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Authors

Ko, Yi-An
Shen, Jenny
Kim, Jeong Hwan
et al.

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Identifying neighbourhood and individual resilience profiles for cardiovascular health: a cross-sectional study of blacks living in the Atlanta metropolitan area

Yi-An Ko ,[1] Jenny Shen,[2] Jeong Hwan Kim,[3] Matthew Topel,[3] Mahasin Mujahid,[4] Herman Taylor,[5] Arshed Quyyumi,[3] Mario Sims,[6] Viola Vaccarino,[7] Peter Baltrus,[8] Tene Lewis[7]

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For numbered affiliations see end of article.

Correspondence to
Dr Yi-An Ko; yko8@emory.edu

ABSTRACT

Objective To simultaneously examine multiple individual-level neighbourhood perceptions and psychosocial characteristics and their relationships with cardiovascular health (CVH) among blacks.
Design Cross-sectional study.
Setting Subjects were recruited between 2016 and 2018 via convenience sampling.
Participants 385 Black men and women, age 30–70 living in the Atlanta metropolitan area (Georgia, USA).
Primary outcome measure Individual's CVH was summarised as a composite score using American Heart Association's Life's Simple 7 (LS7) metrics.
Methods We implemented unsupervised learning (k-means) and supervised learning (Bayesian Dirichlet process clustering) to identify clusters based on 11 self-reported neighbourhood perception and psychosocial characteristics. We also performed principal component analysis to summarise neighbourhood perceptions and psychosocial variables and assess their associations with LS7 scores.
Results K-means and Bayesian clustering resulted in 4 and 5 clusters, respectively. Based on the posterior distributions, higher LS7 scores were associated with better neighbourhood perceptions and psychosocial characteristics, including neighbourhood safety, social cohesion, activities with neighbours, environmental mastery, purpose in life, resilient coping and no depression. Taken together, the first principal components of neighbourhood perceptions and psychosocial characteristics were associated with an increase of 0.07 (95% CI −0.17 to 0.31) and 0.31 (95% CI 0.06 to 0.55) in LS7 score, respectively, after accounting for age, sex, household income and education level.
Conclusion Both neighbourhood perception and psychosocial domains were related to CVH, but individual psychosocial characteristics appeared to contribute to CVH most. Approaches that acknowledge the importance of factors in both domains may prove most beneficial for enhancing resilience and promoting CVH among black communities.

Strengths and limitations of this study

- The study focused on risk and resilience heterogeneity within blacks, an at-risk population.
- We used multivariate clustering analysis to efficiently investigate 11 neighbourhood perception and psychosocial variables related to cardiovascular health as opposed to treating them as separate exposures in previous studies.
- This is a single site study that used convenience sampling, so the results may not be generalisable to the target study population.

Despite the remarkable decline in cardiovascular disease (CVD) mortality among all major racial and ethnic groups in the USA during the past four decades,[1] black-white disparities in the rate of decline in CVD mortality and cardiovascular health (CVH) remain persistent across different age groups.[2–4] Compared with other ethnic groups, blacks have the highest CVD burden and lowest rate of mortality decline.[5 6] Specifically, blacks have a higher prevalence of many CVD risk factors, including obesity, hypertension, diabetes and dyslipidaemia.[7 8] In addition to traditional CVD risk factors, other underlying mechanisms, such as neighbourhood characteristics, psychosocial stress, individual perspectives, socioeconomic status, are likely to be responsible for the increased risk for CVD in Blacks.[9–12] The aggregation of these traditional and non-traditional risk factors, including social determinants, likely contributes to a higher CVD burden among Blacks.[13]

Research on CVD in blacks has focused almost exclusively on their excess risk for poor CVH, relative to other racial/ethnic groups. However, this ignores the fact that there is considerable heterogeneity within the black population, such that some black individuals have better CVH profiles than others. Unfortunately, limited effort has been focused on examining those factors that might promote 'resilience' in this at-risk population. Resilience has been defined as the 'ability of living systems to successfully maintain or return to homoeostasis' in response to a range of challenges, including those that are 'individual, social, societal or environmental.'[14] In the context of CVH research, black 'race' often exposes individuals to a range of multifactorial challenges, at multiple levels, that are believed to drive their excess rates of disease. Similarly, these resilience factors are also likely to be multifactorial, operating at the level of both individuals and their environmental/neighbourhood context. There is a growing body of evidence that individual psychosocial characteristics[15–22] as well as their neighbourhood perceptions[23–25] may be important determinants of CVH. For instance, studies have identified an association between less depressive symptoms and better CVH profiles,[12] including smoking[26] and blood pressure control.[27] CVH studies focusing on other psychosocial health measures in blacks remain limited. A few studies demonstrated that more optimistic individuals engage in more CVH behaviours,[28] and that purpose in life and mastery is associated with a reduced risk for mortality and CVD events.[29 30] On the other hand, several studies have investigated the role of neighbourhood environments in CVH using community samples.[31–37] An in-depth investigation of a comprehensive set of candidate factors that potentially confer resilience to poor CVD outcomes in Blacks is essential to develop recommendations for targeted intervention strategies to improve their CVH.

