國立臺灣大學全球衛生學位學程碩士專班

碩士論文

Global Health Program

College of Public Health

National Taiwan University

Master's Thesis

感知很重要：感知環境品質對身心健康的作用

Perception Matters: On the Role of Perceived Environmental Quality on Mental and Physical Health

謝寶儀

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中華民國113年7月

July 2024

doi:10.6342/NTU202403119

國立臺灣大學碩士學位論文
口試委員會審定書

MASTER'S THESIS (DOCTORAL DISSERTATION ACCEPTANCE CERTIFICATE)
NATIONAL TAIWAN UNIVERSITY

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Perception Matters: On the Role of Perceived Environmental Quality on Mental and Physical Health

本論文係 謝寶儀 (姓名) R11853011 （學號）在國立臺灣大學全球衛生碩士學位學程完成之碩士學位論文，於民國 113 年 07 月 23 日承下列考試委員審查通過及口試及格，特此證明。

The undersigned, appointed by the Master's Degree in Global Health Program On 23 (date) 07 (month) 2024 (year), have examined a Master's Thesis entitled above presented by Alison Tse (name) R11853011 (student ID) candidate and hereby certify that it is worthy of acceptance.

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doi:10.6342/NTU202403119

Acknowledgements

Thank you, Professor Duan-Rung Chen, for your guidance on my thesis over the last year. It has been a privilege and honor to learn from you as I navigated territory that initially seemed so daunting. Your wealth of knowledge has been indispensable, and helped me find direction and purpose with this project, for which I am grateful.

I'd also like to thank my parents for their unconditional support and love over the last two years (and since forever). Thank you to my brother for helping proofread endless sentences. And to my dogs 狗子 and 臘腸 for providing emotional support and comfort, even if lifetimes apart and through pixelated screens. I am able to write this last page not without my family.

And to the friendships I've made, gained, and hope to keep! in Taiwan—謝謝 (specially pronounced *shei shei*)—a million. GHP to the moon. Five-ever.

doi:10.6342/NTU202403119

Abstract (Chinese)

簡介：關於台灣感知環境品質對健康的作用的研究有限。本研究旨在分析感知的社區環境品質對身心健康的影響。

方法：本研究分析了 2021 年台灣社會變遷調查 (TSCS) 中收集的數據，這是一項橫斷面和調查。資料集中包含標準化心理成分總結（MCS）和身體組成總結（PCS）分數。最終分析納入了 1,423 名受訪者。使用Stata進行統計分析。

結果：對鄰裡水質、噪音品質和鄰裡關係的正面看法與較高的 MCS 分數呈正相關。研究發現，對充足陽光和公共安全的正面看法與較高的 PCS 分數相關。人口因素也在心理和身體健康狀況中發揮作用，包括性別、年齡、教育程度、就業、收入和體力活動水平。

討論：雖然眾所周知，人口因素會影響心理和身體健康質量，但這項研究表明，感知的環境品質也會產生影響。由於對環境品質的看法是健康的保護因素，政府可以尋求改善公共空間，這也可能鼓勵社區內的社會凝聚力。同時分析環境品質客觀測量的進一步研究將為台灣人口的心理和身體健康感知的作用提供更多背景。

關鍵字：知覺環境、健康相關生活品質、PCS評分、MCS評分、台灣人口

doi:10.6342/NTU202403119

Abstract (English)

Introduction: There has been limited research on the role of perceived environmental quality on health in Taiwan. This study seeks to analyze the impact of perceived neighborhood environmental quality on mental and physical health.

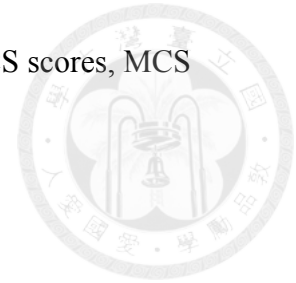
Methods: This study analyzes data collected in the 2021 Taiwan Social Change Survey (TSCS), a cross-sectional and longitudinal survey, tracking changes in health behaviors and attitudes. Normalized mental component summary (MCS) and physical component summary (PCS) scores were included in the dataset. 1,423 respondents were included in the final analyses. Stata was used for statistical analysis.

Results: Positive perceptions of neighborhood water quality, noise quality, and neighborliness were found to be positively associated with higher MCS scores. Positive perceptions of adequate sunlight and public safety were found to be associated with higher PCS scores. Demographic factors also play a role in mental and physical health status, including sex, age, educational attainment, employment, income, and physical activity levels.

Discussion: While demographic aspects are known to influence mental and physical health quality, this study shows perceived environmental quality also has an impact. As perception of environmental quality serves as a protective factor to health, the government can seek to improve public spaces that may also encourage social cohesion within communities. These recommendations are emphasized by the correlation between objective and perceived quality on health outcomes and behaviors. Further research with objective measurements of environmental quality analyzed simultaneously would provide additional context on the role of perception on mental and physical health in the Taiwanese population.

doi:10.6342/NTU202403119

Keywords: perceived environment, health-related quality of life, PCS scores, MCS scores, Taiwanese population



doi:10.6342/NTU202403119

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1. Introduction

天人合一

– There exists harmony between nature and man

Ancient Han Chinese culture has long viewed nature and man as one. This philosophy is rooted in Taoism, which originated in China and later crossed seas to flourish in Taiwan. The island of Taiwan is situated between the East and South China Seas in the Pacific Ocean, covering an area of 13,826 square miles, with a population of 23 million. Over 95% of the population is Han Chinese and the remaining are indigenous and other ethnicities. Most citizens live in the western plains, opposite the mountainous terrain of the central and eastern areas. Those living in Taiwan are surrounded by nature, and a hiking trail is never more than a single bus ride away.

Today, Taoist teachings thrive as both philosophical thought and religion in Taiwan, continuing to shape numerous aspects of life, from politics to interpersonal relationships. Beyond these realms, the underlying theme of reverence for nature persists. The Baoxing Council in Xindian, Taipei installed a holographic image of Tudigong, or “Lord of the Land”, a Taoist god, to deter littering. The image sought to remind illegal dumpers to respect both deity and nature. Within three months, littering was reported to have dropped over 70% (Long, 2023). In art, the veneration of traditional landscape paintings has endured over a millennium; the natural world is immensely valuable. Traditional landscape paintings depict rolling hills, vast mountains, untouched valleys, and raging rivers. Paintings can sell for over £105 million (Haas, 2017). In life practice, it is seen in the Taiwanese affinity for going into that nature, traversing mountain trails, biking along riversides, and enjoying a hot spring soak. It is also evidenced in the government’s investment, maintenance, and promotion of these activities across the country (National Park Law, 2010; Tourism Administration,

doi:10.6342/NTU202403119

MOTC, 2021). Respect for and spending time in nature and the surrounding environment, therefore, is clearly a fundamental part of Taiwanese culture and life.

The social ecological model posits an individual's well-being is influenced by and interacts with several spheres, including the individual, the community, and the physical, social, and political environments in which the individual lives. Social determinants of health examines health at the individual level, with the understanding where one was born, grew up, lives, works, and ages impacts health (Marmot et al., 2008). Both emphasize the role of one's environment as a determinant of health outcomes. Given the context of traditional Taoist teachings and respect for nature in Taiwan, the natural environment may even play a greater role in health quality.

Many studies have investigated the role of environment on health and health-related quality of life. However, this study seeks to understand the role of *perceived* environmental quality on health. It seeks to understand how perceptions of both the natural and built environment can impact mental and physical health in Taiwan. As studies have found, one's perception of his/her surroundings can impact health outcomes (Chen & Lin, 2016; Gomm & Bernauer, 2023; L. Zhang et al., 2019). Most previous studies conducted in Taiwan explore associations between perceived environment and physical activity (Chiang et al., 2019; Liao et al., 2015, 2017). Instead, this study seeks to understand the role of perceived environmental quality of the natural, built, and social environments on one's mental and physical health in Taiwan, utilizing nationwide survey data that provides mental component summary (MCS) and physical component summary (PCS) scores to assess mental and physical health status.

doi:10.6342/NTU202403119

2. Literature Review

To gain understanding about current research perspectives, this chapter will address 6 areas:

1. Role of the Environment and Health
2. Significance of Perceived Environment and Health
3. Influence of Environmental Aspects
4. Influence of Demographic Factors
5. Measures of Health and SF-12
6. Study Aims

2.1 One's Living Environment

Social determinants of health (SDH) are factors in peoples' environments that affect and influence health and quality of life. The World Health Organization (WHO) outlines multiple domains in which these factors exist, which include economic stability, education access, health care access, social environment, and neighborhood environment. SDH are imperative to consider in well-being, as SDH can account for 30-55% of health outcomes (World Health Organization, n.d.-b). Health outcomes can include both physical and mental ailments, like diabetes and depression.

SDH can also affect quality of life (QoL) (Hagan et al., 2023; Kivits et al., 2013). QoL is understood as an individual's subjective evaluation of one's perception of reality with expectations/beliefs that are formed by one's culture and values (WHO, n.d.-c). It is also understood as one's satisfaction with life. Quality of life must also be understood from different approaches. There are objective measures, like demographics and economics and subjective measures, like perception and satisfaction. One's satisfaction can influence one's life. For example, patient perspective is an integral part in the healthcare patient-provider relationship, as evidenced by the rise of

doi:10.6342/NTU202403119

patient-centered care in the last half-century (Grover et al., 2022; Rathert et al., 2013). When an individual feels he/she has the means to make the best and most-informed decision in healthcare settings, he/she is more likely to be satisfied with the care itself, as well as experiencing greater quality of life and social and physical well-being (Kuipers et al., 2019; Rathert et al., 2013). Quality of life (QoL) is one way to measure well-being. QoL considers physical, psychological, social, and environmental aspects of one's life, and how they can influence an individual's overall well-being.

Health-related quality of life (HRQol) is a more specific focus under this branch, and focuses on how the physical, mental, social, and environmental aspects can influence an individual's well-being, as well as how health status can influence quality of life (Yin et al., 2016). HRQoL can be understood to encompass the domains of physiological symptoms, daily functioning, psychological well-being, and social relations (Papadopoulos et al., 2007). It also identifies how an individual's perceived well-being in those aspects impacts daily functioning (Hays & Reeve, 2008). With the introduction of measures of activities of daily living (ADL), researchers and medical professionals are able to assess an individual's level of health outside of visible and pathological symptoms, incorporating the inclusion of patient self-assessment (Armstrong et al., 2007). As HRQoL is a subjective measure of health and an individual's perception of health is all that is needed, HRQoL does not require outsider assessment (Kivits et al., 2013). Questions regarding ADL consider the patient's perception of ability to complete tasks, and help to measure an individual's functional status. HRQoL is used to determine self-rated health. HRQoL itself is measured using tools and questionnaires, such as that of 36-Item Short Form Health Survey (SF-36) and the shorter SF-12 (Turner-Bowker & Hogue, 2014). Data results from SF-12 are included for analysis in this study.

doi:10.6342/NTU202403119

While there is commentary on the indistinguishability of QoL and HRQoL and the potential overlapping of these terms (Karimi & Brazier, 2016), this study does not seek to determine the difference between QoL and HRQoL, and proceeds with the previously explained understanding of HRQoL, especially that of Hays & Reeve (2008): perceived well-being influences quality of life.

2.2 Perception of Environment

The role of perception extends to many aspects of life. In one example, as it relates to health outcomes, how one views his/her health can influence how one behaves. Health behavior change theories posit risk perceptions play a key role in whether one decides to engage in behavior change (Ferrer & Klein, 2015). Risk perceptions are noted as distinct from general outlook or optimism, as risks are limited to certain domains (Ferrer & Klein, 2015). When threats are viewed as uncontrollable, individuals are more likely to experience anxiety (V. J. Brown, 2014). However, if one believes he/she has personal efficacy in the outcome, they are more likely to engage in preventive health behaviors (Jayanti & Burns, 1998) and are overall more likely to have more improved quality of life (M. K. Lee & Oh, 2020; Peters et al., 2019; Selzler et al., 2020). Bandura's idea of self-efficacy is defined as an individual's "belief in personal ability to successfully perform challenging life tasks" (Bandura, 1977; Butler, 2013). When one perceives he/she can have an impact on his/her own health quality, he/she is more likely to engage in actions for positive outcomes. Further, perception itself can influence physiological responses. The placebo effect demonstrates this: studies with placebo interventions have "elicit[ed] quantifiable changes in neurotransmitters, hormones, and immune regulators (Miller et al., 2009). The perception of receiving certain treatments influences physiological responses. Placebos can influence biological effects in the brain and body and cannot be simplified as mere response biases (Price et

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al., 2008). This highlights the connected relationship between perception and behavior, and perception and health outcomes.

