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Environmental Living Conditions in Urban Centers and Their Impacts on Health: Case Study of the Attica Region

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Abstract

Urban living conditions shape health through interlocking environmental exposures, infrastructure constraints, and behavioral opportunities. This paper examines how perceived environmental conditions vary across the Attica Region and how these differences plausibly translate into unequal cardio-respiratory and mental health burdens. A cross-sectional online survey (April–June 2022) captured responses from 1,883 residents across the seven regional units of Attica (Central Sector, North Sector, South Sector, West Sector, Piraeus, East Attica, West Attica). The Central Sector emerged as the most environmentally constrained urban setting: respondents reported the highest perceived density, very high perceived traffic burden, elevated noise disturbance and the highest perceived atmospheric pollution The Central Sector also showed the weakest cycling environment despite relatively high walking/cycling frequency compared with several peripheral units. Piraeus and the West Sector also concentrated multiple stressors. Across Attica, 60% reported walkable access to green space, yet meaningful inequalities appeared by unit; public participation was low, with only ~8% reporting that their opinion had been requested for health-benefiting changes. Associations between unit of residence and key environmental conditions were consistently significant, with effect sizes ranging from small-to-moderate overall and strongest for bicycle-lane availability. Findings support an environmental-planning interpretation: exposures and protective resources cluster geographically, reinforcing health inequities.

Keywords: Urbanization, Environmental health, Quality of life, Cities, Regions, Environment, Society.

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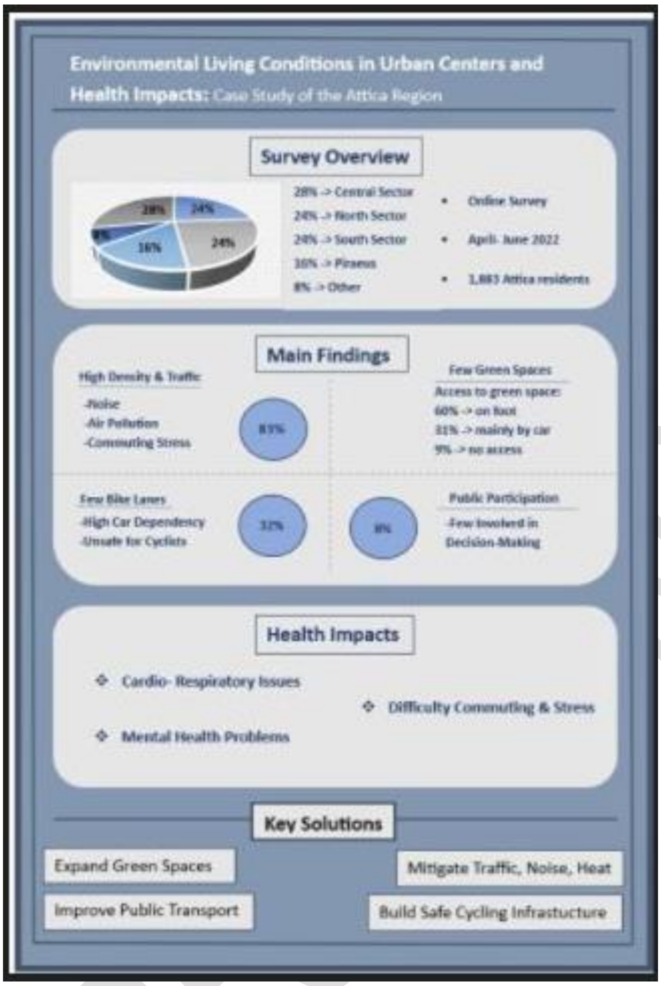
Graphical abstract



1. Introduction

Attica is the country's demographic and economic core, and it carries the typical signature of a Mediterranean metropolitan region: dense central districts, large daily commuting flows, heavy reliance on road transport, and uneven distribution of green infrastructure. (Stefanou, I., & Mitoula, P. 2003, Theodoropoulou & Kaldis 2008).). Those ingredients are not just "urban character." They are upstream determinants of disease risk. Air pollution and environmental noise increase cardio-respiratory morbidity and mortality, while limited green space and weak active-transport infrastructure reduce opportunities for physical activity and psychosocial restoration (EEA, 2024, 2025; WHO, 2018, 2021). These exposures co-occur with climate-related stressors such as heat and extreme precipitation, which increasingly disrupt daily life and compound vulnerability in dense urban areas (Intergovernmental Panel on Climate Change [IPCC], 2022). The contemporary urban-health literature is clear on mechanisms. Combustion-related pollutants (especially $PM_{2.5}$ and NO_2) contribute to systemic inflammation, atherosclerosis progression, and exacerbations of asthma and chronic obstructive pulmonary disease, producing population-level burdens even at relatively low concentrations (WHO, 2021). Environmental noise, especially from road traffic, is not merely "annoying"; it acts through sleep disturbance, stress pathways, and cardiometabolic dysregulation, increasing risk of ischemic heart disease and other adverse outcomes (WHO, 2018). Meanwhile, accessible, safe green space supports physical activity, reduces heat exposure, buffers noise and air pollution in certain contexts, and improves mental wellbeing through stress reduction and social interaction (WHO Regional Office for Europe, 2016).

