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Urban–Rural Disparity in Socioeconomic Status, Green Space and Cerebrovascular Disease Mortality

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Abstract: With rapid urbanization in Taiwan, the green space has become a key factor in modifiable cardiovascular disease (CVD) risks. We investigated the relationships between socioeconomic status (SES), green space, and cerebrovascular disease (CBD) at the township level in Taiwan, focusing on urban–rural disparities. Analyzing data from 358 townships (2011–2020), we examined SES indicators (e.g., low-income households, education levels, median tax payments), green space (Normalized Difference Vegetation Index—NDVI), and CBD mortality rates using the pooled ordinary least squares (OLS) and random-effect models (REM) in panel regression. Additionally, we explored the mediating role of the NDVI in the SES-CBD mortality association. CBD mortality decreased more in urban areas over the decade, with consistent NDVI patterns across regions. Rural areas experienced a decline in low-income households, contrasting with an increase in urban areas. SES variables, NDVI, and time significantly affected CBD mortality in rural areas but not urban ones. Notably, the NDVI had a stronger impact on CBD mortality in rural areas. Mediation analysis revealed the NDVI's indirect effects, especially in rural areas. Despite overall declines in CBD mortality in Taiwan, urban–rural disparities in SES and green space persist. Addressing these disparities is critical for understanding and developing interventions to mitigate health inequalities.

Keywords: urban–rural disparity; socioeconomic status (SES); green space; cerebrovascular disease mortality

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Citation: Lin, W.-Y.; Lin, P.-Y.; Wu, C.-D.; Liang, W.-M.; Kuo, H.-W. Urban–Rural Disparity in Socioeconomic Status, Green Space and Cerebrovascular Disease Mortality. *Atmosphere* **2024**, *15*, 642. https://doi.org/10.3390/atmos15060642

Academic Editor: Daniele Contini

Received: 21 April 2024
Revised: 6 May 2024
Accepted: 24 May 2024
Published: 27 May 2024

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1. Introduction

Cerebrovascular diseases (CBDs), including strokes, represent a major global contributor to morbidity and mortality. The impact of stroke extends beyond high mortality rates, as the substantial morbidity associated with it means that up to 50% of survivors experience chronic disabilities [1]. Over the last decade in Taiwan, advancements in quality improvement initiatives have yielded positive outcomes, resulting in a notable decline in stroke-related mortality and recurrence rates [2]. The association between urban green space and a reduced risk of major neurological conditions, particularly stroke, remains

uncertain. In a population-based cohort study by Paul et al. [3], increased urban green space exposure was associated with reduced dementia and stroke incidence. However, factors like air pollution and road traffic noise also contribute to stroke risk. In a cohort with 18,344,976 years of follow-up and 94,256 stroke cases, only $PM_{2.5}$ (HR: 1.058, 95% CI: 1.040–1.075) and noise at the most exposed façade (HR: 1.033, 95% CI: 1.024–1.042) were independent contributors to higher stroke risk. Both noise and air pollution significantly contributed to the Comprehensive Risk Index (CRI) (1.103, 95% CI: 1.092–1.114) in a model considering noise, green space, and total $PM_{2.5}$ concentrations [4]. Yet, there is limited evidence exploring the interplay between urban–rural disparities in socioeconomic status (SES), green space availability, and mortality related to cardiovascular diseases (CVDs) and CBDs. Nevertheless, gaining insights into how factors such as SES and access to green spaces may influence CBD mortality can inform policies and interventions aimed at reducing health inequalities. Numerous studies [5,6] underscore significant health outcome disparities between urban and rural areas. Urban locales often benefit from greater access to healthcare facilities, specialized medical services, and economic opportunities, contributing to improved health outcomes. Conversely, rural areas may encounter challenges associated with limited healthcare access, lower socioeconomic status, and environmental factors. Addressing these gaps in knowledge is crucial for developing targeted interventions to address and prevent disparities rooted in rurality.

Undoubtedly, SES significantly influences health outcomes. Lower-SES individuals often face barriers to quality healthcare, education, and essential resources, impacting their overall well-being. These disparities can lead to elevated stress levels and unhealthy behaviors, contributing to CVD and CBD. Lower-SES groups may be more susceptible to the effects of unhealthy lifestyle factors, either through stress-related interactions or accelerated biological aging. Green spaces, including parks and recreational areas, offer various health benefits such as improved mental well-being, reduced stress, increased physical activity, and better cardiovascular health. However, despite extensive research, findings on the relationship between SES, green space, and CBD mortality remain conflicting. Further investigation is needed, particularly regarding urban–rural disparities in SES, green space availability, and CBD mortality. In addition, does the presence of green space mediate the relationship between SES and mortality associated with CBD in both rural and urban areas? Clarifying these connections can provide a more comprehensive understanding of the complex interplay between urban and rural environments, socioeconomic factors, and access to green spaces in influencing mortality from CBD. Hence, the aim of this study is to assess urban–rural disparities in SES, green space availability, and CBD mortality in Taiwan.

