Analysis of the Effect of Cul-de-sacs' Permeability Factors in Low-Rise Residential Areas on Burglary

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Abstract

Only a few studies so far have analyzed specific environmental factors of cul-de-sacs' influence on safety from crime. To understand crime, streets' physical characteristics need to be considered along with the collective sociodemographic characteristics of each region. A model was designed that combines the physical characteristics of cul-de-sacs with the demographic characteristics of neighborhoods to examine the effect of such characteristics on the crime rate in cul-de-sacs. The physical characteristics of cul-de-sacs in a target area were categorized and examined based on connectivity, accessibility, and visibility, in addition to sociodemographic characteristics. A hierarchical linear model was then constructed from the collected data related to connectivity, accessibility, visibility, and sociodemographic characteristics at the neighborhood level. Finally, the results of the analyses were combined to determine their relationship with the crime rate. Except for a few variables, the results are significant for connectivity, visibility, and accessibility, which allows for an explanation of the occurrence of burglaries when sociodemographic factors are additionally accounted for.

Keywords: cul-de-sac; burglary; hierarchical linear model; street environment; crime prevention

1. Introduction

Countries pioneering in crime prevention through environmental design research, particularly the United Kingdom, propose various methods for improving physical environments for the purpose of crime prevention. Among such plans, the construction of cul-de-sacs is claimed to be highly effective in providing a safe environment for residents.

In South Korea, cul-de-sacs are usually constructed in low-rise residential areas, where the architectural planning is less intensive compared to that of apartments. It remains to be verified whether cul-de-sacs—constructed through an exclusive method of planning to fit the residential density particular to South Korea—are actually effective at preventing crime. While some previous studies that examined the relationship between the streets located in low-rise residential areas and crime did not apply real crime data, residents in cul-de-sacs expressed higher feelings of insecurity regarding crime, as cul-de-sacs limited accessibility from the outside and reduced visibility due to surrounding residences (Jung, 2009).

In order to determine the relationship between cul-de-sacs and burglary, this study 1) deduces the factors involved in the relationship between burglary and cul-de-sacs by examining existing research; 2) designates an area within the downtown residential area of South Korea where detached houses, multiplex houses, and townhouses are concentrated and subsequently deduces its sociodemographic factors; 3) implements a hierarchical linear model (HLM) in order to comprehensively assess the factors within a cul-de-sac (Level 1) and the sociodemographic factors (Level 2); and 4) compares and contrasts the results of this study with those of existing research.

2. Literature Review

2.1 Studies on the Relationship between Cul-de-sac Permeability and Burglary

In earlier studies, cul-de-sac permeability was regarded as an important criterion in the relationship between surrounding streets and burglary. Earlier studies defined permeability as the number of streets connected to the streets in an area (White, 1990), or as the street network structure identified by analyzing the inner structure of a cul-de-sac and the physical characteristics of the main and surrounding streets (Johnson & Bowers, 2009). In a study that subdivided
the permeability factor (Groff et al., 2014), the relationship between the crime rate and a region was examined by dividing permeability into internal and external permeability. The factors associated with internal permeability that were exercising a positive influence on the crime rate were defined as "accessibility," whereas those having a negative influence were defined as "barrier." According to a study by Groff et al. (2014), higher accessibility to the inner cul-de-sac—a sub-factor of permeability—increases unexpected crime, and an increase in factors that block visibility hinders criminals' access. In order to study the relationship between the physical factors of the inside of a cul-de-sac and the crime rate, it is necessary to examine the physical factors that affect accessibility and visibility.

In studies that investigated the relationship between accessibility and burglary, factors for analyzing accessibility included physical characteristics such as cul-de-sac type, house density within a cul-de-sac, street depth, wall and fence ratio, and street width (Perkins et al., 1993; Johnson & Bowers, 2009; Foster, Giles-Corti, & Knuiman, 2011).

In a study investigating the relationship between visibility and burglary (Shu, 2009), the degree of visibility was measured by the ratio to which the front gate of a residence was placed near the street within a cul-de-sac. This was in tandem with studies that considered the number of windows on the first floor as a visibility factor, as proposed in general crime prevention guidelines (Perkins et al., 1990; Perkins et al., 1993), and those that accepted the availability of parking spaces as a visibility factor (Chih-Feng Shu, 2000; López & Van Nes, 2007) in selecting the physical factors that influenced visibility in the present study.