Then, perception can affect health outcomes, regardless of action. Feelings related to subjective threats can affect health, much like objective ones. The role of perception may exceed objective measures: feelings associated with a threat are often more related to perceived dangers, as opposed to objective ones (de Miquel et al., 2022). Perceived environmental stressors are so observed to impact mental health more than objective aspects (Gomm & Bernauer, 2023; Schwirian & Schwirian, 1993; L. Zhang et al., 2019). As perception is subjective evaluation, how one interprets environmental quality may not be the same for each individual, but they can be influential in health outcomes. As a result, perception is an important aspect to consider in analyzing health.

2.3 Aspects of the Environment

As outlined previously, well-being cannot be measured fully without considering SDH. Contexts of social environment and neighborhood environment (as parts of SDH) are relevant to this study. Following theories of SDH and the social ecological model, the proceeding section will explore qualities of the natural, built, and social environments of neighborhoods on well-being, exploring both objective and subjective effects. For the purposes of this study, the natural environment of one's environment includes: air quality, water quality, noise quality, and sunlight quality. The built environment includes a neighborhood's: walkability, accessibility of fresh produce, and quality of public facilities. The social environment includes the quality of public security and neighborliness. These three realms can have complex interactions within each domain and impact one's health quality.

Subjective effects of one's environment can impact quality of life. For example, long term residents of a small island cited relationships with friends and family (on the

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island) and sense of safety as an incentive to stay on the island year-round, which was not expressed by seasonal residents (Petrosillo et al., 2013). While insularity of living on a small island could be perceived as limiting, long term residents did not agree that to be the case, and despite living within threat of a volcano eruption, residents' perceptions of social cohesion and safety seemed to outweigh that environmental threat. Another study found simply feeling satisfied with one's living environment and perceived access to greenspaces to be associated with higher HRQoL (Cerletti et al., 2021). Where one lives can impact health, and how the individual perceives the quality of environment further influences one's perception of their health quality.

The proceeding section will analyze the effects of neighborhood air, water, noise, sunlight, walkability, produce accessibility, public facilities, public safety, and neighborliness on health quality.

2.3.1 Air Quality

A plethora of studies warn of the negative health effects of air pollution as it remains a global burden of disease (Cohen et al., 2017). Air pollution is associated with mental disorders like depression and anxiety, and may be related to brain structural and functional changes (Ali & Khoja, 2019; Zundel et al., 2022). Living in urban areas more densely populated are found to also negatively affect mental health as a result of increased air pollution exposure (Pun et al., 2019; Zijlema et al., 2024). Air pollution is also associated with poor physical health outcomes, increasing morbidity and mortality. Air pollution is a risk for all-cause mortality, including cancer, cardiovascular diseases, and respiratory diseases (National Institute of Environmental Health Sciences, 2024; WHO, n.d.-a).

However, as discussed, perception also plays a key role in health outcomes. One study found a positive association between perceived air pollution and self-reported

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asthma, even after adjusting for objective NO2 and PM2.5 levels (Clougherty & Ocampo, 2023). This indicates those who thought air quality was worse were more likely to identify themselves as asthmatic, regardless of pollutant concentrations. In other studies, more favorable perceptions of air quality had a positive association with mental health (O'Campo et al., 2009; L. Zhang et al., 2019). Perceptions of better air quality were found to be associated with increased self-rated health (Arifin et al., 2022). Conversely, as air pollution was perceived to increase, self-rated physical and mental health decreased (Zhu & Lu, 2023). These findings suggest perceived air quality can influence mental and physical health, irrespective of objectively measured air quality.

2.3.2 Water Quality

Potential sources of water pollution are numerous, including physical, chemical, microbiological, and radiological elements (Shah et al., 2023). Exposures to polluted waters can increase the prevalence of mental disorders; consuming contaminated water with copper and cadmium may increase the risk for depression, and exposure to manganese, iron, and selenium may increase the risk for anxiety (Zhou et al., 2024). Prenatal exposure to tetrachloroethylene (PCE) increased risk for bipolar disorder, post-traumatic stress disorder (PTSD), and schizophrenia. Contaminated water as a result of poor sanitation also increases the risk for transmission of waterborne diseases like dysentery, cholera, and hepatitis A (Woodall, 2009). Exposure to chemicals can also increase the risk for cardiovascular diseases and cancer (Nawaz et al., 2023; Xu et al., 2016).

The role of perceived pollution affects levels of anxiety, as threats may pose potential harm to health. Positive evaluations of water quality were found to be positively correlated with physical, mental, and social well-being (L. Zhang et al., 2019). A Chinese study found after water pollution was reported, individuals were more

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likely to report lower self-rated health, where perceived levels of water pollution decreased respondents' self-rated health (S. Wang et al., 2022). A separate study even suggests perceived water pollution impacts reported self-rated health status more than air and landfill pollution (Zhao et al., 2022). However, like air quality, subjective water quality measures could be a better predictor of individuals' life quality than objective water quality (Gunko et al., 2022).

2.3.3 Noise Pollution

Effects of noise pollution can affect the development of cardiovascular disease, cognitive impairment, sleep disturbances, tinnitus, and annoyance (WHO, 2011). The 2011 report indicates disability-adjusted life years lost (DALYs) to environmental noise in the EU and western Europe are enormous, including over 45,000 years for cognitive impairment of children, 903,000 years for sleep disturbance, and 587,000 years for annoyance in Western European countries. Cognitive impairment, sleep disturbance, and annoyance can all affect mental health.

Cognitive impairment and depression has been found to be bidirectional; cognitive impairment may be a core symptom of depression, rather than only a result of having depression (Guo et al., 2019; Rock et al., 2014). This stresses the importance of limiting cognitive dysfunction, as it may increase the chances of developing depression. The WHO report highlighted 45,000 DALYs lost in children from cognitive impairment due to noise pollution, which further stresses the gravity of limiting children's exposure to noise pollution. Children are at developmental stages in life, and cognitive impairment can affect a child's ability to learn. This may have larger repercussions for the child's future, including lower educational attainment, lower income, and ultimately, lower health and life quality (The Lancet Public Health, 2020).

doi:10.6342/NTU202403119

A previously mentioned Chinese study also found perceived noise pollution to impact self-rated health status more than air and landfill pollution (Zhao et al., 2022). Noise annoyance was found to be associated with a decrease in mental health (Cerletti et al., 2021). More frequently reported noise disturbances in the neighborhood were found to be associated with fair and poor self-rated health (Ou et al., 2018). A Beijing study found those who perceived high exposure to road noise and railway noise increased likelihood of experiencing fatigue and mental disorders, respectively (Ma et al., 2018). A separate Beijing study found perceived noise exposure affected psychological stress levels more than objective levels of exposure (Kou et al., 2020). Interestingly, when participants were exposed to objectively higher levels of momentary measured noise while engaging in recreational activities, they did not perceive the noise as a problem and instead experienced a decrease in momentary psychological stress (Kou et al., 2020). This suggests the context and perception of importance or interference of noise affects mental health quality more than objective measurements. Alternatively, a concept mapping study found participants' perceptions of noise to be moderately associated with both good and poor mental well-being. This might reaffirm the context of noise may play a larger role in mental health (O'Campo et al., 2009). However, perception of noise pollution is still found to hinder health quality.

2.3.4 Sunlight

While UV effects on skin are known to have carcinogenic effects, data linking sunlight exposure and all-cause mortality exist (Lindqvist, 2020). Regular exposure to sunlight is beneficial; it increases vitamin D supply, can have immunosuppressive effects, immunological tolerance effects, and release endorphins (Mead, 2008). Studies from Europe found sun exposure to be associated with reduced all-cause, cardiovascular, and cancer mortality (Weller, 2024) and conversely, avoidance of sun

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exposure as a risk for all-cause mortality (Lindqvist, 2020). Additionally, those reporting inadequate amounts of natural light in their homes were 1.4 times more likely to report having depression (M. J. Brown & Jacobs, 2011). Children with diminished window sunlight exposure had disrupted circadian rhythms, which negatively affected social behavior in school (Evans, 2003). On the other hand, those reporting high levels of exposure to sunlight and consuming vitamin D were associated with lower odds of having perceived stress (Trovato et al., 2023).

Lack of sunlight can also be harmful in other ways—a European study found those who perceived natural light to be insufficient in their homes were 1.5 times more likely to report a fall (M. J. Brown & Jacobs, 2011). This suggests physical health can be impacted by perception of sunlight quality, apart from usual/common measures of physical health, like cardiovascular and metabolic functioning.

Further, spending time in green spaces is associated with increased exposure to sunlight and physical activity (Taniguchi et al., 2022), which may assist in maintaining or improving physical health. An Italian study found participants who reported medium to high activity levels were also in the highest categories of exposure to vitamin D intake and sunlight (Trovato et al., 2023). Performing physical activities outdoors was also found to be found to be more satisfying for participants and reported to be associated with more positive engagement (Thompson Coon et al., 2011), which may be associated with increased exposure to sunlight, though that connection was not explored in the study. As Lee et al. found, sun exposure increased sleep quality and sleep patterns, and improved overall quality of life. In the study, they found both groups, (1) those exposed to sunlight and exercised and (2) those exposed to sunlight and did not exercise, showed improvement in quality sleep and sleep patterns (Y. Lee et al., 2023). Participants benefited from sun exposure, regardless of physical exercise, which is

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typically associated with improved physical health. This may suggest sunlight quality and exposure to play a large role in physical health outcomes.

2.3.5 Walkability

The walkability of neighborhoods can also play a role in how one evaluates their surroundings. If sidewalks are not common, people are less likely to walk (Kweon et al., 2021), which can decrease the quality of physical health (Wei et al., 2021). Perceptions of walkable areas were highly associated with good mental health (O'Campo et al., 2009) and increased physical exercise levels (Kwon et al., 2019; Sallis et al., 2009). Older adults who perceived higher levels of walkability had higher quality of life (Tiraphat et al., 2017). Fear of safety was also found to negatively impact likeliness to walk in one's neighborhood (Ross, 2000). Perceived levels of road traffic (as perceived threats to safety) were found to be a barrier to walking and spending time outdoors (Soto et al., 2022). If individuals perceive they can walk comfortably and safely, they are more likely to engage in physical activities beneficial to health.

2.3.6 Accessibility of Fresh Produce

Accessibility to produce is a known productive factor for physical health, and further, if people believe they can access healthy food, they are more likely to consume it (Caldwell et al., 2009)Lack of access to healthy foods negatively affects diet quality (Ziso et al., 2022). Perceived barriers to healthy eating include financial stress and high food prices (van der Velde et al., 2019). Barriers to healthy eating in turn affect health outcomes. When people are unable to buy healthy food options, they turn to sources of convenience, which is often less healthy (C.-H. Lin et al., 2023; Pan et al., 2011). As the prevalence of convenience store food options increases (Taipei Times, 2024), people tend to sacrifice convenience for health (Dai et al., 2022). However, perceptions of affordable grocery stores were highly associated with good mental health (O'Campo et

doi:10.6342/NTU202403119

al., 2009). Thus, aspects such as cost can be detrimental to mental and physical health. The ability to consume healthier foods and the perception of food accessibility can impact health quality.

2.3.7 Public Facilities

Public facilities are spaces provided by the government to citizens. These can be spaces in which neighborhood residents gather, interact, and exercise (Tsou et al., 2005). Positive perceptions of public facilities are associated with higher physical, mental, and social health (L. Zhang et al., 2019). Positive perceptions of parks, green areas, and trees were highly associated with good mental health (O'Campo et al., 2009). For example, the presence of and accessibility to greenery was found to improve neighborhood satisfaction (Fonteyn et al., 2024). Thus, the role of accessibility to adequate public facilities cannot be understated, and can influence HRQoL.

