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Asociación entre el entorno comunitario y el síndrome metabólico en adultos chinos de mediana edad y mayores: evidencia en las encuestas longitudinales nacionales de 2011 a 2015

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ABSTRACT

Background: community environments that encourage active and socially engaged lifestyles may help reduce the risk of metabolic syndrome (MetS). This study aims to examine the relationship between community cultural and recreational environments and the incidence of MetS among middle-aged and older Chinese individuals.

Methods: we used data from the China Health and Retirement Longitudinal Study (CHARLS) from 2011 to 2015, we included participants aged 45 years and older with complete relevant data. Community environments were classified into three categories using hierarchical clustering analysis. Multivariate logistic regression models were employed to examine associations between community environments and MetS.

Findings: among 6,321 participants, 1,403 developed MetS during the follow-up period. Those who developed MetS were older, less educated, currently drinking, engaged in agricultural work, and lived in northern or rural areas, primarily in Category 1 communities. Participants in Category 2 (OR: 0.69, 95 % CI: 0.55-0.87) and Category 3 (OR: 0.57, 95 % CI: 0.33-0.93) communities had a lower risk of MetS

compared to those in Category 1. Significant associations were found among middle-aged individuals and males in Category 2, and among females in both Category 2 and Category 3 communities.
Conclusion: our findings suggest that community environments with robust cultural, sports, and recreational support are associated with a lower risk of MetS among middle-aged and older adults in China. These findings emphasize the importance of well-rounded community environments in promoting metabolic health.

Keywords: Metabolic syndrome. Middle-aged and older Chinese. Community environment. Recreational facilities. Aging.

RESUMEN

Antecedentes: los entornos comunitarios que promueven estilos de vida activos y comprometidos pueden mitigar los factores de riesgo del síndrome metabólico (SM). Este estudio investiga la asociación entre los entornos culturales y recreativos comunitarios y la incidencia del SM entre personas chinas de mediana edad y mayores.
Métodos: utilizando datos del Estudio de Salud y Jubilación en China (CHARLS) de 2011 a 2015, se incluyeron participantes de 45 años o más con datos relevantes completos. Los entornos comunitarios se clasificaron en tres categorías mediante análisis de conglomerados jerárquicos. Se emplearon modelos de regresión logística multivariada para examinar las asociaciones entre los entornos comunitarios y el SM.
Resultados: de 6321 participantes, 1403 desarrollaron SM. Aquellos que desarrollaron SM eran mayores, menos educados, consumían alcohol, trabajaban en la agricultura y vivían en áreas rurales o del norte, principalmente en comunidades de la Categoría 1. Los participantes en comunidades de la Categoría 2 (OR: 0,69, IC 95 %: 0,55-0,87) y Categoría 3 (OR: 0,57, IC 95 %: 0,33-0,93) tenían un menor riesgo de SM en comparación con los de la Categoría 1. Se

encontraron asociaciones significativas entre los individuos de mediana edad y los hombres en la Categoría 2, y entre las mujeres en las comunidades de las Categorías 2 y 3.
Conclusión: este estudio encontró que los entornos comunitarios con un fuerte apoyo cultural, deportivo y recreativo están asociados con un menor riesgo de SM entre adultos de mediana edad y mayores en China. Estos hallazgos enfatizan la importancia de entornos comunitarios integrales para promover la salud metabólica.

Palabras clave: Síndrome metabólico. Adultos de mediana edad y mayores. Entorno comunitario. Instalaciones recreativas. Envejecimiento.

INTRODUCTION

Metabolic syndrome (MetS) is a cluster of conditions characterized by central obesity, dyslipidemia, hypertension, and hyperglycemia (1). The global prevalence of MetS has been increasing, posing a significant public health challenge. In China, the prevalence of MetS increased from 8 % to 10.6 % in urban areas and from 4.9 % to 5.3 % in rural areas between 1992 and 2002 (2). Assuming a similar rate of increase, the prevalence of MetS in China in 2017 would be approximately 15.5 % (3). While genetic predisposition contributes to the development of MetS, lifestyle factors such as physical activity, diet, and psychosocial stress are critical determinants (4). Certain elements in the causation of MetS, such as genetic factors, are immutable, but many lifestyle-related factors are amenable to intervention (2). For instance, urban planning that promotes walkability and access to recreational spaces can foster more active lifestyles.