2.2 Studies on the Relationship between Connectivity and Burglary

The relationship between connectivity and burglary has previously been analyzed in order to assess the relationship between the physical characteristics of a cul-de-sac and burglary. Burglaries were claimed to be more frequent in isolated areas with low connectivity to the downtown area (Bernasco & Nieuwbeerta, 2005). In studies that determined the relationship between connectivity and burglary (Xiaowen, 2006; Yang, 2006; Chang, 2008), the distance between the cul-de-sac and the main street and the number of intersections were used as factors for analysis; they also considered the type of street meeting the cul-de-sac. Given its importance, this study examines connectivity.

3. Method

3.1 Selected Area

Among the 25 gus (boroughs) located in Seoul, Republic of Korea, A-gu, where downtown low-rise residences are concentrated, was chosen as the study area. Apartment households were excluded as cul-de-sacs were not relevant to them. A total of 297 alleys surrounded by residences within areas of residential occupancies were selected.

3.2 Crime Data

The crime data used for this study were acquired with the cooperation of the A-gu police department and consisted of burglaries in residential areas that occurred within 12 months. After excluding 457 cases that targeted apartment households, 751 cases of residential burglary were used as data.

3.3 Analysis Method

According to Wilcox et al. (2007), applying simple regression analysis to explain the relationship between cul-de-sacs' internal elements, sociodemographic elements, and occurrence of residential burglaries has its limitations. To comprehensively analyze and determine factors from different levels (cul-de-sac level/neighborhood level), HLM7 software was used to create an HLM for analysis.

First, sociodemographic characteristics at the cul-de-sac and neighborhood levels were verified to determine whether they were appropriate for an HLM analysis. Second, the degree of significance was analyzed for the burglary rate at the cul-de-sac level. Third, the degree of significance was analyzed while taking the neighborhood level into account. Fourth, the factors related to the crime rate were measured by applying significant factors and sociodemographic factors at the cul-de-sac level (Raudenbush et al., 2004).

3.4 Variable Setting of Cul-de-sac Physical Level

A field investigation was carried out from October to November 2014, and the physical factors of cul-de-sacs were surveyed with reference to the map provided on Seoul GIS.

Fig.1 depicts the specific variables within a cul-de-sac. The listed factors combine those that were analyzed in this study (Bernasco & Nieuwbeerta, 2005), and were used to measure connectivity, accessibility, and visibility.

Factors related to connectivity examined the distance of the main street, the depth of the cul-de-sac, and the street type. The distance of the main street was measured by the distance between the cul-de-sac and the main street, the depth of the cul-de-sac was measured by the number of intersections from the main street to the cul-de-sac, and street type was measured by a street's ordinal variable according to the regulation on street classification in South Korea.

Factors related to accessibility included house density, street depth, cul-de-sac type, walls and fences, front gate, street width, and in-between space. House density refers to the number of residences located within a cul-de-sac. Street depth measures the interior depth of a cul-de-sac. Cul-de-sac type was classified as linear and sinuous. Walls and fences refer to the ratio of walls and fences on the inner street circumference of a cul-de-sac. Front gate measures the ratio of front gates within a cul-de-sac. Street width was measured.
as 0 or 1 depending on whether the distance was over 4m or under 4m, as 4m is the mean street width. In-between space assessed the availability of hiding spaces between walls and residential entrances. In-between space here refers to the availability of empty space between residences’ fences and entrances. A space between a building and fence was measured as 1; if there was no space, it was measured as 0.

Visibility related factors consisted of the number of first-floor windows, parking type, and pilotis. Parking type assessed whether parking spaces were available within a cul-de-sac through a dummy variable. Pilotis measured the ratio of pilotis houses among the residences.

3.5 Variable Setting of Sociodemographic Level

To investigate the sociodemographic factors of the selected area, South Korean census data were used. The factors included economic disadvantage, residential mobility, ethnic-heterogeneity, and the population ratio of people aged 14–19. Descriptive statistical analysis with SPSS 18 was used.

4. Analysis Results

4.1 Descriptive Analysis of Variables

Table 2. lists the descriptive statistics for all research variables. The dependent variable used in this study was the occurrence of burglaries. The investigation showed that burglary within cul-de-sacs comprised 15% of the total crime.

4.2 Cul-de-sac and Burglary Coefficient

A correlation analysis was conducted to test for multicollinearity between the cul-de-sac-level factors. As each factor was conclusively determined through Pearson's correlation to have no variables affecting the analysis results, an HLM analysis was conducted.