2. Materials and Methods

2.1. Measurement of Socioeconomic Variables

The study examined three key socioeconomic variables—high educational attainment, low-income households, and median tax payments—across 358 townships in Taiwan, excluding Lienchiang County. The high educational attainment among individuals aged 15 and above in both townships was assessed based on the percentage of those holding a university degree or higher. The relevant data were sourced from the Government Open Data Platform https://data.gov.tw/dataset/8409 (accessed on 2 January 2024). The calculation of this percentage involved dividing the number of individuals with a university degree or above by the total population of each township. Similarly, the proportion of low-income households in each township was determined using population data obtained from the Ministry of the Interior's Department of Household Registration https://www.ris.gov.tw/app/portal/346 (accessed on 2 January 2024) and the Ministry of Health and Welfare's Statistics Department https://dep.mohw.gov.tw/DOS/cp-5337-62357-113.html (accessed on 2 January 2024). This involved dividing the number of low-income households in each township by the total population of the township. Moreover, the median tax payment for each township or city area was

computed using data extracted from the statistical analysis tables featured in the Statistical Monograph published by the Fiscal Information Agency, Ministry of Finance https://www.fia.gov.tw/singlehtml/43?cntId=17dcd598b9fd41939cf98c2e4ae162fd (accessed on 2 January). The median tax payment, expressed in thousands of new Taiwan dollars (NTD), was determined through specific calculations for each township. In summary, the evaluation of educational attainment, proportions of low-income households, and median tax payments relied on data from Taiwan's governmental sources, fostering a comprehensive understanding of the socioeconomic landscape at the township levels. The 358 townships in Taiwan were broadly classified into two main groups—urban and rural areas—based on their categorization into seven clusters: metropolitan core, industrial and commercial areas, emerging towns, traditional industry towns, low-developed townships, aging townships, and remote townships [7].

2.2. Calculation of Normalized Difference Vegetation Index (NDVI) and $PM_{2.5}$

The index of surrounding greenness in Taiwan was assessed using the Normalized Difference Vegetation Index (NDVI), obtained from the MOD13Q1 database (Version 5). This dataset was collected by the US National Aeronautics and Space Administration (NASA) through the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite. Detailed information about NDVI extraction was sourced from Lee et al. (2020). In essence, the NDVI was computed based on near-infrared (NIR) bands and red (RED) bands measured by satellites, resulting in values ranging from -1 to 1. A higher positive value indicates greater greenness coverage. MODIS provides NDVI images at a 250 m grid resolution every 16 days. Detailed information regarding NDVI extraction was referenced from Wu et al. [8]. All greenness statistics were aggregated at the township level. We initially employed a hybrid Kriging/land-use regression (LUR) technique to determine the annual average $PM_{2.5}$ concentration. The validation process incorporated checks for overfitting and robustness through three methods: (1) holdout validation, (2) 10-fold cross-validation, and (3) external data validation. This approach enabled us to simulate the concentration and pinpoint essential spatial variables influencing $PM_{2.5}$ distribution [8,9].

2.3. Measurement of Age-Standardized Mortality Rate (ASMR) for CBD

The ASMR for CBD in this study was sourced from the Center for GIS, RCHSS, Academia Sinica, and their Taiwan SMR Map. Population data utilized in the ASMR calculations were derived from the population statistics of various counties and townships found in the Social and Economic Database of the Ministry of the Interior. This process resulted in the computation of ASMR for each year, gender, and township area level. Through these calculations and data sources, the study obtained ASMR values, providing insights into the mortality patterns within specific townships.

2.4. Statistical Analysis

The data analysis utilized SPSS package version 24. Initially, Student's t-test was employed to explore variations in the ASMR of CBD, the NDVI, and socioeconomic variables in urban and rural areas. Subsequently, one-way ANOVA was employed to assess the differences in ASMR of CBD, the NDVI, and socioeconomic variables across four years within both urban and rural areas. Panel regression was used to investigate the variations in the association between the ASMR of CBD and socioeconomic variables, time, and the NDVI within both urban and rural areas, utilizing both pooled ordinary least squares (OLS) and random effect models (REM). Additionally, a structural equation model (SEM) was employed to assess the mediating effect of the NDVI on the relationship between socioeconomic variables and the ASMR of CBD within both urban and rural areas.