Despite this well-established causal architecture, policy decisions are typically made with incomplete integration of residents' lived experience. Environmental monitoring networks, mobility datasets, and land-use indicators matter, but so do perception-based measures, because perceived exposure and perceived accessibility shape behavior: people avoid outdoor activity if they believe air is "bad," routes are unsafe, or the urban environment is hostile to walking and cycling. Perceptions also influence community acceptance of interventions. This study contributes a region-wide profile of perceived environmental living conditions across Attica, with a particular emphasis on how the highly urbanized Central Sector differs from less dense units. The survey-based approach is intentionally environmental in framing: it treats the urban fabric as an exposure system (pollution, noise, heat, traffic) and a resource system (green space, recreation infrastructure, public transport, social cohesion, and access to services). That framing is aligned with the logic of "healthy urban planning," the EU's zero-pollution orientation, and the prevention-first direction of public health policy (European Commission, 2021; WHO, 2018, 2021).

We could mention studies on the effect of environmental conditions that have been investigated in Greece, such as for example, "Impact assessment of environmental pollution in health: the case of Kifissos river", (Evrenoglou, 2013), "Effects of air pollution on the health of inhabitants of Heraklion city, Crete, Greece", (Tzanakis, 1993). The paper's novelty lies in combining region-wide coverage across all seven units of Attica with perception-based environmental indicators and effect-size interpretation, allowing comparison of how burdens and protective resources cluster within the same metropolitan region. The study's added value lies in comparing all seven regional units through residents' perceptions while interpreting associations by effect size; however, the non-proportionate municipality distribution warrants cautious generalization.

2. The contribution

This paper's contribution is threefold.

First, it offers a comparative, Attica-wide mapping of environmental living conditions from residents' perspective, rather than isolating one municipality or one hazard. Urban health burdens rarely arise from single exposures; they emerge from clustered conditions: traffic congestion correlates with perceived air pollution and noise, while lack of cycling infrastructure correlates with car dependence and reduced routine physical activity. A multi-domain instrument captures that "exposure bundle" more realistically than single-topic surveys. Second, the analysis goes beyond reporting chi-square significance by explicitly using symmetric association measures (Phi and Cramer's V) to estimate the strength of relationships among qualitative variables. This matters because large samples can produce statistically significant p-values even for weak relationships. Reporting effect size responds to the methodological expectation that observed "associations" be interpreted in magnitude, not merely in significance (Cohen, 1988). Third, the paper translates findings into environmental-planning and public-health action, using residents' own priorities as a feasibility filter. In other words: the recommendations are not generic. They align with both established evidence and the expressed preferences of the surveyed population, which increases the plausibility of implementation and long-term compliance.

3. Research Area

The Attica Region comprises seven regional units: Central Sector of Athens, North Sector, South Sector, West Sector, Piraeus, East Attica, and West Attica. These units differ in urban form, population density, land use mix, and transport geography. Central Athens and adjacent sectors exhibit dense built form and high traffic intensity; peripheral areas include lower-density neighborhoods and semi-urban or mixed land-use zones.

From an environmental-health standpoint, Attica is an instructive case for three reasons:

3.1. *Traffic and transport emissions*

Dense road networks and high private-vehicle volumes elevate NO_2 and PM exposure near major corridors, while also increasing noise exposure. Transport emissions remain a core issue for urban air quality in Europe (EEA, 2024). EU air-quality legislation sets limit values and requires management plans, but achieving health-protective exposure reductions often requires structural mobility change, not only compliance measures (Directive 2008/50/EC).

3.2. *Environmental noise*

Road traffic dominates noise exposure in European cities. The Environmental Noise Directive institutionalizes noise mapping and action planning, signaling that noise is recognized as an environmental pollutant requiring governance (Directive 2002/49/EC; EEA, 2025).

3.3. *Climate vulnerability and urban heat*

Mediterranean cities experience heat extremes and wildfire/flood risk, with dense neighborhoods especially affected by the urban heat island effect and limited cooling resources (IPCC, 2022).

The survey's geographic structure permits comparisons that approximate an "urbanization gradient": from highly dense central districts to less dense peripheral units. Even with a perception-based approach, this gradient is meaningful because it reflects how residents experience the environmental consequences of urban form.

4. Research

4.1. *Study design and participants*

A cross-sectional, online survey was administered from April to June 2022. The sample included 1,883 valid cases, with no missing values in the key demographic and primary environmental-access variables reported here. Participants self-identified their regional unit of residence within Attica. The demographic profile was: 56.4% women (n = 1,062) and 43.6% men (n = 821). Age distribution was skewed toward younger adults: 18–25 years (39.6%), followed by 46–60 (23.7%), 36–45 (18.7%), 26–35 (12.1%), 61–75 (4.6%), and above 76 (1.3%). Regional-unit representation was highest in the Central Sector (27.6%), North Sector (23.8%), South Sector (24.2%), Piraeus (16.1%), West Sector (5.0%), East Attica (2.6%), and West Attica (0.6%). The small West Attica subsample is a clear limitation for inference, although it still contributes descriptive value.

Tables 1 and 2 present the regional-unit and municipality distribution of the sample. The sample is satisfactory for descriptive analysis of the most urbanized parts of Attica, but it is not fully representative of the Region as a whole because participation is concentrated in a limited number of municipalities, whereas East and especially West Attica are weakly represented.

Table 1. Regional-unit representation of the sample.

Regional unit	% of total sample
Central Sector	27.6%
North Sector	23.8%
South Sector	24.2%
Piraeus	16.1%
West Sector	5.0%
East Attica	2.6%
West Attica	0.6%

Table 2. Municipalities from which questionnaires were collected and their share in the total sample.