4.3 Hierarchical Linear Model

An unconditional model was devised first in order to assess model fit, and a random-intercept model was subsequently used to determine the overall relationship of all factors, including the sociodemographic factors.

4.3.1 Unconditional Model

The unconditional model was a model in which the factors at the cul-de-sac physical level and sociodemographic level were not considered, and it was used to determine the explanatory power of burglary rate for each level and verify the need for an HLM. It was difficult to conduct a normal HLM analysis when the occurrence/absence of burglary, was separated. As there could have been errors in data analysis, a multi-level logit model was suitable (Raudenbush et al.,

Table 1. Variable Standards

| Variables               | Metric                          |
|------------------------|--------------------------------|
| Burglary occurrence    | 1 = Occurrence, 0 = Absence     |

| Cul-de-sac Level Variables | Metric                  |
|---------------------------|-------------------------|
| Street type               | 1 = major, 2 = minor, 3 = private |
| No. of intersection       | Continuous              |
| Distance of main street   | Continuous              |
| No. of 1st Floor window   | Continuous              |
| Parking availability      | 1 = Available, 0 = Not available |
| Pilotis                   | Continuous              |
| Street depth              | Continuous              |
| Cul-de-sac type           | 1 = Linear, 0 = Sinuous  |
| House Density             | Continuous              |
| Front Gate                | Continuous              |
| Street width              | 1 = over 4m, 0 = under 4m |
| In-between space          | 1 = Present, 0 = Absent  |

Fig.1. Cul-de-sac Sample Scope
Table 2. Descriptive Statistics of Variables

| Variables                          | Mean | SD  | Min  | Max  |
|-----------------------------------|------|-----|------|------|
| **Dependent variables**           |      |     |      |      |
| Burglary occurrence               | 0.15 | 0.47| 0.00 | 1.00 |
| **Cul-de-sac physical level variables** |      |     |      |      |
| Street type (C1)                  | 1.89 | 0.66| 1.00 | 3.00 |
| Depth of cul-de-sac (C2)          | 2.73 | 0.72| 1.00 | 5.00 |
| Distance of main street (C3)      | 165.86 | 96.05| 10.00 | 414.00 |
| **No. of first-floor windows (V1)** | 5.57 | 3.70| 0.00 | 29.00 |
| Parking type (V2)                 | 0.69 | 0.46| 0.00 | 1.00 |
| Pilotis (%) (V3)                  | 10.61| 23.60| 0.00 | 100.00 |
| **Street depth (A1)**             | 22.33| 9.63| 8.00 | 73.00 |
| **Cul-de-sac type (A2)**          | 0.85 | 0.35| 0.00 | 1.00 |
| **Walls & fences (%) (A3)**       | 31.17| 26.66| 0.00 | 92.00 |
| **House density (A4)**            | 4.70 | 1.86| 1.00 | 11.00 |
| **Front gate (%) (A5)**           | 2.10 | 1.63| 0.00 | 9.00 |
| **Street width (A6)**             | 0.59 | 0.49| 0.00 | 1.00 |
| In-between Space (A7)             | 0.41 | 0.49| 0.00 | 1.00 |
| **Socio demography-level variables** |      |     |      |      |
| Unemployment (S1)                 | 0.47 | 0.51| 0.00 | 1.00 |
| Ethnic-heterogeneity (S2)         | 0.29 | 0.47| 0.00 | 1.00 |
| Residential mobility (S3)         | 0.53 | 0.51| 0.00 | 1.00 |
| Population aged 14–19 (S4)        | 0.59 | 0.51| 0.00 | 1.00 |

2004). As a multi-level logit model is used when the dependent variable is not continuous and is categorical, this model can be regarded as appropriate for analysis when the occurrence of burglary is substantially lower than the absence thereof (occurrence: 36, absence: 258). The equation for the unconditional model using the multi-level logit model is written as Equation (1).

