Relationship between the Built Environment in the Community and Individual Health in Incheon, Korea

Suji An, Jeasun Lee* and Dongwook Sohn

1 Graduate Student, Department of Urban Planning and Engineering, Yonsei University, Korea
2 Professor, Department of Urban Planning and Engineering, Yonsei University, Korea
3 Professor, Department of Urban Design and Planning, Hongik University, Korea

Abstract
With increasing global interest in creating healthy communities, research in urban planning and public health has been progressing on this topic. While discussions and researches in South Korea are beginning to occur at the urban planning level, most studies hitherto have centered round public health, with very few considerations of built environments. This paper aims to explore how individual characteristics and built environments in the community are correlated to individual health levels in Incheon, Korea. This study establishes a conceptual model to examine the relationship between public health, individual attributes, and built environments and analyze the effect of built environments on health level using a multilevel regression model. The results reveal that, with the exception of some variables, the correlations between individual health levels and built environment variables are statistically significant.

Keywords: built environment; public health; healthy community; multilevel; Incheon

1. Introduction
With increasing global interest in healthy communities, research in urban planning and public health has been progressing on the topic, “How does the built environment in a community affect public health?” When we consider historically the relationship between urban planning and public health, this trend is nothing new (Jackson, 2003; Schilling and Linton, 2005; Sloane, 2006). In the 19th and early 20th centuries, urban planners helped to overcome infectious diseases like cholera and tuberculosis by designing better buildings, streets, neighborhoods, clean water systems, and parks. In the 21st century, planners and public health professionals began to restudy the built environment and recognized that they can again play a crucial role in combating the most currently growing public health epidemics. In particular, the high obesity ratio in the U.S. has led to people becoming more aware of public health and studies on the relationship between the built environment and public health have been actively carried out since the 2000's (Lee and Moudon, 2004; Frank et al., 2006; Doyle et al., 2006; Zhu and Lee, 2009; Ding and Gebel, 2012). According to such studies, automobile dependency rather than walking and a reduction in their daily physical activities have led to chronic illnesses such as obesity, high blood pressure, diabetes and so on. Furthermore, health problems arising from unhealthy communities are also analyzed to be causing serious social problems in terms of their socio-economic cost (Leyden, 2003; Kim, 2008; Lopez, 2012). In response, Cannuscio et al. (2003) have argued that many features of the built environment could facilitate different opportunities for social interactions and thereby act to protect or improve mental health and overall well-being. In South Korea as well, the rapid implementation of urbanization, a shift to western dietary habits, and a reduction in physical activities have frequently been linked to numerous health-related problems.

In western countries, studies on creating healthy communities that could treat such problems and promote healthier living are being carried out through integrative research among public health, urban planning, transportation and leisure science (Corburn, 2004; Ding and Gebel, 2012). In contrast, although discussion and research in South Korea is beginning to occur at the urban planning level, most studies so far have centered round public health, with very few considering the built environment as a factor influencing one's health (Lee, 2002; Lee and Ahn, 2008a; Lee 2011). As a result, while the Korean government is developing planning policies for
creating healthy communities such as "The National Health Promotion Plan" (Healthy Korea 2010), it has had to rely on research findings produced in western countries owing to the lack of such studies in Korea (KRIHS, 2010). Due to the significant differences of the built environments in Korea compared to those in Western countries, their research findings could possibly show different outcomes (Lee, 2011).

The purpose of this study is to analyze how individual characteristics and community-built environment variables are correlated to individual health levels in Incheon, Korea. Correlation analysis and the multilevel regression model will be utilized. Data for this study include "Korea Health Statistics 2009: Korea National Health and Nutrition Examination Survey IV" (KNHANES IV, 2009), relevant statistics and built environment information on the 10 districts in Incheon Metropolitan City.

2. Literature Review
The term 'environment' is very broad and can imply various meanings to different people. According to Lopez (2012), the environment is divided into three domains: the physical, social and built environment. They are not totally discrete; there is a considerable overlap between them. In this paper, the built environment in a community consists of all the features that have been constructed and modified by humanity. To a certain extent, the history of the built environment and public health extends back almost two hundred years, but even in ancient times, there was a consensus that the environment of cities helps the health status of its residents (Boarnet, 2006). The built environment is consistent with what is traditionally considered to be environment health. In the development of modern social sciences, the study by Durkheim (1951), which showed that the suicidal act of an individual is influenced by the characteristics of the group to which the individual belongs, is considered the first attempt to study the built environment and public health from an academic perspective.

