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The Analysis of Effectiveness for CPTED Project Using Weighted Displacement Quotient (WDQ)

Son, Dongpil[*] · Park, Yuna[**] · Hyeon, Taehwan[***]

Abstract

Since the 2000s, central and local governments have continued to push ahead with Crime Prevention Through Environmental Design (CPTED) projects in order to prevent crimes and reduce the public's fear of crime. Various studies have been conducted of the effectiveness of CPTED projects with the spread of such project, by analyzing the rate of increase and decrease of crime and fear of crime before and after the project. Since then, studies have been conducted on the crime displacement effect and diffusion effect of crime control to nearby areas due to the CPTED project, for which analysis Weighted Displacement Quotient (WDQ) has been applied. This study conducted a WDQ analysis of theft and violent crimes for the CPTED project of the Seoul Metropolitan Government to analyze the crime displacement and diffusion of benefits, confirming that theft crime had the effect of spreading profits to buffer areas, while violent crime data did not confirm the crime displacement or diffusion of benefits. This study is meaningful in verifying that the CPTED project is effective in reducing theft crimes, whose effects spread to surrounding areas. However, for a precise analysis of the sustainability and net effects of the project, it is necessary to establish a methodology and propose a plan that can be applied with various statistical analysis tools in the future.

Keywords Crime Prevention through Environmental Design, Effectiveness, Crime Displacement Effect, Diffusion Effect of Crime Control, WDQ

주제어 범죄예방 환경설계, 효과성 분석, 범죄전이효과, 이익확산효과, WDQ

Ⅰ. Introduction

1. Background and Purpose of Research

According to the 2018 Social Survey by Statistics Korea, 20.6% of Korean citizens felt that the main factor of anxiety was crime occurrence, which was significantly higher than other areas of social safety. Since the 2000s, the central and local governments have implemented CPTED projects under the Crime Prevention Through Environmental Design approach to reduce fear of crime and to prevent crimes. In particular, local governments have actively enforced CPTED projects following the 2012 Yeomni-dong Salt Way project by the Seoul Metropolitan Government.

Many studies have analyzed the effectiveness of CPTED projects and their widespread implementation. Research analyzing the effectiveness of CPTED projects can be largely divided into studies focused on changes in crime rate based on crime data in the target area, and surveys of fear of crime in the target area before and after the project. Due to difficulties involved in acquiring geographic crime data, most studies have analyzed fear of crime and change in disorder through residential surveys and 112 crime reports. Research on crime displacement, which refers to the relocation of

* Research Fellow, Architecture and Urban Research Institute (First Author: dpson@auri.re.kr)
** Assistant Research Fellow, Architecture and Urban Research Institute (ynpark@auri.re.kr)
*** Assistant Research Fellow, Architecture and Urban Research Institute (Corresponding Author: thhyeon@auri.re.kr)

crime to nearby areas under Crime Prevention Through Environmental Design, and the diffusion effect of crime control is hardly available in Korea.

This paper examines the crime prevention effect of CPTED projects using geographic crime data. It analyzes the actual crime prevention effect of CPTED projects, and relates effectiveness to crime type, namely, burglary and violence. In addition, it seeks to verify the crime displacement effect and diffusion effect of crime control, which is the reduction of crime in nearby areas as a result of CPTED projects.

II. Theories and Literature Review of WDQ

1. Analysis of Effectiveness of CPTED Projects

According to the National Police Agency, the number of local CPTED projects increased from 305 in 2016 to 1,555 in 2018. Despite this continuous increase, the effectiveness of CPTED projects in crime prevention was not systematically verified due to the difficulties involved in acquiring data on crime occurrence. Most research analyzing crime prevention effectiveness was in the form of analysis of effectiveness in areas in which CPTED projects were implemented, and analysis of effectiveness of the CPTED approach, including the installation of CCTVs.