2.3.8 Public Security (Safety)

Perceptions of security in one's neighborhood can impact physical and mental outcomes. Negative perceptions of safety can affect physiological response. In areas where residents perceived they lived in an unsafe neighborhood where violent crimes occurred were associated with increases in BMI (Tamayo et al., 2016). It can also affect vulnerable populations such as the young: lower levels of perceived safety was associated with deviations from the recommended sleep range in adolescents (Tsomokos et al., 2024). However, positive perceptions of safety can be beneficial. Perceptions of the neighborhood being a safe environment was highly associated with good mental health (O'Campo et al., 2009). Older adults who felt their neighborhoods were safe reported higher quality of life (Tiraphat et al., 2017). Some studies suggest perceptions of neighborhood danger do not affect physical activity levels (like walking) of those living in more disadvantaged neighborhoods with higher crime rates, but can have a

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larger impact on those of more “middle-class” neighborhoods where crime is minimal (Foster et al., 2021). As Taiwan is generally considered safe (Everington, 2023a; National Immigration Agency, 2023), perceptions of safety may have a significant impact on health quality.

2.3.9 Neighborliness

Neighborliness has been described as a “form of social support that benefits individuals and is a component of psychological sense of community” (Wilkerson et al., 2012). This can be expressed as a form of social cohesion (Cramm et al., 2013). Perceived higher neighborhood cohesion was significantly associated with lower cardiometabolic risk after demographic adjustment (Robinette et al., 2018). Perceived levels of social support also mediated a urbanicity-depression association; when respondents perceived less social support, depressive scores increased (Pun et al., 2019). Perceptions of friendliness of neighbors, a sense of community, and interaction between neighbors were highly associated with better mental-well-being (Ahern & Galea, 2011; O’Campo et al., 2009; L. Zhang et al., 2019). Further, perceived neighbors’ willingness to help is associated with a better sense of neighborhood, which increases physical and mental health (Young et al., 2004). Conversely, perceptions of fear of lacking help from neighbors was reported with low associations with good mental well-being (O’Campo et al., 2009). Older adults expressed the possibility of getting help as an important factor in social connectedness (Padeiro et al., 2022) and those who perceived their neighborhoods as having high social support reported higher quality of life (Tiraphat et al., 2017). This suggests feeling a sense of support within a neighborhood community may contribute to better mental health.

doi:10.6342/NTU202403119

2.4 Demographics

There is evidence demographic factors also influence health. Race, age, and sex are known to affect health outcomes, including morbidity and mortality (*Communities in Action*, 2017). Patients' perceptions and self-reporting of health status is likely dependent on factors like age and sex; demographic SDH can impact HRQoL. Independent of age and sex, relationship status and living situation, educational level, employment status, and income level are found to be determinants of HRQoL (Kivits et al., 2013). Living with a partner is a protective factor for MCS; lowest educational attainment decreased PCS, unemployment decreased MCS and PCS (compared to employment), and lower income decreased both MCS and PCS (Kivits et al., 2013).

There are well established links between better health quality among those employed, where unemployment negatively affects both mental and physical health (Dooley et al., 1996). A more recent meta-analysis found unemployment to decrease the mental health level of an individual by half a standard deviation than that of an employed person's, and supports assumptions unemployment is not only correlated with distress but also causes it (Paul & Moser, 2009). As a result, these demographic factors cannot be omitted from analysis. Exercise frequency was also included in analysis as it is categorized as a health behavior. Including exercise frequency provides objective measurements to assess effect on health, as it was found to positively impact mental (Rahmati et al., 2024) and physical health (Posadzki et al., 2020; Ruegsegger & Booth, 2018).

2.5 SF-12

To measure QoL, researchers have employed the Short Form-36 (SF-36) questionnaire and the condensed Short Form-12 (SF-12) questionnaire. SF-36 and SF-12 allow for self-reported outcome measures assessing the impact of health on an

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individual's daily life. SF-12 is a shortened version of SF-36, which originated from the Medical Outcomes Study (J. E. J. Ware, 2000). The use of the shortened version SF-12 (with 12 questions) versus the longer SF-36 (with 36 questions) helps reduce the burden of response (Rand Health Care, n.d.).

The questionnaires measure mental and physical health functioning, and are represented by mental component summary (MCS) and physical component summary (PCS) scores. Eight scales are included in SF-36 and SF-12: vitality (VT), social functioning (SF), role-emotional (RE), and mental health (MH) for mental health summary measures, and physical functioning (PF), role-physical (RP), bodily pain (BP), and general health (GH) for physical health summary measures (J. E. Ware et al., 1994). The eight scale domains are used to compute MCS and PCS scores through principal components analysis; all 12 items in SF-12 are utilized in both MCS and PCS computation (Turner-Bowker & Hogue, 2014).

As Ware et al. 1996 have found, a high degree of correspondence was achieved in reproducing SF-36 PCS and MCS measures from SF-12 items; correlations between the SF-12 and SF-36 version for PCS and MCS with general population weights were .951 and .969 (J. E. Ware et al., 1996). Comparisons between MCS-36 and MCS-12, and PCS-36 and PCS-12 have indicated good correlation and agreement in the general population, as well as elderly, and several subpopulations (Lacson et al., 2010; J. E. Ware et al., 1995). Additionally, PCS-12 and MCS-12 are independent scales, as confirmed by the weak correlation between the two were $r = 0.06$ (J. E. Ware et al., 1996). Normalized scoring transforms MCS and PCS scores to have a mean of 50 and standard deviation of 10; scores greater than 50 indicate better than average HRQoL, while scores lower than 50 indicate below-average HRQoL (Rand Health Care, n.d.).

doi:10.6342/NTU202403119

The survey administered by TSCS used the second version of SF-12 (Wu, 2022); SF-12v2 is recommended for new studies (Turner-Bowker & Hogue, 2014). Additionally, the traditional Chinese version of SF-12 was found to be a validated version of SF-36 (Lam et al., 2005).

2.6 Aims and Research Questions

As previous studies conducted in Taiwan investigate the associations between attitudes of perceived environment and physical activity, this study aims to fill the knowledge gap in examining the role of perceived environmental quality on mental and physical health quality, particularly in the Taiwanese context.

With the preceding literature, this study proposes hypotheses on the impact of perceived environment on physical and mental health, that are: (aim 1) positive perceptions of qualities of one's environment is positively correlated with MCS and PCS, and (aim 2) positive perceptions of one's neighborhood environment is associated with higher MCS and PCS scores.

3. Methods and Measures

3.1 Survey and Study Participants

The data used in this study was collected in the 2021 Taiwan Social Change Survey (TSCS), a cross-sectional and longitudinal survey. TSCS is overseen by Academia Sinica, a government-funded research institution which aims to track the changes in the Taiwanese population in various areas of life, including health behaviors and attitudes, overtime (Fu & Chang, 2023). Launched in 1984, TSCS now runs two surveys each year with rotating modules every 5 years (ISSP, n.d.). The 2021 TCSC includes a Family module and a Health module, the latter of which is utilized for analysis in this study. The Health portion includes questions from East Asian Social

doi:10.6342/NTU202403119

Survey 2020 and the International Social Survey Programme 2021. 1,604 respondents were surveyed in this module (Wu, 2022).

3.1.1 Participant Demographics

The following potential confounders were selected based on existing literature: sex, age, education, employment status, relationship status, income level, and exercise frequency.

Age

Respondents were asked for their birth year, and age was calculated based on the year of survey. This study divided respondents into seven age groups (18-30, 31-40, 41-50, 51-60, 61-70, 71-80, and 81-94). After age 30, respondents were categorized into ten year groups. This was done to potentially analyze differences within different age groups. Four respondents who chose not to answer or marked "don't know" were omitted.

In addition to age, respondents were asked other demographic information. Among those, this study includes information regarding: education, relationship status, employment status, and income. TSCS listed very specific levels of each of these demographic factors–this study simplifies responses to allow for more insightful statistical analysis.

Highest level of education was categorized into four groups: primary school or less, secondary school, technical or vocational school, and university or higher. From the 21 options provided on the survey, primary school or less included: "none (illiterate)" (無(不識字)) and "elementary school" (小學). Secondary school included: "junior high school" (國(初)中), "vocational junior high school" (初職) "senior high school (general subjects)" (高中普通科), and "senior high school (vocational subjects)" (高中職業科). Technical or vocational school included: "vocational senior high school"

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(高職), “five-year junior college” (五專), “two-year junior college” (二專), “three-year junior college” (三專), “military/police one-year junior college” (軍警校專修班), “military/police two-year junior college” (軍警校專科班), and “open junior college” (空中行(商)專). University and higher included: “Open University” (空中大學), “military/police college” (軍警官學校/大學), “Institute of technology” (技術學院、科大), “college (bachelor’s degree)” (大學), “graduate school (master’s degree)” (碩士), and “graduate school (doctoral degree)” (博士). These groups were used to separate educational attainment into 3 manageable groups for analysis. Two respondents who answered “self study” (自修(識字、私塾)) and “other” (其他) were omitted from analysis.

Relationship status was categorized into four groups: single, married or co-living, divorced or separated, and widowed. Single was categorized from “single and never married” (單身且從沒結過婚), married or co-living was comprised of “married, and we share the same household” (已婚且與配偶同住), “married, but we don’t share the same household” (已婚但沒有與配偶同住), and “cohabitating” (同居). Divorced or separated included “divorced” (離婚) and “separated” (分居), and widowed was categorized from “widowed” (配偶去世). Whereas previous studies simplify single as including divorced, separated, and widowed (Tien & Huang, 2024), this study was interested in exploring the potential differences among these different levels of “single” relationship statuses.

Employment status was categorized into three groups: full-time, part-time, and not working or retired. Full-time work was comprised of: “I have a full-time job” (有全職工作(每週30小時或以上)), “I work for family business with pay” (為家庭事業工作

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，而且有領薪水), and “I work for family business without pay” (為家庭事業工作，但沒有領薪水). Part-time work was comprised of: “I have a regular part-time job” (有固定兼職工作), “I do irregular jobs (odd jobs)” (不固定(打零工)), and “I am a student and do work now” (學生/進修在學且有工作). Those not working or retired included those: “I am unemployed” (目前沒有工作),“I am a student and do not work now” (學生/進修在學且沒有工作), “I am retired” (已經退休), “I am a homemaker and do not work” (料理家務且沒有工作), and “I am taking unpaid leave or parental leave, or my position is retained but without pay” (無薪假/育嬰假/留職停薪). The 77 respondents who answered “I am aged, physically or mentally handicapped, or sick, and cannot work” (高齡、身心障礙、生病不能工作) and “other” (堅持是全職工作或其他，請說明) were omitted.

Income groups were separated into five groups. The first was no income, “no income (for example, working for a family business without pay)” (無收入(例如：為家庭事業工作，但沒有領薪). The subsequent groups were those earning (in New Taiwan Dollar): $1-19,999 per month, $20,000-39,999 per month, $40,000-59,999 per month, and $60,000 per month or more. The 51 responses of “don’t know” (不知道) and “refuse to answer” (拒答) were omitted from analysis. In 2021, the minimum monthly wage was $25,000 (Ministry of Labor Republic of China (Taiwan), 2021)and the monthly average income was $55,792 (Textor, 2024).

Lastly, exercise frequency was also included as a control variable. Exercise frequency was posed as: “how often do you do exercise that lasts at least 20 minutes and makes you sweat or breathe faster than usual?” Respondents answered on an increasing frequency scale: “never” (從不), “once per month or less (several times per year or

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less)" (一個月一次或更少 (一年好幾次或更少)), "a few times per month" (一個月幾次), "a few times per week" (一星期幾次), and "everyday" (每天).

3.2 Measures

Respondents answered these items using a four-point Likert scale ("disagree," "slightly disagree," "slightly agree," or "agree"). The scale items were rated from 1 to 4 (most positive).

The four environmental quality factors surveyed utilized a four-point Likert scale measuring levels of severity. Questions were organized under the main question asking: "within a 1 kilometer radius of your home, do you think the following types of pollution have a severe impact on the area in which you reside?" (住家方圓1公里範圍內, 您認為下列污染對您居住地區的影響程度嚴不嚴重?)

Environmental qualities surveyed were:

1. Air pollution (空氣污染);
2. water pollution (水污染);
3. noise pollution (噪音污染); and
4. insufficient sunlight (日照不足).

Responses were coded 1 through 4, 4 being the most positive. These are: (1) "very serious" (非常嚴重), (2) "serious" (嚴重), (3) "not serious" (不嚴重), (4) "not serious at all" (一點都不嚴重). The 20 "don't know" (不知道) and "refuse to answer" (拒答) responses were omitted from analysis.