Community environments that promote active and engaged lifestyles have the potential to mitigate the risk factors associated with MetS. Facilities such as basketball courts, swimming pools, cultural clubs, dance groups, and senior associations offer opportunities for physical

activity, social interaction, and cultural engagement, all of which contribute to better metabolic health (5). Physical activity has been well-documented to improve insulin sensitivity, blood pressure, lipid profiles, and body weight (6). In addition, social participation and cultural engagement are associated with lower levels of stress and better mental health, which can indirectly influence metabolic risk (7). Community environments encompass both physical and social dimensions (8-10). Recreational facilities, such as outdoor exercise areas, card and chess rooms, and basketball courts, have been shown to enhance subjective well-being (11). These facilities not only directly promote out-of-home activities among older adults but also indirectly influence their biological and psychological health (12). Despite these potential benefits, the relationship between community amenities and the risk of MetS remains insufficiently studied. Existing research primarily focuses on individual-level interventions, often neglecting the broader community context. A comprehensive understanding of how community-based cultural, sports, and recreational facilities impact MetS can significantly inform public health strategies and urban planning, fostering healthier communities.

This study hypothesizes that communities with greater access to cultural, sports, and recreational amenities exhibit a lower incidence of MetS. Using data from the China Health and Retirement Longitudinal Study (CHARLS), this research aims to investigate the impact of community cultural and recreational environments on the risk of MetS among middle-aged and older adults in China.

METHODS

Study population

This longitudinal study used data from the CHARLS collected between 2011 and 2015 to assess the association between community cultural and recreational environments and the incidence of MetS. CHARLS, administered by the National School of Development at Peking University, targets Chinese residents aged 45 years or older. The dataset is publicly available for global research use (13). Participants

was selected using a four-stage stratified probability sampling method (14). Data collection was carried out through face-to-face interviews using computer-assisted personal interviewing (CAPI), with participants' health status assessed through both physical examinations and self-reports participants were followed biennially since 2011, with four waves of surveys conducted, spanning 28 provinces, 150 counties, and 450 villages across mainland China. This study did not require separate ethics approval as it involved the analysis of secondary data. All participants provided informed consent for the original survey (15). To protect participants' privacy and confidentiality, all data were fully anonymized before analysis. Each participant was assigned a unique identification number, and no personally identifiable information (such as names or home addresses) was included in the dataset. Other details were published elsewhere (14).

Participations

The study included residents aged over 45 years who had complete data on HDL cholesterol, LDL cholesterol, total cholesterol, glucose, glycated hemoglobin, waist circumference, and information on community cultural and recreational environments. Exclusion criteria included participants diagnosed with cancer or MetS at the time the CHARLS data were originally collected, as well as those with implausible outlier data. Details were shown in figure 1.

Measures

Community cultural and recreational environments

Community cultural and recreational environments in this study were assessed using 14 binary variables (no, yes): basketball courts, swimming pools, outdoor exercise equipment, ping pong tables, card and chess rooms, ping pong rooms, calligraphy and painting associations, dance teams or other exercise groups, organizations assisting the older and disabled, employment service centers, senior

activity centers, senior associations, nursing homes, and other recreational facilities.

Assessment of metabolic syndrome

Metabolic syndrome was assessed using the unified definition established in 2009, which includes the presence of three or more of the following criteria: elevated waist circumference (≥ 85 cm for males and ≥ 80 cm for females) (16), elevated triglycerides (≥ 1.7 mmol/L or treatment for elevated TG), decreased HDL-C (< 1.0 mmol/L for males and < 1.3 mmol/L for females or treatment for reduced HDL-C), elevated blood pressure (systolic ≥ 130 mmHg and/or diastolic ≥ 85 mmHg or antihypertensive treatment), and elevated fasting plasma glucose (≥ 5.6 mmol/L or treatment for elevated glucose) (16,17).