Kang et al. (2018) investigated trends of crime occurrence and changes in disorder in low-income residential areas where CPTED projects were implemented using crime statistics and 112 crime reports. The results showed that CPTED projects were effective in reducing burglary, but not sexual violence, violence, theft, and murder. In the case of disorder, the positive effects were not as distinct as that of the five major crimes, and differences were observed across regions.

Kim (2007) and Yun (2015) surveyed residents in CPTED project target areas, and analyzed project effectiveness based on residents' fear of crime before and after implementation. Kim (2007) found that physical constituents such as crime prevention facilities and techniques lowered fear of crime, and strengthened social constituents such as social solidarity and reliability. The strengthened social constituents also helped to reduce fear of crime. That is, CPTED projects were effective in reducing fear of crime in target areas. Yun (2015) showed that CPTED projects lowered crime occurrence and

reduced fear of crime. The fear of crime was more strongly influenced by social disorder than physical disorder. As such, efforts should be exerted to prevent social disorder when implementing CPTED projects.

Seo et al. (2018) analyzed the effectiveness of a CPTED project based on indirect factors such as a survey of residents in the target area, interviews with residents, changes in floating population before and after project implementation, and changes in perception of others. The results showed that the floating population increased in the target area, which can be interpreted as a positive effect of the project. However, the floating population decreased one year after the end of the project, which demonstrates that the effect of the project lacks sustainability. Similar results were observed in the survey and interviews. The CPTED project was effective in reducing fear of crime immediately after implementation, but quickly declines in effectiveness if not accompanied by follow-up measures.

Research analyzing the effectiveness of CPTED projects, which aim to reduce crime, is difficult to carry out without the cooperation of the National Police Agency, and most studies tend to rely on indirect measurements of effectiveness.

2. Crime Displacement and Diffusion Effect of Crime Control

The ultimate goal of CPTED projects is to suppress the occurrence of crimes by weakening perpetrators' crime motivation and imposing constraints on criminal acts through changes in the physical environment of spaces vulnerable to crime and community enforcement. This intervention may result in crime displacement, which is the relocation of crime to nearby areas. As such, the effectiveness of CPTED projects should be evaluated with consideration of the crime displacement effect and the diffusion effect of crime control.

Weisburd et al. (2006) defined crime displacement as "shift of crime either in terms of space, time or type of offending from the original targets of crime prevention interventions." The six types of crime displacement are: spatial displacement in which perpetrators move from areas where crime is difficult to commit to another location where they face less risks, temporal displacement in which perpetrators shift the timing of their offenses to hours or days seen as less risky,

target displacement in which offenders give up well-protected targets and focus on more vulnerable ones, tactical displacement in which perpetrators change the tactics they use to avoid an obstacle designed to thwart their efforts, perpetrator displacement in which other perpetrators take the place of perpetrators who are arrested or give up committing offenses, and crime type displacement in which perpetrators commit entirely different type of offenses when a certain crime is not possible (Barnes, 1995:96).

Meanwhile, crime displacement researchers observed effects that are the complete opposite of displacement. Clarke & Weisburd (1994) referred to the spread of crime reduction benefits beyond the target area as "diffusion of crime control benefits," and defined it as "the spread of the beneficial influence of an intervention beyond the places which are directly targeted, the individuals who are the target of control, the crimes which are the focus of intervention or the time periods in which an intervention is brought." The diffusion of benefits occurs when perpetrators are uncertain about the risks of detection and exposure when committing offenses, and when the rewards of certain offenses are weaker than their efforts (Clarke & Weisburd, 1994). Lee & Kim (2009) found that the diffusion of crime control benefits not only suppressed crimes in nearby areas, but also suppressed other types of crime, and could also sustain the effect of crime reduction.

When analyzing the actual effectiveness of crime prevention activities, the analysis should not simply be confined to the target area, but should take into account the possible effects of crime displacement and diffusion of benefits in nearby areas. Past studies on the subject by local and international researchers have mostly relied on the Weighted Displacement Quotient (WDQ) proposed by Bowers & Johnson (2003) to verify the effects of crime displacement and diffusion of benefits.