3. Results

Table 1 presents a comparative analysis of the ASMR for CBD, the NDVI, and socioeconomic variables in rural and urban areas across the years 2011–2020. The results reveal

that the ASMR of CBD was higher in rural areas compared to urban areas, suggesting an inverse correlation between urbanization levels and CBD-related ASMR. Conversely, the NDVI value was significantly lower in urban areas (0.46) than in rural areas (0.61). When examining townships with a proportion of low-income households, rural areas exhibited a higher percentage at 3.00%, surpassing the 1.31% observed in urban areas. Regarding townships with a proportion of the population holding a university education or above, urban areas indicated a higher percentage at 24.31%, compared to the 13.32% observed in rural areas. Additionally, the median tax payment in urban areas was higher than that in rural areas. In summary, urban areas tended to have lower ASMR for CBD, lower NDVI values, and lower proportions of low-income households. However, they showed higher proportions of the population with higher education levels and higher median tax payments.

Table 1. The disparity in ASMR of CBD, the NDVI, and socioeconomic variables in rural and urban areas across the years 2011–2020.

	Rural Area (*n* = 1730)	**Urban Area (*n* = 1850)**	***p***
CBD mortality (1/100,000 people)	39.52 ± 24.17	29.37 ± 8.26	<0.001
NDVI	0.61 ± 0.14	0.46 ± 0.15	<0.001
Low income (%)	3.00 ± 2.68	1.31 ± −0.71	<0.001
Education (%)	13.32 ± 3.83	24.31 ± 7.57	<0.001
Tax payment (NTD 10,000)	506.4 ± 71.5	560.8 ± 102.4	<0.001

In Table 2, we present the trends in the ASMR of CBD, the NDVI, and socioeconomic variables in rural and urban areas across the years 2011, 2014, 2017, and 2020. In rural areas, the ASMR of CBD showed a consistent decline over the years, dropping from 41.34 deaths per 100,000 people in 2011 to 36.46 deaths per 100,000 people in 2020 (a reduction of 11.8%). Conversely, NDVI values exhibited an upward trajectory, increasing from 0.59 in 2011 to 0.632 in 2020 (an increase of 7.1%). The proportion of low-income households in the region decreased from 2.41% in 2011 to 2.07% in 2020 (a decrease of 14.1%). The percentage of the population with a university education or above in the region increased from 14.87% in 2011 to 19.55% in 2020 (an increase of 31.5%). The median tax income (NTD 10,000) in the region decreased from 51.64 in 2011 to 40.07 in 2020 (a decrease of 22.4%). In urban areas, the ASMR for CBD decreased from 32.51 deaths per 100,000 people in 2011 to 26.27 deaths per 100,000 people in 2020 (a reduction of 19.2%). NDVI values experienced a slight increase from 0.44 in 2011 to 0.472 in 2020 (an increase of 7.3%). $PM_{2.5}$ concentration showed a decreasing trend over time, with higher reductions in areas with higher socioeconomic status. The reduction in $PM_{2.5}$ exposure from 2011 to 2020 was 53.6% in urban areas and 52.0% in rural areas. The townships with a proportion of low-income households in urban areas increased from 1.56% in 2011 to 1.67% in 2020 (an increase of 7.05%). The townships with a proportion of a university education or above in urban areas increased from 19.88% in 2011 to 26.20% in 2020 (an increase of 31.8%). The township with the median tax payment (NTD 10,000) in urban areas decreased from 54.3 in 2011 to 41.64 in 2020 (a decrease of 23.3%). In summary, over the ten-year period, the reduction in ASMR of CBD was more pronounced in urban areas than in rural areas, whereas the NDVI indices exhibited comparable patterns in both regions. The proportion of low-income households decreased in rural areas but increased in urban areas. Irrespective of location (rural or urban), the townships with the median tax payment showed a decreasing trend.

Table 2. Difference of age-standardized mortality rate of CBD, NDVI, and socioeconomic variables in the rural and urban areas across four years.