Five neighborhood quality measures utilized a five-point Likert scale measuring agreement. Questions were organized as, "within a 1 kilometer radius of your home (about a 15-minute walk):" (在您住家方圓1公里的範圍內大約走路15分鐘的距離):):

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7. “I am able to jog or walk” (可以慢跑或散步);
8. “I am able to buy a variety of fresh fruits and vegetables” (可以買到多種的新鮮蔬果);
9. “There are public facilities such as schools, parks, and community activity centers” (有學校、公園、社區活動中心等公共活動設施);
10. “There is good security” (治安良好); and
11. “Neighbors are willing to help when needed” (在有需要時，鄰居會願意幫忙)

Responses were re-coded in the opposite order to prepare for analysis, with 5 being most positive. This was re-coded as 5 = 1, 4 = 2, 2 = 4, and 1 = 5. The scale then became: (1) “strongly disagree” (非常不同意), (2) “disagree” (不同意), (3) “neutral” (無所謂同不同意), (4) “agree” (同意), and (5) “strongly agree” (非常同意). The 26 “don’t know” (不知道) and “refuse to answer” (拒答) responses were omitted from analysis.

3.2.1 New Name Coding

For convenience in interpretation, the environmental measures of: (1) air pollution (空氣污染), (2) water pollution (水污染), (3) noise pollution (噪音污染), and (4) insufficient sunlight (日照不足) were renamed. In analysis, they are referred to as: (1) air, (2) water, (3) noise, and (4) sunlight, respectively. Because responses are rated on a decreasing seriousness scale, this study interprets the response scale as increasing positive perceptions of environmental quality.

Similarly, neighborhood quality measures of: (1) “I am able to jog or walk” (可以慢跑或散步), (2) “I am able to buy a variety of fresh fruits and vegetables” (可以買到多種的新鮮蔬果), (3) “There are public facilities such as schools, parks, and

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community activity centers" (有學校、公園、社區活動中心等公共活動設施), (4) "There is good security" (治安良好), and (5) "Neighbors are willing to help when needed" (在有需要時，鄰居會願意幫忙) were renamed for convenience. In the following analysis, they are referred to as: (1) walkability, (2) produce, (3) facilities, (4) safety, and (5) neighborliness, respectively.

3.2.2 Natural, Built, and Social Environment Grouping

For the purposes of analyzing the effects of the 3 domains of natural, built, and social environments on health quality, scores from perceptions of environmental quality were summed. The natural environment group was the sum of the 4 questions regarding pollution: air pollution, water pollution, noise pollution, and insufficient sunlight. Each question's responses ranged from 1 to 4; the higher sum refers to better perceptions of the natural environment qualities in one's neighborhood. The built environment group was the sum of 3 questions regarding walkability, accessibility to fresh produce, and accessibility to public facilities. Each question ranged from 1 to 5; the higher sum refers to better perceptions of the built environment. Lastly, the social environment group included 2 questions regarding public security and feelings of neighborliness. Again, each question ranged from 1 to 5, where the higher sum of the scores refers to better perceptions of the social environment.

3.2.3 MCS and PCS

TSCS data provided normalized MCS and PCS scores. They were calculated based on the SF-12 measurement model, which examines: vitality (VT), social functioning (SF), role-emotional (RE), and mental health (MH) for mental health summary measures, and physical functioning (PF), role-physical (RP), bodily pain (BP), and general health (GH) for physical health summary measures (J. E. Ware et al., 1994).

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In SF-12, VT consists of one item measuring energy or fatigue. SF consists of one item measuring potential limitations of physical or emotional problems on social activities. RE contains two items measuring whether emotional problems affect usual work activities. Lastly, MH includes two items assessing mood. PF includes two items that measure potential limitations on moderate and more intense physical activities. RP contains two items and measures potential limitations in usual activities that may be affected by physical health problems and diminish work productivity. BP consists of one item measuring whether pain affects usual work activities. GH consists of one item measuring the respondent's self-rated level of general health.

The two domains (mental and physical health) were measured with questions scored on a Likert scale of frequency or severity, and yes/no binary. Example items from SF-12 mental and physical measures of the TSCS are included here:

Table 1 SF-12 Example Questions

	Mental Health Summary	Physical Health Summary
Example question 1	SF-9 下列各項問題是關於過去四個星期內您的感覺及您對周遭生活的感受，請針對每一問題選一最接近您感覺的答案。在過去四個星期中有多少時候… 您覺得心情平靜? The following questions are about how you have felt and feel about life around you in the past 4 weeks. For each question, choose the answer that is closest to how you feel. How many times in the past four weeks… Did you feel calm?	SF-2 下面是一些您日常可能從事的活動，請問您目前健康狀況會不會限制您從事這些活動？如果會，到底限制有多少: 中等程度活動，例如搬桌子、拖地板、打保齡球、或打太極拳 Below are some activities you might do during a typical day. Does your current health condition limit your ability to engage in these activities? If so, how much?: Moderate activities, such as moving a table, mopping the floor, bowling, or doing Tai Chi

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Example question 2	SF-10 下列各項問題是關於過去四個星期內您的感覺及您對周遭生活的感受，請針對每一問題選一最接近您感覺的答案。在過去四個星期中有多少時候… 您精力充沛 The following questions are about how you have felt and feel about life around you in the past 4 weeks. For each question, choose the answer that is closest to how you feel. How many times in the past four weeks… Did you have a lot of energy?	SF-8 在過去四個星期內，身體疼痛對您的日常工作（包括上班及家務）妨礙程度如何？ During the past 4 weeks, how much did physical pain interfere with your normal work (including both work outside the home and housework)?

Calculating MCS and PCS are based on principal components analysis, and the strength of correlations with the eight scales in factor analysis is consistent with (1) mental and (2) physical health (J. E. Ware et al., 1994). Calculated MCS and PCS scores were included in the data set; scores were transformed into normalized scores by TSCS (Wu, 2022, 459). As mentioned in the literature review, reliability of these scores is supported by numerous studies. As a result, these measurements will be utilized to assess mental and physical well-being in the Taiwanese population.

The original survey included 1,604 respondents. After omitting ambiguous responses as missing values, the sample size for correlation analysis was 1,424. One respondent had missing MCS and PCS scores, and therefore regression analysis included 1,423 respondents. The MCS scores of the included 1,423 respondents ranged from 16.02 to 68.84. The PCS scores ranged from 16.67 to 63.55.

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3.3 Institutional Review Board

As the data is publicly available at Academia Sinica, no prior approval from the National Taiwan University Institutional Review Board was sought.

3.4 Methods and Packages

Analyses were performed using Stata MP 14 (StataCorp LP, College Station, TX). Pearson correlations were examined between MCS and PCS and (1) demographics, (2) perceptions of environmental quality, and (3) perceptions of neighborhood quality. ANOVAs were run for categorical variables of relationships and employment. Subsequently, statistical multiple linear regressions were used for testing. Regressions were performed between MCS and PCS, demographics, and perceptions of environmental quality. Perceptions of environmental quality were tested both as individual variables and as grouped variables. Association estimations with $p < .05$ were considered statistically significant in analysis.

4. Results

The first section of results will address a description of relationships between MCS, PCS, and environmental and neighborhood quality scale ratings. This will be accomplished through correlations. The second section will attempt to answer the research question of which variables (demographics, environmental, and neighborhood quality) affect MCS and PCS scores, and to what extent. This will be accomplished through multiple regression analysis.

4.1 Descriptive Statistics

1,424 individuals were included in the analysis. Females accounted for 52.46% of the sample. Ages ranged from 17 to 91 with the mean age at 61.36 years (SD = 0.421). A majority of respondents were married and/or living with a partner (57.87%) and employed full-time (61.66%). The greatest proportion of respondents (34.76%)

doi:10.6342/NTU202403119

earned in the $20,000-$39,999 monthly range, which included those earning minimum wage ($25,000).

Regarding environmental quality, the majority of respondents viewed each measure as “not serious,” with air pollution at 57.09%, water pollution at 69.45%, noise pollution at 53.72%, and insufficient sunlight at 55.97%. However, the means of each indicate the average response fell between “serious” and “not serious” for air pollution (2.68), water pollution (2.91), and noise pollution (2.70). The mean for insufficient sunlight was 3.26.

Regarding neighborhood quality, the majority of respondents viewed each measure with “agree[ment]”, with walkability at 62.5%, fresh produce at 54%, public facilities at 58.85%, public safety at 70.58%, and neighborliness at 68.47%. The means of each measure indicate the average response fell between “neutral” and “agree” for fresh produce (3.89), public safety (3.98), and neighborliness (3.96). The means for walkability and public facilities were higher, at 4.17 and 4.16, respectively. See Table 2 for a full description of the sample characteristics.

Demographic variables were cleaned and sorted for analysis. Appropriate items (neighborhood quality measures) were reverse coded so higher scores represented decreasing dissatisfaction (increasing satisfaction) and scale scores were used.

4.2 Pearson’s Correlation

Bivariate correlations using Pearson’s r were run between demographic variables, environmental quality measures, and neighborhood quality measures, MCS, and PCS. See Table 3 for correlations. ANOVA was run between MCS and PCS and categorical demographics factors.

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Demographics

Age was negatively correlated with MCS (r = -0.3047, p = < .01) and positively correlated with PCS (r = 0.3042, p < .01). The correlation between sex (men) was statistically significant for PCS (r = 0.0966, p = < .01) but not MCS. Having higher levels of education were negatively correlated with MCS (r = -0.1734, p = < .01) and positively correlated with PCS (r = 0.2078, p = < .01). Higher income was found to be positively associated with PCS (r = 0.1726, p = < .01).

4.2.1 ANOVA

In addition to the demographic correlations above, the relationship between MCS, PCS, and relationship status, as well as MCS, PCS, and employment were examined. One-way ANOVAs were performed to determine the relationship between relationship status (single, married or co-living, divorced or separated, or widowed) and MCS and PCS.

There was significant effect for relationship status and both MCS, $F(3, 1419) = 22.60$, $p < .01$ and PCS, $F(3, 1419) = 10.12$, $p < .01$. A Tukey post-hoc test revealed that MCS was statistically significantly higher in the married or co-living compared to the single control group (4.0712 ± 0.534, $p = .000$). MCS was also found to be statistically significantly higher in the divorced or separated compared to the single group (2.882 ± 0.888, $p = .007$), as well as the widowed compared to the single group (5.862 ± 1.0512, $p = .000$).

However, a Tukey post-hoc test also revealed PCS was statistically significantly lower for the same groups. PCS was statistically significantly lower for those married or co-living compared to the single control group (-1.9233 ± 0.4169, $p = .000$), those divorced or separated compared to the single group (-2.2016 ± 0.6928, $p = .008$), as well as the widowed compared to the single group (-3.4334 ± 0.8195, $p = .000$).

doi:10.6342/NTU202403119

The relationship between employment (full-time, part-time, or not working) and MCS and PCS was also examined. There was significant effect for employment status and both MCS, $F(2, 1420) = 4.32$, $p < .05$ and PCS, $F(2, 1420) = 36.54$, $p < .01$. A Tukey post-hoc test revealed that MCS was statistically significantly higher in the not working or retired group compared to those working full-time (1.4713 ± 0.5306, $p = .016$). However, there were no statistically significant differences between the part-time and full-time groups (-0.3102 ± 0.8174, $p = .924$), or the not working or retired and part-time groups (1.7816 ± 0.8777, $p = .105$)

A Tukey post-hoc test also revealed PCS was statistically significantly lower for those not working or retired compared to the full-time group (-3.4095 ± 0.3996, $p = .000$) and those not working or retired compared to the part-time group (-2.0195 ± 0.6609, $p = .006$). There was no statistically significant difference between the part-time and full-time groups (-1.3905 ± 0.6154, $p = .062$).

MCS and Environmental Quality

Positive correlations were found between MCS and several measures of lower perceptions of seriousness of environmental quality: air quality ($r = 0.122$, $p < .01$), water quality ($r = 0.116$, $p < .01$), noise pollution ($r = 0.156$, $p < .01$), and sufficient sunlight ($r = 0.077$, $p < .05$). Positive correlations were found between MCS and two measures of neighborhood quality: perceptions of public safety ($r = 0.098$, $p < .01$) and neighbors' willingness to help ($r = 0.101$, $p < .01$).