3. Understanding of WDQ

Bowers & Johnson (2003) developed WDQ as a tool to measure crime displacement effect and diffusion of benefits.

A quasi-experimental design was incorporated as the basic framework of research, and the effects of the experiment were evaluated using a nonequivalent control group design with pretest–posttest. The experimental results were com-

pared for the target area, comparison area, and buffer area (Lee & Kim, 2009:260). The target area is the area in which crime prevention or a CPTED project was implemented. The buffer area is the area expected to be involved in crime displacement as a result of crime prevention activities in the target area. The comparison area, which serves as the control, is unrelated to changes in crime occurring in target and buffer areas. When setting buffer and control areas, it should be noted that the three areas must be homeogenous in terms of geographic properties, demographics, and criminal characteristics to overcome the problem of how variables cannot be controlled between groups (Lee & Kim, 2009:263). The control area must be larger than the target area as a smaller control area would cause severe fluctuations in measurements of crime change rate relative to changes in reference time period. Since the buffer area is set to be within a certain radius of the target area, it is generally larger than the target area (Lee & Kim, 2009:263-264).

Bowers & Johnson (2003) proposed three principles of WDQ. First, the crime change rate of the control area is compared to that of the target area and buffer area, and serves as a criterion in describing the crime displacement effect. Second, spatial displacement to be described by WDQ presumes that crime is displaced from the target area to the buffer area. Third, the occurrence of crime displacement means that the target area sees a decrease in crime due to crime prevention activities, while the buffer area experiences a higher increase in crime than the control area. The WDQ equation below reflects the three principles, and integrates spatial and temporal concepts.

$$WDQ = \frac{Bt_1/Ct_1 - Bt_0/Ct_0}{At_1/Ct_1 - At_0/Ct_0} = \frac{B'}{A'}$$

A: Crime Rate in Target Area
B: Crime Rate in Buffer Area
C: Crime Rate in Control Area
t_1: Before Implementation of CPTED Project
t_2: After Implementation of CPTED Project

Crime displacement and diffusion of benefits can be verified by comparing changes in the crime rate between the target area and control area, and at the same time, changes in crime rate between the buffer area and control area.

According to the above equation, the denominator (A') represents the effect of crime prevention activities or the CPTED project in the target area. The denominator (A') generally assumes a negative $(-)$ value when crime prevention activities are performed, which demonstrates the effectiveness of such activities in reducing crime. A positive denominator (A') means that the decrease in crime rate in the target area is lower than that of the control area, indicating that crime prevention activities were not effective in reducing crime. The numerator (B') measures the crime displacement effect and diffusion of benefits in the buffer area. A negative $(-)$ value means that crime prevention activities resulted in diffusion of benefits, while a positive $(+)$ value indicates that crime was displaced to nearby areas (Bowers & Johnson, 2003:285).

WDQ can be interpreted in seven ways that are shown in Table 1 depending on the combination of denominator (A') and numerator (B') values. First, a WDQ larger than 1 means that crime prevention activities were effective in reducing crime in the target area, and led to diffusion of benefits. That is, crime prevention activities were largely successful. Second, a WDQ close to 1 means that the diffusion of benefits in the buffer area was similar to the crime prevention effect in the target area. Third, a WDQ between 0 and 1 means that the crime prevention effect in the target area was greater than diffusion of benefits in the buffer area. Fourth, a WDQ of 0 occurs when the numerator (B') is 0, which means that there was no crime displacement or diffusion of benefits. Fifth, a WDQ between 0 and -1 means that crime prevention activities were effective in reducing crime in the target area, but that the buffer area was affected by crime displacement. Sixth, a WDQ close to -1 means that crime prevention activities reduced crime in the target area, but the net effect was neutral considering the crime displacement to the buffer area. Lastly, a WDQ smaller than -1 means that crime prevention activities had the reverse effect of increasing crime (Bowers & Johnson, 2003: 285-286).