One main challenge in population-based and observational research is to interrogate CVH profiles in the context of multidimensional (risk and resilient) exposure factors. The inter-correlated nature of exposure factors complicates the task to identify their combined effect on CVH outcomes. In traditional analysis with multiple exposure factors, data are frequently analysed univariately to determine associations with the outcome.[19 24 38–40] These tests of association ignore the potential correlations among the exposure factors, do not account for their effects simultaneously, and often have low power to detect significant effects after multiple testing adjustment. In addition, each exposure factor may only account for a small proportion of variability in the outcome. To bypass these issues, clustering and classification techniques in machine learning have become popular given their ability to handle multiple exposure variables and to detect otherwise unappreciated grouping patterns.

The Morehouse-Emory Cardiovascular (MECA) Center for Health Equity study has identified neighbourhoods with vastly different rates of premature cardiovascular events among Blacks in the metropolitan Atlanta area.[41] The study recruited a cohort of Black residents living in Atlanta and found that individuals living in neighbourhoods with lower cardiovascular event rates reported better neighbourhood characteristics and more positive psychosocial characteristics.[42] This study builds off of these findings in another Atlanta based sample to examine the clustered patterns of self-reported neighbourhood perceptions and psychosocial characteristics and whether the clusters of characteristics are associated with individual-level CVH profile as measured by Life's Simple 7 (LS7) score.[43] Identifying patterns or clusters of important individual-level factors that correspond to high LS7 scores may provide a starting point for promoting CVH among blacks.

METHODS

Patient and public involvement

The development of the research question and outcome measures were not informed by study participants' priorities, experience or preferences. The participants were not involved in the design, recruitment and conduct of the study. The results will be disseminated to study participants through publications and school websites.

Study design and subjects

This is a cross-sectional study design involving secondary analysis of data from the MECA study.[41 42] A total of 400 adults living in the greater Atlanta region, with the age range of 30–70, who self-identified as black or African American were recruited between 2016 and 2018 via convenience sampling. The subjects were recruited by flyers, school's website announcements, or family and friend's referrals. The exclusion criteria included history of CVD (eg, myocardial infarction, congestive heart failure, cerebrovascular accidents, coronary artery disease, peripheral arterial disease, atrial fibrillation and cardiomyopathies), HIV, lupus, cancer, substance abuse (alcohol or drug), psychiatric illness, pregnant or lactating females, and inability to participate in increased physical activity. The exclusion criteria were set up due to an opportunity to participate in a lifestyle intervention trial in the original study (ClinicalTrials.gov Identifier: NCT03308812). Once enrolled, each study participant visited the research laboratory for physical examination, blood draw and completing survey questionnaires at either Emory University or Morehouse School of Medicine (Atlanta, Georgia, USA). Blood pressure and anthropometric measurements were recorded. All blood draws were performed after 12-hour fasting. In the survey, demographic information, residential address, medical history and socioeconomic status (income, education, employment and marital status) were collected. In addition, data on diet and exercise as well as preselected potential risk and resilience factors were obtained (details below). All study subjects provided written informed consents.

LS7 Scores

The 'LS7' concept focuses on primordial prevention with the goal of improving population's CVH through changes in lifestyle to ultimately lower the disease risk. Given that examining individual metrics separately is not efficient (due to multiple testing issues) and only provides marginal information rather than an overall summary of CVH, the American Heart Association (https://mlc.heart.org) has created a composite score by assigning a value to each metric and adding up the scores.[43–50] Specifically, an ideal CVH profile involves ideal physical activity (≥150 or 75 min/week of moderate-intensity or vigorous-intensity exercise, respectively), total cholesterol (<200 mg/dL), blood pressure (<120/80 mm Hg), fasting glucose (<100 mg/dL), body mass index (<25 kg/m^2), non-smoking, as well as healthy diet (defined by fruit/vegetable, whole grain, fish, sugar and salt intake).[43] The definitions of ideal, intermediate and poor level for each metric are provided in online supplemental material based on 'My Life Check', a health assessment and improvement tool (https://mlc.heart.org). We assigned 2, 1 and 0 points to ideal, intermediate and poor level, respectively, for each metric and obtained a LS7 score ranging between 0 and 14. A higher score indicates better CVH.