PCS and Environment Quality

PCS was found to be positively correlated with sufficient sunlight ($r = 0.084$, $p < .01$). No other correlations between PCS and environmental quality factors were significant. PCS was found to be positively correlated with positive perceptions of: neighborhood walkability ($r = 0.061$, $p < .05$), accessibility to fresh fruit and vegetables

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(r = 0.071, p < .01), public safety (r = 0.111, p < .001), and neighbors' willingness to help (r = 0.059, p < .05).

4.3 Spearman's Correlation

For thoroughness and a more comprehensive view of the relationships, Spearman's correlations are also included. See Table 4 for correlations. Age was negatively correlated with MCS (r = -0.328, p < .001) and positively correlated with PCS (r = 0.300, p < .001), consistent with Pearson's correlations. For MCS and environmental quality, significant correlations are observed between the same variables as observed in Pearson's correlations: air pollution (r = 0.120, p < .001), water pollution (r = 0.121, p < .001), noise pollution (r = 0.160, p < .001), sunlight quality (r = 0.080, p < .003), public safety (r = 0.076, p < .004), and neighborliness (r = 0.075, p < .005). For PCS and environmental quality, significant correlations are observed between the same variables as revealed in previous Pearson's correlations: sunlight quality (r = 0.075, p < .005), walkability (r = 0.092, p < .001), produce accessibility (r = 0.075, p < .005), public safety (r = 0.128, p < .001), and neighborliness (r = 0.070, p < .008). However, Spearman's also revealed a positive correlation between positive perceptions of public facilities and PCS (r = 0.077, p < .004).

4.3 Regression

4.3.1 Collinearity

In running Pearson's correlation between variables, correlations are observed between demographic variables, like age and education, relationship, employment, and income, as well between environmental quality factors, like accessibility to fresh fruit and vegetables with age and education. Correlations between environmental measures are also observed, like negative correlations between satisfaction with access to public facilities and better perceptions of air, water, noise, and sunlight quality in the

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neighborhood. As a result, there may be some concern for multicollinearity.

Assessing the potential for collinearity is calculated through variation inflation factors (VIF). See Table 5 for detail. Calculating VIF explains whether the standard error of coefficients has inflated variance. General rules provide a VIF above 4 or tolerance (1/VIF) less than .1 indicates collinearity might exist and to proceed with caution. VIF statistics range from 1.06 to 1.48. With VIF values below 2 for all predictors, proceeding regression analysis can be used to interpret the contributions of these predictor variables. The potential for homoscedasticity was also assessed using the Breusch-Pagan test. The Breusch-Pagan test for MCS regression yielded a χ^2 value of 5.20 with a p-value of .023. Given that the p-value is below our threshold of .05, we reject the null hypothesis of homoscedasticity, indicating that there is significant heteroscedasticity in our model. Similarly, the Breusch-Pagan test for PCS regression yielded a χ^2 value of 170.19 with a p-value less than .05. As a result, robust standard errors were also included to correct for this heteroscedasticity in all subsequent regression analyses. This ensures the reliability of our regression estimates.

Internal Reliability

In addition, MCS and PCS were assessed for reliability using Cronbach's alpha, which yielded a value of .825, indicating good internal consistency (≥.700).

4.3.2 Multiple Linear Regression

Examining MCS and PCS scores by demographic factors provides insight into differences among the Taiwanese population. The model was found to meet assumptions for performing regression. Regression analysis followed the following formulas:

MCS = β0 + β1*(sex) + β2*(age) + β3*(education) + β4*(relationship status) +

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β5(employment) + β6*(income) + β7*(exercise) + β8*(air quality) + β9*(water quality) + β10*(noise quality) + β11*(sunlight) + β12*(walkability) + β13*(fresh produce) + β14*(public facilities) + β15*(public safety) + β16*(neighborliness)+ ε

PCS = β0 + β1*(sex) + β2*(age) + β3*(education) + β4*(relationship status) + β5(employment) + β6*(income) + β7*(exercise) + β8*(air quality) + β9*(water quality) + β10*(noise quality) + β11*(sunlight) + β12*(walkability) + β13*(fresh produce) + β14*(public facilities) + β15*(public safety) + β16*(neighborliness)+ ε

4.3.2.1 MCS

The model was shown to have significant fit for the data, R = 0.3891; F(29, 1393), p < .01= 9.772. The 29 predictor variables account for 15.87% of the variability in the model, where R^2 = .159 and adjusted R^2 = .141. See Table 6 for full regressions. As adjusted R^2 measures overall strength of association, the association between any one particular independent variable and MCS is not determined. When all other variables are held constant, statistically significant variation is observed among age, level of education obtained, income level, perception of low noise pollution, and perception of neighborly help and MCS.

Demographics

Age

When holding those aged 18 to 31 as the reference group, regression analysis reveals MCS scores are likely to be lower for those 41 and older. The coefficient score for each age group is: -4.656 (p < .006) for those 41 to 50, -6.696 (p < .001) for those 51 to 60, -8.137 (p < .001) for those 61 to 70, -8.897 (p < .001) for those 71 to 80, and -9.064 (p < .001) for those 81 and older. Those in the 31 to 40 age group had a negative coefficient score of -3.448, with a p-value slightly over significance (p < .059).

doi:10.6342/NTU202403119

Education

Regression analysis reveals MCS scores are likely to be lower for those with higher education than primary school. Obtaining secondary education, vocational education, and tertiary degrees revealed coefficients -2.309 ($p < .017$), -2.177 ($p < .025$), and -3.015 ($p < .003$), respectively.

Relationship Status

Regression analysis reveals being married versus single increases MCS scores by 1.758 ($p < .005$), whereas the other relationship categories are not significantly affected.

Income level

When compared to the reference group of the lowest income monthly income $1-$19,999), those with higher incomes are more likely to have higher MCS scores. Those earning $20,000-$39,999 per month are observed to have a 1.981 point increase in MCS ($p < .005$), and those earning $40,000-$59,999 are observed to have a 2.209 point increase ($p < .008$). Following this increasing trend, those earning $60,000 and above per month are observed to have the highest point increase, with coefficient score 3.437 ($p < .001$). This indicates those earning at and above minimum wage in Taiwan are more likely to have improved mental health scores.

Exercise

Performing physical activities was also found to increase MCS scores by 0.589 ($p < .001$). Those who exercise are predicted to have higher MCS scores.

Environment

Among environmental quality, significance is observed in perception of low noise pollution. The MCS coefficient score is observed to have an increase of 0.940 of a point ($p < .003$). To note, perception of low water pollution has a coefficient score of

doi:10.6342/NTU202403119

0.790, indicating increased MCS, though significance is not obtained as the p-value ($p < .073$) is slightly over 5%. Among neighborhood quality, significance is observed in perception of neighborliness. The coefficient score is observed to increase MCS by 0.720 ($p < .012$).

4.3.2.2 PCS

The model was shown to have significant fit for the data, $R = 0.4158$; $F(29, 1393)$, $p < .01 = 7.814$. The 29 predictor variables account for 17.3% of the variability in the model, where $R^2 = .173$ and adjusted $R^2 = .155$. See Table 6 for full regressions.

Demographics

Sex

Unlike MCS, regression analysis reveals PCS scores are likely to be higher for males than females with a coefficient of 0.821 ($p < .019$)

Age

Regression analysis reveals PCS scores are increased for individuals as they age. The coefficient score for each age group is: 4.693 ($p < .007$) for those 41 to 50, 5.968 ($p < .001$) for those 51 to 60, 6.010 ($p < .001$) for those 61 to 70, 7.423 ($p < .001$) for those 71 to 80, and 9.422 ($p < .001$) for those in the 81 and older age group.

Education

Those obtaining vocational school training are observed to have increased PCS scores when compared to those with primary school education or less; the coefficient score is 1.642 ($p < .047$).

Employment

Compared to full-time employment, those unemployed have a coefficient score of -1.198 ($p < .043$).

doi:10.6342/NTU202403119

Income

When compared to those earning minimum wage, those with a monthly salary of $40,000-$59,999 are observed to have a 2.123 point increase in PCS ($p < .001$), and those earning $60,000 or more are observed to have a 2.213 point increase in PCS ($p < .003$).

Exercise

Performing physical activities was also found to increase PCS scores by 0.688 ($p < .001$).

Environment

Among environmental quality, significance is observed in more positive perceptions of sufficient sunlight. The PCS coefficient score is observed to have an increase of 0.808 points ($p < .007$). Among neighborhood quality, significance is observed in the positive perception of public security. The coefficient score is observed to increase PCS by 0.668 ($p < .006$).

4.3.2.3 Grouped Environmental Domains

Regressions were run between demographic variables and environmental perceptions as grouped domains. See Table 7 for full regressions. Nature aspects (air, water, and noise pollution, and sunlight quality) observed an increase in MCS scores by 0.642 of a point ($p < .001$). Social environment aspects (public safety and neighborliness) were observed to increase MCS by 0.533 of a point ($p < .006$). Similarly, nature aspects predicted an increased PCS score of 0.270 ($p < .006$) and social aspects predicted an increased PCS score by 0.418 ($p < .006$).

doi:10.6342/NTU202403119

4.3.2.4 Regression

While multicollinearity is not a concern in this paper (as determined by calculating VIF previously), regressions for MCS and PCS are also included without demographic factors. See Table 8 for full regressions. This baseline analysis determines that for MCS, the model was shown to have significant fit for the data, R = 0.211; F(9, 1413), p < .01= 6.752. The 9 predictor variables account for 4.45% of the variability, where R^2 = .045 and adjusted R^2 = .0384. Baseline regression for PCS revealed R = 0.409; F(9, 1413), p < .01 = 3.60. The 9 environmental variables account for 2.24% of variability, where R^2 = .0224 and adjusted R^2 = .0162.

Among environmental quality, significance is observed in positive perception of lower noise pollution. The coefficient score is observed to increase MCS by 1.224 (p < .01). Positive perceptions of neighborliness is observed to increase MCS by 0.705 (p < .02). Interestingly, more positive perceptions of neighborhood walkability obtained a coefficient score of -0.641, indicating an decrease in MCS score, though significance is not obtained as the p-value (p < .061) is slightly over 5%.

Significance is observed in positive perception of sufficient sunlight, where the coefficient score is observed to increase PCS by 0.781 (p < .01). Positive perceptions of accessibility of fresh produce and public safety are observed to increase PCS by 0.454 (p < .02) and 0.769 (p < .01), respectively.

doi:10.6342/NTU202403119

Tables 2-8

Table 2 Study Sample Characteristics

Characteristic		N	Means or proportion, %	*SD*
Sex				
	Male	677	47.54	
	Female	747	52.46	
Age			61.38	15.87
	18 to 30	26	1.83	
	31 to 40	123	8.64	
	41 to 50	259	18.19	
	51 to 60	281	19.73	
	61 to 70	280	19.66	
	71 to 80	263	18.47	
	81 and older	192	13.48	
Marital status				
	Single	389	27.32	
	Married or co-living	824	57.87	
	Divorced or separated	127	8.92	
	Widowed	84	5.90	
Education				
	Primary and below	154	10.81	
	Secondary	262	18.40	
	Technical or Vocational	449	31.53	
	University and above	559	39.26	
Employment				
	Full-time	878	61.66	
	Part-time	136	9.55	
	Not working, Retired	410	28.79	
Income				
	No income	95	6.67	
	1-19,999	341	23.95	
	20,000-39,999	495	34.76	
	40,000-59,999	279	19.59	
	60,000+	214	15.03	
Exercise			3.17	1.35
	Never	221	15.52	
	Once per month	275	19.31	
	A few times per month	242	16.99	
	A few times per week	418	28.35	
	Everyday	268	18.82	
Air pollution			2.68	0.02
	Very serious	93	6.53	
	Serious	395	27.74	
	Not serious	813	57.09	
	Not serious at all	123	8.64	
Water pollution			2.92	0.02
	Very serious	28	1.97	
	Serious	236	16.57	
	Not serious	989	69.45	
	Not serious at all	171	12.01	