In this chapter, research in Western countries, centered round the United States, and research in South Korea will be separately examined. Regarding research in Western countries, Frank and Engleke (2001) have stated that the dynamic interaction between land development and transportation facilities investment bring continuous health benefits. Ewing et al. (2003) and Kelly-Schwartz et al. (2004) carried out studies on the relationship between the health of individuals and the suburbanization of cities. They showed that suburbanization and public health are meaningfully related. Frank et al. (2006) also showed, utilizing 2000 census data, that the walkability indicator was significantly correlated to the walking activities and obesity of local residents. Boarnet (2006), referencing studies on urban planning and public health, argued that the built environment was not the dominant determinant for obesity rates, while Doyle et al. (2006), based on research on the effect of a pedestrian-friendly and safe environment on individual health, proposed that people living in an active community environment which encourages exercise and activities will be healthier. As for research conducted in South Korea, Lee and Ahn (2008b) stated that accessibility to neighborhood parks, along with socio-economic characteristics, affects local residents' health by examining the relationship between neighborhood built environments and walking. Kim and Kang (2011) also reported, through their analysis of the urban environment, the obesity rate of local communities and self-reported health status rates, that the urban environment significantly influences individual health.

In domestic and overseas studies dealing with the built environment and public health, health-level variables such as mortality rate, morbidity rate, self-reported health status index, accessibility to health and medical services, and the cost of such services were used (Wagstaff et al., 1991; Manor et al., 1997; Kerani et al., 2005; Van Doorslawee et al., 1997, 2000; Kiman, 1999; Waters, 2000). There have also been studies that used such health indices as obesity or body mass index (Lopez-Zetina et al., 2006; Pendola and Gen, 2007; Bodega et al., 2009; Scott et al., 2009; Feng et al., 2010; Seong, 2011), levels of subjective health-awareness (Samimi et al., 2009), and subjective depression (Sturn and Cohen, 2004). In this study, four indices from among the health indices used in previous studies or the KNHANES IV were selected and applied. Various preceding studies thus provided this paper with many useful ideas in analyzing the relationship between the built environment and individual health, such as ideas on basic concepts and variable selection. Fig.1 provides a conceptual framework of the relationships between public health individual attributes, and the built environment in which people live and work.

3. Data, Variables and Descriptive Statistics
3.1 Data
To carry out the research purpose, the KNHANES IV was used to obtain data on individual and family attributes and also individual health levels. The data
included information on which administrative districts responders' residences were located in, and the sampling used a proportional allocation method that considered gender and age structures. The research area was limited to Incheon Metropolitan City, and the analysis subjects were 357 adults over 19 years of age living in 10 administrative districts where the survey on health levels was carried out. To obtain data on the built environment, data on the responders' administrative district information were linked using Incheon City's numerical map, statistical database and GIS.

3.2 Variables

The major variables used in this study are as shown in Table 1. Individual characteristics and built environment were used as independent variables and health levels were used as dependent variables. Individual characteristics included age, quartile income, level of education, economic activity status, smoking status, and the number of days per week in which vigorous physical activity occurred, in which moderate physical activity occurred, and in which walking occurred. The built environment variables included mixed land use index, housing type ratio (single family housing and apartment), residential density, park area, number of parks, accessibility to subway stations, number of bus service routes, street connectivity, and the length of bike lanes. The health level variables included quality of life (LQ_VAS), activity limitation (EQ5D), body mass index (HE_BMI), and subjective health status (D_1_1).