Individual-level, self-reported factors for clustering

A total of 11 variables associated with neighbourhood perceptions and individual psychosocial characteristics were considered in the study (see online supplemental materials). Five neighbourhood perceptions were assessed, including aesthetic quality, walking environment, safety, social cohesion and activities with neighbours.[51] Six individual psychosocial characteristics included discrimination (Everyday Discrimination Scale),[52] optimism (Life Orientation Test-Revised),[53 54] environmental mastery (Ryff's psychological well-being),[55 56] purpose in life (Ryff's psychological well-being),[55 56] resilient coping (Conner Davidson Resilience Scale)[57] and depressive symptoms (Beck Depression Inventory II).[58] Across all instruments, the item response rate ranged from 97% to 100%. Missing items (<3%) were replaced with the median value of completed items (within each individual) to calculate the total summary score for each questionnaire. To enable straightforward comparisons across all the variables considered, we reverse-coded the summary scores for certain scales such that a higher score always indicates better health or perception across the 11 questionnaires. For example, a higher score in the Everyday Discrimination Scale or Beck Depression Inventory suggests less frequent experience of discrimination or less depressive symptoms.

Clustering methods

Instead of investigating one variable at a time or including all of them in one single regression model, we applied the following clustering methods to form a number of groups with different neighbourhood perception and psychosocial profiles. People within each cluster group have similar profiles, that is, they are homogeneous in terms of the 11 variables (summary scores from self-reported questionnaires). The 11 variables were standardised prior to analysis.

First, we adopted profile regression based on Bayesian clustering using a Dirichlet process mixture model, which is a non-parametric approach linking a response vector (ie, LS7 score in our study) to covariate data (ie, the 11 neighbourhood perception and psychosocial variables) through cluster membership.[59] This approach consists of a cluster assignment submodel (that assigns individual profiles to clusters) and an outcome submodel (that links clusters to an outcome of interest through regression modelling). Markov chain Monte Carlo methods are used to fit both submodels jointly, which allows the number of clusters to vary between iterations of the sampler. For each fixed number of clusters, the best partition according to a dissimilarity matrix is selected. A final representative cluster is chosen by maximising the average distance between clusters across these best partitions. The R package PReMiuM was used.[60]

In addition, we implemented k-means to define and characterise clusters based on the 11 neighbourhood perception and psychosocial variables. Specifically, k-means is a non-parametric partitioning method.[61 62] The algorithm initially randomly selects k centroids and assigns each data point to its closet centroid by minimising the within-cluster sum of squared distances. Then, the centroids are calculated as the average of all data points in a cluster. Data points were then assigned to their closest centroids again. The algorithm continues until data points are not reassigned or the maximum number of iterations is reached. The optimal number of clusters was determined by plotting cluster number and the corresponding within-cluster sum of squares. As k-means does not use the information of LS7 score to form clusters, it is considered as an unsupervised learning approach.

Statistical analysis

Out of the 400 recruited subjects, 395 were successfully enrolled in the study. Among them, six did not have LS7 scores due to skipping blood draws, and four omitted at least two questionnaires entirely, which resulted in an analysis sample size of 385. Continuous variables for subject characteristics were summarised as means (±SD) or as median (25th and 75th quartiles) while categorical variables were reported as frequency counts and proportions (percentages), as appropriate. Once the clusters were identified by k-means, analysis of variance was applied to compare LS7 scores among the k-means clusters followed by Tukey's honestly significant difference post hoc tests for pairwise comparisons. Next, linear regression was used to regress LS7 score on the k-means clusters with adjustment for age, sex, annual household income per person, and education level as these are known to be associated with CVH. Participants identified their annual household income from eight categories with various ranges of income (eg, US$10 000–US$15 000, US$15 000–US$20 000). A crude representation of annual income per person was configured by dividing the median of a given income bracket by the household size. Participants selected their highest education level from five categories that were later collapsed into three categories for analysis: college graduate, some college or technical school and high school graduate or below.

To evaluate the contributions of neighbourhood perception domain and individual psychosocial domain to individual's CVH, separate principal component (PC) analyses were applied to the five neighbourhood perception variables and the six psychosocial variables, respectively. We then extracted the first PC (PC1) for each domain, namely, $PC1_{nbh}$ and $PC1_{ind}$. A linear regression was used to assess the association between LS7 score and $PC1_{nbh}$ and $PC1_{ind}$ with adjustment of age, sex, income, and education (defined above). All statistical analyses were performed using R V.3.3.1. Two-sided tests were considered and p<0.05 was deemed statistically significant.