Regional unit	Municipality	%
Central Sector	Municipality of Athens	8.8
Central Sector	Municipality of Vyronas	4.7
Central Sector	Municipality of Zografou	1.5
Central Sector	Municipality of Kaisariani	5.4
Central Sector	Municipality of Filadelfeia-Chalkidonos	3.9
Central Sector	Municipality of Ilioupoli	3.3
North Sector	Municipality of Agia Paraskevi	7.6
North Sector	Municipality of Kifisia	9.6
North Sector	Municipality of Penteli	0.5
North Sector	Municipality of Amarousio	1.8
North Sector	Municipality of Vrilissia	3.3
North Sector	Municipality of Nea Ionia	0.1
North Sector	Municipality of Chalandri	0.9
South Sector	Municipality of Elliniko-Argyroupoli	1.5
South Sector	Municipality of Agios Dimitrios	10.19
South Sector	Municipality of Kallithea	6.42
South Sector	Municipality of Nea Smyrni	3.0
South Sector	Municipality of Moschato-Tavros	0.16
South Sector	Municipality of Palaio Faliro	2.92
Piraeus	Municipality of Drapetsona	3.8
Piraeus	Municipality of Korydallos	5.4
Piraeus	Municipality of Piraeus	6.9
West Sector	Municipality of Aigaleo	2.4
West Sector	Municipality of Petroupoli	1.1
West Sector	Municipality of Peristeri	1.5
East Attica	Municipality of Voula	2.6
West Attica	Municipality of Mandra-Eidyllia	0.6

4.2. *Measures*

The instrument included 29 items spanning: perceived neighborhood density; access to green spaces; perceived quality and availability of outdoor recreational spaces; access to gyms/sport facilities; mobility patterns (car use and active travel); perceived availability of bicycle lanes; satisfaction with public transport; perceived traffic burden; difficulty commuting to work; perceived noise and air pollution; perceived drinking-water quality issues; neighborhood social cohesion and safety; recent experience with extreme weather; work conditions; access to public health services; and whether respondents had been asked their opinion about changes that would benefit health.

4.3. *Statistical analysis*

Associations between categorical variables were tested using Pearson chi-square tests. Because categorical relationships can be statistically significant with minimal practical importance in large samples, symmetric measures were included: Phi (for 2×2 or as a general nominal association index) and Cramer's V (for larger contingency tables). In this study, Cramer's V is interpreted as a magnitude indicator: values around .10 often reflect small associations, around .30 moderate associations, and around .50 large associations, with the usual caution that thresholds are context-dependent (Cohen, 1988).

5. Survey results

5.1. *Perceived urban density is unevenly distributed and strongly concentrated in central units*

Across Attica, 82.8% of respondents characterized their area as "very" or "quite" densely populated (28.3% "very," 54.5% "quite"). The distribution differed sharply by regional unit ($\chi^2(18) = 305.845$, $p < .001$), with a moderate association magnitude (Cramer's V = .233; Phi = .403). The

Central Sector stood out: about 85.2% of its respondents rated the area as "very" or "quite" dense, and 38.0% selected "very dense" specifically, far above multiple peripheral units. The South Sector and Piraeus also showed high perceived density, consistent with their urbanized character. West Attica, by contrast, skewed toward "not dense," reflecting a different settlement form (but with very small n). Interpretively, density itself is not a pollutant; it is a structural condition that intensifies exposure to traffic emissions, noise, and heat when not counterbalanced by green infrastructure, low-emission mobility, and public-space planning. In that sense, perceived density is a proxy for cumulative environmental load.

5.2. *Access to green space is high overall but inequitable across the region*

Region-wide, 59.8% reported green space very close and walkable, 31.1% reported access but mainly by car, and 9.1% reported no access. The association with regional unit was significant ($\chi^2(12) = 142.063$, $p < .001$) with a small-to-moderate effect size (Cramer's V = .194). Equity-relevant differences emerged. South Sector respondents reported the highest "no access" share (about 14.7%), and Piraeus also had elevated "no access" (about 16.1%). By contrast, North Sector and East Attica showed relatively high walkable access. The Central Sector showed a mixed profile: many residents reported walkable green space, yet a non-trivial minority reported no nearby green, which is consistent with a dense city core containing both parks and highly built-up neighborhoods with limited greenery. This pattern matters for environmental health because urban green space is repeatedly linked with better mental wellbeing, lower cardio-metabolic risk, and greater physical activity, operating through multiple pathways including stress reduction and mitigation of heat and pollution exposure (WHO Regional Office for Europe, 2016). When green access depends on driving, the net health benefit can be partially offset by reduced routine activity and additional exposure to traffic burdens.

5.3. *Outdoor recreational environments often do not support exercise, especially in Piraeus and the Central Sector*

When asked whether outdoor recreational spaces in the area provide the ability to exercise, only 15.3% answered "yes, a lot," while 49.3% answered "quite," 29.3% answered "no," and 6.1% reported that such spaces do not exist nearby. The relationship with unit was significant ($\chi^2(18) = 89.866$, $p < .001$), but the association magnitude was small (Cramer's V = .126). Even with a modest effect size, the practical difference is visible in the tails. Piraeus showed the highest combined share of "no" plus "no outdoor spaces" (about 42.8%), while the Central Sector also had a high "no or none" share (about 35.8%). East Attica showed the most favorable profile (about 18.4% "no or none"). From an environmental-planning perspective, this result signals that "green space exists" does not automatically mean "space supports physical activity." Design features, maintenance, perceived safety, and connectivity determine whether public space translates into movement. This distinction is central in evidence on effective green-space interventions (WHO Regional Office for Europe, 2016).

