Research Article

Factors Affecting Diabetic Screening Behavior of Korean Adults: A Multilevel Analysis

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S U M M A R Y

Purpose: We investigated the role of individual and community level factors on diabetes screening test behavior.

Methods: We used individual-level data from 170,193 adults aged 30 years or older who were not diagnosed with diabetes and participated in the 2009 community health survey. Community-level data includes 253 communities and were collected from various national statistics. Multilevel logistic regression analysis was conducted.

Results: The rate of diabetes screening within the year prior to this study was 53.2%. Community variance of Model I, Model II and Model III was 0.236, 0.252 and 0.238, respectively. The proportional change in variance of Model II and Model III was e6.8% and e1.2%. The odds ratio for participation of diabetic screening of areas with bottom financial independence compared to areas with top was 0.84 (95% confidence interval, 0.74 e 0.96); the odds ratio of areas with top internist compared to areas with bottom was 1.15 (95% confidence interval, 1.01 e 1.31).

Conclusion: This study identified a contextual effect influencing the participation of Korean adults in diabetes screening. It is necessary to develop specific policies that consider not only individual factors, but also community factors relating to individual behaviors to increase the likelihood of diabetes screening.

Introduction

The prevalence of diabetes has dramatically increased from 1.5% in 1971, 7.6% in 2001 to 7.7% in 2005 (Kim et al., 2006b; Korean Diabetes Association, 2007). In addition, approximately a third to half of diabetes patients go undiagnosed, and about a third of type II diabetes patients are diagnosed with complications (Lee et al., 2009). Early diagnosis and subsequent treatment through diabetes screening can delay its development and prevent complications. Screening for the early detection of diabetes is a major task of primary health care, and all public health centers have been carrying out screenings for the inhabitants in Korea.

An individual’s health is determined by their individual characteristics, their health behaviors and their environment (Jung & Cho, 2011). To some extent, factors such as where they live, the state of their environment, their income and education level, their relationships with friends and family, and access and use of health care services all have impacts on their health and behaviors. How can we estimate the extent to which individual and community factors affect health behaviors? For example, the national health screening rate in Korea has increased every year from 62.1% for office workers and 29.4% for local residents in 2003 to 78.3% and 39.4% in 2008. At the same time, screening rates have shown large variations according to location (based on city, county, and district), with the greatest rate for office workers being 96.4% and the lowest rate being 62.5%, and the greatest rate for local residents being 77.2% and the lowest rate being 25.6% (Press release of audited government offices, 2009).

Multilevel analysis is a statistical method that uses hierarchically structured data. It includes observed values of higher
levels (area or community) and lower levels (local residents or individual) and considers the effects of two different levels on individual outcomes (Diez-Roux, 2000). It has been used in many studies to identify the contextual effect of the local community on many health related issues such as death rate (Kim & Yoon, 2008; Yoon, 2003), medical services use (Jung, Kwon, Kim, Lee, & Kim, 2010; Kim & Cho, 2007), health behaviors (Jang, 2011; Kim, Yun, Kim, & Khang, 2006a), and breast cancer examinations (Lee, 2011). However, there has been no research on the community influences on diabetic screening behavior in Korea.

The purpose of this study is to identify the contextual effects of community on diabetes screening behavior using the analysis of hierarchically structured data with multilevel modeling methods.

Methods

Study design

This was a cross-sectional study using secondary data for a multiple level analysis.

Setting and samples

Both individual-level and community-level data were obtained. Collection of individual-level data used the 2009 Community Health Survey (CHS), which has been conducted annually since 2008 on individuals aged 19 years or older in 253 regions around the country (Ministry of Health and Welfare, 2009). The CHS has a two-stage sampling process: (a) selecting a sample area (tong/ban/ri), which is a primary sample unit selected according to the number of households in each dong/eup/myeon (the smallest administrative unit) using a probability proportional to the sampling method, and (b) selecting sample households using a systematic sampling method, where the number of households in the selected sample (tong/ban/ri) is identified to create a household directory. These methods are used to ensure that the sample units are representative. Among 230,715 CHS participants, 170,193 were included in the individual-level analysis. The remaining 60,552 were excluded because they were aged less than 30 years (n = 30,733), diagnosed with diabetes (n = 16,612), or did not properly answer the survey with missing data (n = 13,207).

