Effectiveness of Crime Prevention Through Environmental Design (CPTED) in Reducing Robberies

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Objective: The objective of this study was to determine the effectiveness of the Crime Prevention Through Environmental Design (CPTED) approach in reducing robberies.

Methods: CPTED evaluations were obtained through a comprehensive search mechanism. Two sets of inclusion criteria were used: 16 primary studies evaluated a CPTED program with a comparison period; 12 secondary studies presented some evidence of CPTED effects but were not required to have the same level of scientific rigor. The percentage change in pre- and post-intervention events was the outcome examined. Studies were stratified by programs implementing multiple components, a single component, and through ordinances.

Main Results: All primary multiple-component CPTED programs experienced a percentage change in robberies ranging from −84% to −30%. Single-component program effects ranged from −83% to +91%, and ordinances ranged from −65% to +130%. Secondary studies reported robbery changes ranging between −92% and +7.6%. Robbery reductions were larger for interventions comprising basic store design, cash control, and training components compared to those including equipment systems. No associations were found between robbery decreases and either the follow-up period or the number of program components. Studies examining nonfatal injuries found a median pre-post change of −61%; those examining homicides found changes ranging from 0% to +11%.

Conclusions: The broad nature of the CPTED approach allows its adaptation to any setting, and results indicate that it is an effective approach to reducing robbery. However, most interventions were not evaluated independently of other factors contributing to robbery risk. More research is needed on individual components and effects in various business settings.

Medical Subject Headings (MeSH): intervention studies, occupational health safety, environment design, crime, violence, workplace, review literature (Am J Prev Med 2000;18(4S):99–115)

Introduction

In the last several years, much has been learned about the incidence, risk factors, and the industries and occupations at risk for workplace violence. Workplace violence accounts for approximately 20% of workplace deaths and ranks second after transportation as the leading cause of workplace death each year.[1] The annual number of nonfatal assaults in the workplace has been estimated by the National Crime Victimization Survey to be as high as 2 million workers.[2] The highest rates of workplace homicide are in the industries of transportation, retail, services, and security, and in the workplaces of taxicabs, liquor stores, gas stations, protective agencies, and restaurants/bars.[3,4] Industries at high risk of nonfatal events include health care, social service, law enforcement, and education.

Approximately 80% of workplace homicides and as many as 60% of nonfatal assaults occur in the course of a robbery or other criminal act.[1,5] These events are concentrated in the service and retail industries, and research addressing these events has been primarily focused on convenience stores. Prevention efforts began in the 1970s in response to a rising number of robberies. Although the primary goal of these programs was to reduce the risk of robbery, they also included approaches that focused directly on preventing injury to workers, such as training employees in how to respond during a robbery.

A basic tenet for robbery prevention programs is Jeffery's Crime Prevention Through Environmental Design (CPTED) model.[6] This model recognizes that much of the risk for robbery can be modified through

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Table 1. Primary CPTED components included in each study

	Multiple component				Single component							
Author	**Crow**	**Roesch**	**SCIPRC**	**Cahn**	**Figlio**	**Schnelle**	**Whitcomb**	**Crow**	**Clarke**	**Figlio**	**Figlio**	**Figlio**
Reference number	**7**	**21**	**23**	**25**	**15**	**22**	**26**	**13**	**24**	**16**	**17**	**18**
Study descriptor					**Two-clerk**	**Alarm**	**Alarm/ camera**	**Alarm**	**Cash**	**CCITV**	**Cameras**	**Guards**
CPTED COMPONENT												
Store design/environment												
Lighting	X	X	X	X								
Visibility	X	X	X	X								
Cleanliness	X	X	X	X								
Escape route	X		X									
Location of register				X								
Signage	X	X	X					X	X			
Training/staffing												
Employee training	X	X	X	X								
Cash handling	X	X	X	X					X			
Time-release or drop safe	X		X						X			
Number of clerks					X							
Business hours/functioning												
Equipment												
Alarms				X		X	X[a]	X[a]				
Cameras				X			X	X		X	X	
Monitors										X	X	
Guards				X								X
Bars/grilles				X								
Door locks				X								
Bullet-resistant barrier												
Total components	8	6	8	11	1	1	2	3	3	2	2	1

[a]Alarm is a paging system to police via a project director.
[b]Also included as a single-component study because able to generate a statistic following addition of two-clerk provision.
[c]Indicates that the inclusion of all factors was not required.

controlling the business environment. The CPTED model identifies four elements for potential modification: natural surveillance, access control, territoriality, and activity support. Natural surveillance includes internal and external lighting, visibility into the store, and placement of the cash register. Access control refers to the number of entrances, door type and placement, and design of the internal environment to control customer movement. The principle of territoriality includes the location of the store within the community, traffic flow surrounding the store, signs and advertisements for the store, and design issues that empower the employees over the customers (such as bulletproof barriers). Activity support encompasses any activity that increases the presence of legitimate customers and encourages increased business and good customer behavior. Although many programs based on CPTED principles have been developed, few have incorporated all defined components.

CPTED-based programs have been developed and recommended nationwide to businesses at high risk of robbery and violence. In the mid-1980s, the National Association of Convenience Stores distributed to its member stores a robbery and violence prevention program based on the work of Crow and Bull.[7] More recently, the Occupational Safety and Health Administration (OSHA) released "Recommendations for Workplace Violence Prevention Programs in Late-Night Retail Establishments," which includes many CPTED components. These CPTED programs were developed from a limited number of studies that have not been empirically synthesized.

A comprehensive set of published and unpublished studies evaluating CPTED interventions on the risk of robbery and subsequent injury have been reviewed to describe the effectiveness of CPTED programs in reducing robberies. Only programs designed to prevent robberies and related injury in a workplace setting, which met methodologic criteria and contained sufficiently detailed data, were included.

Methods

Search Strategy

Published studies were obtained through a search strategy described in detail by Beahler et al.[8] in this supplement. Using a systematic approach to literature searches, relevant studies from peer-reviewed journals, technical and government reports, and unpublished reports were retrieved. Due to the multidisciplinary nature of the research question, the search was conducted across disciplines and included many different databases and collections of literature. The following 17 databases were included in the search:

- Biomedical: MEDLINE, EMBASE, Nursing and Allied Health
- Occupational health: NIOSHTIC, TRIS
- Business: ABI Inform
- Criminal justice and social science: Criminal Justice Periodicals Index, Sociofile, ERIC, PsycINFO

Table 1 (*Continued*)

Ordinance					
Clifton 12 1986 Ord (Gain, FL)	**Clifton 12 1987 Ord (Gain, FL)**	**Hunter 19 1986/87 Ord (Tall, FL)**	**Hunter 20 1986/87 Ord (Jack, FL)**	**Hunter 20 1990 Ord (FL state)**	**Erickson 14 1992 Ord (FL state)**
X	X	X	X		
X	X	X	X	X	X
X	X	X			
X	X	X		X	X
X	X	X	X	X	X
X	X	X	X	X	X
X	X	X		X	X
	X[b]	X			X[c]
					X[c]
				X	X
X	X	X		X	X
					X[c]
					X[c]
8	9	9	4	7	8

- Government: NTIS, PAIS
- General: Books in Print, Dissertation Abstracts, Expanded Academic Index
- Agricultural: Agris International, Agricola

In addition to database searching, other sources were identified by checking references and consulting with experts in the field. Additional unpublished literature (e.g., police documents) or articles not available through academic search strategies (e.g., National Association of Convenience Stores studies) were requested directly from the originating agency.

