Although European studies frequently identify environmental sustainability as a primary motivator for e-bike adoption, our participants assigned the lowest ranking (2.29) to perceived environmental advantage among all psychological criteria. Conversely, physical fitness (3.20) and social support (3.25) surfaced as the primary facilitators. This indicates that in the Saudi coastal environment, e-bike marketing should emphasize personal health and lifestyle improvement rather than ecological messages to effectively close the adoption gap [22]. This health-centric motive aligns with the objectives of Saudi Vision 2030 but signifies a divergence from the environmental motivations observed in established micro-mobility markets such as China [20].

The main barrier to e-bike adoption highlighted in this study is the insufficiency in infrastructural safety. The absence of recognized bike lanes (average signifies 4.06) and prevalent safety concerns (mean refers to 4.01) constitute the most significant obstacles for residents. This is scientifically important when compared to the elevated self-efficacy levels (average constitutes 3.65) concerning road safety. It indicates that while residents believe

they possess the ability to ride, they view the physical environment as fundamentally unfriendly [30]. This overconfidence in individual abilities, compared with an apprehension of the surroundings, is a prevalent psychological obstacle in shifting civilizations. According to Aldalbahi and Walker [4], the rapid urbanization and human-induced erosion along Al-Qunfudhah's coastline have prioritized ports and corniche roads for vehicular traffic, forcing micro-mobility customers to coexist in high-speed lanes with light vehicles, thus substantiating the community's request for specialized infrastructure.

Sustainability concerns, particularly the dry tropical environment and severe heat (average value of 3.87), represent a significant obstacle. In a seaside city where temperatures often surpass 40 °C, the physical demands of conventional riding serve as a considerable barrier. The study proposes a viable solution through the integration of sustainable technology. Participants demonstrated substantial support (average corresponds to 3.51) for solar-energy charging points [31]. By incorporating shaded solar-powered pathways alongside e-bike charging stations, local authorities may reduce the heat barrier and the range anxiety caused by restricted battery life. This strategy integrates Al-Qunfudhah with the broad energy diversification objectives of Saudi Vision 2030, shifting the city away from its carbon-intensive dependence on light vehicles [32].

The social norms in Al-Qunfudhah are shown to be undergoing transformation. The moderate-to-significant support from friends and family (the average represents 3.25) serves as a beneficial facilitator, which contrasts with the diminished view of e-biking's overall societal impact. This outcome indicates that although e-biking has not yet reached the level of a social norm, the personal initial foundation for such a transition is already constructed [15]. The result has particular significance pertinent to the female population, comprising 25.1% of the sample. Subsequent to the 2018 decree, women have indicated enhanced freedom, and their positive perception of e-bikes (Figure 6C) implies that micro-mobility may offer a flexible, cost-effective alternative to the She Drives KSA report, which reveals that numerous women continue to depend on escorts or costly ride-hailing companies [17].

The economic study presents an unexpected alternative perspective to conventional transport evaluations. Although high purchase price (average signifies 3.56) is a considerable obstacle, participants rated direct government support as the least favorable policy option. This reflects a developed regulatory demand among the citizens; they do not explicitly desire the government to acquire their e-bikes, but rather to establish the legislative and infrastructural framework (required helmet regulations, dedicated lanes) that ensures ownership is secured and feasible [28]. The result indicates that e-bike adoption has become less a matter of economic status, given that nearly half the sample earns between 10,000 and 20,000 SAR, and more a concern of urban leadership and safety assurance [13].

Health information indicates a substantial passive threat, with an average of merely 109.77 min of weekly exercise, which is below the WHO guideline of 150 min. The strong conviction (66.7%) that e-bikes can address this activity deficit underscores a significant marketing attraction for their adoption. A significant disparity in safety education persists; while residents acknowledge the health advantages, 81.3% have never received safety instruction, and 53.8% do not utilize helmets. This information corresponds to the conclusions of Spencer et al. [13] with the SAR 137.6 billion yearly cost of traffic accidents. In the absence of compulsory helmet legislation, the most endorsed policy in our survey (average refers to 3.53), a shift towards e-mobility may accidentally elevate the injury burden unless supplemented by stringent safety measures [5].