RESULTS

Participant characteristics

Table 1 shows the characteristics of the 385 participants, with a mean age of 52.7±10.3 years and 60.8% females. The mean LS7 score was 7.99±2.19. Overall, 176 (46%), 75 (20%) and 85 (22%) reported to have hypertension, diabetes and dyslipidaemia, respectively. About one-third (34%) had a college degree, 37% had some college education, whereas 28% had a high school degree or below. Additionally, 47% reported an annual household income of less than US$25 000 with 23% less than US$10 000. The median income per person in the household was US$12 500 (IQR US$5000—US$21 250).

Overall neighbourhood perception and psychosocial health profile groups associated with LS7 via Bayesian Dirichlet process clustering

We applied profile regression via Bayesian Dirichlet process clustering to classify participants based on the 11 variables (summary scores from self-reported questionnaires). Table 1 shows the five identified clusters with the following sample sizes: 27 (7%), 71 (18%), 129 (34%), 108 (28%) and 50 (13%). Their mean LS7 scores were 4.26, 5.58, 7.47, 9.44 and 11.64, respectively. Cluster 5 (with the highest LS7 score) consisted of younger subjects (4–10 years younger on average), less females (50% vs ~60% in other clusters) and higher income and education levels, compared with other clusters. Age and sex distributions in cluster 1 (with the lowest LS7 score) did not appear to be different from other clusters; however, income and education levels were appreciably lower.

Figure 1 displays the posterior distributions of the neighbourhood perception and individual psychosocial scores corresponding to each cluster. Cluster 1 exhibited consistently lower scores compared with other clusters. Cluster 5 exhibited consistently highest scores (except Everyday Discrimination) across all the clusters. Specifically, scores in neighbourhood safety, social cohesion, activities with neighbours, environmental mastery, purpose in life and resilient coping were substantially higher in cluster 5 compared with the rest according to the 90% credible intervals. The majority of the subjects (80%) in clusters 2, 3 and 4 demonstrated intermediate scores in both the neighbourhood perception and psychosocial domains.

Overall neighbourhood perception and psychosocial health clusters derived from k-means

The optimal number of k-means clusters was 4. Figure 2 shows the mean scores of the 11 variables for each k-means cluster. Cluster 1 (n=112) exhibited consistently higher scores, on average, for both the neighbourhood perception and individual psychosocial health domains. Cluster 2 (n=41) demonstrated the lowest scores for variables belonging to the neighbourhood perception domain. Cluster 3 (n=147) had an intermediate mean score for each variable in the neighbourhood perception domain. The scores in the psychosocial health domain, on the other hand, were almost as high as those in cluster 1. Cluster 4 (n=85) also had an average score for each variable in the neighbourhood perception domain but overall exhibited the lowest scores in the individual psychosocial health domain.

Association between the k-means clusters and LS7

Figure 3 illustrates the distributions of LS7 score among the 4 k-means clusters. The LS7 score was significantly different across the four clusters (p=0.006), and the Tukey's post hoc test indicated a significant difference of 0.91 (95% CI 0.11 to 1.71) in LS7 score between cluster 1 and cluster 4 (p=0.019). Table 2 shows the estimated difference in LS7 score among the clusters. The mean LS7 score for cluster 2 and cluster 4 were estimated to be 0.79 (95% CI 0.01 to 1.58) and 0.67 (95% CI 0.05 to 1.29) lower than of cluster 1 after adjusting for age, sex, income and education. Younger age and having a college degree were found to be associated with a higher LS7 score.

Contributions of neighbourhood perceptions and psychosocial characteristics to LS7

On applying PC analysis, $PC1_{nbh}$ and $PC1_{ind}$ explained 56% and 55% variability of the data, respectively. Table 3 displays the loadings for $PC1_{nbh}$ and $PC1_{ind}$, which suggest that all the scores contributed to PC1 fairly evenly. Table 4 shows the estimated differences in LS7 score corresponding to 1 SD increase in $PC1_{nbh}$ and $PC1_{ind}$, adjusting for age, sex, education and income. When both $PC1_{nbh}$ and $PC1_{ind}$ were included in the same model, $PC1_{ind}$, but not $PC1_{nbh}$, was significantly associated with LS7 score. A 1 SD increase in $PC1_{ind}$ is associated with an estimated increase of 0.31 (95% CI 0.06 to 0.55) in LS7 score.