	2011	2014	2017	2020	*p* Trends
Rural areas (*n* = 1730)					
CBD mortality	41.34 ± 20.40	41.93 ± 25.97	36.72 ± 22.09	36.46 ± 19.66 (−11.8%) *	<0.001
NDVI	0.590 ± 0.137	0.598 ± 0.132	0.620 ± 0.141	0.632 ± 0.141 (7.1%)	0.020
$PM_{2.5}$ concentration	29.61 ± 8.35	27.33 ± 7.42	21.61 ± 6.72	13.80 ± 4.62 (−52.0%) *	<0.001
Low income %	2.41 ± 2.73	2.44 ± 2.62	2.21 ± 2.15	2.07 ± 1.89 (−14.1%)	0.327
Education %	14.87 ± 5.87	14.80 ± 5.58	17.19 ± 6.11	19.55 ± 6.62 (31.5%)	<0.001
Tax payment (10,000 NTD)	51.64 ± 6.23	55.63 ± 5.88	57.63 ± 5.95	40.07 ± 5.81 (−22.4%)	<0.001
Urban areas (*n* = 1850)					
CBD mortality	32.51 ± 8.49	31.69 ± 9.00	28.84 ± 8.10	26.27 ± 7.72 (−19.2%) *	<0.001
NDVI	0.440 ± 0.143	0.445 ± 0.144	0.456 ± 0.145	0.472 ± 0.150 (7.3%)	0.996
$PM_{2.5}$ concentration	33.02 ± 8.34	30.27 ± 6.67	23.99 ± 6.03	15.31 ± 4.11 (−53.6%) *	<0.001
Low income %	1.56 ± 1.28	2.04 ± 1.71	1.81 ± 1.55	1.67 ± 1.52 (7.05%)	0.042
Education %	19.88 ± 7.14	20.96 ± 9.0.8	23.75 ± 9.58	26.20 ± 9.29 (31.8%)	<0.001
Tax payment (10,000 NTD)	54.30 ± 7.75	57.79 ± 7.56	59.68 ± 7.01	41.64 ± 7.23 (−23.3%)	<0.001

* Mean ± SD (change % between 2011 and 2020).

Figure 1 presents schematic graphics illustrating the proportion of low-income households (A), the proportion of green space (B), and the ASMR of CBD (C) across 349 townships in Taiwan, each classified after dividing them into ten equal parts. Townships colored red denote the highest proportions of low-income households and ASMR of CBD, predominantly in eastern Taiwan. Furthermore, areas with a high proportion of NDVI were concentrated in central and eastern Taiwan, while industrial zones and urban areas were primarily situated in the northern and western regions. Evidently, the socioeconomic and green space disparities correspond with variations in CBD mortality. In summary, townships in eastern Taiwan exhibited high proportions of low socioeconomic status, NDVI, and ASMR of CBD.

Table 3 illustrates the correlation between socioeconomic variables, the NDVI, and time with ASMR of CBD in both rural and urban areas using pooled OLS and random effect models in panel regression. The hierarchical steps of panel regression were employed to delineate the incremental differences in each independent variable's impact on the ASMR of CBD. In rural areas, the results demonstrate significant effects of socioeconomic variables, NDVI, and time on the ASMR of CBD in both pooled OLS and random effect models. Specifically, townships with a proportion of low-income households and higher NDVI exhibited a positive association with the ASMR of CBD, while townships with a proportion of the individual with a university education or above and the median tax payment demonstrated a negative association. Conversely, in urban areas, there was no significant association between townships with a proportion of low-income households or median tax payment with the ASMR of CBD. Notably, the impact of the NDVI on the ASMR in urban areas ($\beta = 7.0$) was lower than that in rural areas ($\beta = 24.2$) in the random effects model. Conversely, the effect of townships with a proportion of the population with a university education or above was lower in rural areas ($\beta = -0.90$) compared to urban

areas (β = −0.27). Furthermore, there was a negative temporal trend in both rural and urban areas correlated with the ASMR of CBD.