5.4. *Access to gyms/sports facilities is relatively high, but geographic differences persist*

Overall, 58.6% reported a gym/sport facility very close and walkable, 34.5% reported access but mainly by car, and 6.9% reported no access. Regional differences were significant ($\chi^2(12) = 48.498$, $p < .001$), with a small effect (Cramer's V = .113). The Central Sector and North Sector showed high walkable access, while West Attica (again with very small n) showed the weakest access. This pattern can contribute to inequalities in structured physical activity opportunities, though the public-health priority remains everyday mobility and accessible outdoor activity, since they reach more people than gym-based routines (Sallis *et al.*, 2016).

5.5. *Mobility behavior shows a car-oriented region, but central areas are constrained differently*

Across Attica, 45.3% use a car every day, 24.8% often, 17.8% rarely, and 12.1% never. Regional-unit differences were significant ($\chi^2(18) = 66.469$, $p < .001$) with a small effect (Cramer's V = .108). Peripheral units like East Attica showed the highest daily car use (about 69.4% daily), consistent with lower-density land use and potential public-transport limitations. The Central Sector had comparatively lower daily car use (about 34.7% daily) and a much higher "never" share (about 17.5%), which plausibly reflects parking constraints, shorter trip distances, and better public transport coverage. The crucial point is that reduced car use in central areas did not correspond to a "low-exposure environment." Instead, central residents still reported high traffic burden, noise, and perceived air pollution. That is consistent with the idea that dense areas can have lower *individual* car dependence while still experiencing high *ambient* exposure due to traffic volume, street-canyon effects, and concentrated economic activity.

5.6. *Active travel is common, but the cycling environment is structurally weak in the areas that need it most*

Overall, 41.2% reported walking or using a bicycle every day, 30.8% often, 22.1% rarely, and 5.8% never. Unit differences were significant ($\chi^2(18) = 39.255$, $p = .003$) with a small effect size (Cramer's V = .083). Yet the most striking mobility result concerns infrastructure: only 32.3% reported that bicycle lanes exist in their area, while 67.7% reported none. The association with regional unit was extremely strong ($\chi^2(6) = 325.519$, $p < .001$) with a moderate-to-strong effect size (Phi = .416; Cramer's V = .416). The contrast is stark: in the Central Sector, only about 13.7% reported bicycle lanes, while Piraeus was even lower (about 9.5%). Meanwhile, North Sector and South Sector reported higher availability (about 57.9% and 41.4% "yes," respectively). From an environmental perspective, this is a "missed mitigation opportunity." Cycling infrastructure is not only a lifestyle amenity; it is a decarbonization and exposure-reduction tool. Shifting trips from car to active modes reduces emissions and local pollution, and it can reduce traffic noise when implemented at scale and paired with traffic calming (EEA, 2024, 2025; WHO, 2018, 2021). The strongest association in the dataset being about bicycle lanes suggests the urban form of Attica is producing a highly uneven distribution of low-emission mobility opportunity.

5.7. *Public transport satisfaction is moderate, but dissatisfaction exists across all units*

Region-wide, 11.1% were "very" satisfied with urban transport networks, 49.7% "quite," 31.0% "a little," and 8.2% "not at all." Differences across units were significant ($\chi^2(18) = 36.978$, $p = .005$), but with a small association (Cramer's V = .081). This result is consistent with a region where public transport is present but not universally convenient, reliable, or integrated. From a policy lens, the goal is not merely satisfaction; it is mode shift. Even modest improvements in service frequency, accessibility, and last-mile connectivity can reduce car dependence, thereby reducing both pollution and noise exposures (EEA, 2024, 2025).

5.8. *Traffic burden is concentrated in dense, central, and coastal-urban units*

Overall, 40.0% said their area faces traffic problems "very," 49.7% "quite," and only 10.3% "not at all." Differences by unit were significant ($\chi^2(12) = 92.832$, $p < .001$), with a small-to-moderate association (Cramer's V = .157). The Central Sector and South Sector were the most burdened: around 91% of respondents in each selected "very" or "quite." Piraeus also showed a very high traffic-problem profile (~93% "very" or "quite"). Traffic congestion is not only a time cost; it is a pollution and noise generator, and it increases exposure duration for commuters, pedestrians, and residents near major corridors. These pathways are why urban-transport interventions are repeatedly highlighted in health-protective urban policy (WHO, 2018, 2021).

5.9. *Commuting difficulty is highest in the Central Sector, supporting an exposure-plus-stress pathway*

Across Attica, 22.3% reported commuting difficulty "very," 46.9% "quite," and 30.8% "not at all." Unit differences were significant ($\chi^2(12) = 37.254$, $p < .001$), with a small effect (Cramer's V = .099). The Central Sector had the highest combined "very" or "quite" difficulty (about 74.6%). This matters because commuting is not just a mobility behavior; it is a daily stressor that amplifies the health effects of environmental exposures. Noise and air pollution exposures are often concentrated along commuting routes, while stress and time scarcity reduce capacity for physical activity and sleep. The clustering of these burdens in central areas supports a plausible pathway toward elevated cardio-metabolic risk and poorer mental wellbeing.