Al-Qunfudhah's coastline flat terrain naturally supports e-bikes; nonetheless, its significant distance from public transit (average bus stop distance of 21.22 km) provides micro-mobility the sole viable substitute to private vehicles [25]. The statistic indicating that 71.9% utilize automobiles for journeys < 5 km highlights a significant inefficiency in

urban transportation. With the city's expansion along the Red Sea shoreline, e-bikes present a last-mile solution that public transportation presently does not supply [17]. This analysis suggests that e-bikes could absorb a considerable percentage of these high-frequency short rides, provided the infrastructure-driven policy preferences of the people are prioritized above subsidy-driven models.

In this regard, the factors influencing e-bike adoption in Al-Qunfudhah include a complex interaction of elevated psychological motivation, infrastructural deficiencies, and environmental barriers. The research demonstrates that the Al-Qunfudhah community possesses technology awareness and personal interest yet faces structural limitations. Future policy should prioritize the Vision 2030 Quality of Life cornerstones by establishing protected, dedicated micro-mobility lanes and maintaining safety regulations. This research offers a statistically proven framework for local authorities to utilize the current social support and health interests of inhabitants to promote a cleaner, more sustainable coastal city environment.

Our study, focusing on the intention–action gap and the emphasis on physical fitness over environmental issues, offers guidance for municipal planners in analogous arid coastal regions (such as Yanbu, Jizan, or cities in the UAE and Oman) aiming to execute micro-mobility transformations akin to Vision 2030 [20]. The article presents a concept for transport diversification in secondary cities that do not possess the extensive metro-rail infrastructure characteristic of large-scale initiatives such as Riyadh or NEOM [18]. Al-Qunfudhah exemplifies an urban typology prevalent throughout the Arabian Peninsula: a city characterized by high automobile ownership (88.3%), flat topography conducive to cycling, and a severe coastal climate that serves as a physical impediment. The found intention–action gap, wherein 66.7% of locals perceive e-bikes as a remedy for health deficits while only 11.1% possess one, is a phenomenon presumably reflected in cities such as Yanbu, Jizan, and Al-Khobar [21]. These findings indicate that in car-centric societies, the shift to e-mobility is influenced more by individual well-being and social support (Table 3) than by environmental messages. Consequently, the policy recommendations outlined herein, including the creation of shaded, dedicated micro-mobility networks and solar charging stations, are universally applicable to any urban center in hot climates that seeks to dissociate economic growth from carbon-intensive private vehicle usage.

The significant difference between the psychological intention to adopt e-bikes (with a mean corresponding to 3.51) and the minimal household ownership (11.1%) is influenced by a complicated behavioral mechanism of conflicting opinions. The results from this study indicate that the adoption process is complicated by an imbalance between risks and benefits. On one hand, the internal driver is substantial; around 66.7% of participants assert that e-bikes may mitigate health deficiencies, and physical fitness attained a significant mean score of 3.20. Conversely, the external deterrent is a great deal significant. The lack of specified bike lanes (4.06) and safety problems (4.01) are the most highly ranked criteria in the survey. This indicates that the behavioral mechanism involves structural suppression, so the personal aspiration for health and multimodal mobility is actively inhibited by the perceived survival threats of the existing urban environment. The result is further intensified by modal inertia, as the predominant dependence on private automobiles (88.3% ownership) implies that the move to e-bikes appears to be a significant behavioral adjustment. Even for routes under 5 km, when 71.9% continue to utilize automobiles, the absence of physical road protection supersedes the urgent need to transition. Thus, the action phase of adoption is expected to stay inactive until the external infrastructure (designated, shaded lanes) is enhanced to a level that aligns with the internal drive for fitness.