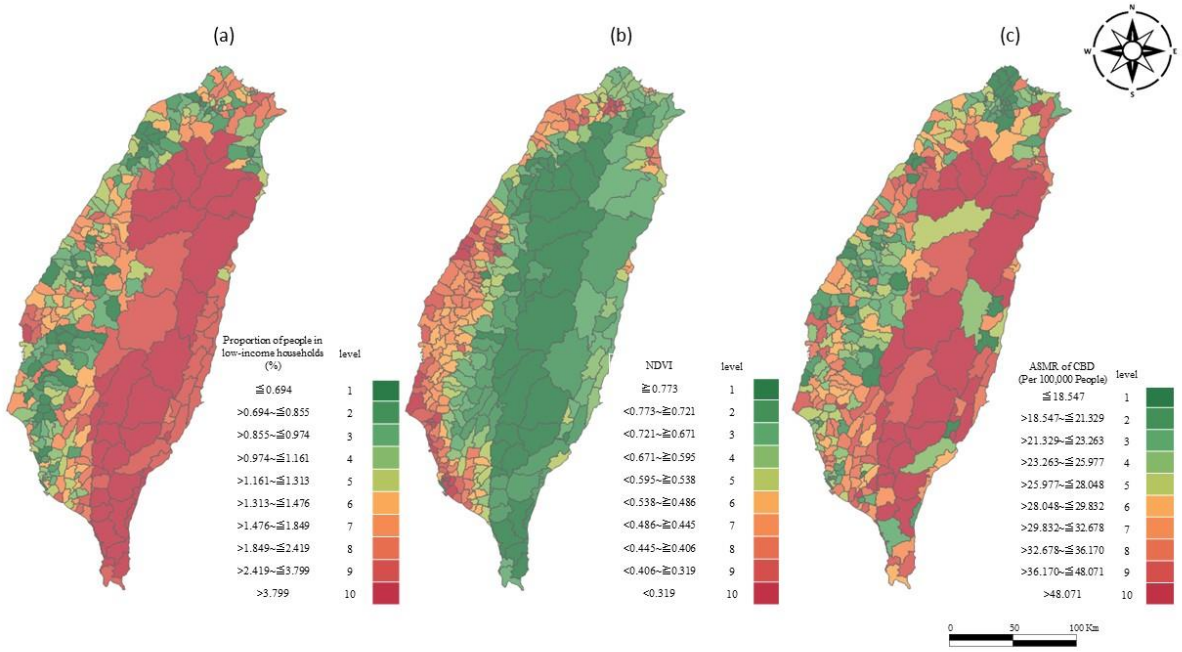

Figure 1. Geographic distribution of proportion of low-income households (**a**), green space (**b**), and age-standardized mortality rate of cerebrovascular diseases (**c**) across 349 townships in Taiwan.

Table 3. Age-standardized mortality rates of CBD correlated with socioeconomic variables, NDVI, and time using pooled OLS and random effects model (REM) in panel regression.

	Pooled OLS	**REM**	**Pooled OLS**	**REM**	**Pooled OLS**	**REM**	**Pooled OLS**	**REM**
Rural areas (*n* = 1730)								
Low income (%)	4.10 **	3.00 **	2.96 **	2.24 *	3.30 **	2.82 **	3.36 **	2.95 **
Education (%)			−1.60 **	−1.39 **	−1.25 **	−1.27 **	−1.12 **	−0.90 **
NDVI					17.4 **	19.5 **	18.6 **	24.2 **
Tax payments							−0.003	−0.013 *
Time							−0.34 **	−0.58 **
R^2	0.207	0.207	0.255	0.255	0.290	0.289	0.291	0.288
Rho		0.334		0.301		0.289		0.286
Urban areas (*n* = 1850)								
Low income (%)	0.41	0.43	−0.05	−0.08	0.30	0.16	0.31	0.18
Education (%)			−0.46 **	−0.44 **	−0.41 **	−0.42 **	−0.39 **	−0.27 **
NDVI					8.1 **	6.2 *	9.0 **	7.0 **
Tax payments							0.003	−0.002
Time							−0.32 **	−0.48 **
R^2	0.001	0.001	0.176	0.176	0.194	0.193	0.211	0.206
Rho		0.358		0.256		0.241		0.227

** $p < 0.001$; * $p < 0.01$.

Figure 2 depicts the interplay between socioeconomic variables and NDVI concerning the ASMR of CBD in both rural (a) and urban (b) areas, utilizing a SEM. In rural areas, townships of individuals with a higher proportion of higher education attainment, as well as greater median tax payments, exhibited negative correlations with the NDVI (β = −0.239 and β = −0.134), while showing a positive correlation with townships characterized by a

higher proportion of low-income households (β = 0.323). Specifically, in rural areas, the indirect effects of the NDVI were 11.0% for townships of individual with higher education attainment and 8.4% for townships with a greater proportion of low-income households. Similarly, in urban areas, townships with a higher proportion of individuals with higher education attainment, as well as those with a higher proportion of low-income households, exhibited negative correlations with the NDVI (β = −0.294 and β = −0.170), while no correlation was observed with townships characterized by a higher proportion of median tax payments. In mediation analysis, the indirect effect of the NDVI was 9.0% for townships with a higher proportion of individual with higher education attainment on the ASMR of CBD. However, the NDVI did not act as a mediator for townships with a higher proportion of low-income households and median tax payments concerning the ASMR of CBD. It appears that there are inconsistencies in the role of the NDVI as a mediator between socioeconomic variables and the ASMR of CBD in both rural and urban areas.