Inclusion Criteria

Two sets of inclusion criteria were developed to maximize inclusion of available data. Primary studies were required to have evaluated a clearly delineated CPTED program, component, or ordinance; included either a comparison period or population; clearly identified the intervention period; measured the risk of robbery; and included well-described outcome measures or enough raw data to generate a summary measure. Secondary studies were also required to have evaluated a CPTED program, but were required to present only a basic outcome or trend statistic without the detail of describing the CPTED intervention or the comparison time period or population. Studies that repeated statistical findings presented more thoroughly in other documents were not included in addition to the primary source. Studies were excluded if presented in a language other than English or if not specific to a retail setting (e.g., parking lots, residences, school districts, pedestrians). Some documents that may have evaluated a CPTED intervention were not reviewed for inclusion because they could not be located even by the primary agency.[9–11]

Included Studies

A total of 26 studies were included in this review, 16 meeting primary[7,12–26] and 12 meeting secondary inclusion criteria.[12,26–36] Two primary studies included results additional to the primary study, and these were included as secondary studies.[12,26] Eighteen (69%) of the primary and secondary studies have not been subjected to peer review because they were either printed in non-peer reviewed journals (n=3)[27,31,32] or generated for an agency (n=15).[7,12–18,23,25,26,28,34–36] All studies were available to the public except one manuscript in progress.[23]

Fourteen of the 16 primary studies utilized a pre-post intervention study design, where either the intervention group served as its own control (one-group) (n=8)[12,14,16–20,25] or a separate group was selected to act as the control (n=6).[13,15,22–24,26] Only one randomized experimental study was available for inclusion in this review.[7] A quasi-experimental design was used in one of the pre-post studies because the CPTED intervention could not be randomized into intervention and control groups due to limitations in the field setting.[13] Another study utilized a repeated follow-up design over 4.5 years.[19]

Two of the primary studies were retrieved from review articles that included crude outcome data over five one-year intervals,[14,20] and one study used a post-intervention, cross-sectional design.[21] All secondary studies utilized a pre-post intervention, one-group design.

Study Populations

Convenience stores were the study population in 11[7,12–21] of the 16 primary studies. Other populations represented were liquor

Table 2. Characteristics and results of primary intervention studies

Reference	Study design and population	Intervention	Outcome	Results	Comments
Crow and Bull (1975)[7]	Randomized community intervention; 120 Southland Corporation convenience stores, Southern CA; 60 experimental and 60 control stores. Study period: 01/01/75–08/31/75	Multiple component Program: Low- to no-cost procedures for preventing robberies and violence Implementation: Franchise owner and employee training; store modifications discussed with franchise owner Implemented: Dec 1974–second week of Jan 1975	Armed robbery frequency; average dollar loss per robbery	(1) 17.5% robbery difference between experimental and control stores. 30% difference assuming robbery occurrence in controls would have been same as that in experimental group had experimental group not received intervention. (2) No difference in average dollar loss between experimental and control stores	Reduction in robbery incidence, particularly in previously robbed stores and those rated attractive to robbers. Authors note that costs and need for development of prevention techniques must be considered before widespread adoption Compliance: 79% of employees trained. All stores posted decals, most cleared window obstructions. Higher compliance in stores implementing low-cost procedures. Few stores implemented expensive recommendations
Cahn and Tien (1983)[25]	Pre-post intervention, one-group; 695 small retail, service and professional establishments in Denver, Long Beach and St. Louis Study period: Pre-intervention, 10/1/79–9/30/80; Post-intervention, 4/1/81–3/31/82	Multiple component Program: Commercial Security Field Test survey used to identify robbery and burglary vulnerabilities in business operations, physical characteristics and cash handling Implementation: Crime prevention and community relations officers of local police departments recommended security changes to business operators Recommendations: 10/1/80–3/31/81	Robbery rates per business per year	(1) 30% reduction in pre-post robbery rates with percentage change reductions ranging between −45.8% and 16.1% across cities. (2) Security surveys resulted in 11.9% reduction of burglary rates, using a split-area research, two-group design. (3) Decrease in assaults and relatively little change in homicides observed on an ecologic level	Authors indicate that results are encouraging although not credible due to uncontrolled biases and low robbery occurrence Compliance: Overall compliance rate across cities was 59.1%; 24.1% of establishments had 100% compliance, 13% had zero compliance. Lower compliance with physical security recommendations than with procedural (e.g., training employees)
Roesch and Winterdyk (1986)[21]	Cross-sectional; 103 convenience stores, Vancouver, Canada Study period: Interviews conducted 1981–1985 (est.)	Multiple component Program: Robbery Information Package (RIP) modeled after Southland Corporation program Implementation: Store operators attended seminar conducted by police; RIP given to attendants Implemented: 1981+ (est.)	Number of stores robbed; average dollar loss per robbery Unit of analysis = store	(1) RIP businesses less likely to be robbed than non-RIP businesses (OR=0.7, 95% CI=(0.3, 1.6), p=0.3647). (2) Participating stores lost average of $100 per robbery, compared to average loss of $130 among nonparticipating businesses.	Authors recommend exterior lighting, keeping windows clear of obstructions, and maintaining low shelf heights be mandated into construction of new stores. Financial institutions, fast food and gas stations expressed interest in RIP since study Compliance: Less than 20% program compliance

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Reference	Study design and population	Intervention	Outcome	Results	Comments
SCIPRC (1997)[23]	Pre-post intervention, two-group; 9 enrolled and 13 non-enrolled liquor stores, Santa Monica, CA (pilot study) Study periods: Pre-intervention 01/01/92–08/30/96; Post-intervention 09/01/96–08/30/98	Multiple component Program: Robbery and violence prevention package modeled after Crow and Bull (1975) program Implementation: Store operator trained by Cal/OSHA Consultation representative; specific store recommendations given to each operator Implemented: Jul–Aug 1996	Robbery rates per store per year	(1) 84% post-intervention robbery reduction, comparing enrolled and nonenrolled businesses. (2) Enrolled businesses experienced 81% pre-post reduction in robberies; nonenrolled businesses experienced 26.5% increase. (3) 86% pre-post reduction in injuries among enrolled businesses; 51% reduction in nonenrolled businesses	Intervention appears effective, although statistics based on small sample size and few robberies. Extraneous factors not controlled Compliance: Less than 40% compliance with recommendations. More compliance with employee training, cash handling, and use of safety decals than with lighting and visibility
Figlio and Aurand (1991)[15]	Pre-post intervention, two-group; 230 two-clerk convenience stores, VA; 346 one-clerk stores, U.S. Study period: Pre-intervention, mid-1985 to mid-1988 Post-intervention, mid-1988 to mid-1991	Single component Program: Policy requiring convenience stores in Tidewater region of VA to employ two clerks 11pm–7am ("third shift") Implementation: Implemented ≈Mar 1, 1988 (no other details provided)	Third shift robbery rates per store per year	(1) Experimental group experienced 2.4% reduction in robberies; controls experienced 18.3% increase. (2) If no previous robberies, then one-clerk stores were robbed at a rate 0.74 times that of two-clerk stores. If previous robberies, one-clerk stores were robbed at rates 1.77 to 3.6 times that of the two-clerk stores	Stores with no robberies either before or after adoption of two-clerk policy were most predominant, regardless of clerk number on duty. Effect of two clerks on robbery rates most pronounced in stores robbed several times in past. Conclusion based on small number of stores with high robbery rates Compliance: Not reported
Schnelle et al. (1979)[22]	Pre-post intervention, two-group[a]; 48 stores "with history of robbery": 20 in one police zone (Z1) and 28 in another (Z2), Nashville, TN; other areas of Nashville used for comparison Study periods: Pre-intervention, 03/01/75–02/29/76; Post-intervention, Z1, 03/01/76–08/30/76; Post-intervention, Z2, 09/01/76–07/31/77; Follow-up, 08/01/77–12/31/77	Single component Program: Armed robbery alarm system with police patrol response Implementation: Installation Jul 1976–Dec 1977 (no other details provided)	Average number of armed robberies per month	(1) Z1: stores experienced 212.5% increase in pre-post robbery rate; Z2: stores experienced 7% decrease. (2) 91% average increase in annual robberies between stores in Z1 and Z2. (3) After intervention removal, robberies declined almost 80%, suggesting late effects of system. (4) Stores in Z1 and Z2 experienced 77% decrease in robberies between post-intervention and follow-up periods. (5) On-scene arrests made in average of 40% of all robbery incidents in Z1 and Z2. (6) Program was not cost effective	Although on-scene apprehensions of armed robbers increased, systems did not deter robbery incidents. Robbery displacement effects not found Compliance: Not reported