DISCUSSION

We used existing clustering methods to integrate multiple variables related to neighbourhood perceptions and psychosocial characteristics in the analysis of overall CVH. These approaches allow for the

Table 1 Subject characteristics corresponding to the five clusters using Bayesian Dirichlet process clustering

	Cluster 1 (n=27)	Cluster 2 (n=71)	Cluster 3 (n=129)	Cluster 4 (n=108)	Cluster 5 (n=50)	All (n=385)
Life's Simple 7 score	4.26 (0.66)	5.58 (0.50)	7.47 (0.52)	9.44 (0.54)	11.64 (0.69)	7.99 (2.19)
Age (years)	53.8 (8.84)	56.1 (8.00)	54.7 (9.35)	50.8 (10.4)	46.3 (12.1)	52.7 (10.3)
Sex (female)	16 (59.3%)	47 (66.2%)	81 (62.8%)	65 (60.2%)	25 (50.0%)	234 (60.8%)
Annual income (USD per person)*	$5000 (2396, 9375)	$12 500 (5625, 23 125)	$11 900 (5000, 22 500)	$14 150 (5625, 21 250)	$14 400 (7500, 21 250)	$12 500 (5000, 21 250)
Education*						
High school and under	15 (55.6%)	19 (26.8%)	37 (28.7%)	28 (25.9%)	10 (20.0%)	109 (28.3%)
Some college or technical	11 (40.7%)	25 (35.2%)	50 (38.8%)	40 (37.0%)	18 (36.0%)	144 (37.4%)
College degree	1 (3.7%)	27 (38.0%)	41 (31.8%)	40 (37.0%)	22 (44.0%)	131 (34.0%)
BMI (kg/m^2)	36.8 (8.58)	36.4 (7.35)	34.4 (8.24)	30.9 (7.49)	25.7 (4.61)	32.8 (8.22)
Physical activity*						
None	9 (33.3%)	9 (12.7%)	11 (8.5%)	3 (2.8%)	0 (0%)	32 (8.3%)
Some	13 (48.1%)	33 (46.5%)	47 (36.4%)	29 (26.9%)	7 (14.0%)	129 (33.5%)
Meets AHA recommendation†	5 (18.5%)	29 (40.8%)	71 (55.0%)	76 (70.4%)	43 (86.0%)	224 (58.2%)
Systolic blood pressure (mm Hg)	137 (16)	141 (21)	133 (19)	125 (18)	119 (15)	131 (20)
Diastolic blood pressure (mm Hg)	85 (11)	85 (13)	83 (12)	77 (10)	72 (9)	80 (12)
Fasting glucose (mg/dL)	108 (95.5, 133.5)	104 (95, 126.5)	92 (87, 100)	88.0 (84, 94)	86.0 (82, 91)	92 (86, 102)
Cholesterol (mg/dL)	199 (41.4)	207 (46.9)	197 (39.6)	184 (33.4)	173 (27.7)	192 (39.6)
Hypertension	25 (92.6%)	53 (74.6%)	69 (53.5%)	25 (23.1%)	4 (8.0%)	176 (45.7%)
Diabetes	16 (59.3%)	30 (42.3%)	25 (19.4%)	4 (3.7%)	0 (0%)	75 (19.5%)
Dyslipidaemia	12 (44.4%)	22 (31.0%)	40 (31.0%)	10 (9.3%)	1 (2.0%)	85 (22.1%)
Smoking history*						
Current smoker	16 (59.3%)	23 (32.4%)	36 (27.9%)	16 (14.8%)	1 (2.0%)	92 (23.9%)
Quit smoking ≤12 months	1 (3.7%)	5 (7.0%)	6 (4.7%)	4 (3.7%)	1 (2.0%)	17 (4.4%)
Never smoked or quit smoking >12 months	10 (37.0%)	43 (60.6%)	87 (67.4%)	88 (81.5%)	48 (96.0%)	276 (71.7%)
Diet (no of non-ideal components)*	4.30 (1.14)	4.01 (1.29)	3.84 (1.37)	3.73 (1.55)	3.32 (1.36)	3.81 (1.41)

Mean (SD), median (lower quartile, upper quartile) or frequency count (percentage) are presented.
*Self-reported measures.
†At least 150 min of moderate aerobic exercise or 75 min of vigorous exercise (or a combination of both) per week.
AHA, American Heart Association; BMI, body mass index.

