



Article

Crime Prevention Effect of the Second Generation Crime Prevention through Environmental Design Project in South Korea: An Analysis

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Abstract: In Yeomni-dong Sogeu-gil, Korea, the first generation CPTED (Crime Prevention Through Environmental Design) project was implemented in 2012, focusing on improving the physical environment. Later, spreading nationwide, it was developed into the second generation CPTED, emphasizing the role of resident participation and improving upon the weak points of the first project. This study makes a comparative analysis of crime reduction and diffusion before and after the second generation CPTED conducted in S-dong, Dongjak-gu, Seoul, Korea, using crime location data to verify the crime prevention effect. Most previous studies on Korean CPTED projects sought verification through surveys that involved subjective opinions of the researchers or participants, creating the need for verification through quantitative and objective analysis based on crime data. This follow-up research examines the effects of the first generation CPTED Project by making an objective analysis of the differences in crime prevention effects between the first and the second project. Findings revealed that the second CPTED had a positive effect in reducing the rate of burglary and violent crime. The second generation CPTED project also led to the crime control benefits of crime diffusion, in contrast to the earlier project, where crime displacement occurred.

Keywords: urban design; second generation CPTED; crime prevention effect; crime location data; GIS; weighted displacement quotient; total net effect

1. Introduction

1.1. Research Background

The term CPTED (Crime Prevention Through Environmental Design) was first used in a book by C. Ray Jeffery (1971). CPTED is a crime prevention strategy that aims to reduce crime opportunities and citizens' anxiety of crime occurrence by improving urban environments through architectural design and urban planning, and ultimately, to improve the quality of life (Jeffery 1971). In Korea, governmental efforts for institutional improvement and research have continued for crime prevention since the first CPTED research in the late 1980s (Kim 2012). In 2012, Yeomni-dong, Mapo-gu, at that time a major crime-ridden district in Seoul, was selected as the first target of the CPTED Project. Yeomni-dong was a highly residential low-rise district formed spontaneously in the 1960s. Since it was formed with no systematic planning, bystreets with low visibility were common, and thus the crime rate was far higher than in areas where urban planning, such as apartment complexes, was applied. The low-rise buildings, which occupy a large portion of Korean cities, except for apartments, are represented by dense residential types in South Korea. However, there are many places that are vulnerable to crime because they are located in urban alleys that are relatively difficult to control

(Cho and Kim 2016). This means that the narrow and winding roads and small multifamily houses, which are difficult to secure visibility for, are difficult to monitor for crimes and are therefore prone to crime. In addition, a study on the crime rate per 100,000 m² of housing area revealed that multifamily housing is more vulnerable to crime, with twice as many crimes as apartments (Cho and Son 2016). Not long before it was initiated, many studies (Park et al. 2013; Seo 2015) reported the substantial effect of the Yeomni-dong CPTED project. In view of the positive effects of this project on crime prevention, local governments around the country started to conduct CPTED projects, and the highly residential low-rise district in S-dong, Dongjak-gu, which is discussed in this study, was also selected as one of the targets for the safe village project (CPTED project) at that time.

1.2. Research Objective

Most empirical studies (Park et al. 2013; Seo 2015; Cha and Jung 2014; Kim et al. 2014) into the Yeomni-dong project have examined residents' perceptions of the effect of CPTED and fear of crime; these perceptions were based on the results of a paper survey. The survey was conducted through questionnaires before and after the project, and the residents' perception and satisfaction with the crime anxiety reduction and CPTED projects were investigated. Surveys could have limitations in that the responses may vary depending on the period and place of the survey, and thus there could be deviations based on the survey sample or the researchers' inclination (Lee 2007). Nonetheless, most empirical studies were probably based on qualitative research methods, such as surveys, because it was otherwise difficult to collect crime data necessary for analysis. In the case of Korea, access to macroscopic crime rate data of districts could be obtained only through a request of information disclosure at that time, and thus quantitative analysis using crime data¹ was rare.

Recently, however, it has become possible to obtain crime data for research with cooperation from local police agencies, although the data permitted are limited. The effectiveness of the CPTED project applied to Yeomni-dong, Seoul, was analyzed based on police-recorded crime data. Unlike findings of previous studies, this research showed that there was no decrease in the crime rate (Jeong et al. 2017; Kim et al. 2018). The crime rate for burglary in the district where CPTED was applied decreased after the project was implemented but there was crime displacement to adjacent areas (Jeong et al. 2017). Regarding violent crimes, the crime rate increased both in the district where CPTED was implemented and in the other districts where it was not. CPTED installations in Yeomni-dong for improvement in the physical environment produced no significant effect, but elements that induced residents' participation produced significant positive effects for crime prevention (Kim et al. 2018). In other words, positive findings of the research based on a survey among Yeomni-dong residents led to the nationwide expansion of the CPTED project, but the result of the crime data analysis showed that crime reduction was insignificant. Instead, there were negative results, such as an increase in the violent crime rate.

The CPTED project conducted in Yeomni-dong, Seoul, was a first generation CPTED strategy focused mainly on improving the physical environments vulnerable to crime. In contrast, the CPTED projects analyzed in the present study, such as the Dongjak-gu S-Dong CPTED project conducted recently in Korea, are second generation CPTED strategies, which emphasize the local characteristics of each community. In addition, the second generation CPTED emphasizes the need for community participation. The fact that the residents who are the customers of the CPTED project actively encourage their participation in crime prevention is included as an important concept of crime prevention design (Newman 1972).

S-dong, the site of this study, is the first place in Korea to establish a crime prevention design department to actively engage in the prevention of crime by seeking resident participation. It is similar to the first generation CPTED in Yeomni-dong. However, the second generation CPTED project,

¹ Crime data are the data recorded by the police. Here, they refer to data on crimes that occurred in the whole area of Yeomni-dong, Mapo-gu, Seoul. It contains information such as date and time of crime, location, receipt of consent, and arrest.

which was applied in S-dong, improved not only the physical environment emphasized in the first generation CPTED project, but also the elements that reflect the characteristics of the second generation CPTED project. It is different from the first generation CPTED project in that it compensates for the shortcomings of the latter. In a more specific comparison with the first Generation CPTED Project of Yeomni-dong, the following differences were examined. First, for a more systematic preparation than in the first generation CPTED project, a CPTED taskforce team was organized to promote safe urban environments against crime, and dedicated workforces were trained with a responsible manager appointed for each “dong” administrative unit. Second, to reflect installations considering the unique local environments of S-dong, the CPTED project system was upgraded to identify zones vulnerable to crime, in cooperation with police stations within the jurisdiction. Third, items emphasizing the resident community were established reflecting residents’ opinions, such as the town brand² and a community center. Fourth, presentations and debates among residents were held to raise social awareness and create an appropriate climate, contributing to promote a safe town community and maintain and improve crime prevention environments continually. As a result, the crime reduction rate of the CPTED project in S-dong, Dongjak-gu, was higher than that of the first generation CPTED project in Yeomni-dong.