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Reference	Study design and population	Intervention	Outcome	Results	Comments
Whitcomb (1979)[26]	Pre-post intervention, two-group; commercial establishments, Seattle, WA; noncommercial setting was comparison group, Seattle, Ecologic Study periods: Pre-intervention, Aug 1975–Jun 30, 1976; Post-intervention, Aug 76–Jun 30, 1977	Single component Program: Hidden surveillance cameras Implementation: Concealed camera installation and employee training in 75 randomly selected convenience stores, drug stores, restaurants and other retail establishments Installation Jun 1976	Robbery rates per month	(1) 38% reduction in monthly commercial robbery rates; 6.7% increase in noncommercial robberies. Difference in commercial and noncommercial changes was significant ($p<0.001$). (2) As number of arrests increased, monthly commercial robbery decreased ($r=-0.63$, $p<0.05$). (3) Higher clearance rates for arrests and larger proportion of convictions reported in 75 experimental businesses, compared to 75 controls. (4) One post-intervention employee injury in experimental businesses and three in control businesses. (5) Hidden cameras cost effective	Increased apprehension rates have a greater effect on commercial robbery rates than the direct deterrent effect of the cameras. Some deterrent effect on employee theft and false reporting of robberies Compliance: Camera units inspected twice a month for malfunctions and employee mistreatment. Project director on-duty 24 hours per day for immediate photo development after a robbery and for distribution of photo to police
Crow and Erickson (1984)[13]	Nonrandomized community intervention, two-group; 55 Southland Corporation test sites, New Orleans and Columbus; 53 Southland comparison stores, Baton Rouge and Dayton Study periods: Pre-intervention, 10/01/79–09/30/80; Post-intervention (1), 10/01/80–09/30/81; Post-intervention (2), 10/01/81–09/30/82	Single component Program: Dictograph cameras and alarm Implementation: Camera installation and employee training. Public awareness of cameras and alarms Installation: Not specifically stated	Mean change in robberies	(1) Test stores experienced a pre-post(1) mean robbery change of −0.855 and control stores experienced a d-0.283 change (Dif=−0.572, 95% CI=−0.424, 1.568). Difference in mean changes could have occurred by chance (F=1.267, $p=0.2629$). (2) No statistically significant difference between pre-post (2) robberies in test and control sites (statistics not provided)	Authors conclude that cameras and alarms did not deter robbery but that robbery reductions were due to existing robbery and violence prevention programs. Authors feel that cameras and alarms give employees false sense of security and influence neglect of other prevention procedures Compliance: Follow-up visits conducted to ensure proper equipment functioning and employee training
Clarke and McGrath (1990)[24]	Pre-post intervention, two-group[a]; 429 (average) betting shops in Victoria, Australia; banks used for comparison, Victoria Study period: Pre-intervention, 1979–1987; Post-intervention, 1988	Single component Program: Cash reduction measures (time-lock cash box and safes, $500 cash limit) Implementation: Time-lock cash box, late 1980; Cash limit, late 1981; Time-lock safes, late 1987	Robbery number per year, 1979–1989	(1) Betting shops experienced pre-post robbery reduction of 38%; banks experienced 19% decrease. (2) Average dollar amount stolen generally declined following introduction of measures. (3) Time-locking cash boxes were cost effective	Authors conclude that cash-handling measures contributed to robbery reductions over a $10\frac{1}{2}$-year period. No statistical controls introduced in evaluation Compliance: Not reported

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Table 2. Characteristics and results of primary intervention studies

Reference	Study design and population	Intervention	Outcome	Results	Comments
Figlio and Aurand (1991)[16]	Pre-post intervention, one-group; 189 convenience stores, U.S. Study period: Pre-intervention, one year before system installation; Post-intervention, two one-year periods after system installation	Single component Program: Installation of closed circuit interactive television (CCITV) Implementation: CCITV installation based on presence of system (from survey response) Installation: Specific time periods not provided	Robbery rates per store per year	(1) 23% decrease in robbery rates between pre-post time periods; 31% decrease during first year of installation and 15% decrease during second year. (2) Difference found in mean rates between baseline (1.58) and first year (1.09), $p=0.02$; no difference between baseline and second year (1.34), $p=0.18$	Authors conclude that CCITV systems have marginal effect on robbery reduction, particularly within first year of installation. The effect over time diminishes Compliance: Not reported
Figlio and Aurand (1991)[17]	Pre-post intervention, one-group; 81 stores within one convenience store company, U.S. Study period: Pre-intervention, one year prior to installation; Post-intervention, one year after installation	Single component Program: Installation of color cameras and color monitors in area where would-be robbers can view themselves Implementation: Installation based on presence of the hardware (from survey response) Installation: Specific time periods not provided	Robbery rates per store per year	Decrease from 1.27 robberies per store per year to 0.59 after implementation. Difference in average robbery rates was significant using t-test ($p=0.001$). 54% one-year reduction in robberies	Authors thought results encouraging, but preliminary because of short follow-up period. They suggest the system be tracked over time to obtain further statistics Compliance: Not reported
Figlio and Aurand (1991)[18]	Pre-post intervention, one-group; three stores within one convenience store company, U.S. Study period: Pre-intervention, one year prior to hiring guards; Post-intervention, one year after hiring guards	Single component Program: Hiring of guards. No specifics on type of guards or extent of their duties were provided Implementation: Implementation based on the hiring of guards (from survey response) Implementation: Specific time periods not provided	Robbery rates per store per year	83% reduction in average robbery rates. Before hiring guards, stores experienced 4.0 average robbery rate; after hire, average rate dropped to 0.67	Results were based on data from three stores, where two stores experienced no robberies before or after guard hire Compliance: Not reported

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Table 2. Characteristics and results of primary intervention studies