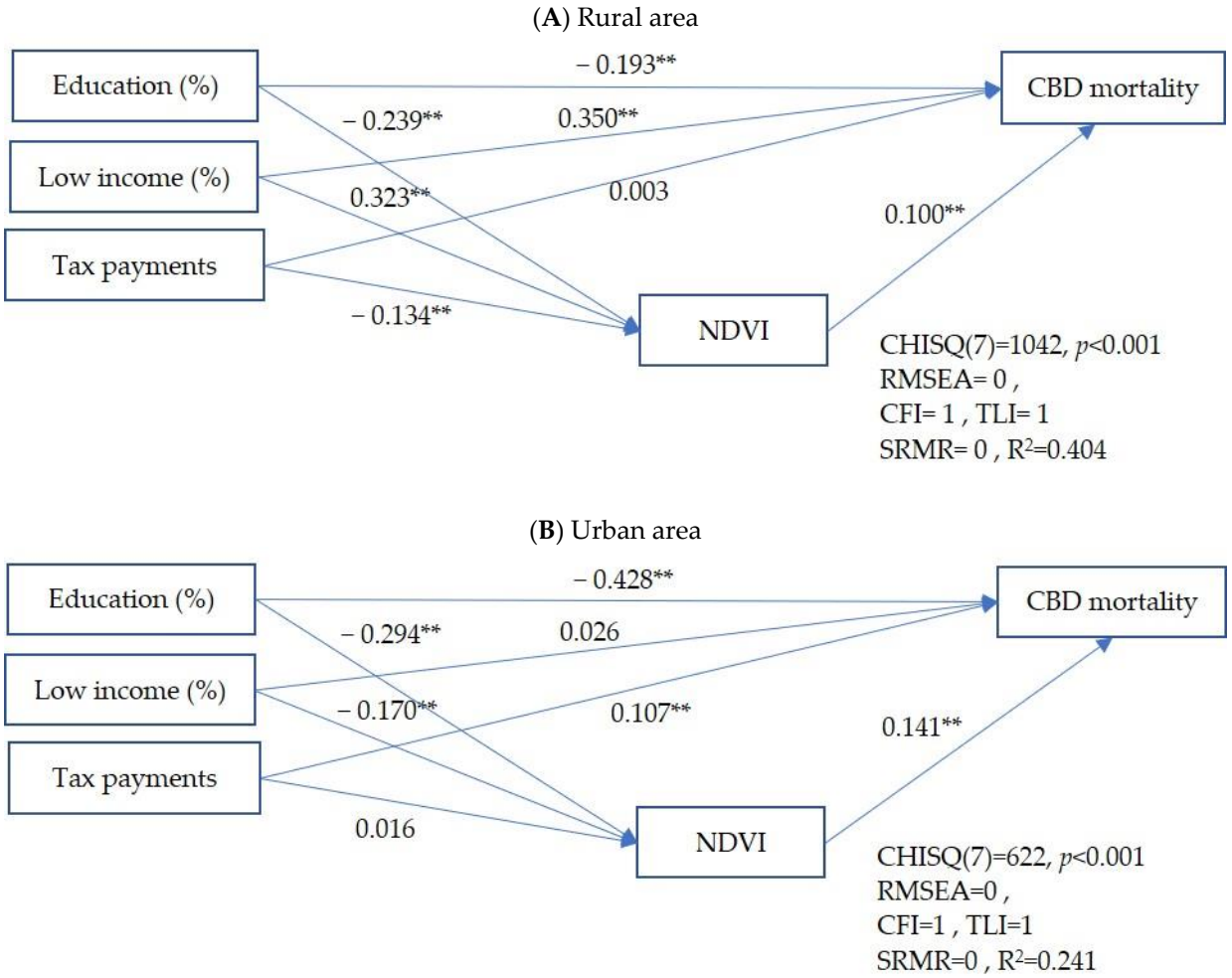

Figure 2. Structural equation model illustrating the relationship between the ASMR of CBD, socioeconomic, and NDVI indices in rural (**A**) and urban (**B**) areas. ** $p < 0.001$.