The present study examines the effectiveness of crime preventive measures quantitatively and using police-recorded crime location data of S-dong, Dongjak-gu, Seoul, the target area where the second generation CPTED was introduced. This is also a follow-up research project on the effect of the first generation CPTED project, conducted in Yeomni-dong Sogum-gil. Unlike the first project, where the crime reduction rate was insignificant, the project in S-dong, Dongjak-gu, resulted in crime reduction. This study aims to analyze the differences between these two projects specifically. In addition, this study is unique because, although the second generation CPTED has been applied before, there has been a lack of research that examines police-recorded crime data alongside the application of a second generation CPTED project.

2. Literature Review

2.1. Second Generation CPTED

The first CPTED project applied in Korea, the first generation CPTED strategy, considered only improving the physical environment (Ha et al. 2015). The project included no measures for continued maintenance of the improved environment and failed to consider the unique characteristics of each region. Hence, there was no significant reduction in the crime rate. Moreover, the focus on the physical environment design had fundamental limitations in terms of crime prevention. It could not prevent irrational crime, and crime relevant to the local demographic, social, and economic characteristics. Accordingly, the second generation CPTED was proposed as a more refined strategy to overcome these weak points. Recently, the safe town project has been implemented in Korea, on the basis of the second Generation CPTED strategy (Park and Yoon 2014).

There has been much research on second generation CPTED that has analyzed cases where community involvement has been emphasized, or the community has positively influenced crime prevention (Whitzman 2012; Shaw 2001; Sampson et al. 1997; DeKeseredy et al. 2005). According to Whitzman C., hundreds of “safe community” and “community safety” projects are currently under implementation around the world (Whitzman 2012). The International Center for the Prevention of Crime also considers community safety as a positive approach to prevent crime (Shaw 2001). Sampson, R. J., et al. reported that the proportion of violence in the streets is lower in communities that combine social cohesion with neighbors and willingness to act in partnership (Sampson et al. 1997). DeKeseredy,

² The town brand is a strategy that activates a safe town by promoting the consciousness of the safety village by applying a symbolic brand based on local specialty to the crime prevention design.

W. S., et al. analyzed how community-related second generation CPTEDs can be effective in reducing private violence against women in public housing (DeKeseredy et al. 2005).

The second generation CPTED theory was first proposed by Saville and Cleveland in 1997, emphasizing the need for promoting a community spirit in the socio-cultural realm by facilitating residents' participation and creating a sense of fellowship among them (Saville and Cleveland 1997). The need for resident participation, emphasized in the second generation CPTED, was addressed in the defensible space theory and collective efficacy perspective. According to the defensible space theory, not only creating physical environments that affect crime prevention directly but also raising social awareness of crime prevention should be considered a major concept of crime prevention design (Newman 1972). From the perspective of collective efficacy, mutual trust among local residents induces them to intervene actively in social problems, such as crime, by sharing a common bond and thereby responding to crime issues effectively. In other words, cooperation between residents, who are the beneficiaries of the CPTED project, must be considered by emphasizing further the importance of community matters (Yu et al. 2016). The second generation CPTED advanced to the point of overcoming the limitations of the first generation CPTED by adding such factors as social cohesion, connectivity, community culture, and threshold competency to the previous first generation CPTED strategy, based on findings of various studies (Saville and Cleveland 1997; Cleveland and Saville 2003; Saville and Cleveland 2003; Saville and Cleveland 2008). "Social cohesion" refers to strengthening the relationships between residents by improving their competencies to address possible conflicts and problems among them. For example, residents may be encouraged to participate in community activities, such as local events, residential center programs, and town problem-solving meetings. Second, "connectivity" refers to a local community maintaining internal exchange and cohesion while also maintaining relationships with external entities, such as governments and organizations, in other regions. In addition, connectivity represents associations with other towns and the establishment of convenient means of transportation to external regions. Third, "community culture" refers to inducing a community spirit among local residents by organizing cultural activities, such as local festivals, as a means to reduce crime. Finally, "threshold competency" refers to developing social safety measures by using land equitably, that is, by establishing a comprehensive town welfare system that provides space for youths' leisure activities as well as economic activities.

2.2. Crime Prevention Effect Analysis

Just as in the case of the Seoul CPTED project based on the first generation CPTED strategy, most studies on the effectiveness of the Dongjak-gu CPTED project—based on the second generation CPTED strategy—initially focused on the positive results, such as crime anxiety reduction and high satisfaction with the project, on the basis of survey results (Jeong 2018; Jung and Lee 2017; Heo and Park 2016; Hong and Bin 2017).

Many international crime studies have measured changes in crime occurrence rates after project implementation. For example, one study (Eck 2004) reported that quick police responses reduced crime. It analyzed two methods comparatively to evaluate the effect of the police response and utilized the net effect (NE) analysis method. According to this study (Eck 2004), the method used to compare the status before and after the implementation helped evaluate whether to stop the effort to address the problem, while the NE method helped evaluate whether the response could be applicable to similar problems (Eck 2004). The TNE (total net effect) analysis method was designed to measure the general effect of response to crime in a target area, considering the changes in the district under control. The above-stated study reported that the effect of the TNE method was statistically significant, based on many similar studies (Clarke and Eck 2016; Guerette 2009).

In addition, there were theoretical discussions on crime displacement in previous studies, recognizing it as a vital element in criminology. One research proposed the WDQ (weighted displacement quotient) analysis method, pointing out that there had been few standardized empirical studies on displacement occurrence rates or on methods to measure such rates (Bowers and Johnson

2003). The WDQ method was developed to measure the geographical displacement of crime. This method was designed to measure the extent of crime occurrence in a buffer (displacement) area, connect any change in this area to a change in the target area, and measure the diffusion effects of all such crime prevention activities. This research also proposed a formula to measure crime displacement and the diffusion effect accurately by utilizing a combined set of GE (gross effect), NE, and TNE instead of using the WDQ method alone. The project's total effect, net effect (NE), and WDQ were measured. In addition, the general effect of the project was analyzed by a TNE model. Guerette and Bowers also utilized a combination of the WDQ and TNE methods. One advantage of the combined use was that both the WDQ and TNE methods were used in an area where a common evaluation was conducted for a designated period (Piza et al. 2016). Furthermore, the trend in recent studies is to use multiple analysis methods, such as WDQ and TNE, in combination for analyzing project effects (Guerette 2009; Bowers and Johnson 2003; Piza et al. 2015, 2016; Guerette 2007; Ratcliffe et al. 2011; Thomas 2013; Bichler et al. 2013).

3. Methods and Materials

3.1. Methods

This study applied methods such as the total net effect (TNE) and weighted distribution quotient (WDQ), which are used mainly for analysis of crime prevention effects to examine crime rate decrease using crime data, in contrast to previous studies, which relied on a survey to judge the effectiveness of the Dongjak-gu CPTED project.

The analysis was conducted as per the following procedures (see Figure 1).