Reference	Study design and population	Intervention	Outcome	Results	Comments
Clifton (1987)	Pre-post intervention, one-group; convenience stores, Gainesville, FL Study periods: 1986 Ordinance: Pre-post intervention, 240 days 1987 Ordinance: (1) Pre-post intervention, 04/02–10/26, 1986 and 1987, respectively, (2) Pre-post intervention, one year, 1986 and 1987, respectively	Ordinance 1986 Ordinance: Gainesville Convenience Store Ordinance. Adopted Jul 14, 1986 1987 Ordinance: Gainesville Convenience Store Ordinance with two-clerk provision. Adopted Feb 2, 1987. Time to hire and train new employees. Adopted Apr 2, 1987 Implementation: Convenience store industry required to adopt a robbery prevention/ reduction plan	Robbery number	1986: Convenience store robberies increased 130% 1987: (1) 64% decrease in convenience store robbery between Feb 2 and Oct 26, 1987. 65% reduction between Apr 2 and Oct 26, 1987. (2) 75% reduction in robberies between 8 pm and 4 am in 1987	1986: Convenience store industry unable to implement plan to reduce robberies 50%. Thus, two-clerk provision added 1987: Robberies decreased after adoption of two-clerk provision. Author acknowledges limited significance of results due to short study period, but reports that results are encouraging to Gainesville community and law enforcement Compliance: Not reported
Hunter and Jeffery[20] (1992)	Pre-post intervention, one-group; convenience stores, FL (Gainesville, Jacksonville, statewide) Study periods: Jacksonville: Pre-ordinances, 1986–1987; Post-ordinances, 1989 Florida: Pre-ordinance, 1989; Post-ordinance, 1990	Ordinance Jacksonville: Voluntary ordinance recommended stores to reduce cash, increase lighting and visibility, and train employees. Adopted 1987/1988 (est.) Florida state: Convenience Store Security Act (mandated). Adopted 1990 Implementation: Not provided	Robbery number per year, 1986–1990 (excl. 1988) Data source: Florida Dept. of Law Enforcement	Jacksonville: Ordinance resulted in 15% reduction of robberies by the end of 1989. Robberies decreased 26% after statewide act adopted Florida state: Robberies decreased nearly 12% after Security Act adopted	Authors note that convenience store robberies decreased following state-mandated strategies while violent crimes in Florida rose; mandated procedures work in Florida even as nation experiences increases in convenience store robberies; Florida experience may not be beneficial in other parts of the U.S. but speculate that NACS will encourage members to implement Florida strategies Compliance: Not reported
Hunter (1990)[19,b]	Repeated follow-up, one-group; 25 convenience stores, Tallahassee, FL Study periods: 1987 study, 01/01/81– 07/01/85; 1990 study, 07/01/85–01/01/90	Ordinance Program: Gainesville Convenience Store Ordinances adopted in 1986 and 1987 (indirectly) Implementation: Same as Clifton (1987)[12]	Robbery number per store	(1) Robberies decreased 24% across all stores, range = (100%, 300%) (2) Ten environmental factors found to significantly affect robbery occurrence in 1987 study, compared to 1990 study with only five significant variables	Author feels that most stores improved their robbery deterrence strategies so as to avoid passage of a restrictive ordinance like that imposed in Gainesville Compliance: Not reported
Erickson (1998)[14]	Pre-post intervention, one-group; convenience stores, FL Study periods: Pre-ordinance, 1991–1992; Post-ordinance, 1993–1995	Ordinance Program: 1992 Florida Convenience Business Security Act. Effective Dec 31, 1992 Implementation: Not provided	Number of robberies and homicides per year, 1991–1995	Robberies decreased nearly 15% one year after adoption of the Security Act; no change in the number of homicides. Three years after adoption, robberies decreased 23% and homicides increased 11%	While the number of robberies decreased after adoption of the Act, homicides increased. Author speculates that employing two clerks increases the likelihood of being killed while at work *Compliance: Not reported*

[a]Distribution of robberies observed in comparison commercial areas (Schnelle, et al.) and businesses (Clarke, McGrath) but not statistically used as a control group for analysis.
[b]Author does not directly evaluate an intervention although the change in robbery prevention efforts seen over time may be attributable to the Gainesville ordinance.

stores,[23] "stores with a history of robbery,"[22] small retail and service establishments,[25,26] and betting shops.[24] Fourteen of the 16 studies were conducted among U.S. businesses,[7,12–20,22,23,25,26] one in businesses in Vancouver, Canada,[21] and another in businesses in Victoria, Australia.[24] Five secondary studies reported statistics from convenience store populations,[12,28,30,32,34] although there was also representation from a variety of retail establishments (n= 6)[26,28,31,33,35,36] and restaurants (n=2).[27,29] All secondary studies were performed using U.S. businesses.

Intervention Types

Three types of CPTED intervention approaches were examined among the primary studies: multiple components,[7,21,23,25] a single component,[13,15–18,22,24,26] or an ordinance.[12,14,19,20] Evaluations of multiple- or single-component programs[12,26–30,32,34–36] and ordinances[12,28,34] or regulations[31,33] were included in secondary studies.

The majority of packaged, multiple intervention programs emphasized the implementation of low- to no-cost recommendations from the CPTED model (Table 1). These recommendations comprise a "basic intervention program" and include keeping a minimum amount of cash in the register, ensuring good visibility into and outside of the business, maintaining good interior and exterior lighting, limiting access and escape routes, and training employees in how to respond to a robbery.[37] Environmental factors examined in the single-component intervention studies included implementing cash handling procedures,[24] adding a second clerk during late-night business hours,[15] hiring guards,[18] or installing an alarm system,[13,22,26] closed circuit interactive television (CCITV),[16] or video cameras with a monitor[17] (Table 1).

The most recognized and cited ordinances have been developed in the state of Florida. In July 1986, the Gainesville City Commission adopted the Gainesville Convenience Store Ordinance which required convenience stores to have an unobstructed view of the cash register, an externally visible sales area, cash handling and safe access signage, parking lot lighting, security cameras, and mandatory robbery prevention training for employees working between 8 pm and 4 am[12] (Table 1). In February 1987, a two-clerk provision was added.[12]

In 1990, the Florida legislature enacted the Convenience Store Security Act. The Act required local governments to mandate convenience stores open between 10 pm and 5 am, which experienced a serious violent event, to implement measures similar to the 1986 Gainesville ordinance, in addition to: posting a height-indicator strip to the internal door frame of the business, training *all* employees, limiting available cash between the hours of 9 pm and 6 am, restraining from window tinting, installing a silent alarm with dispatch to local law enforcement, and installing a safe (or other cash management device).[38]

The Convenience Business Security Act, enacted by the Florida legislature on December 31, 1992, required all convenience stores to implement the 1990 Security Act. Additionally, if a serious violent event had occurred in a business since July 1989, the store operator was required to institute one of the following procedures between the hours of 11 pm and 5 am: employ at least two clerks, utilize a bullet-resistant enclosure, hire a security guard, operate the business through a pass-through window, or close the business.[38]

Outcome Measures

Primary studies selected for review had to evaluate the effects of a prevention program on robbery or robbery-related injury. A standardized definition of robbery used by the Federal Bureau of Investigation Uniform Crime Report System is the "taking or attempting to take anything of value from the care, custody or control of a person or persons by force or threat of force or violence and/or by putting the victim in fear."[39] Studies measuring other types of outcomes, such as apprehension rates, dollar loss due to robbery, and cost-benefit/effectiveness were included only if a primary outcome measure was also evaluated. Secondary studies had to include a measure of robbery or a broader measure of assault or violence. Studies enumerating the risk of events without evaluating a CPTED prevention program were excluded from this review.

Statistical Analysis

An overall summary effect measure across primary studies could not be estimated using meta-analytic methods due to the lack of homogeneity across studies and the lack of available detail in the data presented. Studies were grouped and compared by type of intervention. The percentage change in the measured outcome between pre- and post-intervention time periods was constructed for the intervention group for each study. To compare studies using this statistic, neither control/comparison populations from two-group designs were used nor were studies not permitting calculation of the pre-post measure. Because results from secondary studies were not conducive to constructing a summary measure, published findings were re-presented and summarized.