4. Literature Review and Distinctiveness of Research

Following the introduction of WDQ by Bowers & Johnson in 2003, many studies have applied WDQ to the analysis of crime displacement and diffusion of benefits (Bowers & Johnson, 2003; Park et al., 2011; Lim et al., 2016; Cho & Jung, 2017; Haberman & Stiver, 2018; Park et al., 2018; D. Kim et al., 2019).

1) Research Based on Area Setting

Research based on area setting can be classified into those that set areas based on administrative units, and those that set areas in the form of concentric circles using geographic information systems.

Bowers & Johnson (2003) employed both approaches of setting areas based on administrative units and in the shape of concentric circles. In the former, 21 areas in Northern England were set as target areas, the basics administrative unit containing target areas as the buffer area, and the regional administrative unit as the control area. In the latter, the buffer area was comprised of five concentric circles spaced 400 meters apart, and the change in residential burglary rate was measured for 20 months before and after the implementation of the crime prevention project.

Park et al. (2011) used WDQ to analyze the effectiveness of CCTVs in crime prevention. The target area was a detached house lot in Haan-dong, Gwangmyeong-si where CCTVs

Table 1. Interpretation of the weighted displacement quotient

WDQ value		Interpretation
WDQ > 1	Diffusion greater than direct effects	Positive net effect of the program
WDQ ≒ 1	Diffusion about equal to direct effects	
1 > WDQ > 0	Diffusion but less than direct effects	
WDQ = 0	No displacement or diffusion	
0 > WDQ > -1	Displacement but less than direct effects	
WDQ ≒ -1	Displacement about equal to direct effects	No net benefit to program
WDQ < -1	Displacement greater than direct effects	Program worse than doing nothing

Source: Bowers and Johnson, 2003: 286

were newly installed, the buffer area was Haan-dong, and the control area was comprised of two areas: part of Gwang-myeong 2-dong and 3-dong, and part of Gwangmyeong 6-dong and 7-dong. Lim et al. (2016) analyzed the effectiveness of CCTVs by setting the area within a radius of 100 meters of the CCTV site as the target area, the area within 100 to 250 meters as the buffer area, the area within 250 to 400 meters as the first control area, and the area within 400 to 800 meters as the second control area. Cho & Jung (2017) set Yeomni-dong, Mapo-gu, Seoul as the target area, and nearby neighborhoods similar to Yeomni-dong in area, number of households, and population, namely, Daeheung-dong, Ahyeon-dong, and Yonggang-dong, as buffer areas. Bong-cheon-dong, Gwanak-gu and Eungam-dong, Eunpyeo-ng-gu, which showed similar patterns in occurrence of sexual crime to the target area before CPTED implemented, were selected as control areas.

2) Research Based on Crime Type

Park et al. (2011) conducted WDQ analysis for robbery, burglary, and violence. Crime prevention efforts were effective in reducing robbery and burglary, but not violence. They concluded that Crime Prevention Through Environmental Design can be a better alternative to CCTV.

Cho & Jung (2017) chose sexual violence as the main type of crime in their analysis. The results showed that the CPTED project was effective in preventing crime in Yeomni-dong. While some crime displacement occurred in buffer areas of Daeheung-dong and Ahyeon-dong, the effects were smaller than direct effects. The diffusion of benefits to Yonggang-dong was also smaller than direct effects. Lim et al. (2016) divided crime type into serious crime and disorder crime, and performed regression analysis and WDQ analysis to examine each crime in terms of length of month, temporal trend, and seasonal effect. Haberman & Stiver (2018) analyzed the effectiveness and crime displacement of the foot patrol program in Dayton, Ohio. The crime types covered were violent crime, robbery, theft from motor vehicles, auto theft, disorder crime, and total crime. The foot patrol program reduced the crime rate in the target area by about 28%, and diffusion of benefits was not observed.

3) Implications and Distinctiveness of Research

From a review of studies that employed WDQ to measure crime displacement and diffusion of benefits achieved through crime prevention activities, the two key factors to be considered in measuring crime displacement and diffusion of benefits can be summarized as follows.