Assessment of covariates

Data on sociodemographic factors (sex, age, marital status, education level) and socioeconomic variables (health insurance status, employment status, total household wealth) were collected. Weight was measured to the nearest 0.1 kg using a calibrated scale, and height was measured to the nearest 0.1 m using a stadiometer, with participants not wearing shoes (18). Waist circumference was measured at the level of the umbilicus at the end of exhalation using a soft tape measure, with participants wearing light clothing (18). Obesity was defined as a BMI ≥ 27.5 kg/m², according to WHO recommendations for Chinese populations (19).

Smoking status was categorized as never smoked, former smoker, and current smoker, with smoking defined as having smoked more than 100 cigarettes in a lifetime. Alcohol consumption was assessed based on the frequency and amount of alcohol intake, categorized as never drank, former drinker, and current drinker.

Participants' employment status was classified into four categories based on their last main job: agricultural work, employment in

government/non-governmental institutions/firms/organizations, retirees, and others. The geographical location of participants' residences was classified into northern and southern regions based on the widely recognized north-south division line in China (20). Additionally, participants were categorized based on whether they resided in rural or urban areas.

Statistic methods

All analyses were conducted using R version 4.4.0 (R-project, Vienna, Austria). The distribution of missing and non-missing data across demographic variables was approximately equal, and we assumed that the data were missing completely at random. we employed multiple imputation using chained equations (MICE) to handle missing values. We generated 5 imputed datasets and performed analyses on each, pooling the results following Rubin’s rules

We examined the distribution of the data and found that none of the continuous variables were normally distributed. Quantitative variables are presented as medians and interquartile ranges, while qualitative variables are expressed as numbers and percentages. Differences between categorical variables were analyzed using Chi-square tests, and non-normally distributed continuous variables were analyzed using the Mann-Whitney U-test.

Community cultural and recreational environments were classified using hierarchical clustering analysis. Based on the clustering results, these environments were divided into three categories: Category 1 represented poorly supported cultural and recreational environments, while Categories 2 and 3 represented better-supported environments. Detailed results are presented in supplementary table I and figure 2.

To examine the association between community environments and MetS, we employed multivariate logistic regression models, with odds ratios (OR) and 95 % confidence intervals (CIs) calculated. Covariates that may influence the relationship between community

environments and MetS were adjusted for in Adjusted Model, based on previous studies (21-24). These covariates included sex, age, total household income, job status, education, insurance, marital status, smoking status, alcohol consumption, and general obesity. Due to the strong correlation between waist circumference and BMI ($r = 0.210$, $p < 0.001$), and given that waist circumference is a component of the MetS definition, BMI was not included as a confounder in the models.

Subgroup analyses were conducted by age (45-64 years vs. ≥ 65 years) and sex (male vs. female), using the Category 1 community environment as the reference group in all logistic regressions.

Additionally, a complete-case sensitive analysis was performed using only the original, non-imputed data to assess the influence of missing data.

RESULTS

Participants' characteristics stratified by MetS incidence are presented in table I. Between 2011 and 2015, 1,403 out of 6,321 middle-aged and older Chinese adults developed MetS. Those who developed MetS tended to be older, had lower education levels, were currently drinking, engaged in agricultural work, resided in northern or rural areas, and lived in Category 1 community environments.

Participants living in Category 2 (OR: 0.69; 95 % CI: 0.55-0.87) and Category 3 (OR: 0.57; 95 % CI: 0.33-0.93) community environments had significantly lower odds of developing MetS compared to those in Category 1 communities (Table II). This significant association was not observed among older Chinese but was evident among middle-aged individuals (OR: 0.63, 95 % CI: 0.47-0.83) and males (OR: 0.71, 95 % CI: 0.51-0.97) living in Category 2 community environments. Among females, living in Category 2 (OR: 0.69; 95 % CI: 0.50-0.94) and Category 3 (OR: 0.29; 95 % CI: 0.11-0.66) environments was significantly associated with a lower risk of MetS compared to Category 1 (Table III).