doi:10.6342/NTU202403119

Table 2 Continued

Characteristic		N	Means or proportion, %	*SD*
Noise pollution			2.70	0.02
	Very serious	121	8.50	
	Serious	364	25.56	
	Not serious	765	53.72	
	Not serious at all	174	12.22	
Insufficient sunlight			3.28	0.02
	Very serious	17	1.19	
	Serious	92	6.46	
	Not serious	797	55.97	
	Not serious at all	518	36.38	
Walkability			4.17	0.02
	Strongly disagree	15	1.05	
	Disagree	74	5.20	
	Neutral	2	0.14	
	Agree	890	62.50	
	Strongly Agree	443	31.11	
Fresh produce			3.89	0.03
	Strongly disagree	52	3.65	
	Disagree	199	13.97	
	Neutral	1	0.07	
	Agree	769	54.00	
	Strongly Agree	403	28.30	
Public facilities			4.16	0.02
	Strongly disagree	24	1.69	
	Disagree	87	6.11	
	Neutral	1	0.07	
	Agree	838	58.85	
	Strongly Agree	474	33.29	
Public safety			3.98	0.02
	Strongly disagree	12	0.84	
	Disagree	126	8.85	
	Neutral	8	0.56	
	Agree	1,005	70.58	
	Strongly Agree	273	19.17	
Neighborliness			3.96	0.03
	Strongly disagree	21	1.47	
	Disagree	139	9.76	
	Neutral	4	0.28	
	Agree	975	68.47	
	Strongly Agree	285	20.01	

doi:10.6342/NTU202403119

Table 3 Correlation Analysis

Variables	MCS	PCS	Age	Air	Water	Noise	Sunlight	Walkability	Produce	Facilities	Safety	Neighborliness
PCS	-0.014	1.00	-	-	-	-	-	-	-	-	-	-
Age	-0.305**	0.304**	1.00	-	-	-	-	-	-	-	-	-
Air	0.122**	0.020	-0.088**	1.00	-	-	-	-	-	-	-	-
Water	0.116**	0.004	-0.043	0.467**	1.00		-	-	-	-	-	-
Noise	0.156**	0.033	-0.091**	0.352**	0.298**	1.00	-	-	-	-	-	-
Sunlight	0.077*	0.084**	-0.016	0.109**	0.140**	0.179**	1.00	-	-	-	-	-
Walkability	0.000	0.061*	0.099**	0.143**	0.094**	0.157**	0.190**	1.00	-	-	-	-
Fresh produce	-0.001	0.071**	0.071*	0.044	0.001	-0.134**	-0.063*	0.157**	1.00	-	-	-
Public facilities	-0.027	0.038	0.119**	-0.022	0.009	-0.046	0.015	0.292**	0.460**	1.00	-	-
Public safety	0.098**	0.111**	-0.012	0.178**	0.165**	0.214**	0.141**	0.261**	0.123**	0.199**	1.00	-
Neighborliness	0.101**	0.059*	-0.005	0.121**	0.041	0.135**	0.152**	0.171**	0.079**	0.099**	0.314**	1.00

** shows significance at p<.05*
*** shows significance at p<.01*

doi:10.6342/NTU202403119

Table 4 Spearman's Correlation

	MCS		PCS	
Variables	*r*	*p*	*r*	*p*
Age	-0.328*	.000	0.300*	.000
Air	0.120*	.000	0.044	.098
Water	0.121*	.000	0.021	.429
Noise	0.160*	.000	0.034	.194
Sunlight	0.080*	.003	0.075*	.005
Walkability	-0.017	.513	0.092*	.001
Fresh produce	-0.005	.857	0.075*	.005
Public facilities	-0.049	.065	0.077*	.004
Public safety	0.076*	.004	0.128*	.000
Neighborliness	0.075*	.005	0.070*	.008

** shows significance at p<.05*

doi:10.6342/NTU202403119

Table 5 Variance Inflation Factors for Environmental Qualities

Variables	VIF	Tolerance
Age	1.48	.677
Employment	1.46	.687
Good Air	1.41	.710
Public Facilities	1.39	.721
Good Water	1.34	.748
Fresh Produce	1.32	.757
Good Noise	1.27	.786
Public Safety	1.25	.800
Walkability	1.23	.815
Relationship	1.20	.836
Income	1.19	.837
Neighborliness	1.15	.871
Sunlight	1.10	.912
Exercise	1.06	.940
Mean VIF	1.27	

doi:10.6342/NTU202403119

Table 6
Multiple Regression Results for MCS and PCS with Individual Environmental Factors

	MCS				PCS			
Variables	*B*	SE	*t*	*p*	*B*	SE	*t*	*p*
Male	0.066	0.467	0.140	.888	0.822*	0.349	2.350	.019
Age 31-40	-3.448	1.821	-1.890	.059	3.380	1.784	1.890	.058
Age 41-50	-4.656**	1.706	-2.730	.006	4.693**	1.726	2.720	.007
Age 51-60	-6.696**	1.749	-3.830	.000	5.968**	1.754	3.400	.001
Age 61-70	-8.137**	1.797	-4.530	.000	6.010**	1.771	3.390	.001
Age 71-80	-8.897**	1.822	-4.880	.000	7.423**	1.779	4.170	.000
Age 81 and up	-9.064**	1.888	-4.800	.000	9.422**	1.786	5.280	.000
Secondary school	-2.309*	0.965	-2.390	.017	0.580	0.857	0.680	.499
Vocational school	-2.177*	0.973	-2.240	.025	1.642*	0.826	1.990	.047
Tertiary	-3.015**	1.002	-3.010	.003	1.281	0.864	1.480	.138
Married	1.758**	0.625	2.810	.005	0.173	0.456	0.380	.705
Separated/divorced	0.376	0.990	0.380	.704	-0.325	0.751	-0.430	.665
Widowed	0.819	1.332	0.620	.539	1.639	0.925	1.770	.077
Part-time employment	-0.619	0.897	-0.690	.490	0.732	0.710	1.030	.303
Not employed	-0.323	0.739	-0.440	.662	-1.198*	0.591	-2.030	.043
No income	0.495	1.081	0.460	.647	1.373	0.949	1.450	.148
$20,000-39,999	1.981**	0.749	2.640	.008	1.020	0.619	1.650	.099
$40,000-59,999	2.209**	0.851	2.600	.009	2.123**	0.665	3.190	.001
$60,000+	3.437**	0.935	3.680	.000	2.213**	0.748	2.960	.003
Exercise	0.589**	0.180	3.280	.001	0.688**	0.145	4.740	.000
Air	0.399	0.387	1.030	.303	0.461	0.284	1.620	.106
Water	0.790	0.440	1.800	.073	-0.241	0.357	-0.670	.500
Noise	0.940**	0.319	2.940	.003	0.205	0.262	0.780	.434
Sunlight	0.581	0.375	1.550	.121	0.808**	0.298	2.710	.007
Walkability	-0.280	0.336	-0.830	.404	-0.134	0.244	-0.550	.581
Fresh produce	0.266	0.248	1.070	.284	0.287	0.193	1.490	.136
Public facilities	-0.176	0.325	-0.540	.589	-0.289	0.233	-1.240	.215
Public safety	0.355	0.310	1.140	.253	0.668**	0.242	2.760	.006
Neighborliness	0.720**	0.285	2.530	.012	0.194	0.233	0.830	.404
Constant	43.852**	3.174	13.820	.000	34.008**	2.691	12.640	.000
R-squared	.159				.173			
Adjusted R-squared	.141				.155			
	$F(29, 1393) = 9.772$				$F(29, 1393) = 7.814$			

** p<.05, ** p<.01*

Note: Models were separately conducted

doi:10.6342/NTU202403119

Table 7
Multiple Regression Results for MCS and PCS with Grouped Environmental Domains

	MCS				PCS			
Variables	*B*	SE	*t*	*p*	*B*	SE	*t*	*p*
Male	0.048	0.467	0.100	.919	0.870*	0.349	2.490	.013
Age 31-40	-3.440	1.820	-1.890	.059	3.421	1.818	1.880	.060
Age 41-50	-4.594**	1.711	-2.690	.007	4.705**	1.764	2.670	.008
Age 51-60	-6.693**	1.753	-3.820	.000	5.972**	1.787	3.340	.001
Age 61-70	-8.105**	1.802	-4.500	.000	5.935**	1.809	3.280	.001
Age 71-80	-8.902**	1.825	-4.880	.000	7.384**	1.816	4.070	.000
Age 81 and up	-9.046**	1.891	-4.780	.000	9.286**	1.824	5.090	.000
Secondary school	-2.376*	0.970	-2.450	.014	0.599	0.868	0.690	.490
Vocational school	-2.185*	0.975	-2.240	.025	1.762*	0.838	2.100	.036
Tertiary	-3.044**	1.005	-3.030	.002	1.349	0.876	1.540	.124
Married	1.769**	0.625	2.830	.005	0.149	0.458	0.320	.746
Separated/divorced	0.400	0.987	0.410	.685	-0.402	0.748	-0.540	.591
Widowed	0.899	1.334	0.670	.500	1.570	0.946	1.660	.097
Part-time employment	-0.570	0.893	-0.640	.523	0.735	0.707	1.040	.299
Not employed	-0.348	0.728	-0.480	.632	-1.254*	0.593	-2.120	.034
No income	0.464	1.083	0.430	.668	1.363	0.942	1.450	.148
$20,000-39,999	1.936**	0.739	2.620	.009	0.980	0.620	1.580	.114
$40,000-59,999	2.232**	0.840	2.660	.008	2.128**	0.666	3.200	.001
$60,000+	3.412**	0.923	3.700	.000	2.146**	0.746	2.880	.004
Exercise	0.604**	0.178	3.390	.001	0.698**	0.146	4.790	.000
Nature	0.642**	0.132	4.860	.000	0.270**	0.098	2.750	.006
Built	-0.019	0.121	-0.150	.878	0.013	0.090	0.140	.887
Social	0.533**	0.195	2.730	.006	0.418**	0.153	2.730	.006
Constant	43.599**	3.125	13.950	.000	33.902**	2.656	12.760	.000
R-squared	.156				.167			
Adjusted R-squared	.143				.153			
	$F(23, 1399) = 11.926$				$F(23, 1399) = 9.467$			

** p<.05, ** p<.01*

Note: Models were separately conducted

doi:10.6342/NTU202403119

Table 8
Multiple Regression Model for MCS and PCS with Environmental Characteristics

	MCS				PCS			
Variables	*B*	SE	*t*	*p*	*B*	SE	*t*	*p*
Air	0.593	0.415	1.430	0.153	0.037	0.299	0.120	0.901
Water	0.738	0.457	1.620	0.106	-0.321	0.360	-0.890	0.373
Noise	1.224**	0.336	3.640	0.000	0.105	0.277	0.380	0.706
Sunlight	0.586	0.396	1.480	0.139	0.781*	0.327	2.390	0.017
Walkability	-0.641	0.343	-1.870	0.061	0.14	0.253	0.550	0.579
Fresh produce	0.276	0.261	1.050	0.292	0.454*	0.205	2.220	0.027
Public facilities	-0.403	0.339	-1.190	0.235	-0.149	0.237	-0.630	0.530
Public safety	0.542	0.323	1.680	0.093	0.769**	0.264	2.920	0.004
Neighborliness	0.705*	0.297	2.370	0.018	0.104	0.249	0.420	0.675
Constant	39.71**	2.277	17.440	0.000	44.243**	1.746	25.350	0.000
R-squared	.045				.022			
Adjusted R-squared	.038				.016			
	F(9, 1413) = 6.752				F(9, 1413) = 3.593			

** p<.05, ** p<.01*

Note: All models are separately conducted; table with major independent variables are shown

doi:10.6342/NTU202403119

5. Discussion

This study aimed to analyze the relationship between perceived environmental and neighborhood quality on MCS and PCS scores in the Taiwanese population. It was predicted better perceptions of environmental and neighborhood quality would positively correlate with MCS and PCS scores (aim 1) and predict higher MCS and PCS scores (aim 2).

Aim 1 was partially supported. Statistically significant correlations were found among demographic variables and MCS and PCS scores. Environmental qualities of lower air, water, and noise pollution, as well as sufficient sunlight, public safety, and neighborliness were associated with increased MCS. Statistically significant correlations were observed between perception of adequate sunlight, neighborhood walkability, accessibility to produce, public safety, and neighborliness and PCS.

However, many correlation coefficients presented in this study are considered small or weak. It is understood Pearson's correlations in social psychology studies tend to hover at/around .21, especially when it relates to attitudes and perceptions, and strong correlations are found to be quite rare (Richard et al., 2003). Regardless, this study will place more emphasis on regression analysis results, as they are stronger and provide more context on the relationship between perceived environmental quality and outcomes on health.