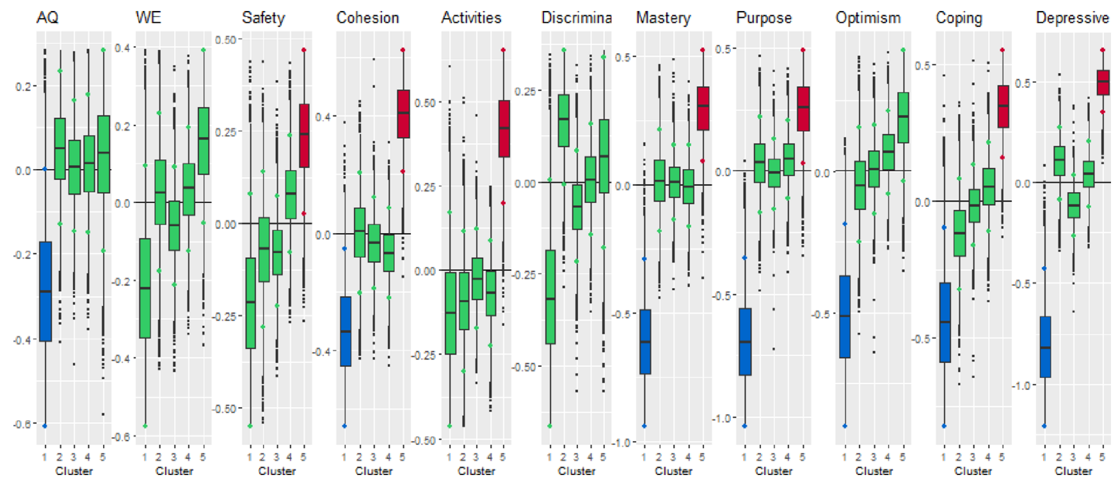

Figure 1 Box plot of the posterior distribution of the standardised self-reported neighbourhood perception and psychosocial scores for the 5 representative clusters (horizontal axis) where 1 has the lowest and 5 has the highest LS7 scores. The coloured points indicate the 5% and 95% quantiles, thereby suggesting the 90% credible intervals. Red and blue colours indicate that the 5% and 95% quantiles are above 0 and below 0, respectively, whereas green colour shows that the 90% credible intervals cover 0. Activities, activities with neighbours; AQ, aesthetic quality; Coping, resilient coping; Discriminat, everyday discrimination; LS7, Life's Simple 7; Purpose, purpose in life; WE, walking environment.

identification of underlying grouping and the development of potential research hypotheses. Additionally, we performed PC analysis to summarise neighbourhood perception and individual psychosocial health variables by retaining the first PC for each domain. Overall, the results indicate that both domains are related to CVH among Blacks. Specifically, higher LS7 scores were observed among those with better neighbourhood perceptions and psychosocial profiles, including neighbourhood safety, social cohesion, activities with neighbours, environmental mastery, purpose in life, resilient coping and no depression.

The Bayesian Dirichlet process clustering produced the posterior distributions of the neighbourhood perception and psychosocial variables for the five identified, representative clusters linking to LS7 scores. This approach allows users to perform a comprehensive examination of the 11 variables, to evaluate the likelihood of each factor's contribution to high or low LS7 scores, and to compare the similarity and dissimilarity measures among the clusters. All the scores, except everyday discrimination, show a consistent increasing

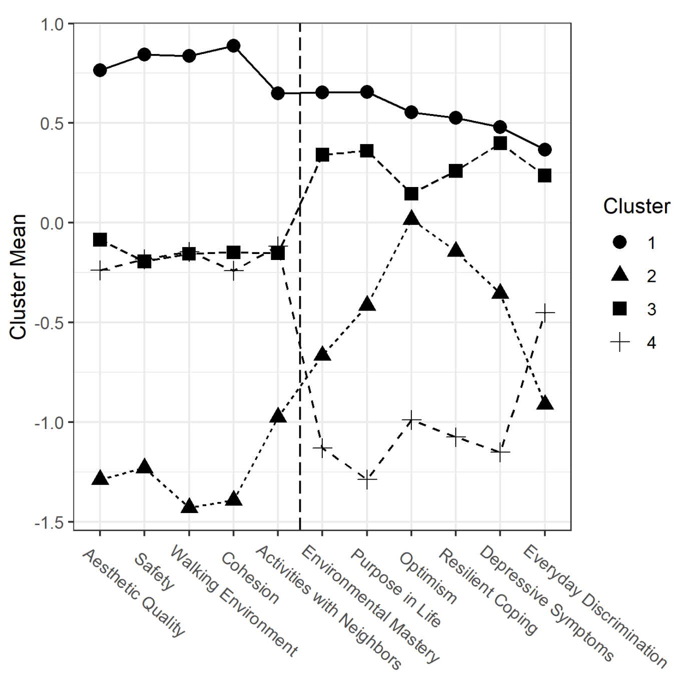

Figure 2 Means of 11 standardised neighbourhood perception and psychosocial for the four clusters resulting from k-means.