3.3 Descriptive Statistics

The age distribution of survey respondents showed that people in their thirties and forties were the largest age groups at 29.1% and 25.8%, respectively. For income level, the mid-high income group was the largest group at 36.1%, followed by the high income group at 26.9%. For education level, high school graduates were the most numerous at 47.1%, followed by university graduates, those who did not graduate from primary school, and those who graduated from middle school. For economic activity, 56.3% of the respondents were employed, while 42.7% of the respondents were either unemployed or belonged to the economically inactive population. As for smoking, 44.5% of the respondents said they smoked, while

| Table 1. Variables |
|-------------------|------------------|------------------|------------------|------------------|------------------|
| Variable | Measurement and Coding | Sources |
| **Independent Variable** | Age | Age (years) | | |
| | Quartile income (household) | 1. Low 2. Mid-low 3. Mid-high 4. High | |
| | Education level | 1 (Did not graduate from primary school) ~ 4 (Graduated from university) | |
| | Economic activity status | 1 (Employed), 2 (Unemployed, economically inactive population), 9 (No information) | KNHANES IV (2009) |
| | Current status for smoking | 1 (Smokes), 2 (Smoked in the past; currently does not smoke) 8 (Not applicable), 9 (No information) | |
| | Number of days per week involving vigorous physical activity | 1 (None), 2 (One day), 3 (Two days), 4 (Three days), 5 (Four days), 6 (Five days), 7 (Six days), 8 (Every day), 88 (Not applicable), 99 (No information) | |
| | Number of days per week involving moderate physical activity | | |
| | Number of days per week involving walking | | |
| **Built Environment** | Mixed land use index | Level of mixed land use | Map |
| | Housing type ratio (single family housing, apartment) | Number of Single family housings / Total number of houses Number of apartments / Total number of houses | Korean Statistical Information Service (KOSIS) |
| | Average residential density | Total number of houses / population*100 | KOSIS |
| | Park area | Area per unit area (km²) | Map |
| | Number of parks | Number of parks per unit area (km²) | Map |
| | Accessibility to subway stations | Number of subway stations within 2km radius | Map |
| | Number of bus service routes | Number of bus service routes within 2km radius | Map |
| | Street connectivity | Street connectivity² | Map |
| | Length of bike lanes (km) | Length of bike lanes | Map |
| **Dependent Variable** | Subjective health status (D_1_1) | Subjective judgment on one's own health: 1 (Very unhealthy) ~ 5 (very healthy) | KNHANES IV (2009) |
| | Quality of life (LQ_VAS) | Quality of life³ | |
| | Activity limitation (EQ5D) | Activity limitation⁴ | |
| | Body mass index (HE_BMI) | Body mass index (BMI) | |
55.5% said they were non-smokers. For the number of days per week involving vigorous physical activity, 61.3% said they did not do any vigorous physical activity, a much higher percentage than those who said they exercised. For the number of days per week involving moderate physical activity, 54.3% said they did not do any moderate physical activity, thus showing that many more respondents did not do any exercise than those who did. For the number of days per week involving walking, however, the highest percentage of the respondents at 36.1% said they walked every day (7 days), showing that respondents walked more frequently than they engaged in vigorous or moderate physical activity. As the basic statistics, the closer the mixed land use index is to 1, the more mixed land use is said to be, with the average in this case being calculated to be 0.4973. Compared to the total number of houses, single family housings averaged only 0.0880, whereas apartments averaged 0.6840. The ratio of apartments was thus shown to be generally much higher than that of single family housings. The average park area was shown to be 747,340 m², and each administrative district had an average of 5.2 parks. The average accessibility to subway stations was 2, while the number of bus stops was 22.7. The average street connectivity was 1.3220 and the length of bike lanes was shown to be 2.1230 km. The results for health levels are as shown in Table 2. The quality of life (LQ_VAS) was on average 74.45, and the activity limitation (EQ5D index) was on average 0.9585, thereby implying that there were generally almost no restrictions on people's activities. The average body mass index (HE_BMI) was 23.79, generally showing a tendency to be overweight, and the subjective health status (D_1_1) was on average 3.27, showing that respondents considered their health to be slightly above average. The correlation coefficients between health-level variables were all below 0.5, thus failing to show any significant correlation among the variables.

4. Analysis and Results
4.1 Correlation Analysis
For correlation analysis on individual characteristics and built environment variables, a multiple linear regression analysis was carried out and variance inflation factor (VIF) values were subsequently calculated. The results show that, with the exception of the number of parks, all variables had VIF values below 10 and tolerance limit (1/VIF) values below 0.1, thus showing no problem in their multicollinearity. As shown in Table 3., the results of the correlation analysis at the level of the built environment also show that, except for the single family housing ratio and the apartment ratio, all variables had values below 0.7, thus failing to show any strong correlation. In the analysis, therefore, variables of the apartment ratio and park number were excluded and seven indices were included in the final model.