Results

Results are summarized in Table 2 (primary studies)[7,12–15,19–26] and Table 3 (secondary studies).[12,26–36]

Methodologic Quality of Studies

A form of experimental study design was used by two studies, including one which randomized the intervention[7] and one which did not.[13] Crow and Erickson[13] had rigorous follow-up to ensure high compliance with the program. Crow and Bull[7] had follow-up with high compliance of low-cost components. In Crow and Bull,[7] a matching procedure was used to identify two groups of businesses, and then these two groups were randomized rather than individual stores. Thus, any bias in the selection of the two groups was not controlled through the randomization process.

Half of the primary studies utilized a pre-post intervention without a control group.[12,14,16–20,25] In these one-group designs, the intervention could not be evaluated independently of the effects of changes in extraneous risk factors for robbery such as store closings, simultaneous prevention activities or general crime trends. In studies that used a separate control popula-

Table 3. Characteristics and results of secondary intervention studies (outcome is robbery unless otherwise stated)

State or organization	Study population	Intervention	Results[a] (percentage change[b] or trend)
Florida	Convenience stores and gas stations in Coral Springs (Clifton, 1987)[12,c]	City convenience store ordinance. Provisions include those of Kent, OH and option of two-clerk or one-clerk in self-contained booth. Implemented 1983	No robberies
	Convenience stores in Brevard county (Chambers, 1988)[34]	Resolution requiring convenience stores to implement similar security measures as Gainesville (excluding two-clerk provision). Adopted January, 1987	−59%
	Convenience stores in Escambia county (Chambers, 1988)[34]	Ordinance requiring convenience stores to implement similar security measures as Gainesville (excluding two-clerk provision). Enacted May 2, 1987	−34%
	Conoco Oil Company locations (Butterworth, 1991)	Comprehensive safety and robbery program including installation of impact resistant safety shields but not multiple clerks. Implemented 1981	−92%; no homicides
	Convenience stores in Hillsborough county (Butterworth, 1991)[28]	Both mandatory and voluntary security provisions, including two clerks. Implemented 1988	Steady decrease
	Convenience stores in Sanford (Butterworth, 1991)[28]	Two-clerk ordinance. Adopted December 1989	−60%
	Convenience stores in Pierson (Butterworth, 1991)[28]	Two-clerk ordinance. Adopted 1988 (estimate)	No robberies
	Convenience stores in Citrus county (Butterworth, 1991)[28]	Local ordinance, which includes two-clerk provision. Implementation date not provided	−82%
	"At-risk businesses" in Vero Beach (Butterworth, 1991)[28]	Ordinance requiring stores to use two clerks, safety enclosures or audio/visual monitoring system. Implemented August 1988	Two robberies
Ohio	Convenience stores in Brooke Park, Berea, Lorraine, Akton and Kent (Clifton, 1987)[12,c]	City convenience store ordinances. Provisions include employee training, cash handling, visibility and lighting. Kent: further includes two-clerk requirement. Implemented 1982	Range=(−30.1, +7.6%); Kent: −74%
Oregon	Commercial establishments in Portland (Wallis, 1980)[35]	Law enforcement recommendations designed to change physical environment and increase citizen participation. Implemented February 1976	−17%
United States	Convenience stores, gas stations and other storefront establishments (Eliot et al., 1976)[3]	Early-warning robbery reduction alarm system and police response. Implemented prior to April 1975	Range=(−80%, −65%)
	Convenience stores, liquor stores, fast food outlets, and motels (Whitcomb, 1979)[26,c]	Hidden surveillance cameras. Implemented between 1970 and 1976	Range=(−73%, −45%)
	Little General convenience stores in southeastern U.S. (Chambers, 1988)[34]	Employee training program borrowing preventive measures from Crow and Bull (1975).[7] Full implementation 1980	−49%

Continued on next page

tion,[13,15,21–24,26] the control group was selected by voluntary nonparticipation in three studies,[21–23] by absence of the intervention in three studies,[15,24,26] and by sampling of stores with similar environmental characteristics as intervention stores in two studies.[7,13] Studies with a control group were able to assess temporal changes in baseline risk. In the studies using nonparticipating stores as controls, it is expected that predisposing factors for robbery will influence selection differentially for control and intervention groups.

Many of the studies evaluated raw numbers of events before and after the program,[7,12,14,19,20,24] and one

Table 3. Characteristics and results of secondary intervention studies (outcome is robbery unless otherwise stated)

State or organization	Study population	Intervention	Results[a] (percentage change[b] or trend)
Roy Rogers/ Hardees Restaurants	1100 company-owned Hardees and Roy Rogers restaurants east of the Rockies (Anfuso, 1994)[27]	Comprehensive violence prevention program including training strategies, such as cash handling and control of back doors. (Not exclusive to violence resulting from criminal activity.) Implemented 1990	−48%
	Roy Rogers restaurants in Philadelphia (D'Addario, 1996)[29]	Violence prevention and awareness training program, including employee training, installation of alarms and closed-circuit television cameras. Implemented 1993	−84%
Washington	Retail establishments operating between 11 pm and 6 am, with the exception of restaurants, hotels, taverns and lodging facilities (Nelson and Kaufman, 1996)[33]	"Late-Night Retail Workers Crime Protection" regulations. Provisions include employee training, cash handling, lighting and visibility components. Enacted February 1990	−35% assault- and violence-related events among food store employees
	Same as above (Hewitt, 1997)[31]	Same as above	−53% violence-related worker compensation claims among food store workers
Southland Corporation	Seven-Eleven convenience stores in Gainesville, Florida (Clifton, 1987)[12,c]	Prevention procedures modeled after program developed by Crow and Bull (1975).[7] Nationwide adoption 1978	Southland chain experienced inconsistent trend in robberies per year. Southland chain was second-highest chain victimized by robberies
	Seven-Eleven stores nationwide (Erickson, 1996)[30]	Robbery deterrence program including cash handling, visibility, lighting and employee training. Implemented 1975	−65%
	Seven-Eleven stores nationwide: 2100 company-owned and 2900 franchised stores (Lins and Erickson, 1998)[32]	Crime deterrence program developed from several studies (Crow and Bull, 1975[7]; Crow et al., 1987[12]; Erickson, 1997[14]; Figlio, 1991[15–18]). Includes cameras and alarms installed between 1993–1996	−70%; average dollar loss from each robbery reduced to $37

[a]Statistic or trend represents change since implementation of intervention.
[b]Negative (−) statistics represent a percentage decrease in incidents between time periods; positive (+) statistics represent a percentage increase.
[c]Study inclusion by primary and secondary criteria.

used an ecologic approach.[26] Measuring the effectiveness of an intervention using only raw values is compromised by changes in the number of stores over time, sensitivity to outliers, and robbery history. In all studies, the unit of analysis was a measure of robbery frequency, except one study that followed individual stores.[21] Simple measures were used in the majority of studies, most providing a percentage change measure with no calculation of effect estimates. Multivariate methods to control for confounding and to explore the possibility of effect-measure modification were used by one study.[15]

The magnitude of compliance with the interventions was examined in six studies.[7,13,21,23,25,26] The average for compliance in robbery prevention programs was less than 30%.[21,23] Stores recommended to implement low-cost robbery prevention procedures had higher compliance compared to stores recommended to implement more expensive measures.[7,23,25] In studies evaluating an equipment system,[13,16,17,22,26] proper functioning or utilization of the equipment was not monitored in three.[16,17,22] City and state ordinances were seemingly not enforced and compliance not measured, except in Gainesville where the police department conducted some follow-up visits.[40] Failure to examine the level of compliance results in a methodologic problem, that is, the implication that store operators who do comply may have a different risk of robbery than store operators who do not comply.