5.10. *Noise pollution is a major urban complaint, especially in central and western sectors*

Overall, 15.0% reported noise problems "very," 28.7% "quite," 37.2% "a little," and 19.2% "not at all." Differences by unit were significant ($\chi^2(18) = 111.481$, $p < .001$) with a small-to-moderate effect size (Cramer's V = .140). The West Sector showed the highest "very or quite" noise burden (about 53.2%), followed by the Central Sector (about 49.5%), and Piraeus (about 50.7%). These patterns align with the known dominance of transport noise in urban environments and the particular vulnerability of dense street networks and high-traffic areas. This is not a cosmetic issue. WHO's environmental noise guidelines treat transport noise as a priority pollutant with established adverse health impacts (WHO, 2018). The EEA similarly frames noise as a widespread, under-addressed environmental health risk in Europe (EEA, 2025). For Attica, the convergence of traffic burden and noise complaints suggests that noise-abatement measures (traffic calming, low-noise road surfaces, speed management, and better enforcement) are not optional add-ons; they are core health interventions.

5.11. *Perceived atmospheric pollution is high in central and coastal-urban units*

Across Attica, 43.9% answered "yes" to experiencing atmospheric pollution problems in their area, 29.7% "maybe," 17.2% "no," and 9.2% "don't know." Differences by unit were significant ($\chi^2(18) = 102.736$, $p < .001$), with a small-to-moderate association (Cramer's V = .135). The Central Sector had the highest "yes" proportion (about 46.8%) and a high combined "yes or maybe" share (about 76.9%). South Sector and Piraeus were similarly elevated in combined "yes or maybe." The West Sector showed the highest "yes" proportion (about 53.2%), despite its smaller size, suggesting localized pollution concerns. These perceptions are consistent with the broader European evidence base on urban air pollution burdens and the health rationale for stricter air-quality targets (EEA, 2024; WHO, 2021). Perception-based data cannot substitute for monitoring, but it does identify where residents feel the burden and therefore where interventions may gain support.

5.12. *Drinking-water quality concerns exist but are less dominant than air/noise, with uncertainty a key theme*

Overall, 7.1% reported water-quality problems ("yes"), 63.3% "no," 14.1% "maybe," and 15.5% "don't know." Differences by unit were significant ($\chi^2(18) = 42.840$, $p = .001$), with a small effect size (Cramer's V = .087). Notably, uncertainty ("maybe" and "don't know") accounted for nearly 30% of responses. This suggests a communication and trust dimension: even when the majority does not report direct problems, a substantial portion lacks confidence or information. Environmental health governance often depends as much on transparent communication as on infrastructure performance.

5.13. *Social cohesion and safety vary by unit, and central areas show weaker social ties*

Social context is part of the environmental-health system because it influences perceived safety, outdoor activity, and stress. Relationships with neighbors varied significantly across units ($\chi^2(24) = 61.842$, $p < .001$) with a small effect (Cramer's V = .091). Social contact frequency also differed ($\chi^2(12) = 34.788$, $p = .001$), again with a small effect

(Cramer's V = .096). Still, the Central Sector consistently looked less cohesive: about 23.5% reported "no social contacts with neighbors," higher than other units, and about 40.5% rated neighbor relations as "poor" or "no relationship," again among the highest. These are not merely sociological curiosities; weaker social cohesion is associated with poorer mental wellbeing and reduced informal safety, both of which can discourage outdoor activity and increase stress. Safety perceptions differed by unit ($\chi^2(12) = 33.088$, $p = .001$; Cramer's V = .094). Across Attica, the majority reported "moderate safety," but a meaningful minority reported high insecurity. In dense areas, insecurity is not only a crime issue; it becomes a physical-activity barrier and a mental health stressor.

5.14. *Extreme weather disruptions are widespread, signaling climate-health relevance*

Overall, 60.1% reported having faced recent extreme weather phenomena in their area. Differences across units were significant ($\chi^2(6) = 172.634$, $p < .001$), with a moderate association magnitude (Phi = .303; Cramer's V = .303). The North Sector and West Attica reported especially high "yes" proportions, while Piraeus reported lower "yes" (about 35.9%). This pattern is consistent with the spatially uneven nature of climate hazards: wildfire exposure, flash flooding, and heat impacts differ by topography, vegetation, and built form. The health significance of this result is not hypothetical. The IPCC highlights climate-related risks to health in urban areas, including heat stress, infrastructure disruption, and compound hazards (IPCC, 2022).

5.15. *Access to public health services and civic participation show equity-relevant gaps*

Regarding access to public health systems, overall 16.8% reported "very" easy access, 57.8% "quite," 12.7% "not at all," and 12.7% reported having access but preferring private structures. Differences across units were significant ($\chi^2(18) = 49.522$, $p < .001$), with a small effect (Cramer's V = .094). Equally important, civic participation was notably weak. Only 7.6% reported that they had been asked their opinion about changes that would benefit their health; 75.5% said "no," and 16.8% did not remember. Unit differences were significant ($\chi^2(12) = 28.697$, $p = .004$), with a small association (Cramer's V = .087). Low participation is an environmental governance problem because successful interventions (cycling networks, traffic calming, green-space changes) require public trust and co-ownership. Without participatory channels, the region risks implementing fragmented or politically reversible measures rather than durable environmental-health improvements.

Respondents suggested specific changes for improving living conditions within the urban environment such as: increase parks, dealing with traffic and increasing parking spaces, dealing with crime, improving health system, dealing with noise pollution, strengthening of social relations.

6. Discussion

This survey across Attica (N = 1,883) paints a pretty coherent story: where urbanization intensity is highest, residents report a tighter knot of environmental stressors and mobility barriers. The Central Sector of Athens stands out most clearly, with respondents disproportionately describing their area as "very" or "quite" densely populated (χ^2 significant; $\Phi = .403$; Cramer's V = .233), alongside stronger complaints about traffic congestion (χ^2 significant; V = .157), noise (χ^2 significant; V = .140), and perceived atmospheric pollution (χ^2 significant; V = .135). These are not trivial differences. While Cramer's V values here mostly fall in the small-to-moderate range, they are consistent across multiple exposures, implying a patterned urban environmental burden rather than random annoyance.