First, the buffer and control areas in CPTED projects should be areas physically and socially similar to the target area, and set as large as possible. By controlling the various factors influencing WDQ, the reliability of measurements of crime displacement and diffusion of benefits can be improved. The area coverage should be appropriately large as the lower number of crimes in smaller areas may lead to a greater difference in crime change rate before and after crime prevention activities.

Second, when choosing a type of crime for WDQ, it should be the same type of crime targeted by crime prevention activities in the target area. A WDQ analysis was performed on various crime types in past research, and crime prevention efforts were proven effective for burglary and disorder crime, but not violence and other crimes. Since the WDQ analysis of this study aims to demonstrate the effectiveness of CPTED projects, it should be limited to the crime types targeted by CPTED projects in target areas. However, it may be meaningful to analyze other crime types as crime prevention activities may have an impact on unintended crime types.

In past research, buffer and control areas were set within a certain radius of the target area, or the buffer area was set as the administrative unit containing the target area, and the control area as a nearby administrative unit similar in area to the buffer area. This study set the buffer area as an area close to the target area, and not larger than the target area by two times. To ensure a similar physical and social environment, the selected buffer area had a similar building use classification to the target area. In particular, this study excluded areas with apartments, dense concentrations of retail shops, and green space, which were of different physical and social characteristics compared to the target area. The control area also had a similar environment to the target area, and was an area not targeted by the CPTED project. For clear distinction, the control area was set as an area surrounded by major roads. Based on these conditions, the selected buffer and control areas were highly homogeneous to the target area.

Crime type was limited to burglary and violence. While CPTED projects target five major crimes (murder, theft, sexual violence, burglary, violence), there are two few cases of

murder, burglary, and sexual violence in the target area for effectiveness analysis. Burglary and violence in high-density residential areas were seen as crimes resulting from break-ins and CPTED projects were analyzed for their effectiveness in reducing housebreaking in residential areas .

III. Research Methodology

1. Setting of Target Area

This study analyzed the effectiveness of CPTED projects in consideration of crime displacement and diffusion of benefits. For this purpose, the target area was set as the area in which Project B was implemented by District A.

Seoul has a higher number of crimes than other regions, and many CPTED projects were implemented following the 2012 CPTED project in Yeomni-dong. District A has the highest proportion of single-person households in Seoul, and has seen a high number of burglary and violence due to break-ins. In 2016, District A enacted the Ordinance of Urban Environment Design for Crime Prevention to help prevent crime and lower fear of crime. Under the ordinance, the district has implemented various CPTED projects, and even received the grand prize in the 2017 Korea Crime Prevention Awards for its systematic and efficient efforts.

The target area of Project B implemented by District A in 2016 is largely comprised of single-person households in multiplex housing, and shows high homogeneity in physical environment across areas. Most buildings are less than five stories high, and sidewalks are not separated from roads. Visibility is limited by the narrow streets and alleys between buildings. The area had a high proportion of residential burglary and violence before the implementation of Project B. The residents have a high fear of crime, but are less aware of crime prevention methods.

This study selected a target area where the CPTED project had been implemented in a residential area, allowing analysis of effects before and after the project, and where crimes had occurred to an extent such that changes in crime rate can be examined for the period between 2015 and 2017.

2. Status of Target Area and Project Details

This study selected Project B, implemented by District A of

Seoul in 2016, to analyze crime displacement and diffusion of benefits. The target area has a high density of multiplex housing, and the narrow, dimly lit alleys make it more vulnerable to crime. The park in the target area may become a high-intensity crime area due to its poor accessibility and few night-time users. The CPTED project was implemented to improve spaces more prone to crime.

Under the CPTED project, various elements shown in Figure 1 were installed. Building security was improved with security windows, mirror sheets, safe fences, and fluorescent substance on gas piping, and alleys with hand rails on uphill sections, patrol number on telegraph poles, shelters, town information maps, patrol point signs, and lights. In addition, to enforce natural surveillance in the park, extra lights, crime prevention facilities, and a shelter were installed.