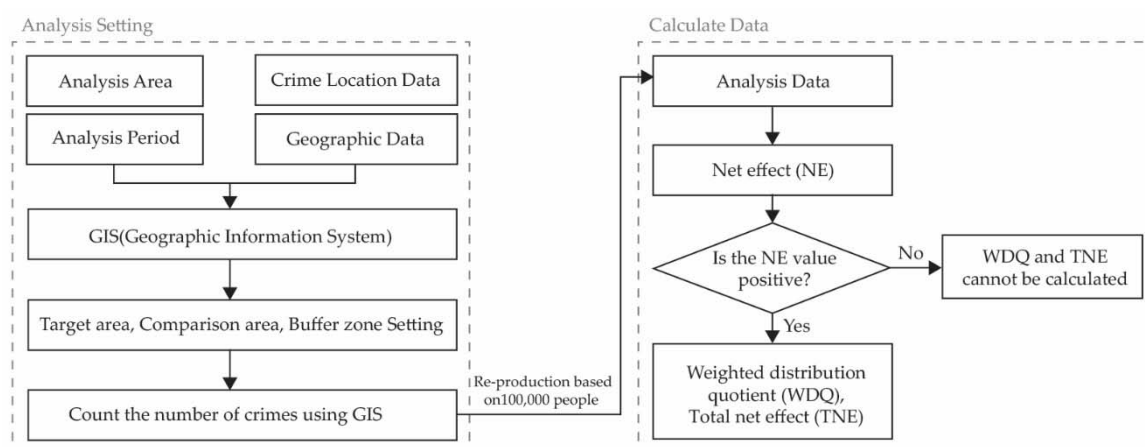


Figure 1. Analysis process.

First, the analysis period and area were decided. Second, the target area's geographical data (buildings, roads, etc.) were collected through the GIS (geographic information system), in addition to crime data. Regarding data inputs, the number of crime occurrences was calculated for each analysis area by means of a GIS tool. Based on the extracted data, the number of crime occurrences per 100,000 people was calculated, based on the population in the year, to compare the number of crime occurrences and crime rate between the pre- and the post-implementation period. The reproduced data went through NE analysis. If the NE value was positive, WDQ and TNE analyses were conducted.

3.1.1. Analysis Area

The target area of this study is presented in Figure 2. The purpose of the CPTED Project was to improve the quality of life by preventing factors that might lead to crime (Seoul 2014). The Dongjak-gu CPTED project sought to prevent crime not only by improving the physical environments through crime preventive facilities but also by facilitating residents' participation through resident education

and promotion activities. In addition, the CPTED project was promoted in various ways, including on-site investigations by CPTED experts, residents, and Dongjak police officers on crime causes in areas vulnerable to crime. Dongjak-gu is divided into 14 “dong” administrative units. S-dong, which was the target area of this study, is a highly residential area with the highest crime rate in Dongjak-gu.

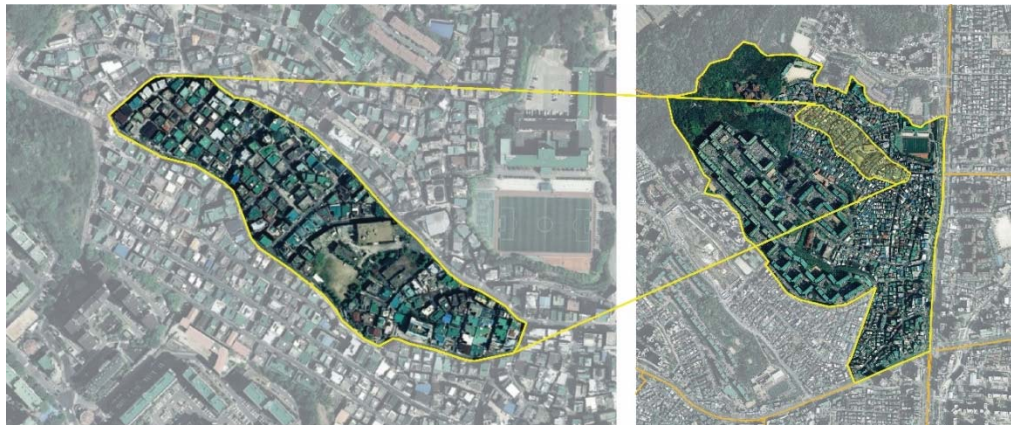


Figure 2. Current conditions of the target area and surrounding areas (**left:** Crime Prevention Through Environmental Design (CPTED)-applied area, **right:** S-dong, Dongjak-gu).

For the analysis, the target area, comparison area, and buffer zone were designated as shown in Figure 3. The target area was a highly residential low-rise district, where the CPTED elements were installed. This was the response area wherein the crime rate change would be determined. The comparison area was set as large as the target area (77,508 m²). It was not connected to the other two areas (target area, buffer zone). Since the comparison area had to be in environmental conditions similar to those of the target area (Bowers and Johnson 2003), a highly residential low-rise district was selected. Since the buffer zone was the area where crime displacement or crime control benefits in the target area would be determined, an area adjacent or close to the target area was selected (Eck 2004; Braga and Bond 2008). In addition, it should have an area not bigger than twice the target area (Hamilton-Smith 2002), and include no other elements that might cause pollution (Guerette and Bowers 2009). Thus, this study included highly residential low-rise districts that surrounded the target area, which were likely to be affected by the CPTED elements. This surrounding area was as large as 78,927 m² in total and was at a distance of 55 m away from the boundary of the target area (Bowers and Johnson 2003; Weisburd and Mazerolle 1995).³

³ Since the CPTED project aimed at a residential area, no shopping district irrelevant to this analysis was included, and the distance of 55 m was viewed as appropriate.

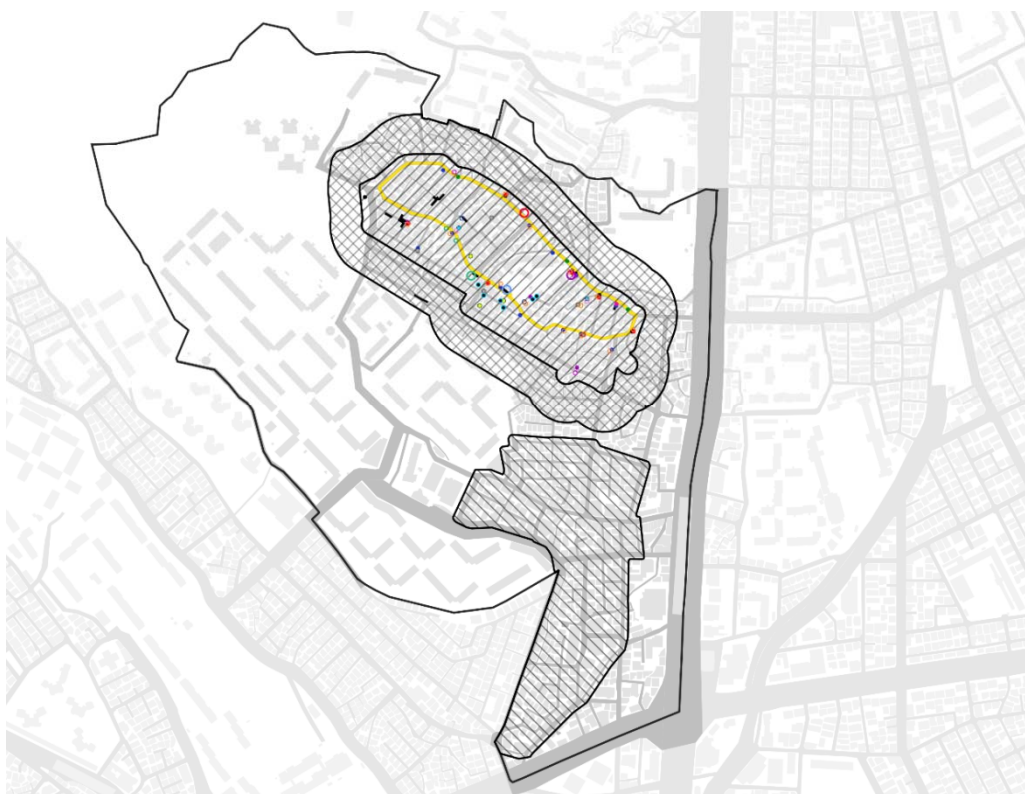


Figure 3. Analysis area.