That pattern aligns with established environmental health pathways. Traffic-related air pollution is robustly linked to cardio-respiratory morbidity and mortality, with both short-term and long-term exposure contributing to acute events and chronic disease progression (Kanellopoulos, N. 2023). More broadly, pollution remains a major global health driver, with air pollution a key component and an especially relevant stressor in dense, traffic-heavy urban regions (Fuller *et al.*, 2022). Central Sector findings are, basically, what the literature predicts when large volumes of vehicles, street canyons, and constant movement meet limited buffering infrastructure. This is consistent with the studies cited in the theoretical section and with WHO/EEA evidence that dense, traffic-intensive urban settings accumulate transport-related air-pollution burdens.

Noise shows a similar convergence. Residents in higher-density units report more noise problems, and the association by unit is significant (V = .140). Environmental noise is not just "annoying"; epidemiological and mechanistic evidence ties chronic transportation noise to hypertension, ischemic heart disease, and stroke risk, mediated through stress physiology, sleep disturbance, endothelial dysfunction, and oxidative stress (Münzel *et al.*, 2014; Münzel *et al.*, 2018). When data show that traffic congestion is more frequently reported in the same places where noise complaints are elevated, that co-occurrence is environmentally meaningful: traffic is a shared upstream source for both exposures, so interventions that reduce car volume or speed can plausibly improve both air and noise conditions simultaneously.

A second major theme is the "activity environment": access to green space, recreational opportunities, and safe everyday mobility. By unit, access to green space differs significantly (V = .194). The Central Sector is not the absolute worst on raw counts for "walkable" green access (because proximity exists), but the broader profile suggests that dense areas face scarcity, fragmentation, overcrowding, and lower restorative quality, which residents often experience as "lower access" in practical terms. The public-health literature is clear that urban green space supports health through multiple channels: stress reduction, opportunities for physical activity, social interaction, reduction of heat, and buffering of air and noise pollution (WHO Regional Office for Europe, 2016; Hartig *et al.*, 2014). Large-scale syntheses show greener exposure is associated with better self-reported health and reduced cardio-metabolic risks (Twohig-Bennett & Jones, 2018). So when respondents prioritize expanding and maintaining green spaces, that preference is not just aesthetic. It is consistent with evidence-based prevention, especially in high-stress, high-exposure urban environments. Cycling infrastructure is where results get almost painfully direct. The availability of bike lanes differs strongly by unit (χ^2 significant; $\Phi = .416$; Cramer's $V = .416$), with the Central Sector and Piraeus reporting "no" at especially high levels. This effect size is among the largest in outputs, implying that cycling is structurally enabled in some Attica areas and structurally suppressed in others. That matters because infrastructure is one of the strongest predictors of cycling uptake: reviews and evaluations repeatedly find that dedicated or protected lanes are associated with increased cycling, improved perceived safety, and, in many contexts, narrowing gender gaps in participation (Mölenberg *et al.*, 2019; Pellicer-Chenoll *et al.*, 2025). This survey's mobility behaviors track that logic: units differ in car dependence ($V = .108$) and in walking/cycling frequency ($V = .083$). The pattern suggests that when safe cycling networks are absent, residents default to cars even when congestion and pollution are high, reinforcing a feedback loop of emissions, noise, and inactivity. Likewise, the gap between nominal proximity to green space and actual exercise-supportive environments agrees with WHO Regional Office for Europe (2016), Hartig *et al.* (2014), and Twohig-Bennett and Jones (2018), which emphasize usability and restorative quality, not only presence.

Public transport satisfaction also varies by unit ($V = .081$). Even though the effect is modest, it becomes important when interpreted as part of a system: weak satisfaction can push households toward car dependence, which then amplifies the environmental burdens that residents are already complaining about. This is exactly why EU-level policy frames a shift to public transport and active mobility not only as a climate measure but as a public health measure that reduces environmental harm in cities (European Commission, 2020). The respondents' solution preferences mirror that policy logic: better, more accessible public transport plus continuous cycling networks and green infrastructure. The mobility pattern also matches Sallis *et al.* (2016) and Mölenberg *et al.* (2019): active travel is more likely where the built environment and network continuity make it realistic, safe, and routine.

On the social environment side, this unit comparisons show statistically significant differences in perceived neighbor relations and social contact ($V \approx .091–.096$) and in safety perceptions ($V = .094$). These are not huge effects, but they matter because social cohesion and perceived safety influence outdoor activity and mental well-being, acting as either "enablers" or "brakes" on healthy behaviors (Hartig *et al.*, 2014). Recent evidence also links higher neighborhood cohesion with better health profiles and reduced multimorbidity risk (Rowley-Abel *et al.*, 2025). In practical terms, if people do not feel safe or connected, they are less likely to walk, use parks, or engage in local recreation, which indirectly increases sedentary behavior and stress.