The community-level data source of 253 communities came from the Korean Statistical Information Service for the proportion of aged people (Korean Statistical Information Service, 2008). Data collection was public health center based. It included the 2008 Local Government Statistical Year Book for financial independence, health institution counts, and internist counts (Seoul Metropolitan Government, 2008), and data from the 2009 CHS for unemployment rates, diabetic screening rates and diagnosed diabetes rates (Ministry of Health and Welfare, 2009). Overall, data from 253 communities were subjected to community-level analysis. When one administrative unit had two public health centers, they were treated as a single unit.

Ethical considerations

This study design was approved by the institutional review board of Korea Centers for Disease Control and Prevention (ID: 2010-02CON-22-P).

Data collection

Community social capital affects health (Mohnen, Groenewegen, Völker, & Flap, 2011; Van, Droomers, Deerenberg, Mackenbach, & Kunst, 2008), but the mechanism by which it has an effect on an individual’s health is not clear. Some studies have explained that it had two steps: the first is the positive influence of community social capital on health-related individual behavior (smoking, alcoholic consumption, physical activity) and the second is effect of changed health behavior on health (Mohan, Twigg, Bernard, & Jones, 2005; Poortinga, 2006). In addition to social capital, socioeconomic features of the community, physical environment, health policy, and medical service supply—related environmental factors have independent influences on an individual’s health behaviors (Pollack et al., 2007). No study to date focused on the effect of these elements on diabetic screening behavior.

Based on some studies (Bae et al., 2008; Kang, You, & Kwon, 2009; Korea Center for Disease Control and Prevention, 2010), sex, age, education, spouse, job income, smoking, exercise, obesity and hypertension were selected as individual-level variables related to diabetic screening. Among the indices on community, the proportion of the aged population, unemployment rate, the financial independence of the local government, the number of medical institutions, the number of internists, and the rate of diagnosed diabetes were selected as community-level variables.

Measurements

Variable of diabetic screening behavior

As a dependent variable, participation in diabetes screening was defined as whether blood sugar level was measured within 1 year prior to the date of 2009 CHS survey (examinee & non-examinee for diabetes screening).

Individual variables

Individual variables included demographic features such as gender, age, education, marital status, job status, and monthly family income, and health-related features such as smoking status, regular exercise, body mass index (BMI), and hypertension. Education level was based on graduation; dropping out and leaving school were not considered as having graduated. Job status was defined as four groups, employer (or self-employed), paid-worker, nonpaid worker, and others (e.g., student, housewife, unemployed). Income level was based on the average income of a two-person family in 2009 (3.04 million won). Those with an income below 50% of the average were classified as lower class, 50–150% were classified as middle class, and greater than 150% were classified as upper class. Exercise is a binary variable indicating those who exercise more than 30 minutes per workout, 5 days a week and those who do not. Using height and weight, we calculated the BMI which was classified into two categories: normal or healthy weight (BMI < 25.0 m²/kg) and obese (BMI > 25.0 m²/kg).

Community variables

The proportion of the aged population was the proportion of people aged 65 years or older among registered residents. The unemployment rate was the proportion of people aged less than 65 years who were unemployed and seeking a job according to the 2009 CHS. Financial independence of the local government was calculated by dividing the sum of local taxes, nontax receipts, local grant taxes, control grants, and local share taxes by the total budget of general accounts. The number of internists was the number of internists per 100,000 people. The number of health institutions was the number of health organizations, general hospitals, hospitals, and clinics per 100,000 people. The rate of diagnosed diabetes was the proportion of people who were diagnosed with diabetes and were aged 30 years or older according to the 2009 CHS. The community variables were classified into top and bottom, with the median value as the standard.
Multilevel analysis and models

Three different models were established to analyze the data (Bickel, 2007; Gelman & Hill, 2007; Twisk, 2006). Model I (empty model) did not include explanatory variables, and estimated the community variance. In using this model, we simply aimed to identify a possible contextual phenomenon that could be quantified by clustering screening rates within community (Merlo, Chaix, Yang, Lynch, & Rastam, 2005). The intercept of the regression model was the screening rate value for people with value 0 for all explanatory variables considered and with an average community effect. Through these models, we could determine differences between community (fixed effect) and the size of the contribution to the difference in dependent variables (variance of variables) classifying 253 communities. Fixed effects and random effects are expressions that are often used in multilevel logistic regression analysis. Essentially, fixed effects are used for model averages (e.g., means or regression coefficients), whereas random effects are used for difference among neighbors (e.g., community variance) (Diez-Roux, 2002). Model II (Individual-level model) expanded upon Model I by including individual variables, such as sex and age as fixed effects. Thus, Model II could evaluate the extent to which community-level differences were explained by the individual composition of the areas. Model III (mixed model) incorporated both individual and community variables into Model I.