4.2 Model
To analyze the effect of the built environment on health levels, a multilevel regression model was used. When the analysis data has a hierarchical structure, however, it is not reflected in a normal linear model and there is thus the problem of all variables being analyzed at the same level. It is deemed appropriate, therefore, to carry out a multilevel analysis in order to raise the reliability of the analysis results, separating and analyzing the differences that exist between the individuals purely as a difference between individuals and a difference between groups to which individuals belong. HLM 7.0 was used for the analysis, and the significance level for the analysis was set at 10%. First, the Level 1 individual and household model is as follows: Y = β0j + β1j (Age) ij + β2j (Income) ij + β3j (Education) ij + β4j (Economic Activity) ij + β5j (Smoking) ij + β6j (Vigorous Physical Activity) ij + β7j (Moderate Physical Activity) ij + β8j (Walking) ij + γij. The health level of i-th man in district j can be explained using β0j, the fixed effect of location j, and the individual and household-level regression variables.

Next, the Level 2 built environment model is as follows: β0j = γ00 + γ01 (Mixed Land Use Index) j + γ02 (Single Family Housing Ratio) j + γ03 (Average Residential Density) j + γ04 (Park Area) j + γ05 (Accessibility to Subway) j + γ06 (Street Connectivity) j + γ07 (Length of Bike Lane) j + μ0j and β1j = γ10, β2j = γ20, β3j = γ30, β4j = γ40, β5j = γ50, β6j = γ60, β7j = γ70, β8j = γ80. In the built environment model,
which is a district-level model, $\beta_0j$ is expressed in terms of $\gamma_{00}$, representing the population average, the variables for explaining district $j$, and $\mu_0j$, the district-level random effect. When the above individual and household-level model is combined with the district-level model to construct a multilevel model, it can be expressed as follows: $Y = \gamma_{00} + \gamma_{01} \text{Mixed Land Use Index}_j + \gamma_{02} \text{Single Family Housing Ratio}_j + \gamma_{03} \text{Average Residential Density}_j + \gamma_{04} \text{Park Area}_j + \gamma_{05} \text{Accessibility to Subway}_j + \gamma_{06} \text{Street Connectivity}_j + \gamma_{10} \text{Age}_ij + \gamma_{20} \text{Income}_ij + \gamma_{30} \text{Education}_ij + \gamma_{40} \text{Economic Activity}_ij + \gamma_{50} \text{Smoking}_ij + \gamma_{60} \text{Vigorous Physical Activity}_ij + \gamma_{70} \text{Moderate Physical Activity}_ij + \gamma_{80} \text{Walking}_ij + \mu_0j + \gamma_{ij}.

4.3 Factors Influencing Individual Health

The results of using the multilevel regression model for each of the four health-level variables and analyzing the effects of individual characteristics and built-environment variables on health are as shown in Table 4. It skips over the results of the Null Model (Model 1), which does not include any explanatory variables, and Model 2, which includes individual characteristics. The table shows the results from the Full Model (Model 3), which was found to have the highest level of reliability due to the addition of built-environment variables. Regarding the subjective health status and individual characteristics variables, these had a positive correlation with the number of days per week involving vigorous physical activity. The analysis results show that respondents subjectively felt that their health was better when they engaged in more vigorous physical activity. Other variables did not show any statistically significant correlations. With built-environment attributes, subjective health state had a positive correlation with accessibility to subway stations but had no statistically significant correlation with any other variable, thus showing that the built environment and subjective health state may not be correlated.

Regarding the quality of life and individual characteristics variables, these had statistically significant correlations with education level and the number of days per week in which walking occurs. A detailed examination shows that respondents perceived their quality of life to be higher when their level of education was higher and the number of their walks for over 10 minutes per week was greater. Quality of life was also found to have statistically significant correlations with the ratio of single family housings, accessibility to subway stations, and the length of bike lanes, thus showing that quality of life and the built environment were intimately connected.

Regarding the activity limitation and individual characteristics variables, these had statistically significant correlations with age and economic activity status. Activity limitation was lower when the age was younger and there was more economic activity. With built-environment attributes, no variables were found to have any statistically significant correlation with activity limitation, showing that it was affected more by individual and household attributes than by the built environment.