Demographic stratification adds nuance rather than overturning the main narrative. Sex is mostly not associated with perceptions of density, noise, or air pollution in these outputs, but it is linked to mobility and safety-related items: differences appear in access to gyms ($p = .034$), walking/cycling frequency ($p = .005$), bike-lane reporting ($p = .006$), commuting difficulty ($p = .003$), water quality concern ($p = .021$), and crime safety appraisal ($p < .001$). This is consistent with the broader mobility literature showing that safety perceptions and infrastructure availability shape participation in active travel and can structure gender differences (Pellicer-Chenoll *et al.*, 2025). Age shows stronger, more consistent associations across density perception, green space access, activity opportunities, mobility choices (car use, walking/cycling), public transport satisfaction, social contact, and safety (multiple χ^2 tests significant). That pattern likely reflects both life-stage mobility constraints and differential exposure: younger adults may have different travel modes and neighborhood experiences than older adults, and older groups may be more vulnerable to environmental burdens.

Finally, extreme-weather variable differs substantially by unit ($\Phi = .303$), reinforcing a climate-adaptation angle: residents across Attica are not only dealing with chronic stressors (traffic, noise, pollution) but also episodic disruptions consistent with climate risks in Mediterranean urban regions. This supports an environmental framing that links mitigation (reducing traffic emissions) and adaptation (cooling and flood-resilient green infrastructure) as a combined health protection strategy.

7. Implications of the results

The practical implication is that Attica's health-relevant environmental conditions are not evenly distributed. They cluster, predictably, in the most urbanized areas. For regional and municipal decision-makers, that means "universal" policies are not enough; targeted environmental upgrades in high-density units will likely produce the largest marginal health gains. In the literature, air and noise pollution reductions are among the most scalable population-health interventions because they shift risk for everyone, including people who cannot "choose" healthier behaviors due to time, income, disability, or neighborhood conditions (Fuller *et al.*, 2022; Münzel *et al.*, 2018). These results also suggest a strong case for integrated transport-environment planning. Residents reporting high congestion also report noise and air pollution issues, implying shared sources and shared solutions. Policies that reduce private car dependence (better transit coverage, reliability, affordability, and intermodality) can reduce traffic-related emissions and noise in the same stroke. This aligns with the EU's Sustainable and Smart Mobility Strategy, which explicitly frames decarbonization, reduced urban pollution, and improved quality of life as linked outcomes (European Commission, 2020). In Attica, translating that strategy into place-based investments could mean: bus priority corridors, improved first/last-mile connectivity, and street redesigns that reduce through-traffic in residential areas. The cycling infrastructure finding is especially actionable.

The very large unit differences (V = .416) suggest that cycling in Attica is less a "culture" issue and more a built-environment issue. Evidence indicates that creating continuous, separated cycling networks increases usage and perceived safety, and can reduce gender gaps (Mölenberg *et al.*, 2019; Pellicer-Chenoll *et al.*, 2025). Given that residents in several units report limited cycling infrastructure and lower active-mobility frequency, building connected networks is not just a transport amenity; it is a health promotion and emissions-reduction tool.

Green space comes out as a multi-benefit intervention, and respondents prioritize it accordingly. Expanding and maintaining green spaces can support physical activity, reduce stress, buffer heat, and reduce exposure to noise and air pollution (WHO Regional Office for Europe, 2016; Hartig *et al.*, 2014). Meta-analytic evidence links greener exposure with improved cardio-metabolic markers and lower all-cause mortality risk (Twohig-Bennett & Jones, 2018). For Attica, an environmental journal-friendly framing is straightforward: urban greening functions as both climate adaptation (heat reduction, stormwater management) and a preventive public health measure. The implication is that "green infrastructure" should be treated like essential urban health infrastructure, not decorative landscaping. Lastly, the social environment results (neighbor relations, social contact, safety perceptions) imply that public-health gains from environmental upgrades may be amplified when paired with measures that improve perceived safety and community usability of spaces. A park that feels unsafe or inaccessible does not deliver the same health value as one that is connected, maintained, shaded, and socially "inhabited."

8. Conclusions

This Attica-wide survey provides a coherent picture: urbanization intensity is associated with clustered environmental burdens, and these burdens are not evenly distributed across the region. The Central Sector, South Sector, and Piraeus concentrate many of the exposures most strongly linked in the literature to cardio-respiratory and mental health outcomes: traffic burden, noise disturbance, and perceived air pollution, combined with constraints on low-emission mobility (notably bicycle-lane absence in the Central Sector and Piraeus). These findings align with the broader European evidence that transport-related pollution and noise remain major preventable environmental health risks (EEA, 2024, 2025; WHO, 2018, 2021).

Methodologically, the consistent use of Cramer's V and Phi strengthens interpretability: many associations are statistically significant, but effect sizes are mostly small to moderate, with the strongest structural inequality appearing for bicycle-lane availability. That result is policy-relevant because it points to a concrete, scalable intervention area where infrastructure change can plausibly drive co-benefits: reduced emissions, reduced noise (at scale), increased physical activity, and better mental wellbeing through more pleasant streetscapes.

The environmental framing also clarifies why isolated interventions often fail. Improving public transport without addressing safety and last-mile connectivity limits mode shift. Adding green space without maintenance, accessibility, or shade design limits usage and heat mitigation. Promoting physical activity without reducing perceived insecurity and traffic stress sets residents up for predictable non-compliance. Environmental health improvement requires systems planning across transport, land use, green infrastructure, and climate resilience.