The CPTED project in the target area was implemented based on the principles of CPTED.⁴ The basic principles of the crime prevention elements installed in the target area were as classified in Table 1.

Table 1. S-dong crime prevention design implementation elements.

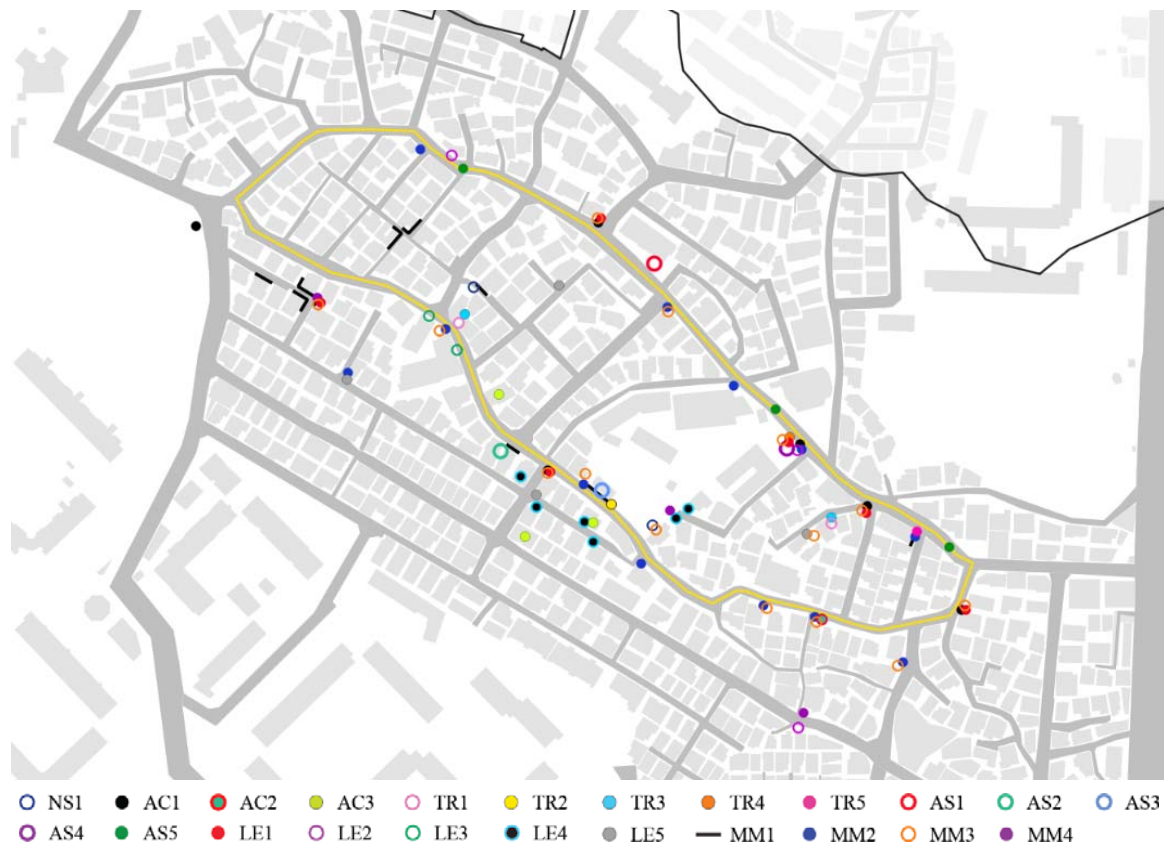
Category	Crime Prevention Design Implementation Elements	
Natural Surveillance	Security Lighting	○ NS1
	CCTV and Recording Sign	● AC1
Access Control	Mobile CCTV	● AC2
	Fluorescent invisible detection paste and notice sign	● AC3
Territoriality	Territoriality reinforcement security door	○ TR1
	Territoriality reinforcement town notice board	● TR2
	Territoriality reinforcement guide sign	● TR3
	Guide map and Crime prevention design project notice	● TR4
	Crime prevention design area sign	● TR5
Activity Support	Duri Jikim Maru (Community Center)	○ AS1
	Fence of memories (Fence board)	○ AS2
	Doori meeting place	○ AS3
	Doori Shelter	○ AS4
	Pavement marking “safe road for women”	● AS5
Legibility	Emergency bell	● LE1
	Gobo lighting	○ LE2
	Retroreflective sheet	○ LE3
	Mirror sheet	● LE4
	Cul-de-sac sign	● LE5

⁴ Six basic principles of CPTED: natural surveillance, access control, territoriality, activity support, legibility, maintenance and management.

Table 1. Cont.

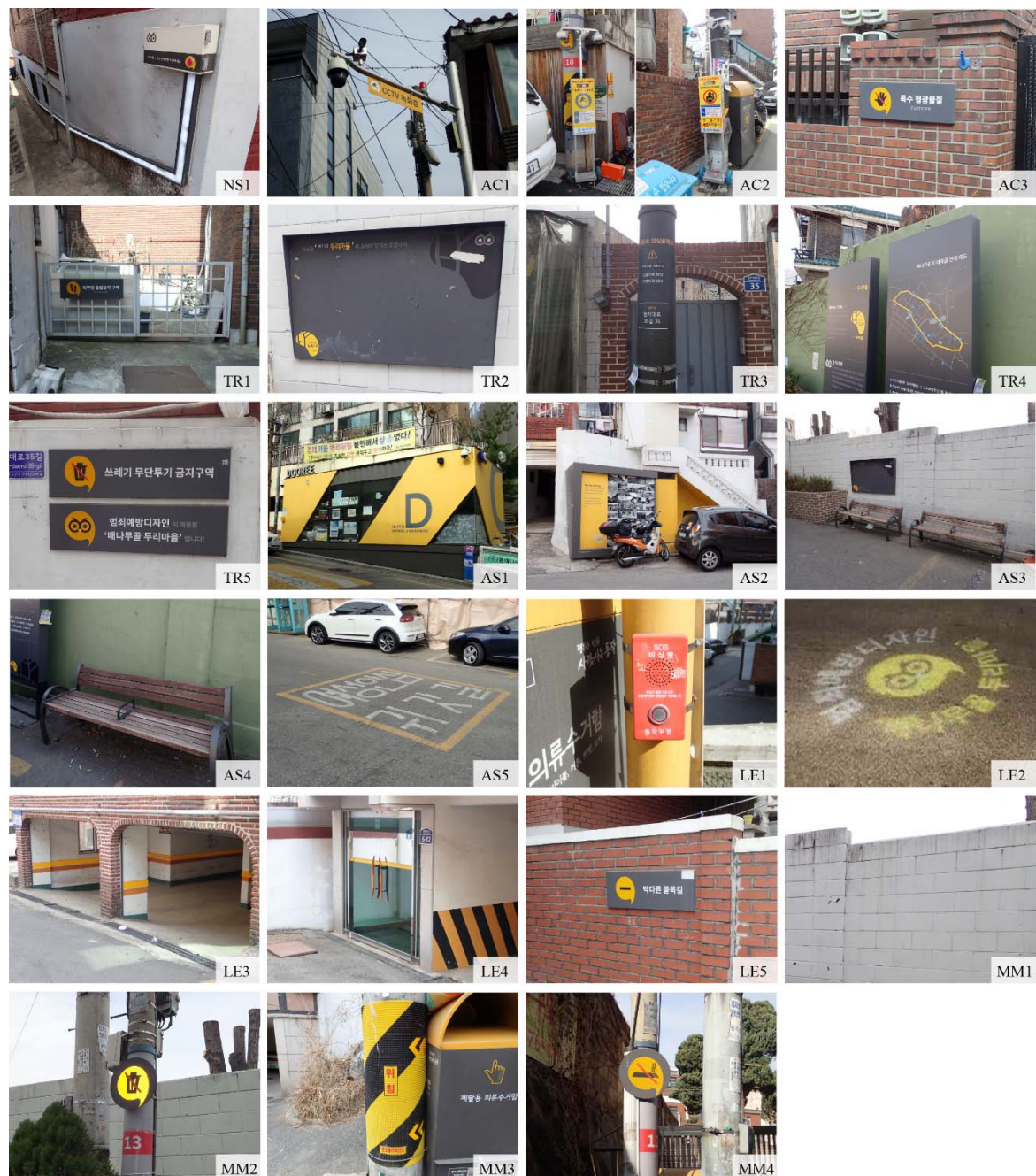
Category	Crime Prevention Design Implementation Elements	
Maintenance and Management	Fence painting	— MM1
	No littering sign	● MM2
	Illegal attachment prevention sheet	○ MM3
	No smoking sign	● MM4