5.1 Implications of Findings

The role of environment and its impact on health is well-documented in the field. However, the role of perceived environmental quality is less explored, particularly in Taiwan. This study contributes to this research gap, and adds evidence that the role of perception has an impact on both mental and physical health.

Although perception of environment is important to mental and physical health as demonstrated by the findings of this study, it is also still highly related to objective

doi:10.6342/NTU202403119

measures of environmental quality. Neighborhood satisfaction is influenced by both objective levels and subjective interpretations of one's environment. The relation between objective and perceived measures of environmental quality are found to be significant. In neighborhoods where access to public facilities and green space is objectively easy, residents are more likely to have better perceptions of accessibility, and as a result, be more satisfied with neighborhood quality (Barnett et al., 2020). Perception of environmental quality can also be a mediator in the effect of objective built environment on one's life satisfaction (Cao, 2016).

When it comes to the natural environment, associations between measured air quality and perception of concern for air quality have been observed (Cobbold et al., 2022; Cori et al., 2020). Positive associations were also found between neighborhood quality satisfaction and objective levels of air quality (Carp & Christensen, 1986). This suggests measured exposures of pollution are related to the perception of those aspects. These associations also affect behaviors. Both objective and perceived air pollution levels increase residents' negative affects and decreased satisfaction with the government's control of air quality, which negatively impacts environmentally conscious behavior (Yang et al., 2023). This then asserts objective measurements are linked to perceptions of quality, which in turn can affect behavior, and ultimately can affect health outcomes.

Similar findings are observed with the built environment. More green space in Hong Kong, for example, was found to be related to increased perceptions of the built environment and sense of community, and higher mental health and subjective well-being (Guo et al., 2021). This suggests the objective levels of green space is related to the perception of it, which in turn positively affects mental health and self-rated health. Again, these perceptions can affect behaviors. Physical activity can be impacted

doi:10.6342/NTU202403119

by both perceived and objective measures of the environment (Hoehner et al., 2005). Engaging in any bicycling activity for transportation and meeting recommendations through recreational activity were significantly associated with perceiving that bike lanes were present on most streets in the community. Not only are there correlations between objective and perceived environmental qualities, perceived quality of facilities has been found to mediate the relationship between objective facilities and leisure physical activity (Van Dyck et al., 2013; S. Zhang et al., 2024). In other studies, however, perceived built environment aspects were found to provide stronger evidence of positive associations with physical activity than objectively measured aspects (Hua et al., 2022). Nevertheless, this emphasizes how the mechanisms of objective and perceived qualities of the built environment are also intertwined, which may also affect behavior.

In the social environment aspect, objective environmental conditions also affect satisfaction of neighborhood environments. Objective measures of safety from crime were found to be associated with satisfaction of the living environment (Carp & Christensen, 1986). People are more likely to spend time outside engaging in physical activity when they perceive their environment is safe (Cerin et al., 2013). This engagement with the neighborhood environment can also shape social behaviors. Perceptions of high social disorder in the neighborhood were found to be associated with higher objective levels of social disorder and lower levels of social cohesion (Plascak et al., 2021). When individuals feel there is less social cohesion in the neighborhood, it manifests in measured levels of less social cohesion.

Both perceived and objective measures in each domain of the environment are associated with the other. This suggests perceived environmental quality and objective environmental quality are closely related. Perceived quality and objectively measured

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factors are also shown to have an effect on behavior. There is a complex relationship among perceived quality, objective quality, satisfaction, health, and behavior. While the relationship is not explained in this study, the preceding literature demonstrates the interconnectedness of such mechanisms, and the following discussion provides commentary and recommendations with the understanding these factors are intertwined.

5.1.1 Regression Analysis

Aim 2 was also partially supported. In regards to environmental quality, perceptions of lower water pollution, lower noise pollution, and neighborliness was associated with increased mental health. Better perceptions of adequate sunlight and public safety in one's neighborhood was associated with higher physical health quality.

5.1.1.1 Perceived Environmental Quality and Mental well-being

The most influential aspect of environmental quality on mental health scores are positive perceptions of low noise pollution ($p < .003$) and low water pollution ($p < .073$).

This supports World Health Organization reports on noise pollution as a growing burden of disease, and water pollution as a contributor to the spread of disease.

The majority of respondents did not view noise pollution as a health concern, however 34% of respondents reported noise pollution as a serious or very serious concern, indicating there remains concern among the general population about the impact of noise. Regression analysis suggests positive perceptions of lower noise pollution can serve as a protective factor in mental health, increasing MCS by nearly 1 point. Findings support the need for local governments to take heed to noise pollution, especially in metropolitan areas, where population density is also higher. While most people do not find current noise bothersome, dissatisfaction exists among over a third of the population. As findings in the literature suggest, noise disturbance impacts health

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outcomes in both objective and subjective spheres. Those highly annoyed by environmental noise are found to have a higher risk for mental health problems (Gong et al., 2022). As noted in the literature review, the context of noise may also play a role in mental health quality. If one lives near an airport, the individual's perception of noise pollution is likely to be different from that of one who lives next to the ocean.

What is deemed noise pollution may be unique to the individual. The term "noise pollution" is up to the respondent's interpretation, which suggests context of noise may be an important factor in what may constitute noise pollution. If an individual is unaffected by night traffic and can sleep undisturbed, they may perceive noise pollution to be lower than another who is sensitive to noise. Still, what remains is the importance of the perception of noise, regardless of objective levels. What one perceives to be important can impact one's health outcomes. This emphasizes our findings on the significance of perceived environmental quality on health, regardless of objective effect.

Similarly, perceived exposure to water pollution can increase the prevalence of mental disorders, as explored previously. While 95% statistical significance was not met for water quality, the p-value was approaching at .073.This aligns with findings that perceived pollution and threats to health affect anxiety levels, negatively impacting mental health. Again, these perceptions may be driven by inadequate education about objective levels of pollution and the impact on health. Regardless, as noise and water concerns often occur in the public domain, there is room for improvement in the public sphere. More uniform definitions of acceptable noise and water pollution levels allow for it to be a policy issue, as it can be addressed or controlled by local authorities. And therefore, there exists a potential policy avenue for improvement in noise and water quality. However, to emphasize again, perception plays a crucial role in mental health

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outcomes, as better perceptions of noise quality and water quality in one's neighborhood increased MCS scores by 0.940 of a point ($p < .003$) and 0.790 ($p < .073$), respectively.

Neighborliness was found to be associated with higher mental health quality, where MCS increased 0.720 of a point ($p < .012$). This is because when individuals perceive they can rely on neighbors for help, regardless of whether or not it is needed, individuals feel a sense of social cohesion (Du et al., 2023), which increases feelings of security, and can provide improved mental health status. Community-led initiatives can increase feelings of social cohesion, as individuals can grow to feel part of a collective by increasing resilience during times of crisis (Cruwys et al., 2022). Different levels of strategy exist to increase social cohesion, including through social interaction, environmental avenues (encouraging action in and through public spaces and how they are set up), and through institutional avenues (such as establishing a shared community space) (Jennissen et al., 2023). When people are familiar with whom they live around and can recognize one another in public spaces, relationships are formed, regardless of whether or not they know one another more intimately (Blokland & Nast, 2014). This study's findings bolsters the support for increased social cohesion, because individuals are able to find commonalities with others they would otherwise view as strangers. They can feel a sense of belonging, albeit in nontraditional ways. This encourages local governments or associations to create avenues in which individuals from a neighborhood can regularly interact, whether in a public recreation center, or at a nearby cafe. Feeling a sense of support within a neighborhood community serves as a protective factor contributing to better mental health.

5.1.1.2 Perceived Environmental Quality and Physical Well-being

Regression results align with previous literature on better perceptions of sunlight quality and better physical health. This is related to the likelihood of increasing time

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spent outdoors and whether one engages in physical exercise. As beauty standards in Asian contexts may hinder time spent outdoors in the sun (Jang et al., 2013; Nimitphong & Holick, 2013), this can lead to an increase of vitamin D deficient individuals (Man et al., 2017). Vitamin D deficiency is associated with higher risk of developing cancers, autoimmune diseases, and infectious diseases (Holick & Chen, 2008). Alarmingly, Asian populations have been observed to have a higher prevalence of vitamin D deficiency as compared to other continents' in a systematic review of 472 studies (Z. Jiang et al., 2023). As a result, the government may consider educational strategies to encourage increased sun exposure in Taiwan, as sun exposure is beneficial to human health. While subjective interpretations of what might be excessive sunlight or insufficient sunlight vary, the context of East Asian standards suggests perceptions of adequate sunlight may not actually be enough for people on the island. This can be especially true for those living in the North of Taiwan and women (M.-J. Lee et al., 2019). Again, objectively measured and perceptive interpretations are intertwined. As this study shows, perceptions of adequate sun exposure increases physical health by 0.808 of a point ($p < .007$). This might suggest people who perceive there to be adequate sunlight have better overall physical health. However, standards of adequacy may need to be improved by the government for educational purposes, as it is observed East Asia has higher prevalences of vitamin D deficiency in numerous studies.

Increasing feelings of public security will encourage individuals to spend time outdoors. This study found PCS to increase by 0.668 ($p < .006$) when perceptions of public security were higher. In Taiwan, public trust in the police has manifested in general satisfaction in public safety—when citizens perceive the government to be performing well, they are also more likely to have more trust in the police (Sun et al., 2014). As most respondents (89.75%) surveyed indicated agreement or strong

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agreement with public safety in their neighborhoods, there is overwhelming consensus Taiwanese feel generally safe. Strengthening relationships with those in one's neighborhood may also increase time spent outdoors. As studies have found, when people feel safe outside, they are more likely to engage in activities, like exercise (Rees-Punia et al., 2018). Additionally, by strengthening the relationships with others, it may increase exercise behaviors, directly impacting physical health (Giles-Corti & Donovan, 2002).

This may suggest efforts to continue to reinforce trust within communities and police force to maintain high levels of perceived safety in one's neighborhood. Taiwan is generally very safe (even viewed as such globally) (Everington, 2023). However, there always remains room for improvement. Some say public safety measures developed in recent years have not been effective among the government or society, which can be attributed to the numerous agencies that operate mostly independently in Taiwan (Hebenton et al., 2023). Agencies separately publish statistics on incidents, crimes, and cases. However, that lack of uniformity makes it difficult for citizens to easily gain information. So while perceptions of safety on the day-to-day for most is satisfactory, there remains room for improvement within the bureaucracy to help measure and assess perceptions of crime for the general public.

5.1.1.3 Regression with Domains of Environmental Quality

By separating environmental quality factors into natural, built, and social groups, the impact of each domain can be better assessed. Regression analysis found significance between the natural and social environment and an increase in MCS scores. This suggests perceptions of perceived pollution and feelings of safety and social cohesion may be more important to mental health than qualities of the built environment. Similarly, significance was also observed between the natural and social

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environment domains and an increase in PCS scores. This also suggests perceptions of the natural environment and social environment in which one lives have more significant impact on physical health. Better perceptions of these domains can be a protective factor in both mental and physical health quality in the Taiwanese population.

Perception of the natural environment, in areas of reduced pollution, may also be more impactful on health than the built environment quality. Perceived air pollution was found to impact physical activity more than qualities of the surrounding environment, like “attractive natural sightings” (Patel et al., 2024). The built environment can have less of an effect on physical activity than social environments. The likelihood of exercising reported higher increases when respondents had positive social environments (like relationships) that encouraged exercising more so than supportive built environments (access to facilities) (Giles-Corti & Donovan, 2002). Feelings of safety and social cohesion can moderate perceived barriers in the built environment on physical activity (Sawyer et al., 2017; Y. Wang et al., 2023). Regardless of perceived built environment challenges to physical activity, the social aspects of one’s neighborhood can encourage residents to remain active. This helps to substantiate the findings of this study, where social aspects of one’s environment can promote or increase physical activity, and as a result, impact health.