Outcomes: Primary Inclusion

Multiple-component programs. In all studies examining a packaged, multiple-component program, the intervention groups experienced a greater reduction in the number of robberies[7,23,25] and in the number of stores robbed[21] than the comparison groups. The magnitude of the percentage change ranged from −84% to −30% (Figure 1). In the Southern California Injury Prevention Research Center (SCIPRC) study,[23] which shows the largest reduction in robberies (percentage

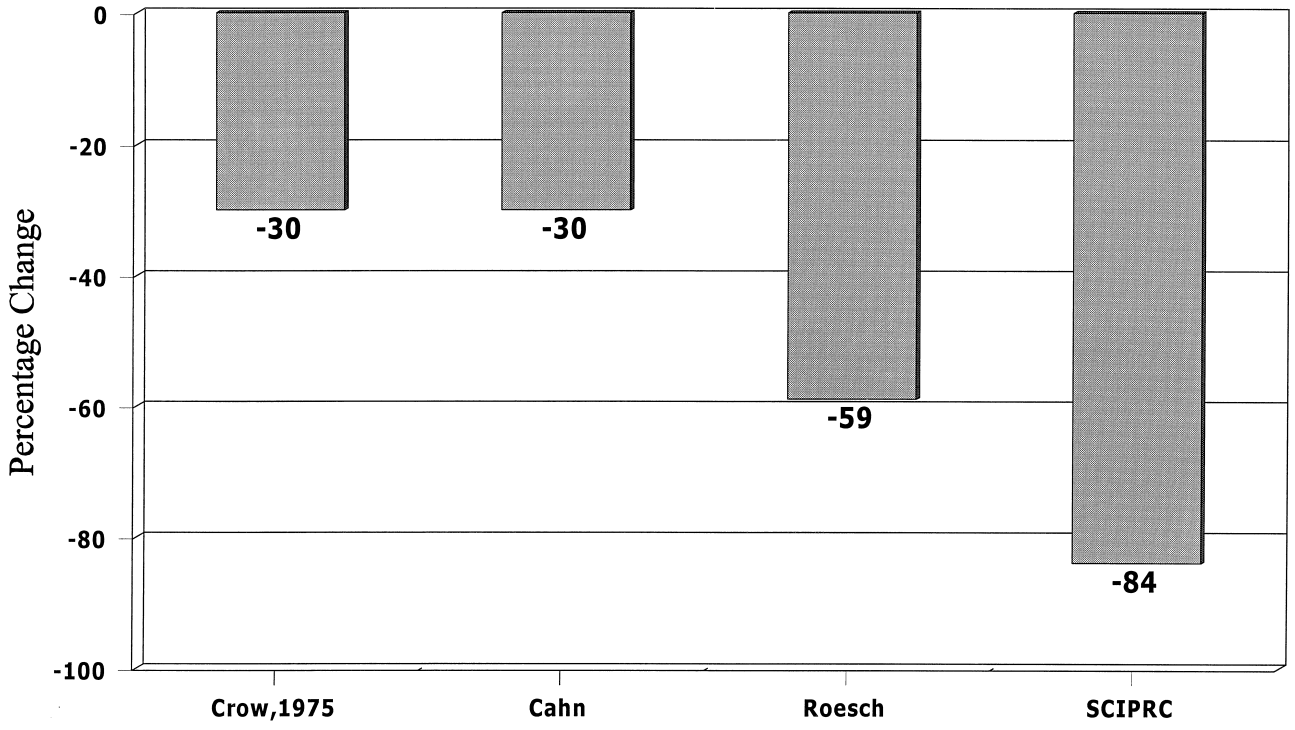

Figure 1. Percentage change in robberies between intervention and comparison groups for multiple-component interventions, post-intervention, primary studies. (Notes: The Cahn and Tien[25] study statistic represents the percentage change in robberies, pre-post intervention periods. In the Roesch and Winterdyk[21] study, the statistic represents the percentage change in number of stores robbed between intervention and comparison groups.)

change=−84%; 95% CL=−291%, −123%), a training session was conducted with each store owner using an action plan specially developed to address the robbery prevention needs for that store. The magnitude of the percentage change cannot be attributed to the program alone because of the presence of uncontrolled biases, the small sample size (n=22 stores), and few robbery occurrences.

Single-component programs. In all but one of the single CPTED-component studies, there was a decrease in the number of post-intervention robberies (Figure 2). Employing a second clerk resulted in a median percentage change of nearly −34% (range=−65%, −2.4%), and installing security hardware systems (e.g., alarms, video cameras, CCITV) and hiring guards resulted in a median change of −38% (range=−83%, +91%). Reducing cash and implementing time-lock cash boxes and safes resulted in a −38% pre-post change in robberies.

Adding the two-clerk provision to the 1986 Gainesville, Florida ordinance resulted in a −65% change in robberies.[12] In contrast, the percentage change reported by Figlio and Aurand,[15] in a study that examined the effect of employing two clerks between the hours of 11 pm and 7 am, was −2.4%. Evaluations examining only one intervention were not controlled for other prevention activities that may have been implemented simultaneously or subsequently added.

Installation of alarm systems resulted in a percentage change in robberies ranging from −38% to +91%. An unexplained influx in the number of robberies during one month of the post-intervention time period likely influenced the 91% increase. A comparable percentage change measure for Crow and Erickson[13] could not be generated for inclusion in these results. The study, however, reported that the difference in the pre-post mean robbery changes between test and control stores (−0.572; 95% CL=−0.424, 1.568) was not statistically significant (F=1.267, p=0.2629).

Convenience stores experienced mean annual robbery rate reductions after installation of CCITV systems (−23%); installation of video cameras with monitors (−54%); and hiring of guards (−83%).[16–18] The −83% change found by hiring guards is based on the experience of only one store, and the stability of the statistics for the CCITV intervention (n=189) and the video camera/monitor intervention (n=81) is moderate. Speculation on why the reductions were so large is limited by the lack of knowledge about when the interventions were implemented and how those dates corresponded with the availability of universal robbery prevention programs or with background crime in general.

Ordinances: The pre-post percentage changes in robberies reported in primary studies for ordinances are summarized in Figure 3. Enactment of local ordinances