The locations and applications of each element were as in seen in Figure 4.



(a) Location of elements

Figure 4. Cont.



(b) Application status of elements

Figure 4. CPTED elements (these photos were taken by means of an OLYMPUS Tough TG-5).

3.1.2. Formulas for Measuring Changes in Crime

The extent of crime reduction in the target area was measured with reference to NE (net effect). Crime displacement or diffusion of crime control benefits was measured with reference to the WDQ (weighted distribution quotient). Finally, the general effectiveness of the project was determined based on the TNE (total net effect).

The NE determines crime rate increase or decrease in the target area in comparison with that of the area of comparison. In other words, NE is used to determine whether a project applied to a certain target area is relevant to changes in the crime rate over the comparison area. As shown in (1), therefore,

NE was based on the differences between the crime rate in the comparison area and target area before and after the CPTED project:

$$NE = \left(\frac{T_b}{C_b} \right) - \left(\frac{T_a}{C_a} \right), \quad (1)$$

where T_b indicates the number of crime occurrences over the target area prior to the CPTED project, and T_a indicates the number of crime occurrences over the target area after the CPTED project. C_a indicates the number of crime occurrences over the comparison area after the CPTED project, and C_b indicates the number of crime occurrences over the comparison area prior to the CPTED project.

If the NE value is 0, it indicates that there was no effect. If the value is a positive number, it indicates that the CPTED project had a positive effect on crime prevention. In contrast, if the NE value is a negative number, it indicates that the CPTED project had a negative effect on crime prevention, and thus no further analysis is required. For the analysis of the WDQ and TNE elements, therefore, the NE value needs to be positive.

WDQ is used to measure the diffusion effect of crime displacement or crime control benefits. This provides a single indicator that quantifies the extent of crime control of CPTED elements in the target area, crime increase over an adjacent buffer zone (crime displacement), or crime reduction (diffusion effect of benefits). WDQ can be obtained using (2), as shown below:

$$WDQ = \frac{B_a/C_a - B_b/C_b}{T_a/C_a - T_b/C_b}, \quad (2)$$

where B_a indicates the number of crime occurrences over the buffer zone after the CPTED project, and B_b indicates the number of crime occurrences over the buffer zone prior to the CPTED project.

Additionally, WDQ measurements add more explanation on each of the numerator and denominator as in Formulas (3) and (4):

$$\text{Success Measure (WDQ denominator)} = T_a/C_a - T_b/C_b; \quad (3)$$

$$\text{Buffer Displacement Measure (WDQ numerator)} = B_a/C_a - B_b/C_b. \quad (4)$$

Success measure is a measuring tool to determine whether a crime prevention strategy was successful in a target area by comparing crime rates in the target area before and after the implementation of the crime prevention strategy. If it has a positive value, it indicates that the crime prevention strategy failed. If the value is negative, the crime prevention strategy has been successful. If the crime prevention strategy is found to be successful, the buffer displacement measure for a buffer zone indicates the diffusion effect of crime displacement and crime control benefits by comparing crime rates before and after the crime prevention strategy over the buffer zone. If the value is positive, a positive effect of crime displacement is expected. If it is negative, a diffusion effect of crime control benefits is expected. Table 2 shows how to measure and interpret the numerator and denominator.

Table 2. Interpretation standards for the weighted distribution quotient (WDQ) measuring tool.

Category	Results	Interpretation
Success Measure	(3) > 0	Failure of the crime prevention strategy
	(3) < 0	Success of the crime prevention strategy
Buffer Displacement Measure	(4) > 0	Crime displacement effect expected
	(4) < 0	Diffusion effect of crime control benefits expected

WDQ results may be classified into the following seven cases (Bowers and Johnson 2003; Park et al. 2011): with regard to WDQ interpretation, if the value of the success measure (WDQ denominator) is a positive number, it indicates that the crime prevention strategy has failed and there is

no need to further interpret the displacement effect or the diffusion effect. Hence, WDQ interpretation assumes that a value of (3) is a negative number (see Table 3).

Table 3. Standards for WDQ interpretation.

WDQ Value	Interpretation	
$WDQ > 1$	Diffusion of control benefits $>$ direct effect $>$ crime displacement	With a considerable positive effect
$WDQ \approx 1$	Diffusion of control benefits \approx direct effect $>$ crime displacement	With the same effect on the buffer zone as in the target area
$1 > WDQ > 0$	Direct effect $>$ diffusion of control benefits $>$ crime displacement	With a positive effect on the buffer zone as well
$WDQ = 0$	Crime displacement ≈ 0 and diffusion of control benefits ≈ 0 or crime displacement \approx diffusion of control benefits	Trade-off predicted; additional test on crime rate fluctuation over the target area required
$0 > WDQ > -1$	Direct effect $>$ crime displacement $>$ diffusion of control benefits	Crime rate decrease over the target area; crime displacement over the buffer zone
$WDQ \approx -1$	Crime displacement \approx direct effect $>$ diffusion of control benefits	No effect of the crime prevention strategy
$-1 > WDQ$	Crime displacement $>$ direct effect $>$ diffusion of control benefits	Deterioration after crime prevention strategy implementation