**Level-1 Model**

\[ \text{Level-1 Model} \]

\[
\begin{align*}
\text{Prob}(\text{BULGLARY}_{it} = 1 | \beta_i) &= \Phi(\beta_i) \\
n_{mi} &= \log(\Phi(\beta_i)/(1 - \Phi(\beta_i)))
\end{align*}
\]

Equation (1)

**Level-2 Model**

\[ \text{Level-2 Model} \]

\[
\begin{align*}
n_{mij} &= \beta_{0j(m)} + \sum_{q=1}^{Q_m} \beta_{qj(m)} X_{qij}
\end{align*}
\]

Equation (2)

**Level-3 Model**

\[ \text{Level-3 Model} \]

\[
\begin{align*}
\beta_{qj(m)} &= \gamma_{q0(m)} + \sum_{s=1}^{S_m} \gamma_{qsm} W_{sj} + u_{qj(m)} \\
q &= 0 \ldots Q_m
\end{align*}
\]

Equation (3)

Equation (3) is a model that combines the Level 1 and 2 models for verification. \(X\) and \(W\) in this equation are independent variables that indicate the attributes of Levels 1 and 2, respectively, and \(\beta, \gamma\) are coefficient estimates. Table 3 shows the analysis results when the burglary rate of each dong passed the statistical significance of \(p < 0.001\). Dong is an administrative region of a population of less than 20,000 in South Korea. It reveals that there are discrepancies between dongs in terms of burglary rate, and that neighborhood-level variables are additionally required to explain the occurrence of burglaries.

The intraclass correlation coefficient (ICC) of the model indicates the degree to which neighborhood level variables explain the burglary rate and the degree to which cul-de-sac level variables explain the burglary rate. Examining the dispersion for the model, the Level 1 dispersion (\(r\)) is 0.97672, whereas the Level 2 dispersion (\(\mu_0\)) is 0.49356.

Table 3. Unconditional Model

| Fixed Effect | Coefficient | Standard error | t-ratio | p-value |
|--------------|-------------|----------------|---------|---------|
| **INTRCPT2**, \(\gamma_0\) | -1.677 | 0.226 | -7.431 | <0.001 |
| **Random Effect** | Variance component | d.f. | \(X^2\) | p-value |
| **INTRCPT1**, \(\mu_0\) | 0.494 | 16 | 34.838 | <0.001 |
| **level-1, r** | 0.977 | | | |

In the intraclass correlation coefficient equation (Equation (4)),

\[ ICC = \frac{\mu_0}{(\mu_0 + r)} \]

Equation (4)

\(\mu_0\) indicates the Level 2 dispersion and \(r\) indicates the Level 1 dispersion. From this equation, the Level 2 region-level variables have an explanatory power of 33.6%, while the Level 1 cul-de-sac-level variables have the remaining explanatory power of 66.4%. Generally, in the social sciences, Level 2 explanatory variables have an explanatory power ranging from 5–25%, and an HLM is not appropriate if this value is below the given range. Therefore, as the Level 2 explanatory variables show an explanatory power of 33.6% from the analysis, the model fit is verified for the HLM.

4.3.2 Random-intercept Models of Burglary

Now that the model fit for the HLM through the unconditional model has been verified, Table 4 summarizes the results of the analysis of cul-de-sac factors and sociodemographic factors. The significance between the model factors and burglary rate was determined by their coefficient value, and they are understood to have a negative effect when their t-ratio value is below 0 and a positive effect when it is above 0. Model 1-1, which examines cul-de-sac factors, analyzes the variables of connectivity and visibility; Model 1-2 additionally analyzes accessibility; and Model 2 analyzes all factors including sociodemographic factors.
Six variables were analyzed in Model 1-1, among which the depth of cul-de-sac and number of first-floor windows were significant at $p<0.001$. All the significant variables had a negative influence on burglary rate.

Accessibility variables were added to the variables examined in Model 1-1 for a total of 13 variables to be examined in Model 1-2. Among those examined, the variables depth of cul-de-sac from connectivity; number of first-floor windows from visibility; and house density, walls and fences, front gate, and in-between space from accessibility were significant at $p<0.001$. Street width was significant at $p<0.01$. Significant variables from accessibility had a positive influence on burglary rate. By adding the accessibility factor, the explanatory power of Model 1-2 on burglary rate had a cul-de-sac-level dispersion of 0.45305, which was about 53% more accurate than the cul-de-sac-level dispersion (0.97672) of the unconditional model.