Table 3. Correlation Analysis

| Category                        | Mixed land use index | Single family housing ratio | Apartment ratio | Average residential density | Park area | Number of parks | Accessibility to subway stations | Number of bus stops | Street connectivity | Length of bike lanes |
|---------------------------------|----------------------|-----------------------------|-----------------|-----------------------------|-----------|----------------|-------------------------------|---------------------|--------------------|---------------------|
| Mixed land use index            | 1                    |                             |                 |                             |           |                |                               |                     |                    |                     |
| Single family housing ratio     | 0.560                | 1                           |                 |                             |           |                |                               |                     |                    |                     |
| Apartment ratio                 | -0.523               | -0.844**                    | 1               |                             |           |                |                               |                     |                    |                     |
| Average residential density     | -0.264               | -0.309                      | 0.366           |                             |           |                |                               |                     |                    |                     |
| Park area                       | 0.481                | 0.525                       | -0.495          | -0.529                      |           |                |                               |                     |                    |                     |
| Number of parks                 | -0.344               | -0.213                      | 0.139           | -0.052                      | 0.418     | 1              |                               |                     |                    |                     |
| Accessibility to subway stations| -0.522               | -0.441                      | 0.198           | 0.153                       | -0.139    | 0.358          | 1                             |                     |                    |                     |
| Number of bus stops             | 0.448                | 0.056                       | -0.041          | -0.187                      | 0.292     | 0.121          | -0.311                        | 1                   |                    |                     |
| Street connectivity             | 0.048                | 0.000                       | -0.174          | 0.172                       | 0.237     | **0.637**      | 0.046                        | 0.353               | 1                  |                     |
| Length of bike lanes            | 0.218                | -0.210                      | 0.380           | -0.225                      | 0.243     | 0.290          | -0.409                        | **0.700**           | 0.065              | 1                   |

**: The correlation coefficient is significant at 0.01 (2-tailed)
*: The correlation coefficient is significant at 0.05 (2-tailed)
### Table 4. Multilevel Regression Model Analysis Results

| Variable | Subjective Health Status (D_1_1) | Quality of Life (LQ_VAS) | Activity Limitation (EQ5D index) | Body Mass Index (HE_BMI) |
|----------|----------------------------------|--------------------------|----------------------------------|-------------------------|
|          | Coef. | P-value | Coef. | P-value | Coef. | P-value | Coef. | P-value |
| Constants | 3.264*** | <0.001 | 74.912*** | <0.001 | 0.942*** | <0.001 | 23.835*** | <0.001 |
| Age      | -0.003 | 0.392 | -0.114 | 0.144 | -0.002*** | <0.001 | 0.029** | 0.094 |
| Quartile income | 0.015 | 0.781 | 1.354 | 0.220 | 0.005 | 0.394 | -0.044 | 0.856 |
| Education level | 0.074 | 0.247 | 2.176*** | 0.095 | 0.007 | 0.319 | 0.188 | 0.510 |
| Economic activity status | -0.037 | 0.702 | -0.032 | 0.987 | 0.027*** | 0.009 | -0.365 | 0.397 |
| Smoking status | 0.068 | 0.448 | -0.360 | 0.845 | -0.003 | 0.793 | 0.608 | 0.134 |
| Level 1: Individual Characteristics | | | | | | | | |
| Number of days per week involving vigorous physical activity | 0.066** | 0.017 | 0.426 | 0.447 | 0.001 | 0.624 | 0.289** | 0.019 |
| Number of days per week involving moderate physical activity | 0.021 | 0.382 | 0.535 | 0.270 | -0.001 | 0.688 | 0.145 | 0.172 |
| Number of days per week involving walking | 0.029 | 0.123 | 0.658* | 0.092 | 0.003 | 0.163 | -0.058 | 0.495 |
| Level 2: Built Environment | | | | | | | | |
| Mixed land use index | -0.237 | 0.460 | - | - | -0.017 | 0.768 | 0.726 | 0.760 |
| Single family housing ratio | 1.312 | 0.138 | 54.289*** | 0.021 | -0.024 | 0.892 | 6.226 | 0.431 |
| Average residential density | - | - | - | 0.000 | 0.858 | 0.003 | 0.969 | |
| Park area | - | - | - | 0.000 | 0.776 | -0.005 | 0.613 | |
| Accessibility to subway stations | 0.073* | 0.072 | 2.088** | 0.045 | 0.000 | 0.972 | 0.305 | 0.348 |
| Street connectivity | -0.693 | 0.271 | -12.446 | 0.438 | -0.176 | 0.248 | 5.566 | 0.341 |
| Length of bike lanes | 0.058 | 0.125 | 2.310** | 0.030 | 0.002 | 0.797 | 0.202 | 0.517 |
| Variance of Individual-level | 0.015 | 0.500 | 2.309 | 0.142 | 0.018 | 0.098 | 0.738 | 0.095 |
| Variance of District-level | 0.816 | 16.625 | 0.088 | 16.625 | 0.088 | 3.640 | |
| -2RLL (deviance) | 907.78 | 2986.290 | -592.630 | 1946.304 | |
| Random Effect Parameter Estimates | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| log-likelihood | -4.54E+02 | -1.49E+03 | 2.96E+02 | -9.73E+02 | |