First, if the WDQ value is higher than 1, it indicates that the crime prevention strategy over the target area succeeded, with a positive diffusion effect of crime control benefits. With the value of (3) larger than that of (4), the diffusion effect of benefits is more significant than the crime prevention effect on the target area. In other words, the CPTED project applied to the target area resulted in considerable positive effects. Second, if the WDQ value is close to 1, it indicates that the diffusion effect benefits are similar to that of the direct crime prevention, with the same effect on the buffer zone as on the target area. If the extent of the diffusion effect of crime control benefits was similar to that of the direct effect although the crime prevention strategy succeeded, the WDQ value would be close to 1. Third, when the WDQ value is between 0 and 1, the value of (4) is higher than that of (3). The absolute value of (4) is higher than that of (3). In other words, the direct crime prevention effect is more significant than the diffusion effect of benefits. The buffer zone is also affected positively in this case. Fourth, if the WDQ value is 0, it indicates that the value of (4) is 0. In this case, the crime displacement effect or the diffusion effect of crime control benefits are insignificant. Fifth, if the WDQ value is between 0 and -1 , it indicates that the effect of CPTED elements on crime rate reduction over the target area is outstanding but there is a displacement effect on the buffer zone at the same time. However, the direct effect on the crime reduction rate over the target area is more significant than the extent of crime rate increase over the buffer zone, and thus it may be interpreted that the crime prevention strategy resulted in an overall positive effect. Sixth, if the WDQ value is close to -1 , it indicates that the CPTED project has a positive effect on the target area, but the extent of displacement is similar to that of direct effect. In other words, this value may indicate that the crime rate decrease over the target area is absorbed into the crime rate change over the buffer zone (100% displacement into the buffer zone). This indicates that although the crime prevention strategy succeeded, there is no distinctive result, due to the crime displacement effect, and the crime prevention strategy is considered ineffective. Finally, if the WDQ value is smaller than -1 , it indicates that the displacement effect is more significant than the control effect, and that the CPTED Project resulted in an increase in crime.

In the final step, the TNE indicates the total increase or decrease of crime resulting from the CPTED project, in consideration of benefit displacement or diffusion. The TNE is utilized to determine the general effect of a project. The formula is presented in (5), as below:

$$\text{TNE} = \left[T_b \left(\frac{C_a}{C_b} \right) - T_a \right] + \left[B_b \left(\frac{C_a}{C_b} \right) - B_a \right]. \quad (5)$$

If the TNE value is 0, it indicates that the project had no effect. If the value is less than 0, it indicates that the project had no effect and rather might involve problems. In contrast, if the TNE value is larger than 0, it indicates that the CPTED project applied to the target area had some effect in general. The larger the value, the more effective the project. If $\text{TNE} = 35$, it may be interpreted that the CPTED project applied to the target area can prevent 35 crime occurrences.

In (5), $\left[T_b \left(\frac{C_a}{C_b} \right) - T_a \right]$ indicates the increase or decrease in crime occurrences over the target area resulting from the CPTED project, based on crime changes in both the target area and the comparison area. $\left[B_b \left(\frac{C_a}{C_b} \right) - B_a \right]$ indicates the increase or decrease in crime occurrences over the buffer zone resulting from the CPTED project, based on crime changes in both the buffer zone and the comparison area.

3.2. Crime Location Data

It is possible to measure the effect of a project on crime quantitatively and by securing crime location data before and after the CPTED project implementation. Thus, this study secured crime location data, with the cooperation of the police station, for 2014 and 2017, the periods respectively before and after the CPTED project in S-dong, Dongjak-gu. Using these data as reference, the effectiveness of the second generation CPTED elements on crime prevention in S-dong was analyzed in a quantitative and objective manner. These data were related to crime over the area of S-dong, Dongjak-gu, Seoul, including the date and location of occurrence, reported crime type, crime type of arrested criminals, whether criminals were arrested, and so forth. Although the data were comprehensive, the possibility of under reporting could arise (Wahidin and Carr 2013). In other words, not all crimes in an area may have been recorded. The crime data used in this study were the official record of crimes notified or reported to the police. However, numerous studies have shown that the official data of crimes recorded by the police represent only a small proportion of all actual crimes (Maguire 2007; Jansson 2007; Maguire 2012). According to a 1982 criminal investigation in England, 11 million crimes occurred in England and Wales, but less than 3 million crimes were officially recorded by the police (Jansson 2007). This implies that even if a crime occurs, it need not necessarily be reported, and there are several cases of crimes that may not have been reported and recorded. It should be noted that criminal data recorded by the police used in this study may also be a criminal record that is underreported. However, official crime data can provide a broad indication of trends (Maguire 2007; Maguire 2012). Therefore, this study recognizes the limitations of underreporting, but uses the criminal data officially recorded by the police to examine the broader trends of crime in the area.

The data were analyzed for the periods before and after the Dongjak-gu CPTED project (23 October 2015 to 31 December 2016): the pre-implementation period was from 1 January 2014 to 31 December 2014 and the post-implementation period was from 1 January 2017 to 31 December 2017 (see Figure 5).

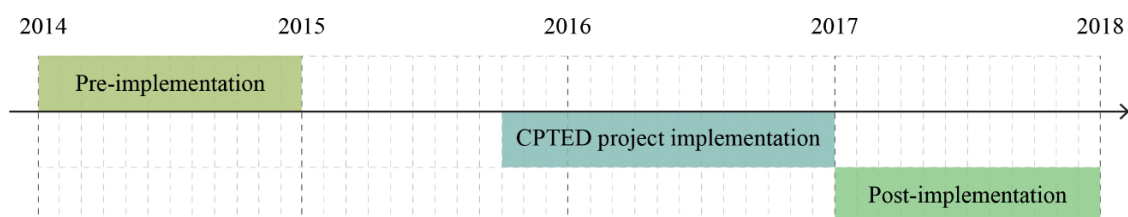


Figure 5. Analysis period.

The S-dong crime data regarding the number of crimes in each period were as shown in Table 4 (see Table 4).

Table 4. Occurrence of five major crimes over the entire area of S-dong.

Category	1 January 2014–31 December 2014	1 January 2017–31 December 2017
Burglary	116	145
Violence	144	207
Rape	7	15
Robbery	1	0
Murder	0	0
Total	268	367

Among the five major crimes in Korea, this study includes burglary and (sexual) violence, which are related to CPTED directly or indirectly. Rape, however, was excluded from this study since the number of occurrences was small.

The spot where burglary and violence crime occurred in 2014 and 2017 is shown in Appendix A. And the details of the crimes of burglary and violence in the target area, buffer zone, and the area for comparison both pre- and post-implementation were as shown in Table 5.

The number of crime occurrences per 100,000 people was recalculated based on the population in the year to compare the number of crime occurrences and the crime rate between the pre-implementation period and the post-implementation period on the same basis. The recalculated number of crimes is also presented in Table 5.

Table 5. Crime count and recalculated crime count for consistency as the number of crimes per 100,000 people.

Category	Pre-Implementation ¹		Post-Implementation ²	
	Crime Count	Per 100,000	Crime Count	Per 100,000
Burglary				
Target area	9	29	11	39
Comparison area	39	128	58	205
Buffer zone	14	46	10	35
Violence				
Target area	13	43	9	32
Comparison area	50	163	92	324
Buffer zone	8	26	12	42

¹ Population in S-dong as of 2014: 30,583; ² Population in S-dong as of 2017: 28,358 (Kosis Source: http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B04005N&conn_path=I3).