The three equation of multilevel logistic regression are as follows: In model I, the probability of participating in diabetic screening is only a function of the community in which the study population live.

\[
\logit(P_i) = \log\left(\frac{P_i}{1-P_i}\right) = M + E_A
\]

- \(P_i\) = probability of participating in diabetic screening.
- \(M\) = overall mean probability (prevalence) expressed on the logistic scale.
- \(E_A\) = residual of community. The area level residuals are on the logistic scale and normally distributed with mean 0 and variance \(\sigma^2_V\), where \(\sigma^2_V\) is the community residual variance expressed on the logistic scale.

In model II, the probability of participating in diabetic screening is a function of the community, residence, the people and the individual variables (e.g., sex, age, and education).

\[
\logit(P_i) = M + \beta_1 \text{sex}_i + \beta_2 \text{age}_i + \beta_3 \text{edu}_i + E_A
\]

- \(\beta_1, \beta_2, \beta_3\) = regression coefficients for the individual covariates.

In model III, the probability of participating in diabetic screening depends on the residential area of the individuals, on the individual variables, and on the community variables such as financial independence.

\[
\logit(P_i) = M + \beta_1 \text{sex}_i + \beta_2 \text{age}_i + \beta_3 \text{edu}_i + \beta_4 \text{fi}_A + E_A
\]

- \(\beta_4\) = regression coefficient for the community level such as fi (financial independence).

Multilevel logistic regression analysis calculates the odds ratio among explanatory variables, 95% confidence intervals (95% CI), community variance and its standard error, and proportional change in variance. Community differences in mean screening rate may be attributable to contextual influences or to differences in the individual composition of community. By adjusting for individual characteristics in Model II, we took into account some part of the compositional differences and explained some of the community variance detected in the empty model (Model I). The equation for the proportional change in community variance is the following:

\[
PCV_{N-2} = \frac{(V_{N-1} - V_{N-2})}{V_{N-1}}
\]

- \(PCV_{N-2}\) = proportional change in community variance.
- \(V_{N-1}\) = community variance in the empty model.
- \(V_{N-2}\) = community variance in the model including individual characteristics.

The proportional change in variance is often referred to as explained variance. However, the addition of individual variables in the model may increase the second-level variance. In cases in which the community differences are hidden by their individual composition, the total variance may decrease, but the community component of the variance increases. Therefore, the term “proportional change in variance” is more appropriate than “explained variance”.

Data analysis

SAS version 9.2 (SAS Institute, Cary, NC, USA) was used to analyze data with a significance level of 5%. Chi-square analysis was conducted to identify the differences in diabetes screening rates by variables. Multilevel logistic regression analysis (proc glimmix) was conducted to identify whether there were individual and/or community-level factors that influenced the diabetes screening test rate and to calculate their relative contribution. Multilevel logistic regression was performed on significant variables in the Chi-square test. Pseudo-likelihood technique was used as the estimation method. We applied the log likelihood ratio test to find the significance of variance differences between Model I and II, Model II and III, and Model III and I. The results yielded the odds ratios of variables at the 95% CI.