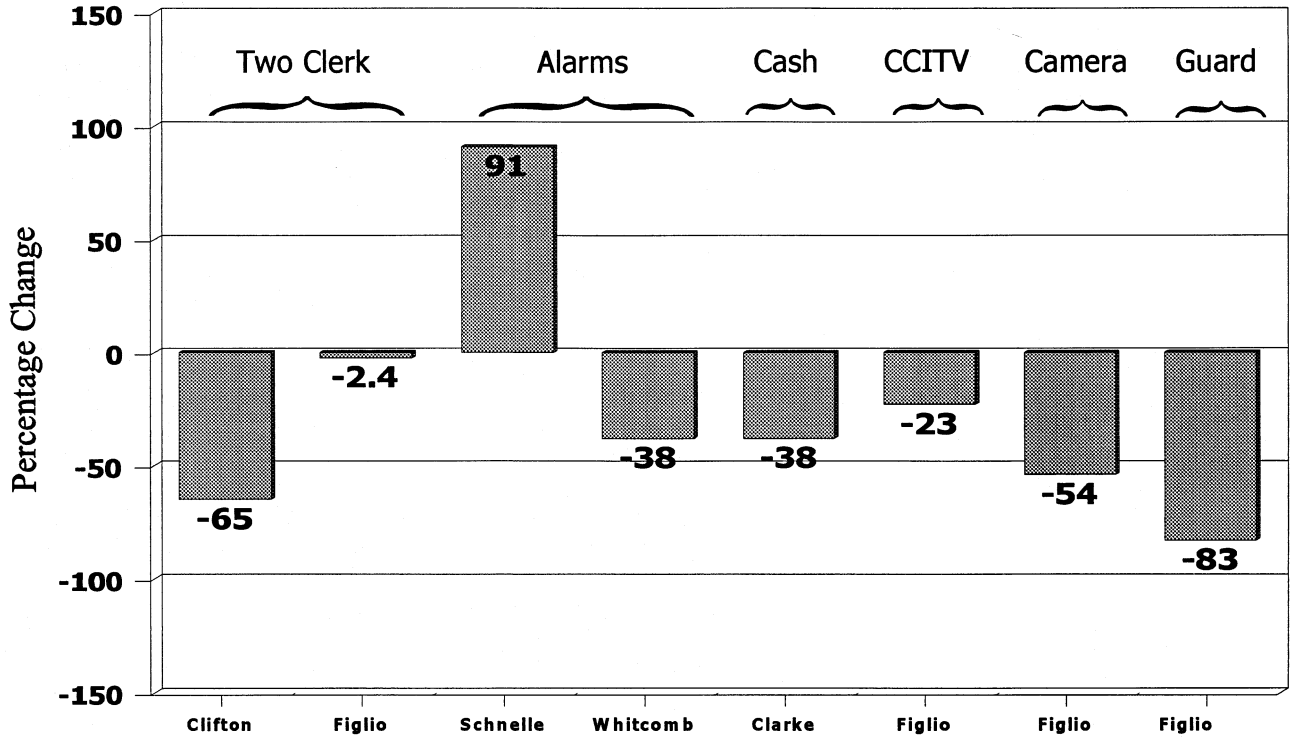

Figure 2. Percentage change in robberies between pre- and post-intervention time periods for single-component interventions, primary studies. (Notes: CCITV = closed circuit interactive television. Because Crow and Erickson[13] did not provide data to derive an estimate comparable to those presented in this figure, this study was excluded. The statistic for Figlio and Aurand[18] reflects the change in robberies occurring in one store only.)

resulted in a −20% median change (range=−65%, +130%) in the number of robberies across municipalities in Florida. Following the enactment of statewide acts, the median change in robberies was −25% (range=−38%, −12%).

After implementation of the original 1986 Gainesville ordinance, robberies increased 130%.[12] Rising robbery rates prior to its implementation and a general tendency toward increased reporting may have contributed to this increase. Adding the two-clerk provision in 1987 led to a −65% pre-post change in robberies,[12] which was maintained for two years of follow-up.[20] Although this suggests that the 1986 ordinance had no apparent effect until the two-clerk provision was commissioned, the 1987 provision was not measured independently of the 1986 conditions. Additionally, the Gainesville police chief reported that robberies had actually started to decline before adoption of the two-clerk provision due in part to the cash control and visibility program required in 1986.[40] Thus, the effect of two clerks without the presence of a basic prevention program is unknown.

The Gainesville ordinances may have indirectly affected robberies in convenience stores in Tallahassee[19] and Jacksonville,[20] contributing to a median change in robberies of −20% (range=−24%, −15%). Convenience stores in both municipalities may have voluntarily implemented prevention measures to avoid adoption of restrictive Gainesville-type ordinances. In both studies, the actions taken by individual stores are unknown.

Following the first statewide Security Act in Florida (1990), robberies continued to decrease in Gainesville (−38%) and Jacksonville (−26%). The 1990 Act led to a statewide pre-post change in robberies of −12% in the first year,[20] and the revised 1992 Security Act led to an additional change of −23% in the next four years.[14] The −12% change appears relatively small but represents an overall statewide change based on varying degrees of robbery risk in different cities and municipalities. Furthermore, local ordinances adopted throughout the state before enactment of the 1990 Act may have contributed to a smaller background risk of robbery and injury. There was a larger statewide decrease (−23%) when the more comprehensive 1992 ordinance was introduced after the 1990 Act. Since the 1992 Act imposed very strict, more expensive conditions on convenience stores, it is speculated that businesses may have chosen to close or move rather than be subjected to harsher criteria.

Outcomes: Injury/Homicide

Three studies examined the outcome of employee injury and homicide.[14,23,25] Assaultive injuries changed by −86% in a small sample of liquor stores[23] and −35%

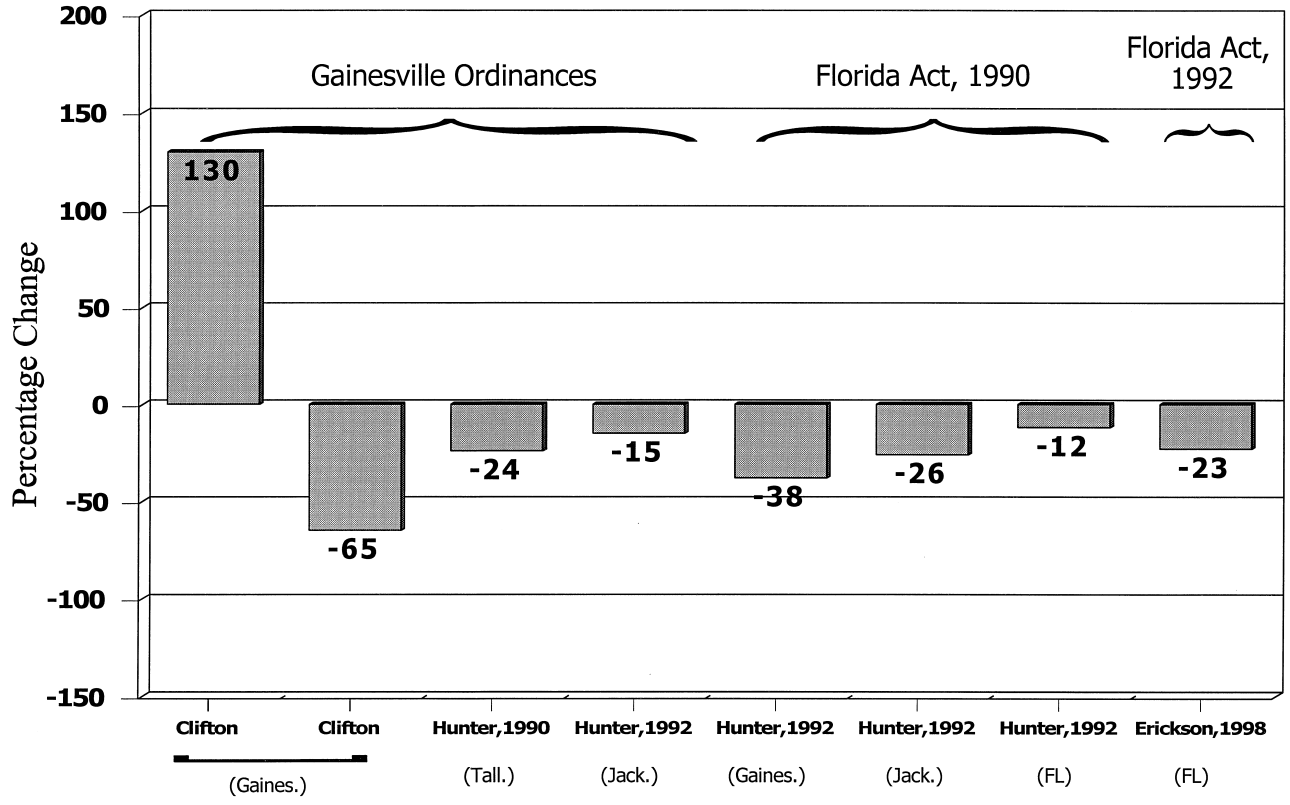

Figure 3. Percentage change in robberies between pre- and post-intervention time periods for ordinances, primary studies. (Note: Erickson[14] is the only study evaluating an ordinance that measured the change in employee injuries.)

in various retail and service establishments[25] following intervention. While little change in the number of homicides was observed following recommended security changes in commercial areas in one study,[25] another found an 11% increase in homicides in Florida convenience stores after adoption of the 1992 Florida Security Act.[14] None of these studies controlled for overall crime trends, and results are based on few fatal and nonfatal events.