4. Discussion

Over the course of approximately a century, Taiwan underwent a remarkable transformation, transitioning from a traditional agricultural society to a modern, industrialized country. This rapid economic development has led to improvements in both socioeconomic status and the healthcare system [10]. Consequently, our results revealed discernible trends in the ASMR for CBD, the NDVI, and socioeconomic variables across the years 2011, 2014, 2017, and 2020 in both rural and urban areas. In both settings, there were declining trends observed for the ASMR of CBD and median tax payments. Conversely, increasing trends

were identified in the NDVI and the proportion of individuals with high educational attainment. The sole inconsistency was noted in the trend of the proportion of low-income households, which exhibited an increase in urban areas (7.05%) and a decrease in rural areas (14.1%). Likewise, the reduction in ASMR of CBD in urban areas (−19.2%) surpassed that observed in rural areas (−11.8%) over the period spanning 2011 to 2020. Patients in suburban and rural areas had a greater likelihood of congestive heart failure, stroke, and end-stage renal disease than those in urban areas, providing evidence for potential urban–rural disparities in diabetes-related complications in Taiwan [11]. Similarly, our findings align with a systematic review and meta-analysis encompassing 9407 identified records and 26 population-based studies. While the prevalence and incidence of stroke have risen, the case fatality related to stroke has shown a decrease in China in recent decades. Additionally, notable regional and rural–urban variations exist in incidence rates [12]. The explanation provided indicates that risk factors were more widespread in rural residents without prior stroke, yet they were less likely to be controlled compared to their urban counterparts. Conversely, in individuals with prior stroke, the prevalence of risk factors and their treatment showed similarities between rural and urban areas. Furthermore, rural residence remained associated with both stroke rate and mortality even after adjusting for risk factors [13]. Another factor contributing to urban–rural disparity is elucidated in the study by Cheng et al. [14], which notes that rural patients in Taiwan, being older and having a higher prevalence of chronic diseases than their urban and suburban counterparts, experience procedural patterns employed by rural family physicians that do not significantly differ from those followed by urban and suburban family physicians.

While the concept of the "social crossover" in cardiovascular disease (CVD) mortality, initially described by Marmot et al. [15], suggests a greater risk in higher socioeconomic groups compared to lower socioeconomic groups, there is a lack of evidence supporting this phenomenon in Taiwan. Utilizing OLS and a random effects model through panel regression, our research uncovered that townships marked by a high proportion of socioeconomic status displayed an increased ASMR for CBD in both rural and urban areas. The heightened impact was particularly noticeable in townships characterized by a high proportion of low-income households and individuals with high educational attainment in rural regions. The findings align with a study conducted by Mallinson et al. [16], which utilized a standardized dataset from an economy undergoing economic transition. This study offers robust evidence indicating that individuals in low socioeconomic groups face the highest risk of CVD.

Cerebrovascular diseases rank as the third leading cause of death in Taiwan and is recognized as the most prevalent cause of complex disability. The risk factors for CBD in Taiwan are like those identified in other countries, encompassing hypertension, diabetes, hyperlipidemia, obesity, atrial fibrillation, and smoking [17,18]. According to the National Health Interview Survey in Taiwan [19], stroke prevalence exhibited a steady increase with age, ranging from 0.51 per 1000 in individuals aged 35 to 44 years to 113.6 per 1000 in those aged 85 years or older. Notably, there was a weak association between higher stroke prevalence and individuals residing in eastern Taiwan or those with lower educational levels. Similarly, inequalities in CVD mortality and CVD risk factors in Brazil demonstrate that low-SES groups are indeed at a greater risk compared with high-SES groups. Prevention efforts for CBD should focus on low-SES populations, which continue to bear the burden of higher CVD rates [20]. Meanwhile, individuals with low SES residing in rural areas experienced elevated CBD mortality. This can be attributed to factors such as limited access to the emergency medical system, low health literacy, financial constraints, and limits in their ability to afford healthcare services, medications, and regular check-ups. Addressing these issues requires a comprehensive approach, including improvements in healthcare infrastructure, health education, and addressing socioeconomic disparities.

The existing evidence indicates that residing in proximity to green spaces is linked to various physical and mental health benefits. However, the association between green space and CVD survival remains contradictory. On one hand, some studies [21,22] sug-