*: 0.1 significance level, **: 0.5 significance level, ***: 0.01 significance level

Regarding the body mass index and individual characteristics variables, these had statistically significant correlations with age and the amount of vigorous physical activity. The body mass index was lower when the age was younger and there was more vigorous physical activity in a week. With built-environment attributes, no variables were found to have any statistically significant correlation with body mass index, showing that, like activity limitation, it also was affected more by individual and household attributes than by the built environment.

### 5. Discussions

For most of the twentieth century in western countries, conventional development patterns promoted automobile dependency, disconnected street networks, monotonous land use, and other norms that are now thought to be associated with increased environmental burdens and increased health problems. Since planners and public health professionals began to study the built environment, a growing body of evidence is suggesting that certain types of features are associated with increased physical activity and the improvement in the overall health status of individuals and communities. The analysis results of this study are as follows. Our results on the correlation between individual characteristics and health showed that the individual characteristics variables of age, education level, economic activity status, the number of days per week involving vigorous physical activity and the number of days involving walking were significantly correlated statistically with at least one of the four health indices. With income level, smoking status and the number of days per week involving moderate physical activity did not show any statistically significant correlation in any of the analysis models. Regarding age, it was statistically significant with the two models of activity limitation and body mass index. In other words, older respondents had more activity limitation and the body mass index also tended to be associated with being overweight. Education level and quality of life had a positive relationship, indicating that respondents tended to associate a higher education level with a higher quality of life. The analysis results on age and education level are similar to the research results reported by Seong (2011). Economic activity status was found to be statistically significant only in the activity limitation analysis model. This likely
means that positive economic activity stemmed from employment, which would require a greater level of activity. These results match those of existing public health studies. The number of days per week involving vigorous physical activity was found to be significant in the subjective health state and body mass index analysis models, which shows the tendency of respondents to see their health level as generally increasing. Also, the number of days per week involving walking was statistically significant in the quality of life analysis model, which shows that those who walked more felt their quality of life to be higher. Lastly, the analysis results showing that higher numbers for vigorous physical activity were associated with higher health levels match the analysis results of some existing studies (Frank and Engleke, 2001; Frank et al., 2006; Scott et al., 2006; Lee and Ahn, 2008b; Kim, 2008; Seong, 2011) The analysis for the community-built environment and health showed that the ratio of single family housings, accessibility to subway stations, and the length of bike lanes had statistically significant correlations with at least one or more health index models. However, the mixed land use index, average residential density, park area, and street connectivity were not shown to be statistically significant in any of the models. These results are noteworthy because they differ from the results of some existing studies in western countries (Saelens et al., 2003; Kelly-Schwartz et al., 2004), which state that the mixed land use index, density and street connectivity influence health. One possible explanation is that in Korea, concepts such as mixed land use index and density are situated in a very different housing environment in comparison to suburban regions in the U.S. Accordingly, when examining the correlation between built environment variables and health, the results of this paper will need to be compared to studies that have used data from within Korea. Examining the variables that have shown statistical significance, it can be seen that respondents felt their quality of life was higher when the ratio of single family housings was higher. This differs from the results presented by Kelly-Schwartz et al. (2004) that a higher ratio of single family housings correlates with lower health status. The reason for this difference may be that, in Korea, the settlement environment is better in locations where the ratio of low-density single family housings is high than in locations of high-density apartments, with residents of such single family housing neighborhoods thus feeling that the state of their health will improve. Accessibility to subway stations shows positive correlations with subjective health status and quality of life, while the length of bike lanes shows a positive correlation with quality of life. These analysis results are similar to those in existing studies (Frank and Engleke, 2001; Kelly-Schwartz et al., 2004; Kim and Kang, 2011; Seong, 2011; Lee, 2011), which state that health level is higher when the lengths of bike lanes are longer and the accessibility to subway stations is greater. This result likely means that people who live in communities where the accessibility to subway stations is high will more likely exercise by walking or pursue other physical activities, and the lengths of bike lanes will lead to leisure activities involving bicycles, which will ultimately exert a positive influence on the quality of life.