Model 2 examined 17 variables, including both cul-de-sac and sociodemographic factors with regard to their explanatory power on burglary rate. Individual cul-de-sac factors that were determined to be significant up until the analysis using Model 1-2 were each analyzed together with the most relevant sociodemographic factor. Factors that were significant in Model 1-2 were also significant in Model 2. Moreover, among the additionally analyzed sociodemographic factors, residential mobility had a positive influence on burglary rate and was significant at $p<0.05$. As for dispersion—which indicates a model's explanatory power—Model 2 had a dispersion of 1.420, which was lower than that of Model 1-1 at 1.486; this shows that the inclusion of sociodemographic factors provided additional explanation regarding the burglary rate. Furthermore, sociodemographic factors related to significant variables had both positive and negative influences, requiring a clear interpretation regarding the results for the individual factors.

| Table 4. Hierarchical Linear Analysis with a Standard Poisson Model |
|---------------------------------------------------------------|
| Fixed Effect | Model 1-1 | Model 1-2 | Model 2 |
|--------------|-----------|-----------|--------|
| **Coefficient** | **SE** | **t-ratio** | **Coefficient** | **SE** | **t-ratio** | **Coefficient** | **SE** | **t-ratio** |
| **Cul-de-sac Physical Level** | | | | | | | |
| Street type | 0.264 | 0.239 | 1.100 | 0.251 | 0.252 | 0.993 | 0.219 | 0.183 | 1.193 |
| Depth of cul-de-sac | -0.758*** | 0.111 | -6.801 | -0.730*** | 0.145 | -5.010 | -0.898*** | 0.159 | -5.634 |
| Aged 14-19 | | | | | | | |
| Ethnic-heterogeneity | 1.339** | | | | | | |
| Distance of main street | 0.009 | 0.136 | 0.069 | 0.032 | 0.213 | 0.149 | 0.123 | 0.168 | 0.727 |
| No. of first-floor windows | -0.419*** | 0.066 | -6.259 | -0.393*** | 0.069 | -5.688 | -0.406*** | 0.056 | -7.227 |
| Ethnic-heterogeneity | | | | | | | |
| Parking type | 0.045 | 0.188 | 0.240 | 0.058 | 0.384 | 0.151 | -0.009 | 0.247 | -0.035 |
| Pilotis (%) | 0.361 | 0.115 | 3.113 | 0.130 | 0.082 | 1.561 | 0.046 | 0.136 | 0.736 |
| Walls & fences (%) | | | | | | | |
| Ethnic-heterogeneity | | | | | | | |
| House density | 1.069*** | 0.171 | 6.250 | 0.972*** | 0.239 | 4.066 |
| Residential Mobility | | | | | | | |
| Front gate (%) | 0.834*** | 0.348 | 3.594 | 0.925*** | 0.238 | 3.881 |
| Street width | 0.662** | 0.226 | 2.922 | 0.586** | 0.225 | 2.596 |
| Residential Mobility | | | | | | | |
| In-between Space | 0.727*** | 0.235 | 3.082 | 0.778*** | 0.215 | 3.606 |
| Unemployment | | | | | | | |
| Street depth | 0.219 | 0.160 | 1.359 | 0.227 | 0.247 | 0.917 |
| Cul-de-sac type | 0.098 | 0.126 | 0.771 | -0.263 | 0.304 | -0.863 |
| **Sociodemographic Level** | | | | | | | |
| Unemployment (%) | | | | | | | |
| Ethnic-heterogeneity (%) | | | | | | | |
| Residential mobility (%) | | | | | | | |
| Aged 14–19 (%) | | | | | | | |
| **Random Effect** | **Variance** | **SD** | **$X^2$** | **Variance** | **SD** | **$X^2$** | **Variance** | **SD** | **$X^2$** |
| INTRCPT1 | 1.486 | 1.219 | 140.59 | 1.463 | 1.209 | 122.34 | 1.420 | 1.191 | 80.62 |
| Level-1 | 0.476 | 0.690 | 0.453 | 0.673 | 0.446 | 0.668 | | | |

*p<0.05; **p<0.01; ***p<0.001*
5. Discussion

The results indicated that reduced cul-de-sac depth (C2) from the main street among connectivity factors and lower ratio of first-floor windows (V1) among visibility factors led to higher vulnerability to crime. Regarding accessibility, a higher ratio of walls and fences (A3), more in-between space (A7), higher house density (A4), and wider streets (A6) resulted in increased vulnerability to crime. Furthermore, sociodemographic characteristics at the neighborhood level had a complex effect on cul-de-sac-level physical characteristics.

Increased depth of the cul-de-sac from the main street (C2) resulted in a low crime rate. This result contrasts with the general idea that an increased number of intersections results in higher vulnerability to crime due to the increase in escape routes. This is because the number of intersections between the main street and the cul-de-sac was measured in this study by limiting the connectivity characteristic of intersections that connect all ways. This phenomenon is aggravated further in neighborhoods with a higher population of people aged 14–19 (S4) and more ethnic heterogeneity (S2).