The crime prevention facilities in the target area were installed based on CPTED principles such as surveillance, access control, territoriality, activity support, legibility, and maintenance and management that are shown in Table 2.

a) Park CCTV   b) Maindoor light   c) Visibility of CCTV

d) Shelter on flower bed   e) Sign on patrol point

f) Clean house & board   g) Sign on alley coner

h) Hand rail on uphill   l) Mirror sheet

Figure 1. Applied CPTED elements at target area

Table 2. Principles and elements of CPTED

| Principle	Element
Surveillance	Fence Light, Wall Light, LED Light, Mirror Sheet, Maindoor Light, Park Fence Light, Safe Reflector
Access control	Safe Fence, Security Window, Fluorescent Substance on Gas Piping, Sign on Patrol Base
Territoriality	Information Board on Alley Corner, Logo Light, Town Information Map, Logo Light in Park
Activity support	Shelter under Safe Board, Park Bench, Safe Shop, Shelter on Flower Bed, No Parking Shelter
Legibility	Emergency Bell in Parking Lot of Pilotti, Safe Board, Reinforce Visibility of Personal CCTV, Voice Recognition Emergency Bell in Park, Patrol Number on Telegraph Pole, Sign on Patrol Point, Simple Board on Telegraph Pole
Maintenance and management	Maintenance of Fence, Retaining Wall and Runway, Hand Rail on Uphill, Improvement of Stairway and Alley

Various spatial environment design techniques were also employed to improve the visibility of crime prevention facilities.

3. Setting of Buffer and Control Areas

The buffer and control areas that are shown in Figure 2 were set as described below to analyze crime displacement and diffusion of benefits.

The buffer area in this study had to be as close as possible to the target area, but no larger than two times the target area in order to be consistent with criteria used in past research (Hamilton-Smith, 2002:36, Lee & Kim, 2009:279). The boundary of the buffer area was 50 meters away from the target area. To ensure a similar physical and social environment, the selected buffer area had similar building use, land use, and crime patterns. That is, the area had a high-density of multiplex housing, and saw a similar proportion of burglary and violence caused by housebreaking.