To assess the robustness of our findings, we conducted a sensitivity analysis using complete-case data and compared the results with those from the multiply imputed datasets. The effect estimates remained highly consistent, with no significant differences in the key associations (Supplementary Table II). These findings suggest that missing data had minimal impact on the main conclusions.

DISCUSSION

The primary findings of this study demonstrate a significant association between community cultural and recreational environments and the incidence of MetS among middle-aged and older Chinese individuals. Specifically, living in communities with better-supported cultural and recreational amenities (Categories 2 and 3) was associated with a lower risk of developing MetS compared to poorly supported communities (Category 1). This protective effect was particularly evident among middle-aged individuals and females, while males benefited from living in Category 2 environments. These findings underscore the potential role of community infrastructure in mitigating MetS risk and highlight the importance of fostering supportive community environments to enhance public health outcomes.

The findings of this study align with previous research that highlights the importance of community environments in influencing metabolic health. Specifically, our results suggest that communities with better-supported cultural and recreational amenities are associated with a lower incidence of MetS. This is consistent with studies that have found a greater availability of free facilities for habitual physical activity in a district correlates with a reduced risk of MetS among its residents (25). Similarly, research has shown that recreation facilities, street connectivity and high walkable environment were associated with physical activity (26). Chandrabose et al. (27) found that the protective effects of walkable neighborhoods against obesity were partially mediated by baseline physical activity but not by increases in

physical activity during the study period. Another research found that Adolescent neighborhood disadvantage was directly associated with metabolic syndrome in young adulthood (28). This suggests that while environmental factors may promote initial engagement in physical activity, sustained benefits may involve other mechanisms.

Moreover, environmental characteristics have been found to have differential influences on various measures of physical activity, which might account for the variations observed across different demographic groups in our study. For example, while males and middle-aged individuals in communities with better recreational support showed a reduced risk of MetS, this effect was not as pronounced among older adults. This suggests that the benefits of community environments may vary by age and gender, possibly due to differing levels of engagement with community facilities or varying responses to the available amenities. These findings suggest that local governments should prioritize community design and infrastructure that fosters physical activity and social engagement to help reduce the risk of metabolic syndrome.

The mechanisms underlying the influence of community environments on metabolic health likely involve both direct and indirect pathways. Directly, access to recreational facilities encourages physical activity (29), which is known to improve metabolic parameters such as insulin sensitivity, blood pressure, and lipid profiles. Indirectly, social participation and cultural engagement fostered by community amenities may reduce stress and enhance mental well-being (30), further contributing to metabolic health (31). This holistic approach to community environment design may therefore be crucial in addressing MetS at a population level. Although dietary factors were not directly measured in this study, previous research has established a strong association between unhealthy dietary patterns and the risk of metabolic syndrome among Chinese middle-aged and older adults (32,33). Furthermore, there is growing evidence that community environmental features—such as

access to healthy food outlets, walkability, and neighborhood socioeconomic status—can indirectly shape dietary behaviors (34-36). While studies explicitly testing diet as a mediator between environment and metabolic health are limited, especially in China, our findings contribute to this emerging field by highlighting the role of community-level determinants in shaping health outcomes. Future research could further explore the mediating role of dietary behaviors in this pathway.

Strengths and limitations

This study has several notable strengths. One of the key advantages is the use of a cluster analysis approach to classify community environments, which offers a more nuanced understanding of these environments compared to previous studies that primarily relied on simply counting the number of available facilities. By grouping communities based on a combination of characteristics rather than just facility quantity, this method provides a more comprehensive and convincing assessment of the community's impact on MetS. Additionally, the study leverages a large, nationally representative dataset from the CHARLS, which enhances the generalizability of the findings to the broader Chinese population.