4. Results

The differences in crime count before and after the CPTED project implementation are presented in Table 6, below.

Table 6. Changes in crime attributable to the project.

Category	Pre	Post	No. of Changes	Change Rate	NE
Burglary					
Target area	29	39	−10	34.48	0.04
Comparison area	128	205	−77	60.16	
Buffer zone	46	35	11	−23.91	
Violence					
Target area	43	32	11	−25.58	0.17
Comparison area	163	324	−161	98.77	
Buffer zone	26	42	−16	61.54	

During the period after CPTED element application, 10 more burglaries occurred in the target area (34.48%), while 77 more occurred in the comparison area (60.16%). In the buffer zone, the number of burglaries was reduced by 11 (23.91%). During the period after CPTED element application, 11 fewer cases of violence occurred (25.58%). In the comparison area and buffer zone, crime increased by as much as 98.77% and 61.54%, respectively. NE analysis was conducted to compare the crime reduction rate between the comparison area and the target area. The extent of NE on burglary was 0.04 and that on violence was 0.17, which indicates that the CPTED project had positive effects on crime prevention. As these values were positive numbers, it was valid to analyze WDQ and TNE data. Analysis results are presented in Table 7, below.

Table 7. Changes in crime attributable to the project, accounting for displacement or diffusion.

Category	Pre	Post	WDQ	TNE
Burglary				
Target area	29	39	5.19	46.12
Comparison area	128	205		
Buffer zone	46	35		
Violence				
Target area	43	32	0.18	63.15
Comparison area	163	324		
Buffer zone	26	42		

The WDQ value of burglary was 5.19, a number larger than 1. This indicates that the crime prevention strategy over the target area was successful, with a positive diffusion effect of crime control benefits. Thus, the diffusion effect of crime control benefits was more significant than the crime prevention effect on the target area. In other words, the CPTED project applied to the target area resulted in considerable positive effects. The WDQ value of violence was 0.18, a number between 1 and 0. Thus, the direct crime prevention effect was more significant than the diffusion effect of crime control benefits. Although there was a positive effect on the buffer zone as well, the crime prevention effect on the target area was more significant.

Regarding the TNE results in the final analysis step, the total value was a positive number larger than 0, which indicates that the CPTED project resulted in positive effects, specifically diffusion effects of crime control benefits, not only on the target area but also on the buffer zone. Regarding each type of crime, TNE on burglary = $(29(205/128) - 39) + (46(205/128) - 39) = 7.45 + 38.67 = 46.12$. This indicates that 46.12 crimes were prevented over the target area after the CPTED project was implemented. More specifically, 7.45 fewer crimes occurred over the target area, and 38.67 fewer crimes occurred over the buffer zone after the project was implemented. TNE on violence = $(43(324/163) - 32) + (26(324/163) - 42) = 53.47 + 9.68 = 63.15$. This indicates that 63.15 crimes were prevented over the target area after the CPTED project was implemented. More specifically, 53.47 fewer crimes occurred over the target area, and 9.68 fewer crimes occurred over the buffer zone after the CPTED project was implemented. Overall, the number of crimes reduced by 63.15.

5. Discussion

It has been verified that burglary occurrence rates are relevant to crime opportunities. Accordingly, the burglary crime rate was expected to decrease after the CPTED project in Dongjak-gu. Since the WDQ value was greater than 1, it indicates that the crime rate in both the target area and the buffer zone decreased compared to that in the control area. It also turned out that the diffusion effect of crime control benefits over the buffer zone was more significant than the crime reduction effect on the target area. In the case of burglaries in the target area, where CPTED elements reduced crime opportunities, it is considered that the recognized design elements of crime prevention caused psychological pressure on those who intended to commit a crime and that the influence of such CPTED elements reached a

block 55 m away from the location of installation. CPTED elements installed in the target area positively reduced crime rate, which corresponds to the finding of a previous study on the first generation CPTED, in which the CPTED elements caused burglary crime rates to decrease (Jeong et al. 2017). Compared to the crime reduction rate change in Yeomni-dong, the crime rate in Dongjak-gu decreased significantly after the second generation CPTED. This could be attributed to efforts toward designing appropriate physical environment improvements after an investigation of the residential conditions and zones vulnerable to crimes in the target area, in cooperation with the competent police station, by training the CPTED workforce for creating a safe urban environment against crime. For example, a CPTED taskforce was organized and responsible managers were appointed for each dong administrative unit to implement the CPTED project, reflecting the unique characteristics of Dongjak-gu. In addition, TNE values indicated that 7.45 fewer crimes occurred in the target area than in the comparison area, and 38.67 fewer crimes occurred in the buffer zone than in the comparison area. Efforts toward formation and revitalization of the community in the target area, in addition to the installation of physical elements, contributed to the diffusion of crime control benefits to adjacent areas. Accordingly, the second generation CPTED strategy applied to the target area also emphasizes the importance of strengthening the capabilities of the local community for facilitating public crime reduction (Saville and Cleveland 1997). According to Yu (Yu et al. 2016), active interventions of local residents, who are beneficiaries of the CPTED Project, in tackling social problems, such as crime, contribute to quick and effective responses to crime issues. As the CPTED project in Dongjak-gu motivated residents to actively participate, it also strengthened the capabilities of the local community and had positive effects not only in the areas where CPTED elements were installed but also in adjacent areas.

In the target area, the crime rate of violence decreased. Regarding the level of NE, the violence reduction rate (0.17) was higher than the burglary reduction rate (0.04). Regarding the level of WDQ, the value was lower than that of burglary, while the reduction rate (63.15) was higher than that of burglary (46.12) in the case of TNE. In the case of violence, the value of WDQ was 0.18, a number between 1 and 0. This result indicates that the direct crime prevention effect was more significant than the diffusion effect of crime control benefits. While CPTED elements affected the crime rate of violence in the buffer zone as well, the extent was relatively insignificant compared to the case of burglary. TNE values also indicate that 53.47 fewer crimes occurred in the target area than in the comparison area, and 9.68 fewer crimes occurred in the buffer zone than in the comparison area. This result shows that CPTED elements resulted in positive effects on decreasing the violence occurrence rate over the target area. This is in contrast to the findings of a previous study, which showed that the first generation CPTED in Yeomni-dong had a negative effect on the crime of violence (Jeong et al. 2017). CPTED elements in S-dong, where the importance of the resident community was emphasized, had a positive effect on reducing violent crimes. The fact that the first generation CPTED in Yeomni-dong failed to do so implies that it is impossible to reduce crime rate by physical solutions alone, as pointed out by Saville and Cleveland (Saville and Cleveland 1997). In contrast, CPTED elements applied to S-dong facilitated residents' participation by creating various forms of community spaces, as well as by improving physical environments in the target area, contributing to natural surveillance and prevention of violence crime. Regarding violent crimes that occur mostly in certain areas, community activities with neighbors can contribute to decreasing their occurrence rate (Moser 2006), and the rate of violent crimes on the street is relatively low in areas where community activities are promoted to create a social bond with neighbors, according to previous studies (Sampson et al. 1997). The finding of this study that community activities reduce violent crime occurrences corresponds to the above-stated findings of previous studies. Therefore, it is certain that efforts to strengthen the community bond in S-dong, where the second generation CPTED strategy emphasized residents' participation, had a positive effect in reducing violent crime. Besides creating physical environments that affect crime prevention directly, as pointed out by Newman in his defensible space theory, raising social awareness of the importance of crime prevention is highly essential (Ha et al. 2015). According to Gilligan (Gilligan 2001), educating residents and forming a consensus among them through community centers and workshops helps

community development among them. As efforts were put forth into the continued prevention of crime and creation of social atmospheres through presentations and workshops for residents around the period of the Dongjak-gu CPTED project, the reduction in violent crime in S-dong after the CPTED project was distinctive in comparison with the results of the CPTED project in Yeomni-dong.