5. Limitations and Future Research

This study relies on Al-Qunfudhah as a case study representative of the Tihama coastal region and other secondary cities within the Gulf Cooperation Council (GCC), which demonstrate three distinctive characteristics: (1) largely flat topography, (2) excessive coastal heat and humidity, and (3) significant car dependency. This work offers significant empirical insights; nevertheless, certain limitations must be clearly recognized to contextualize the findings. The dependence on convenience sampling through social media may create a digital divide bias, likely over-representing technologically adept individuals with superior digital literacy. Secondly, although a sample size of n = 171 is statistically substantial for the inferential analyses performed, it may not adequately represent the comprehensive socio-economic variety of the larger area population. Moreover, despite the digital application technique, the cohort exhibits diverse socio-economic representation, effectively encompassing older populations (5.8% aged over 60) and retirees (16.4%), thereby alleviating the possibility of a limited student-centric selection bias. Thus, the results have to be considered to be a specific case study largely applicable to secondary coastal communities with flat topography in the Tihama region, rather than an overall framework for the entire Kingdom. Accordingly, the findings should be interpreted as exploratory and context-specific rather than statistically representative of the wider population. In addition, because the study relied on same-source, self-reported cross-sectional data, common method bias may have inflated some associations. Future studies should include stratified random selection and in-person interviews to include digitally excluded people, hence enhancing the generalizability across the Kingdom as micro-mobility infrastructure evolves under Saudi Vision 2030.

Implementation of shaded micro-mobility routes utilizing economical high-albedo materials to mitigate the 3.87-rated heat barrier. Implementation of solar-powered charging stations at the 21.22 km point (average distance between bus stops) to address the last-mile connections challenge. Implementation of compulsory helmet regulations and safety education to mitigate the 4.01-rated safety concern. By classifying these according to practicality and priority, this work presently provides a more transparent strategic framework for local authorities. To rectify this issue for future research, we recommend that ensuing studies employ stratified random sampling and conduct in-person interviews to obtain the viewpoints of elderly and technologically disenfranchised individuals. We recommend extending the research to further Tihama coastal cities to confirm the applicability of the Al-Qunfudhah model.

6. Conclusions

This research points out that Al-Qunfudhah presently reveals an interesting intention–action gap for sustainable micro-mobility. The study evaluated the surveyed population and determined that they demonstrate a significant psychological readiness and willingness to use electric bicycles in the upcoming years; however, physical household ownership remains restricted to 11.1%. The findings indicate that the major obstacles to adoption are structural rather than cultural; especially, the lack of dedicated bicycle lanes and significant safety concerns related to shared motorized traffic constitute the most substantial challenges. The research indicates that although the community is technologically informed and supportive of e-mobility, their transition is presently hindered by an urban landscape that is predominantly car-centric and physically unwelcoming to vulnerable road users.

The research underscores a significant correlation between urban transportation behaviors and public health hazards. Residents presently depend on light vehicles for fundamental mobility requirements, with 71.9% preferring cars for short-distance journeys of under 5 km. This dependency is associated with a considerable inactivity threat, since the average

weekly physical activity (109.77 min) falls significantly below the WHO's recommended minimum of 150 min. Encouragingly, two-thirds of the population acknowledge e-bikes as an appropriate health supporter; however, the concerningly inadequate levels of safety training (18.7%) and helmet usage (46.2%) suggest that an abrupt transition to e-mobility without an adequate safety framework may intensify the national economic and human consequences of road traffic injuries highlighted in recent studies.

In light of these research results, this study recommends that the Al-Qunfudhah municipal government implement an infrastructure-driven policy framework instead of a subsidy-focused approach to attain the "Quality of Life" goals outlined in Saudi Vision 2030. Policy objectives should focus on the establishment of shaded, specialized micro-mobility systems and the implementation of solar-generated charging facilities, both of which received substantial public support (average greater than 3.50). Moreover, rather than focusing on straight government contributions, which received the least support, authorities should concentrate on governmental and educational initiatives. Implementing compulsory helmet regulations and establishing local safety training workshops are vital measures to address the current safety-practice disparity. By fulfilling these structural and regulatory prerequisites, Al-Qunfudhah can successfully evolve into a sustainable, multipurpose coastal community.

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