Original Article
An application of latent transition analysis in defining socioeconomic and obesity status in adults living in three counties in the central region of Iran

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Abstract: Introduction: Socioeconomic status is a critical factor for human health, but it has a complex definition. In some previous studies, latent class analysis has been used as a method of Socioeconomic status characterization. In this study, we applied latent transition analysis to better understand how Socioeconomic status is related to obesity and to assess its changes over time. Methods: This study included 6504 people who participated in the Isfahan Cohort Study, aged over or equal to 35, living in three counties in the central region of Iran. Seven items were used as indicators for the socioeconomic variables which were evaluated three times over 12 years (2001-2013). The obesity status was considered as another item in the latent transition analysis model. Results: Education and average household income were the most effective items in the latent transition analysis classification. The model with three statuses (low, middle, and high) in all measurement times was selected. People in the middle classification of socioeconomic status were more likely to be obese in comparison with two other statuses. Almost all individuals remained in their first identified statuses over time. Conclusion: Latent transition analysis can help to summarize socioeconomic variables and to assess their transitions through time.

Keywords: Socioeconomic status, obesity, latent transition analysis

Introduction

Obesity is an important public health issue in both developed and developing countries [1]. Some of the variables that are associated with obesity status include aging, low educational levels, being married, residing in an urban area, female sex, and socioeconomic factors [2].

Socioeconomic status (SES) is a multidimensional concept and has a wide range of SES measures such as education, occupation, income, medical insurance, material ownership, and wealth; all of which have been used for defining SES in different studies [3, 4]. In some studies, different multivariate methods including Principal Component Analysis (PCA), Factor Analysis (FA), and Latent Class Analysis (LCA) have been used to define an index for SES [5-9].

In this study, we employed Latent Transition Analysis (LTA) to better understand how SES is related to obesity and how it changes over time [10].

Materials and methods

Population

We used the information of individuals who participated in a longitudinal population-based study, entitled the Isfahan Cohort Study (ICS) [11, 12]. The ICS included individuals aged over or equal to 35-years-old, with Iranian nationality, who were not pregnant, mentally competent, without a history of CVDs, and from urban or rural areas of three counties in the central part of Iran (Isfahan, Arak, and Najafabad) [11, 13]. Respondents in this study included 6504 individuals in first, 3356 in second, and 1735

Table 1. Model selection

Number of classes	AIC	BIC	Log-Likelihood	G-squared
2	7086.58	7364.56	-2548487.37	7004.58
3	5841.77	6302.82	-24837.96	5705.77
4	4186.66	4857.90	-23979.41	3988.66

in the third stage. Changes in phone numbers and addresses of some individuals in some regions were mentioned as the leading cause of loss to follow-up in the ICS [12]. The loss to follow-up process was not related to previous observations, was not biased, and was at random (MAR) [14]. Ethical approval was obtained from the Ethics Committee of Isfahan Cardiovascular Research Center (ICRC) [11]. Details of the study design and ICS challenges were described in previous papers [11-13].

Seven items (education, occupation, average household income, ownership status for a house, number of children, number of travels in one year, and health insurance) as indicators for the socioeconomic index were measured three times over 12 years (2001, 2007, 2013). A validated questionnaire, including questions on demographic characteristics, and socioeconomic status, was used for measuring the items. Also, obesity status was considered as another item in the model. Obesity was considered as BMI more or equal to 30 kg/m^2 according to the definition provided by the World Health Organization (WHO). Weight and height of participants were measured in a physical examination by trained physicians and nurses [15].

Statistical analysis

Considering the socioeconomic and obesity status as a latent variable, LTA which is a longitudinal extension of LCA has been applied. LCA is an established statistical method that allows the classification of individuals into groups based on conditional probabilities. Within each class, individuals will have a similar pattern of response to the categorical variables [10, 16]. LTA is a method to model development in discrete latent variables, over time. In the LTA model, change is quantified in a matrix of transition probabilities between two consecutive times [10]. Parameters for LTA are estimated by the maximum likelihood (ML) method

[10]. For model selection, LTA models with various numbers of latent statuses can be compared using several criteria, including the likelihood-ratio, G^2 statistic, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). It is important to consider the interpretability of the latent statuses as well [10].

Results

Respondents in this study included 6504 people in the first stage, 3356 in the second, and 1735 in the third stage. The average age of participants in this study was 50.23 (SD = 11.73) years old. Slightly more than half of the respondents (51.3%) were female and 48.7% were male. The majority of the respondents (90.6%) were married. Most of the people included in the study sample (94%) had 12 years of education or less. Also, 22.1% of the people were obese at baseline, 26.3% at the second stage, and 30.4% in the third stage.

LTA model selection

Using LTA, we constructed latent statuses of the respondents based on measurements for seven SES items (education, occupation, average household income, ownership status for a house, number of children, number of travels in one year, and health insurance) plus obesity items and evaluated transitions between statuses over time. To find the appropriate number of statuses, we first fitted three simple LTA models (without considering sex as a grouping variable), and with different number of statuses (2-4 statuses). According to the fit criteria and the interpretability of the models, a model with three latent statuses was chosen. The most effective items in the LTA classification were average household income, education, and obesity. It is shown in the **Table 1**.