5.1.1.4 Regression without Demographic Factors

Additionally, when comparing environmental factors and MCS and PCS, baseline regressions indicate the same perceived environmental quality factors affect health summary scores. MCS is seen to increase when perceptions of lower noise pollution ($\beta = 1.22$, $p < .01$) and neighborliness ($\beta = 0.71$, $p < .05$) are higher. PCS is seen to increase when perceptions of adequate sunlight quality ($\beta = 0.78$, $p < .01$), access to fresh produce ($\beta = 0.45$, $p < .05$), and public safety ($\beta = 0.77$, $p < .01$) are

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higher. This mirrors regression analysis for MCS and PCS scores with demographics variables included. This indicates perception of environmental quality still affects mental and physical health without the inclusion of demographics factors of sex, age, relationship status, education, and income level.

However, it should be noted demographic factors contribute meaningful information to the regression model, enhancing explanatory power. Even though the environmental quality aspects alone provide a good fit, the inclusion of demographics provides additional insight to mental and physical health quality.

5.1.1.5 Demographic Factors and Mental and Physical Health

Alongside environmental quality variables and MCS/PCS scores, demographic aspects were also found to play a role in mental and physical health outcomes. This is not unusual, as this parallels theories of social determinants of health and the social ecological model. Statistical significance was observed between several demographic factors and MCS. Increasing age and increasing education was associated with decreased mental health, while higher income was associated with higher mental health quality. Statistical significance was observed between demographic factors and PCS, as well. Being male, increasing age, and higher income was associated with better physical health. Higher educational attainment and unemployment was associated with decreased physical health. Most of these findings are substantiated in previous literature. Men have better physical health when compared to women (Hugh-Jones et al., 2023; Sialino et al., 2022). Higher income is a protective factor for both mental and physical health (Sallis et al., 2009; Shields-Zeeman & Smit, 2022).

And as revealed by ANOVA and post-hoc testing, being married, divorced, and/or widowed led to higher MCS scores, as compared to those single. Interestingly, being single led to lower PCS scores than those married, divorced, or widowed.

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Demographic analysis reveals being single increases physical health, but not mental health. Being married might be better for one's mental health, but not physical health. Those married and cohabiting are often found to have better mental health than those not (Amato, 2015). However, those married might be more likely to become overweight (Quan & Zhang, 2024) or obese (Cobb et al., 2016). Perhaps people are happier in marriage and eat more…food for thought.

Those not working or retired reported lower PCS scores than those working full-time and part-time. This suggests not working worsens physical health. A systematic review revealed better mental health was found among retirees, though physical health could not be determined (van der Heide et al., 2013). Other studies found decreased physical health among those not working may be a result of increased sedentariness, which is viewed as natural with aging (Dave et al., 2008; Eklund et al., 2021). However, this study's findings report the opposite.

In Taiwan, this may have implications for the older adult populations, as the country quickly approaches the super-aged threshold. The coefficient scores for each age group associated with MCS was: -3.583 ($p < .01$) for those 51 to 60, -5.186 ($p < .01$) for those 61 to 70, -5.993 ($p < .01$) for those 71 to 80, and -6.204 ($p < .01$) for those 81 and older. This indicates as people age in Taiwan, their mental health markedly decreases per decade, with the highest change between aged groups 51 to 60 and 61 to 70. This perhaps can be attributed to changes in circumstances experienced, such as retirement. PCS was seen to increase with age, increasing incrementally from 3.58 ($p < .01$) for those 51 to 60 to 8.93 ($p < .01$) for those 81 and older. This is unaligned with most existing literature that suggests increasing age as a protective factor of mental health (Lorem et al., 2017).

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As the age distribution of Taiwan's population is changing, it may be important to consider this aspect of impact on health. Over 51% of adults sampled included those aged 61 and older. Nearly 32% were aged 71 and over. While Taiwan is set to become a super-aged society by 2026, this distribution may indicate it can occur sooner than expected. Aging adults tend to spend more time near their homes, increasing attachment to both the built and social environments of their neighborhoods (Guo et al., 2019, 2021), which places further emphasis on the need for satisfactory environments, especially if older adults are to age in-place well. It has been found that higher levels of perceived quality of neighborhood spaces for leisure and exercise facilitate healthy aging in place (P.-J. Chang et al., 2020).

Perhaps Taiwan is currently successful at creating age-friendly environments for physical health outcomes, but not mental outcomes. Local governments in Taiwan have signed cooperation agreements to promote age-friendly environments, and the central government has provided subsidies to each of the 22 administrative divisions to create new age-friendly communities (Health Promotion Administration, Ministry of Health and Welfare, 2021). In Taiwan, older adults are commonly seen exercising in parks. Chinese adults view physical activity as important parts of their daily lives (Liu et al., 2015). On the other hand, mental health may be a difficult health issue to approach. Mental health issues in Taiwan are still often stigmatized (Yao & Hong, 2024), and those who seek solutions through healthcare avenues have not received adequate service or effective treatment (T.-Y. Chang et al., 2022). This would help explain why older adults are more likely to have higher physical health quality, but lower mental health quality with increasing age. As neighborliness in this study was observed to predict higher mental health scores, older adults could especially benefit from increased

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feelings of social cohesion. Being able to depend on neighbors may help reduce mental health losses that are experienced with aging (Cramm et al., 2013).

5.2 Limitations

Homogeneity of the participants and culture may affect the generalizability of this study's findings on a global scale. Additional studies among various and more multiracial populations can be helpful for general population conclusions.

In utilizing self-rated health status, the survey runs the risk of creating bias, especially in social-desirability bias (Piedmont, 2014). As stigma surrounding mental health issues exists in Taiwan, this may affect how survey respondents report their mental health quality in more positive ways. Predictors of social-desirability responses have been found among those older, less educated, and of lower socio-economic status (Dawes et al., 2011). This aspect remains a limitation to this study's findings.

This study did not utilize objective measurements, which would have been useful in comparing further the role of perception on mental and physical health quality. Gaps in studies exploring objective and perceived environmental quality simultaneously persist, as other demographic factors may play mediating roles (Weden et al., 2008), which encourages further research. And, perceived quality can reflect objectively measured environmental quality. This, however, cannot be explored in this study. Future studies involving both perceived and objective environmental quality would add support for more evidence on the role of perceived environmental quality on health and well-being.

The scales used in measuring perception of environmental quality were also limited and could not account for more variety or detailed answers. This could result in forced-choice bias (Barakji, 2017). Because the Likert scales utilized to measure perceived natural environment was limited to four options between "disagree" to

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"agree", respondents were forced to select an option that best fit their judgment. There was no "other" option, and respondents did not have the ability to explain or justify their responses if they chose not to answer. Similarly, the Likert scales utilized to measure perceived neighborhood environment was limited to five options, and did not allow for a diverse range of responses. As a result, practical significance must be recommended with caution as responses may not reflect more nuanced answers.

Lastly, although VIF was found to be less than 4, which supports the assertion there is no multicollinearity within the independent variables, correlations are still observed between several variables. And while correlation coefficients are very small, many are statistically significant. R-squared is also quite low for both models (MCS = 15.6%, PCS = 16.7%), which suggests environmental perceptions may play a smaller role in MCS and PCS scores.

Additionally, this study can provide additional context to establish associations between the mechanism of perceived environmental quality and health quality outcomes, but cannot conclude on findings of causation. Further research can help determine causal linkages between perception and health outcomes.

5.3 Strengths, Other Considerations, and Future Directions

While correlations are low, regressions analysis reveals significant coefficients for several environmental qualities, which adds to literature on the importance of considering perceived environmental quality on mental and physical health. Regression results provide more substantial evidence supporting the role of perceived environment on mental and physical health outcomes. Both regression models for MCS and PCS outcomes had F-statistic values significantly higher than the critical value. Adjusted R^2 values for both models were below .2, which is generally acceptable in social science

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research, as the aim of the study was to test theories on the influence of perception on health, rather than to predict (Moksony, 1999; Ozili, 2022).

The MCS and PCS scores in this study are normalized, so findings from this study can be used for comparison with other populations, with similar methods. It would certainly be insightful to conduct cross-country analysis. It would provide additional context on the role of perception and environment in other country contexts.

More locally, this study also provides insight on how Taiwanese people feel about their neighborhood environments. Influenced by Confucian, Buddhist, and Taoist values, traditional Han culture places emphasis on respecting nature and the surrounding environment; expressly, the responsibility of man is to "maintain the healthy development of heaven and earth" (W. Jiang & Zhang, 2020). As Taiwan expands its semiconductor industry, for example, do these values still hold significant influence on general attitudes toward the natural and built environment? Could perceptions of pollution be lower than that of objective measurements to compensate for knowledge of anthropogenic environmental degradation? *Have* perceptions changed? It would then be useful to measure changes in perceptions overtime, and explore the potential changes in associations between perception of environmental quality and health quality with the next data set.

Additionally, the majority of respondents viewed each environmental aspect associated with pollution as "not serious" with air pollution at 57.1% and water pollution at 69.5%. This may suggest most of the general Taiwanese population does not perceive aspects of environmental pollution to be a serious matter in their daily lives. However, air pollution is objectively problematic for health in Taiwan, especially for those living on the more densely populated, urbanized western coast. While improvement in air quality has been documented over the last quarter century, seen in

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tapering off of ozone levels and decline in PM10, PM2.5, carbon dioxide, nitrous oxide, and sulfur dioxide, the major constituents of PM2.5 have not changed, suggesting those pollutants continue to impact air quality (Chou et al., 2020). Those with higher environmental awareness are more likely to view pollution as a serious threat (Ruan et al., 2022). This can suggest additional educational resources or strategies to deliver information regarding environmental pollution can be implemented and improved. For initiatives to be successful, citizens need to actually care. For example, government restrictions since 2002 on the use of certain plastics in Taiwan have not been effective; while its recycling industry was successfully converted into a circular economy model, the proportion of plastic in garbage waste actually increased from 2017 to 2020 (Tsai, 2022). While it is not lack of awareness that may have contributed to this continued problem, the personal inconvenience at the individual keeps plastic as a go-to product for single-use shopping bags and utensils. (C.-H. Lee, 2019). This demonstrates the ineffectiveness of a pollution reduction policy that in theory, should be very impactful. If individuals are not motivated to genuinely care about their contributions to pollution and how to mitigate the effects of their footprint, they may be unwilling to change their behaviors. This ties back to the importance of perception. Self-efficacy in climate change predicts pro-environmental behavior (Geiger et al., 2017). If individuals perceive their self-efficacy to be strong enough to change their surrounding environment and their own health, they may be more willing to initiate behavior change.

Similarly, most respondents viewed each neighborhood quality with agreement in finding satisfaction with notably high public safety and neighborliness at 70.6% and 68.5%, respectively. General satisfaction with built environmental quality suggests immediate improvements to neighborhood aspects perhaps are not necessary, but as regression results show, feelings of the ability to rely on one's neighbors for help can

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protect mental health. There is room for future discussion on the role of perception of neighborhood integration in different geospatial locations. For example, are those in southern Taiwan more likely to report positive perceptions of neighborliness? Southern townships are more likely to have stronger affinity toward the Taiwanese identity than northern townships, which can be explained by behavior conformity (T.-M. Lin et al., 2006). Geospatial differences may be useful for comparison of the role of perceived environment on populations in future studies.

Interestingly, walkability was rated quite high, despite the lack of walkable sidewalks in most of Taiwan, which has been described as a "living hell" for pedestrians (W. Chang, 2022). The first quarter of 2024 reported a nearly 16% rise in pedestrian deaths from the first quarter of 2023 and is the result of failure to yield to pedestrians (S. Wang & Ko, 2024). This comes after Taiwan implemented stricter enforcement of traffic laws (Everington, 2023b). While traffic safety is an obvious problem, why are most respondents in the survey satisfied with the quality of walkability in the surrounding environment? This is worth further exploration, as well as investigating Taiwanese attitudes toward other environmental qualities in general. This section poses many unanswered questions, which hopefully can be answered in future discussion.

6. Conclusion

Perceptions of environmental quality play a role in mental and physical health quality in Taiwan. This study found more positive perceptions of neighborhood water quality, noise quality, and neighborliness to be associated with higher mental health component scores. It also revealed positive perceptions of sunlight quality and public safety to be associated with higher physical component scores. In regards to grouped environmental quality, better perceptions of natural and social environmental qualities

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were associated with higher MCS and PCS scores. This may suggest certain aspects of one's neighborhood environment play a larger role on health quality. Regardless, one's perception of his/her surrounding environment really does matter to health. Findings suggest the Taiwanese government may consider initiatives to continue building healthier environments for individuals to thrive and strategies to increase the public's perception of living in environments conducive to healthy living.

doi:10.6342/NTU202403119

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