The finding that a lower number of first-floor windows (V1) exacerbates the crime rate corresponds with existing studies (Perkins et al., 1990; Perkins et al., 1993). This is because fewer windows on the first floor of residences within cul-de-sacs decreases passive surveillance, which results in a higher crime rate. This is particularly apparent in neighborhoods with higher ethnic heterogeneity (S2), owing to the difficulty in establishing a sense of community between residents in neighborhoods with a higher number of foreigners, and that passive surveillance is dependent on such a sense of fellowship.

In recent studies by the UK SBD (ACPO, 2014) and Armitage (2011), a higher ratio of walls and fences (A3) is claimed to provide for safer residences. In South Korea, however, a higher ratio of walls and fences aggravates the crime rate, and this result contradicts that of past studies (Foster, Giles-Corti, & Knuiman, 2011). In countries such as the United Kingdom—where crime prevention guidelines are in effect—see-through fences are usually installed, which ensure passive surveillance from both inside and out while also providing a physical barrier against criminals. However, in South Korea, where privacy fences are mostly installed, they provide a physical barrier at the cost of reduced passive surveillance; the contrary results may be attributed to this discrepancy. Such results indicate that fences in South Korea work to reduce passive surveillance instead of increasing accessibility.

This study’s results matched those of earlier studies (Ratcliffe, 2003; López & Van Nes, 2007) that claimed that in-between space heightens vulnerability to crime, because such spaces can be exploited as hiding spots for criminals.

Higher house density (A4) leading to a higher crime rate is another finding identical to the existing research (Hough & Marshall, 1995). Higher house density in the context of cul-de-sacs indicates that residences are clustered closely together. As many houses are located within a cul-de-sac, outsiders face fewer limitations in accessing the street disguised as visitors, and this encourages criminals to approach their targets. This phenomenon is aggravated in neighborhoods with greater residential mobility (S3), and this is attributed to an extra crime factor of territoriality. Generally, greater residential mobility indicates a greater number of incomers; this hinders both the formation of a lasting sense of community between residents and the ability to distinguish between a resident and an outsider which heightens vulnerability to crime by lowering territoriality within the cul-de-sac and making access by outsiders easier.

Contrary to existing research (Loukaitou-Sideis et al., 2001) that claims that street width (A6) is not related to the crime rate, narrower street width was revealed to lower the burglary rate in this study. This can be understood as wider street width diminishing territoriality by increasing the access of non-resident outsiders, which heightens vulnerability to crime. This phenomenon is particularly aggravated in neighborhoods with high residential mobility (S3), and this can be attributed to the fact that higher residential mobility lowers territoriality, as mentioned above.

Focusing on sociodemographic factors, those related to residential mobility (S3) were house density (A4) and street width (A6), whereas those related to ethnic-heterogeneity (S2) included the number of first-floor windows (V1), depth of the cul-de-sac (C2), and the ratio of walls and fences (A3). The factor related to the population of people aged 14–19 (S4) was the depth of the cul-de-sac (C2) from the main street.

6. Conclusion

Existing studies on cul-de-sacs mostly focus on either the physical characteristics of cul-de-sacs in terms of individual streets (cul-de-sac level), or on sociodemographic factors at the regional level (neighborhood level). However, since crime is a complex phenomenon, the physical characteristics of each street need to be considered in conjunction with the collective sociodemographic characteristics at a regional level. Therefore, the significance of this study is that a complex analysis was conducted on burglary in cul-de-sacs with regard to both physical characteristics at the cul-de-sac level and demographic characteristics at the neighborhood level.

The results revealed that variables for connectivity, visibility, and accessibility factors—with the exception of a few variables—were significant, and further explanation on the burglary rate was possible when sociodemographic factors were added.
This study examined how the specific environmental factors of cul-de-sacs affect crime in individual countries where this design is thought to prevent crime, and how residential areas with multiple cul-de-sacs are affected by sociodemographic characteristics in a complex manner. Accordingly, it is necessary to conduct a sociodemographic investigation as well as to identify the characteristics of surrounding structures and environments when designing a cul-de-sac within a residential area.

As this study targeted a single region located within a downtown area of South Korea, it is limited by its restrictive sample size and the subjects of this study cannot be seen as representative of typical cul-de-sacs in the country. Therefore, further research is necessary with an expanded area of investigation, and if analysis on the behavior of residents in cul-de-sacs could be also incorporated by examining the actual factors that cause crime insecurity, a more definite plan could be designed for burglary prevention.

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