Results

Rate of diabetes screening in study subjects within the past year

The rate of diabetes screening within the past year for the study subjects was 53.2% (Table 1). The screening rate for men was 53.5%, which was higher than that for women (53.0%; *p* = .034). The group of people aged 60 years or older showed the highest screening rate of 62.9%; the rate increased with age (*p* < .001). The rate of middle school graduates or below was 59.4%, for high school it was 47.7%, and for university or higher it was 50.0% (*p* < .001). The group of participants with a spouse had a screening rate of 54.0%, which was significantly higher than that of participants without a spouse (50.8%; *p* < .001). The screening rate of paid workers was 54.1%, which was higher than that of unpaid workers (52.8%; *p* < .001). With respect to health behaviors, nonsmokers had a diabetes screening rate of 54.6% (*p* < .001): 55.6% of participants who did medium level of exercise were screened (*p* < .001), while obese people had a rate of 57.2% (*p* < .001), and those who were diagnosed with hypertension had a rate of 67.7% (*p* < .001). Diabetes screening rates in areas of bottom financial independence (56.1%) were significantly higher than those in top areas (50.7%; *p* < .001). Top areas, when compared to bottom areas showed significantly higher diabetes screening rates when comparing the proportion of the aged population, the unemployment rate, the number of health and medical institutions, and number of interns (*p* < .001). The rate of diabetes diagnosis in top areas was 53.5%, significantly higher than the bottom areas (53.0%, *p* = .025).
The result of the multilevel logistic regression analysis is shown in Table 3. Community variance of Model I, II and III was 0.236, 0.252 and 0.238, respectively. The proportional change in variance of Model II and III was −6.8% and −1.2%. Variance differences between Model I and II, Model II and III, and Model III and I were all statistically significant (p < .001).

In addition to many significant individual level variables, some community characteristics had significant effects. The odds ratio for participation of diabetic screening of areas with bottom financial independence compared to their counterpart was 0.84 (95% CI, 0.74–0.96). The odds ratio of areas with top internist compared to their counterpart was 1.15 (95% CI, 1.01–1.31).

Discussion

The strength of this study is that it dealt with effect of both the individual and community on the behavior of diabetes screening simultaneously. This is the first study of its kind in this area. The traditional model only explained the individual factors on the behavior of diabetes screening.

The frequency of adults aged 30 years or older, who were not diagnosed with diabetes and took part in a diabetes screening test within the previous year was 53.2%. This study revealed that community-level factors related to high screening rates were financial independence of the local government (lower) and number of internists per 100,000 residents. Significant individual factors included age (older), marital status (married), job status (paid workers), income level (higher), obesity, hypertension, smoking status, and regular exercise.

Participation rates of diabetic screening in this study were lower than the rate of national health screening (58.8% conducted by the
National Health Insurance Corporation in 2008; Press release of audited government offices, 2009) and lower than the rate of hemoglobin A1C (78.6%) testing on adults aged 30 years or older with diabetes (Lee, 2009). This may be because the proportion of paid workers in the 2008 national health screening was higher than in the 2009 CHS survey or because study population belonged to a healthier group for they were not diagnosed with diabetes.

The results in this study were similar to those in other domestic studies that show older people, those with higher incomes, and those with higher education levels have higher rates of diabetes screening (Bae et al., 2008; Kang et al., 2009). However, studies done in other countries have shown that older people had lower screening (Bae et al., 2008; Kang et al., 2009). However, studies done in other countries have shown that older people had lower screening rates than those with higher education levels, greater interest in health, and lower risk factors tend to participate more in medical examinations (Simon, Albright, Belman, Tom, & Rideout, 1999). This may be because Korea has strengthened their medical system for the vulnerable, thereby enabling many medical examinations for the elderly and for people at high risk for chronic disease. In addition, the medical examination fee charged by National Health Insurance Corporation is low in Korea (under US$30) and deductibles for examinations are free. However, direct costs vary widely depending on insurance types or service programs and are high. For example, cost of screening for random plasma glucose is US$5.48, cost of oral glucose tolerance test to confirm is US$17.99, and health system cost to confirm is US$518 in Center for Medicare and Medicaid Services in the United States (Chatterjee, Narayan, Lipscomb, & Phillips, 2010).

After multilevel analysis, variance differences among Model I, Model II, and Model III were all statistically significant. Variance of community-level factors in Model II was higher than that of Model I. This indicates that individual variables increase the variance of community. That is, individual variables strengthened the difference in variance of community. In Model III, however, the variance of community decreased to 0.239, which means that addition of community variables to Model II decreased the difference in variance of community. That is, community variables of 6 explained 5.6% of variance of community in Model II.

Our results indicate that community-level contextual effects influence individual examination rates in addition to compositional effects of the individual. That is, areas with higher financial independence showed significantly lower screening rates than those with lower financial independence. Based on our results, financial independence does not have a positive relationship with participation rate of diabetic health screening. Thus, it is desirable to use direct budget such as welfare budget, public program budget of public health center instead of financial independence. In addition, the areas with a greater number of internists showed higher screening rates than those with less. This implies that it is necessary to secure the medical manpower, the internists who can conduct examinations to increase diabetes screening rates. There were no community-level relationships found between aged population, unemployment rate, medical institutions, or the rate of diabetes diagnosis and diabetes screening rates.