However, the study is not without its limitations. One significant constraint is the relatively short follow-up period from 2011 to 2015, which limits the ability to conduct sensitivity analyses that exclude cases of MetS that developed early in the study period. This could potentially lead to an overestimation of the association between community environments and MetS. Another limitation is the limited availability of detailed physical activity data, as the survey only included this information for a small subset of participants. Consequently, the study could not fully account for physical activity as a confounding factor in the models, which may have influenced the results. Future research with longer follow-up periods and more comprehensive data on physical activity is necessary to address

these limitations and further validate the findings. While our findings suggest an association between community environments and MetS risk, the observed relationships could still be influenced by unmeasured confounders or reverse causality. Future research with longer-term follow-ups is needed to better assess the causal pathways. Potential sampling bias may exist due to the exclusion of participants with missing data. Although we applied multiple imputation (MICE) to handle missing values and conducted a complete-case analysis to confirm the robustness of our results, selection bias cannot be entirely ruled out. Additionally, the study sample was drawn from a national survey, but participants who remained in the study throughout follow-up may differ systematically from those lost to follow-up, potentially affecting the generalizability of the findings. Future studies should aim for more comprehensive data collection and strategies to minimize attrition bias. Our findings are based on observational data, and while we adjusted for several confounding factors, causal interpretations should be made with caution. Due to the nature of the CHARLS dataset, we were unable to incorporate structured intervention programs or conduct longitudinal follow-up beyond the available waves. Future studies with designed intervention trials are warranted to establish causality. Additionally, CHARLS lacks detailed information on individual family-level behaviors such as dietary patterns or intra-household health practices. Therefore, we could not distinguish the relative influence of family versus community environments. Future research should consider integrating both household and community-level exposures to better understand their interplay in shaping health outcomes.

CONCLUSION

This study suggests that well-supported community environments—including cultural, sports, and recreational facilities—may be associated with a reduced risk of MetS among middle-aged and older adults in China. While our findings underscore the potential

importance of fostering well-rounded community environments for metabolic health, future longitudinal studies with extended follow-up are needed to confirm these associations and assess potential long-term effects.

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Table I. Baseline characteristics of participants with and without metabolic syndrome

Characteristic	Metabolic syndrome		*p*-value[†]
	No, *n* = 4,918[*]	Yes, *n* = 1,403[*]	
Age	57 (50, 64)	59 (53, 65)	< 0.001
Education			< 0.001
Illiterate	1,527 (31 %)	549 (39 %)	
Primary and Junior High School	1,248 (25 %)	315 (22 %)	
High School	1,972 (40 %)	510 (36 %)	
University and above	171 (3.5 %)	29 (2.1 %)	
Marriage			0.920
Married	4,299 (87 %)	1,225 (87 %)	
Unmarried	619 (13 %)	178 (13 %)	
Gender			0.623
Male	2,613 (53 %)	735 (52 %)	
Female	2,305 (47 %)	668 (48 %)	
BMI	21.6 (19.8, 23.9)	23.1 (20.6, 26.1)	< 0.001
Smoking			0.180
Currently smoking	1,748 (36 %)	500 (36 %)	
Never smoked	2,761 (56 %)	765 (55 %)	
Quit smoking	409 (8.3 %)	138 (9.8 %)	
Drinking			0.012
Currently drinking	1,274 (26 %)	419 (30 %)	
Never drank	3,381 (69 %)	909 (65 %)	
Quit drinking	263 (5.3 %)	75 (5.3 %)	
Abdominal obesity			< 0.001
Yes	1,419 (29 %)	650 (46 %)	
No	3,499 (71 %)	753 (54 %)	
Hypertension			< 0.001
Yes	1,019 (21 %)	679 (48 %)	
No	3,899 (79 %)	724 (52 %)	
Diabetes			< 0.001
Yes	1,713 (35 %)	816 (58 %)	
No	3,205 (65 %)	587 (42 %)	
Insurance			0.473
Yes	4,561 (93 %)	1,309 (93 %)	
No	357 (7.3 %)	94 (6.7 %)	
Working status			0.009
Agricultural work	3,424 (70 %)	1,038 (74 %)	