The control areas had similar environmental characteristics with the target area, and met the criteria of the buffer area. They were areas not targeted by the CPTED project. Two control areas were selected to ensure consistency in the analysis. To ensure a similar environment, the control areas were areas within the same administrative unit as the target area and had a high density of multiplex housing.
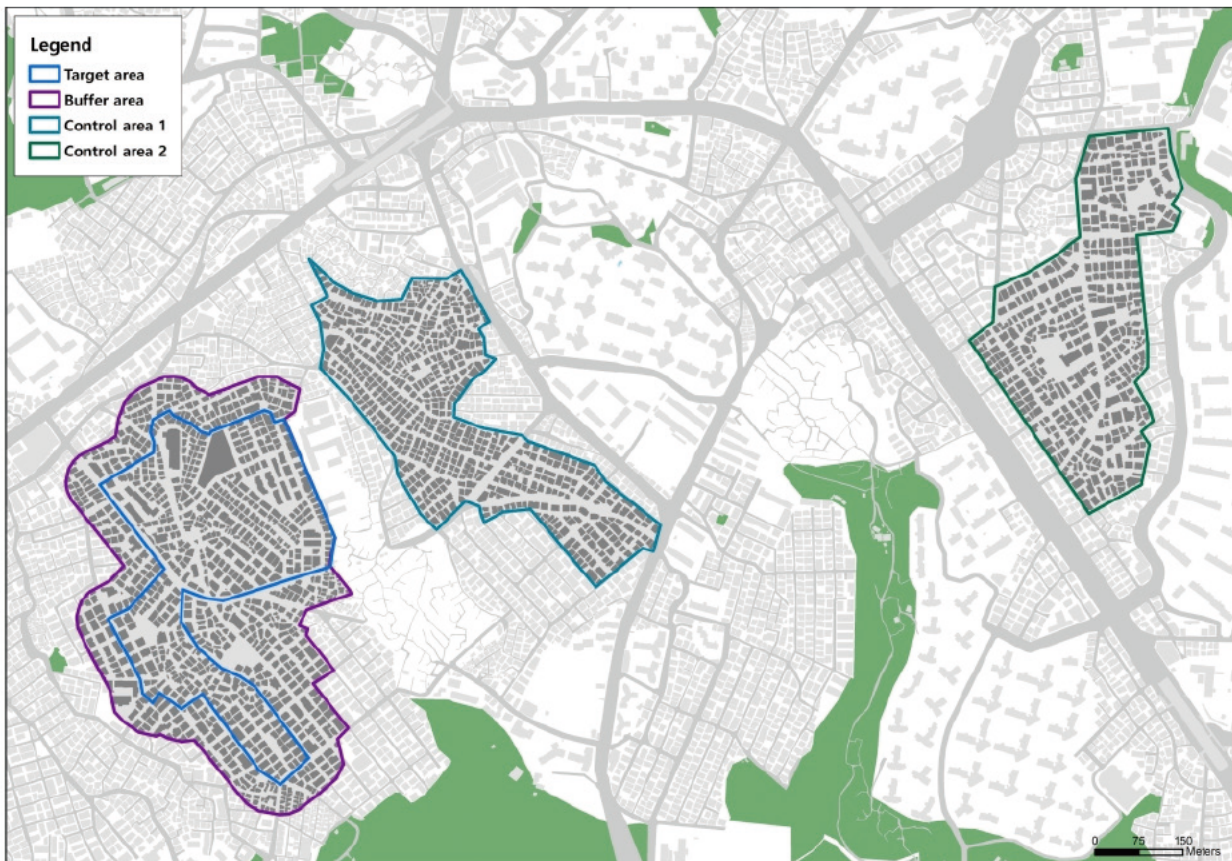
Figure 2. Settings of buffer area and control areas

4. Setting of Hypotheses

The following hypotheses concerning crime displacement or diffusion of benefits were set based on crime counts for burglary and violence, which occurred at higher rates among the five major crimes, in the selected target area, buffer area, control area 1, and control area 2.

Hypothesis 1. The project will have positive effects on the target area and buffer area.
    1.1 The number of crimes in the target area will decrease.
    1.2 The buffer area will see a diffusion of benefits.

Hypothesis 2. Consistent results will be seen for burglary, but not violence.
    2.1 WDQ results will be the same for burglary regardless of control area.
    2.2 WDQ results will be different for violence depending on control area.

Ⅳ. Analysis of Effectiveness of CPTED Project

1. Changes in Crime Rate

The crime count in the target area was reviewed as shown in Table 3 before analyzing crime displacement or diffusion of benefits under the CPTED project. First, the cases of five major crimes in the administrative district containing the target area of Project B increased by 12 cases from 397 in 2015

Table 3. Crime count in study area

		Pre (2015)	Post (2017)	△Crime
Administrative district	Burglary	187	159	-28
	Violence	194	239	45
Target area	Burglary	18	16	-2
	Violence	14	24	10
Buffer area	Burglary	24	19	-5
	Violence	19	22	3
Control area 1	Burglary	13	19	6
	Violence	14	20	6
Control area 2	Burglary	10	16	6
	Violence	6	16	10

Source: National Police Agency (Internal Crime Data)
Note) The crime data is not open to the public

to 409 in 2017. Burglaries decreased by 28 cases (187 cases →159 cases), while violence increased by 45 cases (194 cases →239 cases) in the same period from 2015 to 2017. The change in crime count of burglary and violence in the target area was similar to that of the administrative district. Burglaries decreased by 2 cases (18 cases→16 cases), while violence increased by 10 cases (14 cases→24 cases) in the same period.