6. Conclusion
This paper examined how individual characteristics and built environment variables in a community were correlated to individual health levels. The results reveal that, with the exception of some variables, the correlations between individual health levels and the individual characteristics and community-built environment variables were statistically significant in much the same way as the research results reported in western countries. The findings in this paper suggest the important role of urban planning and public health, and they will contribute to designing healthy cities, sustaining healthy environments, and encouraging healthy communities.

The implications of this study are as follows. First, in researching the built environment and health, South Korea’s environment is seen to be very different from that of other countries. Therefore, rather than accepting the results of studies done in western countries as-is, various detailed studies need to be carried out that consider built environments in Korea. Second, considering that variables such as walking and bicycling which increase physical activity can exert a positive influence on the promotion of health, we need to create a pedestrian-friendly community environment that can promote health by increasing physical activity. Lastly, in creating a healthy community, the work of improving the built environment within the community also needs policy and institutional support. In fact, there has been a recent movement to make public health a direct concern of cities’ general plans. Cities such as Richmond, California have adopted health elements into their General Plan (Kelly, 2009).

An important truth is that, while creating and managing a city, planners will consider some factors as more important than others as they sift through the many various elements that enhance the health of residents and the urban space will change according to the choices they make and how they plan to create their city. At times, some of those major factors that planners are considering could conflict and collide. That is why the effort to create and manage a healthy city needs to be supported and validated by research based on objective and verifiable data. That is the job of those of us who deal with urban planning. Urban planners need to understand that we have the power to improve or harm health. Development pattern does modify health risks and, therefore, planning decisions should incorporate what is known about the built
environment and public health. Creating a healthy urban environment has to be perceived in everyday urban living as important. The effort to create a healthy community cannot become a cure-all, but if consideration could be given at the beginning stages to having an approach to urban planning that would at least prevent the creation of unhealthy urban spaces, it would contribute to producing healthier and more sustainable cities.

Notes
1 Land use mixed index is measured by entropy index reflecting the evenness of distribution of 4 types of land use with the area. The level has a value between 0 and 1. A value close to 1 shows the mixed land use index is high.
2 The connectivity index is calculated by dividing the number of street links by the number of street nodes.
3 LQ_VAS is a rating scale for evaluating qualities of life by visual analogue scale from 0 to 100.
4 EQ-SD is a standardized instrument for use as a measure of health outcome.