gest that access to green spaces may positively influence cardiovascular health outcomes. Green spaces can provide opportunities for physical activity, stress reduction, and social interaction, all of which are factors that can contribute to improved health and potentially enhance survival after a CVD [23]. A systematic review with meta-analyses found a significant association: A 0.1 increase in the NDVI was linked to a 2–3% lower likelihood of CVD mortality (OR: 0.97, 95% CI: 0.96–0.99), ischemic heart disease (IHD) mortality (OR: 0.98, 95% CI: 0.96–1.00), CBD mortality (OR: 0.98, 95% CI: 0.97–1.00), and stroke incidence/prevalence (OR: 0.98, 95% CI: 0.96–0.99) [22]. However, caution is needed when interpreting the long-term reduction in mortality associated with green spaces in urban areas, as this finding may be influenced by residual confounding from sociodemographic and lifestyle factors. A study in Korea [24] suggested that higher green space coverage in urban areas might decrease the risk of CVD. The authors recommend the implementation of urban planning intervention policies aimed at increasing green space coverage as a potential strategy to mitigate the risk of CVD. On the other hand, conflicting findings in the literature highlight the complexity of this relationship. Factors such as the type and quality of green spaces, individual health conditions, and socioeconomic factors may influence the impact of green spaces on cause-specific mortality [25]. Additionally, methodological differences across studies, including variations in the high degree of heterogeneity in study design and statistical models, can contribute to conflicting results. Additionally, further research is needed to clarify the underlying mechanisms of this association and gain a better understanding of exposure–response relationships and susceptibility factors contributing to higher mortality in areas with low green space [26]. Qualities warranting more in-depth research include indices that encompass the forms, patterns, and networks of both objectively and subjectively measured green space attributes [27].

The study reveals the association between the ASMR of CBD, socioeconomic variables, and the NDVI, indicating a mediating effect of the NDVI on this association. Notably, the indirect effects of the NDVI were 11.0% for rural areas and 9% for urban areas among individuals with higher education, and only 8.4% for rural areas with a higher proportion of low-income households. Inconsistencies in the role of the NDVI as a mediator between socioeconomic variables and the ASMR for CBD were observed in both rural and urban areas. Socioeconomic inequality in cardiovascular health seems to be influenced by green space, potentially due to various factors. These may include improved access to physical activity opportunities, stress reduction and enhanced mental well-being, better air quality and reduced environmental exposures, stronger community cohesion and social support, as well as associations with a healthier lifestyle, including improved dietary habits. Higher socioeconomic status is often correlated with better access to healthy lifestyles and environments, which is a key factor in maintaining cardiovascular health. In addition, disparities in urban planning may lead to unequal distribution of green spaces, with wealthier neighborhoods having better access. Socioeconomic inequality in cardiovascular health may, in part, be a result of disparities in the availability and quality of green spaces in different communities. These are just a few potential reasons, and the actual mechanisms could be multifaceted. This research delves into the complex relationship among socioeconomic factors, green spaces, and cardiovascular health outcomes. In contrast to Yang et al.'s [28] study in China, it found that cardiometabolic disorders mediate the link between residential greenness and CVD. Mediation effects include 4.5% for hypertension, 4.1% for type II diabetes, 3.1% for overweight or obese status, 12.7% for hypercholesterolemia, 8.7% for hypertriglyceridemia, and 11.1% for high low-density lipoprotein cholesterol levels. This suggests that CVD risk factors are not solely tied to residential greenness but are intertwined with socioeconomic variables. A UK Biobank study with 350,000 participants aged 38–70 found that residential greenness is linked to lower respiratory mortality. The study suggests long-term exposure to green spaces reduces COPD risk. In addition, the mediation effect on COPD was partially influenced by physical activity (1.0%), $PM_{2.5}$ (21.0%), and NOx (17.0%) [29].

5. Conclusions

This study comprehensively examines the relationship between SES, green space, and CBD mortality at the township level in urban and rural areas over a decade, providing valuable insights into health outcomes. Longitudinal panel data strengthen the study's robustness, while mediation analysis deepens understanding of complex relationships. Urban–rural disparities in ASMR reduction and NDVI patterns highlight geographical variations. However, limitations include the inability to establish causation, data source quality concerns, and the NDVI's limitations in capturing green space quality [23,24]. Future research should explore specific mechanisms governing these interactions. Notably, urban areas show less significant associations between socioeconomic variables and the ASMR compared to rural areas, suggesting a need for targeted interventions to address urban–rural disparities in health outcomes.

Author Contributions: All authors contributed to the study conception and design. Conceptualization, H.-W.K. and W.-Y.L.; methodology, P.-Y.L. and H.-W.K.; software, W.-Y.L. and C.-D.W.; validation, H.-W.K., W.-M.L. and W.-Y.L.; formal analysis, W.-Y.L. and C.-D.W.; investigation, P.-Y.L. and H.-W.K.; resources, W.-Y.L. and W.-M.L.; data curation, W.-M.L.; writing—original draft preparation, H.-W.K.; writing—review and editing, H.-W.K.; visualization, W.-Y.L.; supervision, P.-Y.L. and H.-W.K.; project administration, W.-Y.L. All authors commented on previous versions of the manuscript, and approved the final manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability Statement: The datasets generated and/or analyzed during the current study are available from open-access websites.

Conflicts of Interest: The authors declare no conflicts of interest.

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