This indicates that the CPTED project is more effective in preventing premeditated crimes, which is consistent with past research. The buffer area saw a similar decrease in burglaries (5 cases, 24 cases→19 cases), and an increase in violence (3 cases, 19 cases→22 cases). Unlike the target area and buffer area, control area 1 experienced 12 more cases of burglaries (27 cases →39 cases) and 6 more cases of violence (14 cases→20 cases). Control area 2 showed a similar trend with 6 more cases of burglaries (10 cases→16 cases) and 10 more cases of violence (6 cases→16 cases).

2. WDQ Results

The results of the WDQ analysis for burglary and violence are shown in Table 4. The change in burglary rate in the target area is −0.54 relative to control area 1 and −0.80 relative to control area 2. The values were less than 0 regardless of area, meaning that the change in crime rate in the target area is greater than that of the control area regardless of control area number. Similar results were observed for the change in crime rate in the buffer area relative to control area. The change in burglary rate in the buffer area was −0.85 relative to control area 1 and -1.21 relative to control area 2, which are larger than values obtained for the target area. This is reflected by the WDQ values being greater than 1 for both

Table 4. Result of WDQ

Category		△T	△B	WDQ
Burglary	C1	-0.54	-0.85	1.56
	C2	-0.80	-1.21	1.52
Violence	C1	0.20	-0.26	-1.29
	C2	-0.83	-1.79	2.15
Interpretation				
Burglary	- Diffusion effect>Direct effect - Positive net effect of the program			
Violence	- Unknown			

control area. In other words, the CPTED project can be seen as having greater diffusion of benefits than a direct effect, which translates to a positive net effect.

For violence, WDQ values were different depending on control area. This is consistent with the findings of Park et al. (2011) in their study on crime displacement by WDQ analysis.

The change in crime rate was greater than 0 for both the target area and buffer area relative to control area 1. This shows that there was a higher number of crimes in the target area relative to the control area after project implementation. On the other hand, the change in the buffer area was smaller than 0 at −0.26, meaning that there was a smaller number of crimes in the buffer area relative to the control area after project implementation. Theoretically, measuring the crime displacement effect is meaningless if the target area has seen an increase in crime rate. The change in crime rate of the target area relative to control area 2, which is represented by the denominator in WDQ, was smaller than 0 (-0.83). The change in crime rate of the buffer area was −1.79, which is greater than that of the target area. As a result, the WDQ was larger than 1 at 2.15. While violence increased in the target area, the increase was smaller than in the control area. Since crime count decreased in the buffer area, the CPTED project can be seen as having a positive net effect. However, due to the different WDQ values for control area 1 and control area 2, crime displacement and diffusion of benefits cannot be measured.

V. Conclusion

This study applied the concept of WDQ to analyze the effectiveness of CPTED projects in preventing burglary and violence. The analysis showed that Project B achieved a decrease in burglaries, and there was a diffusion of benefits to the buffer area. The WDQ analysis gave the same results for burglary regardless of control area, but an increase in violence was observed. The results were insufficient to determine whether crime displacement and diffusion of benefits had occurred.

While the above can have several interpretations, a possible explanation based on past research is that crime prevention techniques used in the project were mostly focused on installing security devices to prevent break-ins and facilitating natural surveillance by improving the environment.

Access control and surveillance enforcement are effective in preventing break-ins, and the project was effective in reducing burglary but not violence since break-ins are synchronized only with the former.

The preception of perpetrators that crime-causing factors were removed by the CPTED project is likely to have influenced surrounding areas. Crime prevention activities in areas with high crime rates and the maintenance of surrounding areas gave perpetrators the impression that such areas were closely managed, and this contributed to the spreading of diffusion of benefits.

The significance of this study lies in demonstrating the effectiveness of the CPTED project in reducing burglary and having influence over surrounding areas. However, one limitation is that the target area of the CPTED project is too small to analyze changes in crime rate for other crime types such as murder, robbery, and sexual violence. WDQ results can verify the extent to which crime displacement and diffusion of benefits have occurred, but are less precise when it comes to the sustainability of outcomes and the net effect of the project.

The above weaknesses can be addressed through follow-up research on statistical tools and methodologies that are useful in analyzing the effectiveness of CPTED projects.

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