The results obtained through this study are summarized as follows.

First, as a result of the implementation of the CPTED project, the crime rate of burglary decreased not only in the target area but also in the buffer zone. By comparing the crime reduction rate in the target area and the buffer zone, it was confirmed that the effect of crime prevention had expanded. Based on these results, the CPTED project has been considered to have a positive effect on not only the application area but also the surrounding area in the case of burglary crimes. In the case of the second generation CPTED conducted in S-dong, it was found that the spreading effect of crime control gains was greater than the first transfer CPTED in Yeomni-dong. Therefore, more detailed study is needed on why the crime prevention effect is greater in the buffer zone than in the target area. Second, in the case of violent crime, the crime rate in both the target area and the buffer zone reduced after the CPTED project. This is because the first generation CPTED project implemented in Yeomni-dong did not positively affect violent crime in the target area. The second generation CPTED in S-dong positively affected the decrease in violent crime, because the second generation CPTED elements are not only elements for improving the physical environment but also elements emphasizing the community and activities of the local residents. Therefore, as in the second generation CPTED project applied to S-dong, emphasizing the community in the implementation of the CPTED project seems more effective in preventing violent crime and in crime prevention in general. Based on these results, preventing crime can become more effective if we extend the elements emphasizing community, that can cope with not only the crime of burglary but also violent crime, in future CPTED projects.

However, the following limitations of this study emphasize the need for future study. First, this study failed to analyze the crime prevention effect of each specific CPTED element installed in the target area. It is difficult to understand how certain CPTED factors affect crime prevention. Therefore, it is necessary to develop a design that can produce better results in future projects by using a micro approach, such as an address or street segment, to judge the effectiveness of the CPTED project implemented in S-dong. To do this, it is necessary to study the characteristics of crime types and the characteristics of the CPTED installation elements. Also, it was confirmed that the CPTED project applied to the target area was effective by evaluating the degree of crime transition and degree of crime control using the WDQ index and the TNE index, like the change in crime rate. However, this study is limited in that it does not explain why the crime prevention effect was maximized in the buffer zone compared to the target area, which was the CPTED business area, for burglary crimes. In this study, it is considered that this limitation was caused because the area where the CPTED project was implemented was set as the target area and the analysis was performed in the area unit. Therefore, it is necessary to carry out more detailed research and supplement this limitation. To do this, characteristics of each crime type and each CPTED element need to be examined in detail. The study also has generalized its analysis results, since the target area was limited to S-dong, Dongjak-gu, Seoul. Therefore, if comparative analyses are conducted in more regions where the second generation CPTED project has been implemented, it will be possible to derive the differences and common elements of CPTED factors influencing crime prevention, based on regional characteristics. This could also establish which CPTED installations should be examined in other parts of Korea. Furthermore, it would be helpful to establish and implement CPTED guidelines for each region and CPTED implementation guidelines in Korea, such as the installation of CPTED elements based on the regional characteristics of each region.

6. Conclusions

The present study is of significance in that it is the first quantitative and objective analysis of the crime prevention effect of the second generation CPTED that was implemented in S-dong, Dongjak-gu, Seoul, using the reference of police-recorded crime location data. In addition, it examined the effect of

the second generation CPTED specifically on burglary crime and violence crime. This is a follow-up study on the effect of the first generation CPTED project implemented in Yeomni-dong Sogeum-gil. Specific differences between the first generation CPTED and the second generation CPTED were examined, and their crime prevention effects were analyzed in reference to the crime location data.

As a result of the analysis, the second generation CPTED resulted in reductions for both burglary and violence. The findings of this study also imply that simply improving physical environments through CPTED elements is of little use in crime prevention, and that in addition to the CPTED elements installed in reflection of each district's characteristics, elements facilitating community activities among residents are of great importance in crime rate decrease. In addition, continued monitoring and maintenance contribute to preserving the crime preventive functions of CPTED elements installed in the target area. Residents' feedback complements the CPTED project. In addition, if the limitations of the study mentioned in the Discussion section are complemented, it may be possible to produce more meaningful results in the implementation of the CPTED project.

This study suggests that the second generation CPTED has a more positive effect on crime prevention. In addition, if we continue to work to maximize the positive effects by complementing the limitations of this study, the development of third and fourth generation CPTEDs will be possible.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A



Figure A1. Cont.

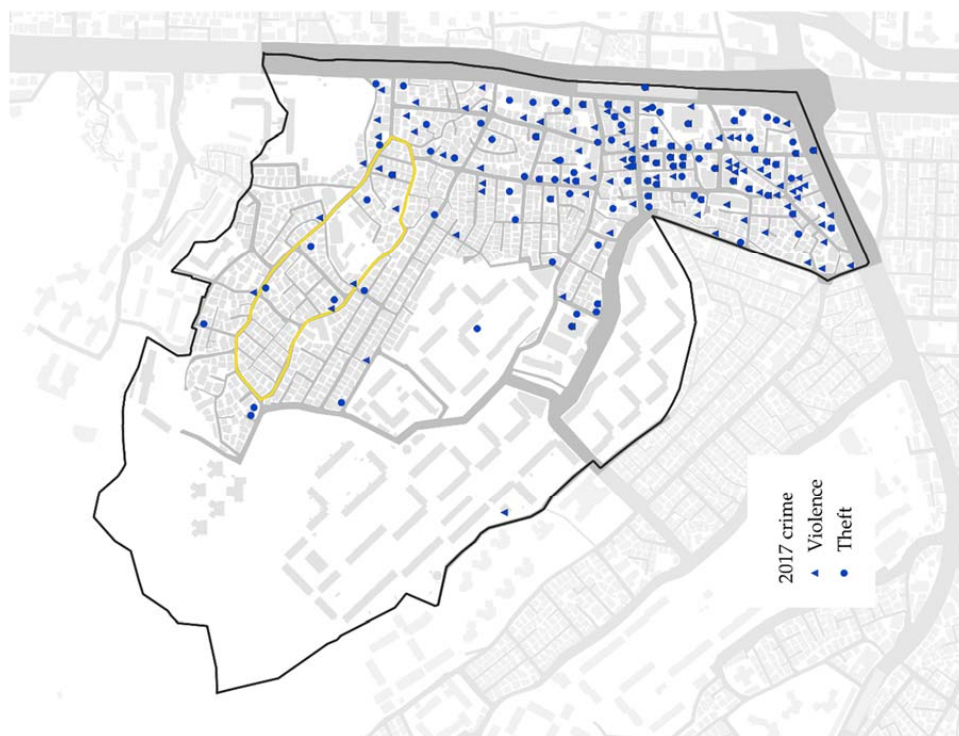


Figure A1. Crime Spot 2014 and 2017.

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