There is no multilevel analysis study that has considered community-level influence on diabetes screening rates. Therefore, it is difficult to compare research methods and results. Recently, a study on women’s breast cancer screening rates that utilized the Korean National Health and Nutrition Examination Survey used the multilevel analysis that was the similar to our approach (Lee, 2011).
Community variance on the breast cancer screening rate was 0.061 in their Model I, but the variance decreased to 0.034 in Model II, indicating that individual variables could explain 44.3% of the community differences in breast cancer screening rates. This is contradictory to our result that had increased variance in Model II. In addition, as the proportion of the welfare budget of general accounts increased, the breast cancer screening rate decreased. This is similar to our finding that areas with higher financial independence showed significantly lower screening rates than areas with lower financial independence.

In conclusion, people can be affected by social capital which is defined as the access to resources that are generated by relationships between people in a friendly, well-connected and tightly knit community (Mohnen et al., 2012). Neighbors have more opportunities between people in a friendly, well-connected and tightly knit community (Mohnen et al., 2012). Norms of behavior are provided by well-connected communities rather than one or two close friends (Taylor, Repetti, & Seeman, 1997). We think that well-connected communities should assist individuals using budget, organization (e.g., public health center) and community resources (e.g., medical institutions, health professionals) to improve the health of individuals. Behavior is a result of internalized community norms, imitation, and social feedback (Mohnen et al., 2012). Finally, we have to foster a community that makes us improve our health behavior.

This study has the following limitations. First, communities were classified based on public health centers that executed local health policies. Therefore, some of the data generated based on an administrative district that was used in our analysis did not match with the community unit of our study. In addition, an individual’s scope of activity could lie outside the defined community, which would decrease connectivity with the community. Jung and Cho (2005) reported that Korea has many different elements in a single local unit and that ways of thinking and acting spread fast in areas with little land and high social density. They added that residents move frequently and live in one area for a relatively short period of time, and they also live both in and out of one’s residence. All of these elements make conceptualization of a community unit difficult. Therefore, it is necessary to continue to make use of the concept of community factors that relate to individual health behaviors or screening rates through various definitions of, and approaches to, community. Second, this investigation points out that individual-level variables and community-level variables do not match from the viewpoint of time. That is, community-level data should be evaluated prior to individual behaviors to evaluate their relationship. However, our research used data made public in 2009 which reflected the status from 2008. Therefore, there was no clear order of dependent and independent variables. However, the community variables used in our study do not suddenly change. Hence, it is appropriate to identify community features and community-level influence on individual behaviors. Third, this study did not include psychosocial variables of the individual such as attitude, belief, affection, personal relationship as an independent variable that could be controlled by intervention. This was a result of our use of secondary data that did not contain such information. Forth, because this study used a very large sample, only a small difference would lead to the statistical significance without clinical significance. So it is necessary to identify the clinical significance of the results of this study in the studies that follow.

However, the main purpose of this study is to find community individual and community-level data that can help identify factors related to diabetes screening that can be controlled by intervention.

**Conclusion**

This research was conducted to identify factors related to diabetes screening behavior using hierarchically structured data with multilevel modeling methods that considered both individual-level and community-level variables. This study showed that community-level factors could affect the participation rates of diabetic screening for individuals and some of those could be controlled by intervention. Recently, nurses have played an important part in community health practice through public health centers. Nurses who work for public health centers or for policy making departments within the government should work towards increasing the participation rates of diabetes screening at the community level as well as at the individual level.

Our results contribute to the field in the following ways: We found that there are significant differences in the rate of diabetes screening rates according to variables of at the individual and community level. In addition, individual-level features have a greater influence on the diabetes screening rate than community-level factors. Therefore, individual-level features should be considered when addressing vulnerable subpopulations. In addition, the number of internists in a community plays an important role in the participation in diabetic screening. For the success of the diabetes early detection project, conducted by most local governments and public health centers, it is necessary to develop strategies to enhance the likelihood of diabetes screening, including both individual-level and community-level approaches.

**Conflict of interest**

The authors state that they have no competing financial interests to declare.

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