employee	811 (16 %)	212 (15 %)	
Retired	553 (11 %)	122 (8.7 %)	
Other	130 (2.6 %)	31 (2.2 %)	
Location			< 0.001
Southern Region	2,743 (56 %)	607 (43 %)	
Northern Region	2,175 (44 %)	796 (57 %)	
Community category			< 0.001
Category 1 community	4,184 (85 %)	1,259 (90 %)	
Category 2 community	621 (13 %)	126 (9.0 %)	
Category 3 community	113 (2.3 %)	18 (1.3 %)	
Total household wealth with imputed values	82,940 (27,915, 181,882)	80,847 (28,015, 169,811)	0.347
Rural or urban			0.036
Rural	3,042 (62 %)	911 (65 %)	
Urban	1,876 (38 %)	492 (35 %)	

*Median (IQR); *n* (%). †Wilcoxon rank sum test; Pearson's chi-squared test.

Table II. Association of community category and risk of metabolic syndrome among middle aged and older Chinese

Characteristic	**Crude**			**Adjusted**		
	OR	**95 % CI**	***p*-value**	**OR**	**95 % CI**	***p*-value**
Community category						
Category 1 community	—	—		—	—	
Category 2 community	0.67	0.55, 0.82	< 0.001	0.69	0.55, 0.87	0.002
Category 3 community	0.53	0.31, 0.85	0.013	0.57	0.33, 0.93	0.033

OR: odds ratio; CI: confidence interval.

Table III. Association of community category and risk of metabolic syndrome among subgroup populations

Characteristic	**OR**	**95 % CI**	***p*-value**
Elderly			
Community Category			
Category 1 community	—	—	
Category 2 community	0.89	0.59, 1.31	0.6
Category 3 community	0.54	0.23, 1.16	0.14
Middle-aged			
Community Category			
Category 1 community	—	—	
Category 2 community	0.63	0.47, 0.83	0.001
Category 3 community	0.63	0.30, 1.20	0.2
Male			
Community Category			
Category 1 community	—	—	
Category 2 community	0.71	0.51, 0.97	0.037
Category 3 community	0.92	0.46, 1.71	0.8
Female			
Community Category			
Category 1 community	—	—	
Category 2 community	0.69	0.50, 0.94	0.021
Category 3 community	0.29	0.11, 0.66	0.007

OR: odds ratio; CI: confidence interval.