Based on residents' priorities and established guidance, a coherent policy package for Attica would include:

- Green infrastructure expansion and maintenance, with equitable distribution and design for usability (shade, seating, safe access), consistent with evidence on green-space health benefits (WHO Regional Office for Europe, 2016).
- Continuous cycling networks (not isolated segments), prioritizing central and coastal-urban units where lanes are currently scarce, to enable real mode shift and exposure reduction (EEA, 2024; Sallis *et al.*, 2016).
- Public transport improvements focused on accessibility, frequency, integration, and reliability to reduce car dependence and congestion-related exposures.
- Noise-abatement strategies grounded in traffic management (speed reduction, traffic calming, surface improvements, enforcement) as recommended within environmental noise governance frameworks (Directive 2002/49/EC; EEA, 2025; WHO, 2018).
- Climate resilience measures addressing extreme weather disruptions (heat adaptation, flood management, urban cooling through trees and reflective materials), consistent with urban climate-health risk guidance (IPCC, 2022).
- Participatory governance mechanisms so residents' lived experience informs planning, increasing legitimacy and sustainability of interventions.

Finally, while this study is perception-based and cross-sectional, it delivers a strong environmental-health message: the places where people live in Attica structure the exposures they cannot easily avoid and the healthy behaviors, they may not realistically practice. Reducing preventable cardio-respiratory morbidity and stress-related burden in Attica is not mainly a question of individual choices; it is a question of environmental design, transport policy, and equitable urban infrastructure. These conclusions should nevertheless be read in light of the perception-based, cross-sectional, and self-selected online sample, which limits causal inference and full regional representativeness. Future research should combine subjective responses with objective environmental indicators and more balanced municipality-level sampling, ideally through longitudinal or repeated cross-sectional designs.

9. Limitations

This study is cross-sectional, so it cannot establish causality. The observed associations between region/unit and reported exposures (traffic, noise, perceived air pollution) are consistent with plausible environmental pathways, but the design cannot determine whether environmental conditions caused specific health outcomes or behaviors, or whether people with certain preferences or constraints sort into certain areas. At best, these results provide a strong descriptive and comparative snapshot and a credible basis for hypothesis-driven follow-up. Second, the survey is online and self-selected, which introduces coverage and selection bias risks. Web surveys can under-represent individuals with limited internet access, lower digital literacy, or lower engagement with online recruitment channels, and self-selection can skew prevalence estimates and associations (Bethlehem, 2010; Dillman *et al.*, 2014). The sample is large, but size does not magically cancel selection bias. The findings should be interpreted as strong signals of differences across units rather than precise population prevalence rates for each attitude or exposure.

Third, most variables are self-reported perceptions (noise problems, air pollution problems, water quality concerns, density). Perceived exposure is meaningful for mental health, stress, and behavior, but it may not perfectly align with objective measures (e.g., PM2.5 concentrations, modeled noise levels). Research shows that perceived air quality can be associated with health outcomes even when objective measures are modest, and the two can diverge due to visibility, odor, local knowledge, trust, or media salience (Clougherty, Ocampo, 2023). This is a limitation if the goal is environmental monitoring, but it is also a strength if the goal is understanding lived experience and policy acceptability.

Fourth, common-method bias is possible because many predictors and outcomes are collected using the same instrument at the same time. This can inflate associations via shared response tendencies (Podsakoff *et al.*, 2003). The fact that some associations are null (e.g., several sex comparisons) helps, but it does not eliminate the concern. Future designs could reduce this by mixing data sources (administrative indicators, geospatial exposure metrics, mobility traces) and by separating measurement in time. Fifth, the chi-square tests indicate statistical significance for many comparisons, which is expected with large samples. Effect sizes (Phi, Cramer's V) are therefore essential, and results show that most relationships are small-to-moderate, with a few larger structural differences (notably cycling infrastructure). Interpretation should emphasize magnitude and practical relevance rather than "$p < .05$" triumphalism. Finally, the unit-level approach risks ecological oversimplification. Within-unit heterogeneity can be substantial in Attica: neighborhood-level differences in traffic corridors, topography, street design, and green-space quality can produce very different exposure profiles. The absence of objective spatial exposure mapping limits the ability to identify micro-hotspots and to propose precise interventions block by block.

10. Future research

The next step should combine subjective experience with objective environmental indicators. A mixed-methods design could link respondent locations (at least at neighborhood or postal-code level, with privacy safeguards) to modeled or monitored air pollution (PM2.5/NO2), transportation noise layers, land surface temperature, and green-space metrics. This would allow testing where perception tracks measured exposure and where it diverges, which is useful both for risk communication and for prioritizing interventions (Clougherty, Ocampo, 2023).

A longitudinal or repeated cross-sectional approach would be especially valuable in Attica, given ongoing transport projects, climate stresses, and potential greening initiatives. Tracking the same units across time would help distinguish stable structural inequalities from short-term disruptions and would support quasi-experimental evaluation when policies change (e.g., new bus lanes, new cycling corridors, pedestrianizations). That matters because the literature on infrastructure often shows that behavior change follows network continuity and perceived safety, not isolated "pilot" segments (Mölenberg *et al.*, 2019). In Future work should also examine differential vulnerability: older adults, people with chronic disease, low-income households, and residents near major roadways may experience higher physiological risk from the same exposures (Münzel *et al.*, 2018). Stratified analyses and interaction models could identify where health-protective interventions are likely to be most cost-effective.

Finally, qualitative research can deepen the environmental framing your journal wants. Interviews or focus groups could explore why residents prioritize green space, cycling networks, and transport upgrades, and what barriers they experience in daily life (safety, time, accessibility, maintenance). That would strengthen the policy translation: not only "what differs" across Attica, but "why it differs" and "what residents would actually use" if the urban environment changed. (Mitoula *et al.*, 2013)

LLM Usage Declaration: We used Grammarly to refine the English Grammar to the whole article.

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