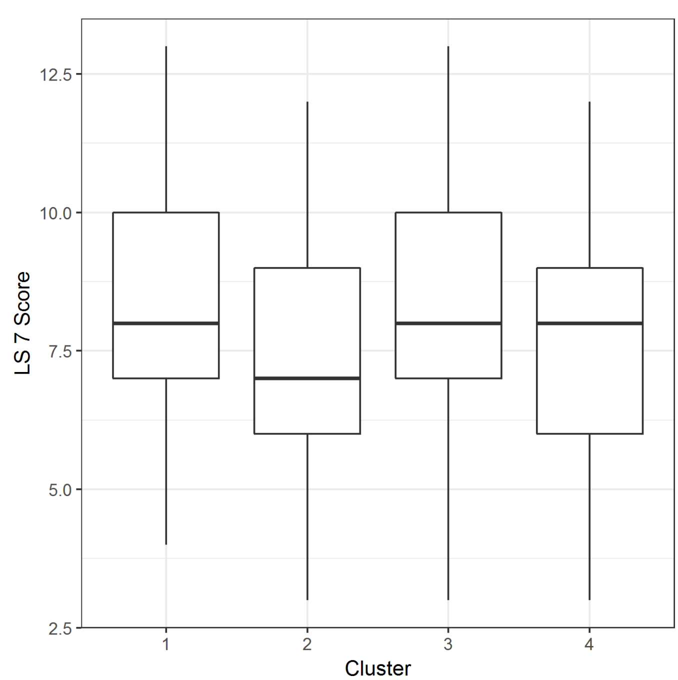

Figure 3 Distributions of Life's Simple 7 (LS7) scores of the 4 k-means clusters. The numbers in Clusters 1–4 are n=112, 41, 147 and 85, respectively.

Table 2 Estimated difference in LS7 score among clusters defined by k-means with adjustment of age, sex, education and income

	Estimated difference in LS7 (95% CI)	P value
Cluster 2 vs 1	−0.79 (−1.58 to -0.01)	0.047
Cluster 3 vs 1	−0.13 (−0.66 to 0.40)	0.64
Cluster 4 vs 1	−0.67 (−1.29 to −0.05)	0.033
Age (year)	−0.06 (−0.08 to -0.04)	<0.001
Sex (male vs female)	0.38 (−0.06 to 0.83)	0.093
Education		
Some college	0.30 (−0.27 to 0.86)	0.31
College graduate	0.88 (0.26 to 1.50)	0.005
Annual Income ($5000/person)	0.02 (−0.07 to 0.10)	0.73

LS7, Life's Simple 7.

Table 4 Association between LS7 score and the first principal components (PC1) of neighbourhood perception and individual psychosocial health scores with adjustment of age, sex, education and income

	Estimated difference in LS7 (95% CI)	P value
$PC1_{nbh}$ (per SD)	0.07 (−0.17 to 0.31)	0.56
$PC1_{ind}$ (per SD)	0.31 (0.06 to 0.55)	0.013
Age (year)	−0.06 (−0.08 to -0.04)	<0.001
Sex (male vs female)	0.43 (−0.03 to 0.88)	0.064
Education		
Some college	0.27 (−0.29 to 0.83)	0.35
College graduate	0.83 (0.22 to 1.45)	0.008
Annual income (US$5000/person)	0.01 (−0.07 to 0.09)	0.80

LS7, Life's Simple 7.

trend with LS7 score, indicating that a better neighbourhood perception and psychosocial profile may promote CVH. Although individuals with extremely low LS7 scores reported a relatively increased amount of discrimination experience, those with moderate or ideal LS7 scores showed no appreciable difference in their discrimination scores. This observation is consistent with the Jackson Heart Study.[19]

On the other hand, k-means seeks to define homogeneous groups among the 11 variables of interest without connecting to the outcome variable. The resulting 4 k-means clusters allow for the investigation of individual psychosocial characteristics (high vs low scores) with similar neighbourhood perception scores (ie, clusters 3 vs 4) and vice versa (ie, clusters 1 vs 3). After adjusting for age, sex, income and education, we found that cluster 3 had a significantly higher LS7 score compared with cluster 4. The results are consistent with the PC analysis findings that when both factors were considered simultaneously, only $PC1_{ind}$ was significantly associated with LS7 score. The results suggest that both domains are important to CVH with the psychosocial health domain being more dominant.