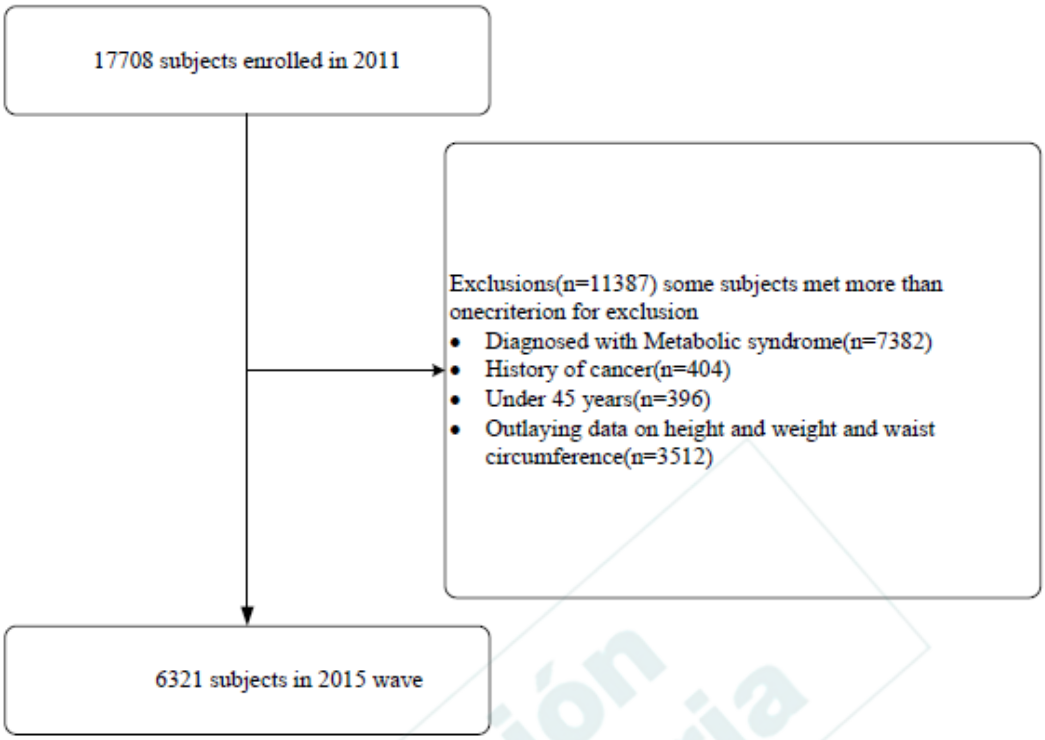

Figure 1. Flow chart of participants selection.

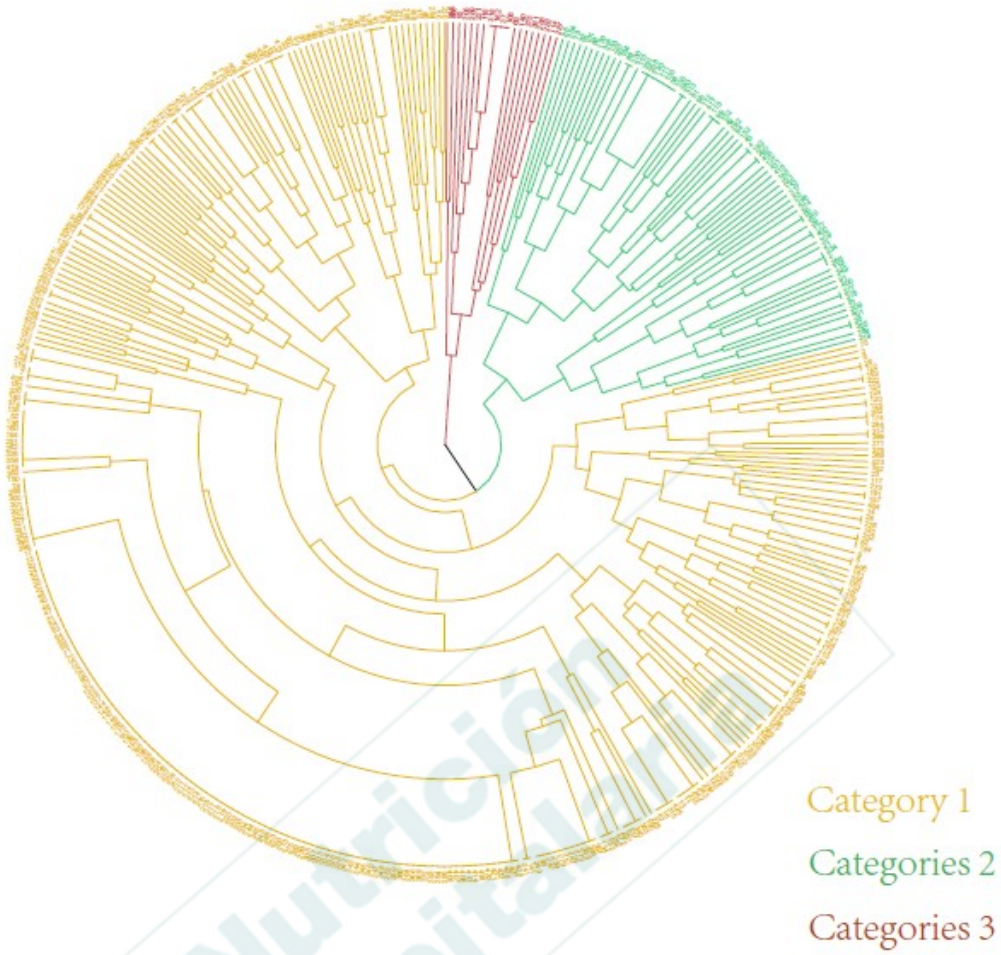

Figure 2. Hyerarchical clustering dendrogram of sociocultural and recreational environment variables.