LTA model with three latent statuses

In the next step, an LTA model with seven SES items (as mentioned before) plus an obesity item was fitted, considering sex as a grouping variable (**Tables 2** and **3**). **Table 2** shows the prevalence of answers to the questions in constructed statuses at the first measurement time. Each status can be interpreted in terms

Table 2. Item-response probabilities (probability of item response given latent status) and prevalence of latent statuses in the first measurement time

Item-response probabilities		Group	socioeconomic and obesity status The first measurement time		
			Status 1	Status 2	Status 3
Average household income	Low	Women	0.7943	0.9671	0.7937
		Men	0.8914	0.9639	0.5754
	Middle	Women	0.2011	0.0286	0.1986
		Men	0.1029	0.0331	0.4001
	High	Women	0.0046	0.0043	0.0077
		Men	0.0057	0.0029	0.0245
Education level	Illiterate	Women	0.0016	0.8501	0.0521
		Men	0.1208	0.8657	0.0038
	Elementary School	Women	0.5294	0.1499	0.6203
		Men	0.7733	0.1301	0.0125
	Middle School or High School	Women	0.4065	0.0000	0.2891
		Men	0.1059	0.0000	0.6924
	Higher than High School	Women	0.0626	0.0000	0.0385
		Men	0.0000	0.0043	0.2913
Obese	No	Women	0.9081	0.7482	0.0014
		Men	0.8596	0.8954	0.8722
	Yes	Women	0.0919	0.2518	0.9986
		Men	0.1404	0.1046	0.1278
Prevalence of latent statuses		Women	0.3091	0.5465	0.1444
		Men	0.3948	0.2786	0.3265

Table 3. Transition probabilities in latent status membership

Transition probabilities for group 1: Women									
Probability of transitioning to...		...latent status in the second measurement time			Probability of transitioning to...		...Latent status in the third measurement time		
Conditional on the first measurement time latent status		Status 1	Status 2	Status 3	Conditional on the second measurement time latent status		Status 1	Status 2	Status 3
	Status 1	0.8748	0.0053	0.1199		Status 1	0.9893	0.0107	0.0000
	Status 2	0.0076	0.9924	0.0000		Status 2	0.0096	0.9804	0.0100
	Status 3	0.0000	0.0000	1.0000		Status 3	0.0000	0.0100	0.9900
Transition probabilities for group 2: Men									
Conditional on the first measurement time latent status		Status 1	Status 2	Status 3	Conditional on the second measurement time latent status		Status 1	Status 2	Status 3
	Status 1	0.9934	0.0066	0.0000		Status 1	0.9857	0.0000	0.0143
	Status 2	0.0000	1.0000	0.0000		Status 2	0.0000	1.0000	0.0000
	Status 3	0.0000	0.0022	0.9978		Status 3	0.0000	0.0000	1.0000

of the level of education and average household income. In **Table 2**, only the values related to the first measurement time were reported because the status structure stays the same across measurement times and the measurement invariance assumption is reasonable.

Labeling the statuses

According to the prevalence of responses over all measurement times, status 2 can be considered as a low SES level for both men and women because this status included a higher prevalence of illiterate and low-income people in comparison with other statuses. Status 1 can be considered as the class of high SES for women and middle SES for men. Moreover, we can consider status 3 as the middle SES for women and high SES for men. An important observation was that the maximum prevalence of obesity belonged to people in the middle SES

for both men and women although there was not a remarkable difference between the prevalence of obesity in the three socioeconomic statuses for men.

Prevalence of latent statuses membership

The prevalence of latent status membership in the first measurement time is represented in the lower part of **Table 2**. The prevalence of being in status 1 across all measurement times was more than other statuses for men (the prevalence of being in status 1 for men were 0.3948, 0.3922, and 0.3866 in the first, second, and third measurement time, respectively), while women had more prevalence of being in status 2 in comparison with other statuses (the prevalence of being in status 2 for women were 0.5465, 0.5440, and 0.5381 in the first, second, and third measurement time, respectively); that means most of the women in this study were in the low level of SES and most of the men were in the middle status.

Transition probabilities

Table 3 shows the transition probabilities across the study periods. According to the transition probability matrix, almost all participants remained in their first identified statuses over time. Only for women in the high SES at the first measurement time, a low probability of transition to the medium SES at the second measurement time was observed (transition probability = 0.12). Other transition probabilities were near zero.

Discussion

In this study, we assessed how SES is related to obesity and how it changes over time in a general population of three counties in the central part of Iran. We found that among the seven measured socioeconomic factors, the most effective ones for determining SES were education level and average household income. These two items have been recognized as important indicators for SES in many other studies [2, 17].

In our study, the maximum prevalence of obesity belonged to individuals in middle SES. However, for men, there was not a remarkable relation between SES and obesity. Furthermore, most of the women in this study were in the low level of SES while most of the men were

in middle status. In Iran, several studies indicated that obesity is more prevalent in individuals with lower SES and only a few studies reported obesity among individuals in a high level of SES [1, 18-20]. Improvement in the SES of the Iranian population during the past decades has resulted in a higher prevalence of obesity in groups of low and middle SES [1]. However, differences in the definition of SES and target regions should be taken into consideration [21]. Moreover, in previous studies in Iran, a broader range of socioeconomic inequality was reported for women in comparison with men [1].

Finally, in our study, almost all individuals remained in their first identified statuses over 12 years (2001-2013). This indicates that the probability of change in the SES for individuals was very low during the study period according to the socioeconomic conditions in Iran.

In conclusion, applying LTA in the definition of socioeconomic status, can help to summarize socioeconomic measures, assessing the changes over time, and improving interpretations. Moreover, LTA can contribute to our understanding of socioeconomic drivers of health.

Disclosure of conflict of interest

None.

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