References
1) Boarnet, M. (2006) Planning's Role in Building Healthy Cities: An Introduction to the Special Issue, Journal of the American Planning Association, 72(1), pp.5-9.
2) Cannuscio C., Block J. and Kawachi I. (2003) Social Capital and Successful Aging: the Role of Senior Housing, Annals of Internal Medicine, 139(5 part 2), pp.395-399.
3) City of New York (2012) Active Design Guideline, New York.
4) Corburn, J. (2004). Confronting the Challenges in Reconnecting Urban Planning and Public Health, American Journal of Public Health, 94, pp.541-546.
5) Ding, D. and Gebel, K. (2012) Built environment, Physical activity, and Obesity: What Have We Learned from Reviewing the Literature? Health and Place, 18, pp.100-105.
6) Doyle, S. et al. (2006) Active Community Environments and Health: The Relationship of Walkable and Safe Communities to Individual Health, Journal of the American Planning Association, 72(1), pp.19-31.
7) Durkheim, E. (1951) Suicide: A Study in Sociology, The Free Press.
8) Ewing, R. et al. (2003) Relationship between Urban Sprawl and Physical Activity, Obesity, and Mortality, American Journal of Health Promotion, 18(1), pp.47-57.
9) Frank, L. D. and Engleke, P. O. (2001) The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health, Journal of Planning Literature, 16(2), pp.202-281.
10) Frank L. D. and Engelke P. O. (2005) Multiple Impacts of the Built Environment on Public Health: Walkable Places and the Exposure to Air Pollution. International Regional Science Review, 28(2), pp.193-216.
11) Frank, L. D. et al. (2006) Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality, Journal of American Planning Association, 72(1), pp.75-87.
12) Jackson, R. (2003) The Impact of the Built Environment on Health: An Emerging Filed, American Journal of Public Health, 93, pp.1382-1384.
13) Je, H. and Lee, J. (2010) A Study on the Impact of High-rise Living on the Health of Residents, Journal of Asian Architecture and Building Engineering, 9(2), pp.331-338.
14) Kim, E. (2008) Effects of Built Environmental Factors on Perceived Health Status and Health Disparity, The Korea Spatial Planning Review, 59, pp.203-222.
15) Kim, E. and Kang, M. (2011) Effects of Built Environmental Factors on Obesity and Self-reported Health Status in Seoul Metropolitan Area Using Spatial Regression Model, The Korea Spatial Planning Review, 68, pp.85-98.
16) Kelly, E. (2009) Community Planning: an Introduction to the Comprehensive Plan. Washington D.C.: Island Press.
17) Kelly-Schwertz, A. C. et al. (2004) Is Sprawl Unhealthy? A Multilevel Analysis of the Relationship of Metropolitan Sprawl to the Health of Individuals, Journal of Planning Education and Research, 2492, pp.184-196.
18) KIHASA. (2010) Korea National Health and Nutrition Examination Survey in 2009.
19) KRIHS. (2010) Study on the Spatial Planning and Public Policies for Creating a Healthy City, Seoul: Korea.
20) Lee, C. and Moudon A. V. (2004) Physical Activity and Environment Research in the Health Field: Implications for Urban and Transportation Planning Practice and Research, Journal of Planning Literature, 19(2), pp.147-181.
21) Lee, K. and Ahn, K. (2008a) An Empirical Analysis of Neighborhood Environment Affecting Residents’ Walking, Journal of Architectural Institute of Korea, 246(6), pp.293-302.
22) Lee, K. and Ahn, K. (2008b) Effects of Neighborhood Environment on Residents Health, Journal of Korea Planners Association, 43(3), pp.249-261.
23) Lee, S. (2011) Research Trends and Limitations of the Integrated Study of Urban Planning and Public Health for a Healthy Community, Seoul Studies, 11(2), pp.15-33.
24) Leyden, K. (2003) Social Capital and the Built Environment: The Importance of Walkable Neighborhoods, American Journal of Public Health, 93, pp.1546-1551.
25) Lopez, R. P. (2012) The Built Environment and Public Health. Jossey-Bass.
26) Min, B., Hoo., H. and Lee, H. (2006) Children's Behavioral and Conceived Domains in Neighborhood Environment, Journal of Asian Architecture and Building Engineering, 5(1), pp.83-90.
27) Saelens, B. E. et al. (2003) Neighborhood-BASE Differences in Physical Activity: Environment Scale Evaluation, American Journal of Public Health, 93, pp.1552-1558.
28) Schilling, J. and Linton, L. S. (2005) The Public Health Roots of Zoning: In Search of Active Living's Legal Genealogy, American Journal of Preventive Medicine, 28(2S2), pp.96-104.
29) Sloane, D. C. (2006) From Congestion to Sprawl: Planning and Policy, 30, pp.S177-S202.
30) Sung, H. (2011) A Study on the Impacts of Residential Neighborhood Built Environment on Personal Health Indicators, Journal of Korea Planners Association, 46(3), pp.235-251.
31) Zhu, X. and Lee, C. (2009) Correlates of Walking to School and Health Status, Journal of Preventive Medicine, 28(2S2), pp.96-104.