Association of CPTED Components and Robbery Risk

Among all intervention studies with pre-post robbery data,[12,14–20,22–26] no linear association was found between the pre-post percentage change in robberies and the number of post-intervention years of follow-up ($r = -0.12$, $p=0.6398$). Similarly, there was no linear relationship between the pre-post percentage change in robberies and the total number of components per intervention ($r=-0.03$, $p=0.8987$).

For interventions including only store design/environmental components and training/staffing features,[15,20,23,24] the median percentage change in the number of robberies was −34% (range=−81%, −2.4%). When equipment components were added to interventions already containing these features,[12,14,19,20,25] the median percentage change was −25% (range=−65%, +130%).

The pre-post median change in robberies was similar for studies evaluating a package of components (−25%, range=−81%, +130%) and for those evaluating a single component (−31%, range=−54%, +91%). The intervention package developed by the SCIPRC and the 1987 Gainesville, Florida ordinance yielded the largest pre-post intervention reductions in robberies. The SCIPRC results are based on a very small self-selected sample with voluntary compliance, while the Florida ordinances applied to all stores but with very little enforcement. The study examining security guards was not considered in this analysis because the statistic was based on the change in robberies occurring in only one store.

Outcomes: Additional Measures

Among studies examining the mean dollar loss per robbery, the median percentage change between intervention and control businesses was −9.5% (range=−23%, +4%).[7,21] Another study observed a general decline in the mean loss following implementation of cash handling measures.[24] One study found that regardless of prevention measures, previous robberies were the most important predictor for subsequent robberies

(p=0.0001),[15] while another found that the robbery difference between experimental and control stores was greatest for stores with two or more previous robberies (difference=−10 robberies, p=0.04).[7]

On-scene apprehension arrests of robbery suspects increased 40% following implementation of an alarm system backed by police patrol.[22] According to the same study, the effect did not extend to suspects not apprehended on the scene, although another study reported that both off-scene apprehensions and convictions increased following installation of a camera/alarm system.[26] While the cost effectiveness of the alarm system with police response was deemed poor,[22] the evaluation of a hidden camera project was economical.[26]

Outcomes: Secondary Inclusion

A −74% median percentage change in robberies (range=−82%, −60%) was experienced by convenience stores in selected Florida and Ohio cities and counties following the adoption of local ordinances consisting of basic program components and a two-clerk provision.[12,28] Other localities claiming success with two-clerk provisions reported either having no or few robberies or a steady decrease in robberies since adoption of the provision.[12,28] Convenience stores regulated by ordinances comprising basic program components, without a two-clerk provision, experienced changes in robberies ranging from −30.1% to +7.6% in Ohio cities[12] and from −59% to −34% in Florida municipalities.[34]

Secondary studies with multiple-component interventions found pre-post robbery changes of −92% among locations of an oil company chain,[28] a median change of −66% (range=−84%, −48%) among sites of a restaurant chain,[27,29] a −17% change in various retail and service establishments in Portland,[35] and a median change of −65% (range = −70%, −49%) among Southland Corporation convenience stores nationwide[30,32] and a convenience store chain in the southeastern United States.[34] All programs promoted basic robbery and violence prevention procedures, although three included the installation of cameras and alarms or bullet-resistant enclosures.[28,29,32] Programs including the hardware systems[28,29,32] had a larger percentage decrease in the number of robberies than programs without such systems (difference=12%).[14,27,34,35]

Food store employees in the state of Washington experienced a −35% percentage change in assault- and violence-related events[33] and a −53% change in violence-related worker compensation claims[31] after adoption of the "Late-Night Retail Workers Crime Protection" regulation. Reviews of early-warning alarm systems and hidden surveillance cameras found a change in robberies ranging from −80% to −45% compared to existing conventional police measures.[26,36]

Discussion

The review process identified 16 primary CPTED evaluations from all sources over the past 30 years. Most of these interventions were implemented in convenience stores more than a decade ago.

All studies evaluating a multiple-component intervention found that the intervention groups experienced fewer robberies than the comparison groups after program implementation. With the exception of one single-component intervention study, the number of robberies decreased between pre- and post-intervention time periods. An intervention composed of an alarm system with police patrol was the only CPTED component not resulting in an overall reduction in the average number of robberies. With the exception of the first Gainesville ordinance, adoption of all local and statewide ordinances and acts resulted in a decrease in robberies. The value of specific components in reducing robbery risk was not evaluated in any of the multiple-component or ordinance studies; only the effectiveness of the program as a whole was examined. Thus, there was no way to differentiate how basic program components, equipment, and two clerks contributed to the decrease in robberies.

Although most findings are in agreement, the lack of controls for factors contributing to robbery risk make it difficult to conclude whether the interventions were independently effective in reducing robbery risk. Community crime and environmental factors have been shown to influence robbery risk,[41,42] but were controlled only in one of the studies included in this review. The ability to synthesize results across studies was limited by the systematic variation across studies in sample size, program implementation and length, and compliance. The Crow and Bull study,[7] which matched control stores to intervention stores, provided the strongest support for CPTED measures contributing to the reduction of robberies.

Disagreement continues on whether employing two clerks is an effective measure for reducing robberies. Although two-clerk provisions as part of larger programs showed effectiveness in this review, controlled studies of this issue are needed. The federal Occupational Safety and Health Administration has included a two-clerk condition in its release of "Recommendations for Workplace Violence Prevention Programs in Late-Night Retail Establishments" and has received negative feedback from some researchers in workplace violence prevention and representatives from the National Association of Convenience Stores. Critics argue that there is limited scientific evidence demonstrating the validity of the two-clerk provision, the cost of implementation is high, and it is believed to potentially increase the risk of employee injury or death in the event of criminal activity by increasing the number of employees exposed. Although an evaluation of the 1992 Florida

Security Act, which included two-clerk and security guard provisions, found an 11% increase in homicide, another study specifically examining injury risk found no association between two clerks and employee injury rates.[43]

In any systematic review, there is usually concern for whether included studies are a biased sample of all studies and results available. Although both published and unpublished documents were identified for this review, positive publishing bias is present in both peer-reviewed and other types of publications. There may be less inclination to publish unfavorable results, particularly when employee welfare is involved. Thus, the magnitude and consistency of positive results from this study may be misleading if not interpreted with the understanding that biases may be operating.

The results of this study show that the CPTED approach appears effective in reducing robbery. However, it does not show clear trends regarding which components of the CPTED approach are most effective. Programs with multiple components, especially those that include measures with low-cost implementation and maintenance, may be the most easily introduced and accepted by the business community. Because the number of business settings covered in this review was limited, it cannot be concluded that the CPTED approach is effective for all businesses. However, the devastating effects of robberies on employees, high costs to businesses and the increasing threat of litigation are all strong reasons to incorporate prevention measures and to continue to study their effectiveness in reducing robbery and employee injury.

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