Table 3 Loadings for the first principal components of neighbourhood perception ($PC1_{nbh}$) and individual psychosocial health scores ($PC1_{ind}$)

Loadings for $PC1_{nbh}$		Loadings for $PC1_{ind}$	
Cohesion	0.4981	Purpose in life	0.4657
Safety	0.4698	Environmental mastery	0.4634
Walking environment	0.4659	Depressive symptoms	0.4337
Aesthetic quality	0.4368	Optimism	0.3974
Activities with neighbours	0.3512	Resilient coping	0.3968
		Everyday discrimination	0.2549

We present a comprehensive investigation of multiple dimensions in both the neighbourhood perception and psychosocial domains in one study rather than inspecting one single 'exposure' and CVH at a time. Our study provides a unique opportunity to evaluate the link between neighbourhoods, psychosocial factors and achieving ideal CVH, which is critical for Blacks given their higher CVD burden. However, our study has a number of limitations. The study participants with 60% being female and nearly 50% being low income were recruited using convenience sampling, so the results may not be generalisable to the target study population. Given the study design and data availability, we only considered five neighbourhood perception scores and six individual psychosocial characteristics scores as potential risk and resilient factors for CVH. However, additional neighbourhood characteristics (eg, access to healthy food, physical activity resources) and individual psychosocial health status (eg, social support) may also contribute to CVH resilience. In addition, cluster uncertainty is an issue when using clustering and classification methods. A comprehensive validation procedure is desired and would be meaningful with a much larger-scaled study, but it is beyond the scope of our current exploratory study with a modest sample size. Lastly, we are not able to determine the directionality of association as to whether modifying psychosocial factors would lead to behaviour changes related to CVH given a cross-sectional study design. It is possible that people with healthier psychological characteristics are more likely to engage in CVH activities and CVH activities, in turn, are likely to foster better psychosocial health and neighbourhood perceptions.

CONCLUSIONS

We demonstrated the use of clustering methods to translate multiple questionnaire scores to one grouping variable for the analysis of CVH, which provides a useful characterisation of overall neighbourhood perception and psychosocial health profiles and avoids investigating individual variables separately. Our findings suggest that CVH profiles are potentially affected by both neighbourhood perceptions (ie, neighbourhood safety, social cohesion and activities with neighbours) and psychosocial factors (environmental mastery, purpose in life, resilient coping and no depression). This suggests that policies aimed at improving the ability of black adults to support and gather safely with others in their neighbourhood (eg, crime reduction initiatives, support for community gathering locations and other community services) might ultimately enhance CVH at the neighbourhood level. At the same time, psychosocial treatments that focus on improving feelings of mastery, providing a sense of purpose, improving coping and reducing depression might enhance CVH at the individual level. However, approaches that acknowledge the importance of factors at both levels might prove most beneficial for enhancing resilience and promoting CVH among black communities.

Author affiliations
[1]Department of Biostatistics and Bioinformatics, Emory University Rollins School of Public Health, Atlanta, Georgia, USA
[2]Department of Biostatistics, Epidemiology and Informatics, University of Pennsylvania, Philadelphia, Pennsylvania, USA
[3]Division of Cardiology, Emory University School of Medicine, Atlanta, Georgia, USA
[4]Division of Epidemiology, University of California Berkeley School of Public Health, Berkeley, California, USA
[5]Department of Medicine, Morehouse School of Medicine, Atlanta, Georgia, USA
[6]Department of Medicine, University of Mississippi Medical Center, Jackson, Mississippi, USA
[7]Department of Epidemiology, Emory University Rollins School of Public Health, Atlanta, Georgia, USA
[8]Department of Community Health and Preventive Medicine, Morehouse School of Medicine, Atlanta, Georgia, USA

Contributors YK designed the analytic strategies, analysed the data, interpreted the results and wrote the manuscript. JS helped conduct literature review, data analysis and drafting the result section. JHK and MT helped with the implementation of the main study, including data quality assurance. MM, HT, AQ, MS and VV reviewed the paper and provided constructive feedback. AQ and HT are the centre grant PIs. PB and TL are the project PIs. All of the authors reviewed the manuscript, shared comments and edited the manuscript.

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ORCID iD
Yi-An Ko http://orcid.org/0000-0002-6543-9765

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