Improved Street Lighting and Crime Prevention

A Systematic Review

Report prepared for
The Swedish National Council for
Crime Prevention

Brå – a centre of knowledge on crime and measures to combat crime

The Swedish National Council for Crime Prevention (Brottsförebyggande rådet – Brå) works to reduce crime and improve levels of safety in society by producing data and disseminating knowledge on crime and crime prevention work and the justice system´s responses to crime.

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ISBN 978-91-85664-78-8
Printing: Edita Västerås 2007

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Foreword

Darkness, particularly in built up areas, can create a feeling of personal insecurity - which is a problem in itself, even if the risk for personal victimisation is actually small. Concern for being attacked outdoors after dark prevents some people from using public spaces, and thus has a negative effect on their quality of life. But darkness also creates a favourable environment for vandalism and theft, including bicycle thefts and thefts from vehicles, offences which are very common. The crime preventive effects of improved street lighting are therefore often discussed, and such measures are often also introduced as a means of combating crime.

There are never sufficient resources to conduct rigorous scientific evaluations of all the crime prevention measures employed in individual countries. Nor has an evaluation been conducted in Sweden of efforts employing dedicated lighting initiatives to prevent crime. For this reason, the Swedish National Council for Crime Prevention (Brå) has commissioned two distinguished researchers to carry out an international review of the research published in this field.

This report presents a systematic meta-analysis of the effects of improved outdoor lighting that has been conducted by Professor David P. Farrington of Cambridge University (United Kingdom) and Associate Professor Brandon C. Welsh of the University of Massachusetts Lowell (United States), who have also written the report. The study follows a rigorous method for the conduct of systematic meta-analyses. The analysis combines the results from a number of evaluations that are considered to satisfy a list of empirical criteria for measuring effects as reliably as possible. The analysis then uses the results from these previous evaluations to calculate and produce an overview of the effects that improved lighting does and does not produce. Thus the objective is to systematically evaluate the results from a number of studies from different countries in order to produce a more reliable picture of the opportunities and limitations associated with lighting initiatives in relation to crime prevention efforts. Studies of this kind are also valuable when assessing which circumstances contribute to a certain measure producing a positive effect.

In this case, the research review builds upon a relatively small number of evaluations and only examines evaluations that have been conducted in the United States and United Kingdom. A number of questions concerning the potential crime preventive effects of lighting initiatives in a country like Sweden thus remain unanswered. But the study does offer the most accessible overview to date of the use of improved outdoor lighting in order to prevent crime and improve public safety.

Stockholm, October 2007

Jan Andersson
Director-General

Summary

Evaluation research to measure the impact of improved street lighting on crime appears to have come to a standstill. This six-year update of the first systematic review on the subject (Farrington and Welsh, 2002a), which included only the highest quality evaluation studies, did not find one new evaluation that measured the effect of lighting on crime. This lack of new studies does not, however, detract from the existing knowledge base on the crime prevention effects of improved street lighting, which is the focus of this report.

There are two main theories of why improved street lighting may cause a reduction in crime. The first suggests that improved lighting leads to increased surveillance of potential offenders (both by improving visibility and by increasing the number of people on the street) and hence to increased deterrence of potential offenders. The second suggests that improved lighting signals community investment in the area and that the area is improving, leading to increased community pride, community cohesiveness, and informal social control. The first theory predicts decreases in crime especially during the hours of darkness, while the second theory predicts decreases in crime during both daytime and nighttime.

Studies were included in this systematic review if improved lighting was the main intervention, if there was an outcome measure of crime, if there was at least one experimental area and one comparable control area, if there were before and after measures of crime, and if the total number of crimes in each area before the intervention was at least 20. (Any study with less than 20 crimes before would have insufficient statistical power to detect changes in crime.)

Four search strategies were employed to locate studies meeting the criteria for inclusion: searches of electronic bibliographic databases, searches of literature reviews on the effectiveness of improved lighting on crime, searches of bibliographies of lighting reports, and contacts with leading researchers. Thirteen studies met the inclusion criteria, eight from America and five from Britain.

Results were mixed for the eight American evaluation studies. Four studies found that improved street lighting was effective in reducing crime, while the other four found no effect. Why the studies produced different results was not obvious, although there was a tendency for effective studies to measure both daytime and nighttime crimes and for ineffective studies to measure only nighttime crimes. However, all except one of these American evaluations date from the 1970s. A meta-analysis found that the eight studies showed that improved lighting led to a non-significant 7% decrease in crime in experimental areas compared with comparable control areas.

Five more recent British evaluation studies showed that improved lighting led to decreases in crime. Their results showed that improved lighting led to a significant 29 per cent decrease in crime in experimental areas compared with comparable control areas. Furthermore, in two studies, the financial savings from reduced crimes greatly exceeded the financial costs of the improved street lighting. A meta-analysis found that the 13 studies, taken together, showed that improved lighting led to a significant 21per cent decrease in crime in experimental areas compared with comparable control areas.

Since these studies did not find that nighttime crimes decreased more than daytime crimes, a theory of street lighting focusing on its role in increasing community pride and informal social control may be more plausible than a theory focusing on increased surveillance and increased deterrence. The results did not contradict the hypothesis that improved street lighting was most effective in reducing crime in stable homogeneous communities.

It is recommended that future research should be designed to test the main theories of the effects of improved lighting more explicitly, and should measure crime using police records, victim surveys, and self-reports of offending. Levels of illumination, as well as crime rates, should be measured before and after the intervention in experimental and comparable control areas. Future research should ideally include experimental, adjacent, and non-adjacent control areas, in order to test hypotheses about displacement and diffusion of benefits. Attempts should be made to investigate how the effects of improved lighting vary according to characteristics of areas and how far there are different effects on different kinds of crimes.

It is concluded that improved street lighting should be included as one element of a situational crime reduction program. It is an inclusive intervention benefiting the whole of a neighborhood and leads to an increase in perceived public safety. Improved street lighting is associated with greater use of public space and neighborhood streets by law-abiding citizens. Especially if well targeted to a high-crime area, improved street lighting can be a feasible, inexpensive, and effective method of reducing crime.

Acknowledgements

The research reported here was made possible by a grant from the National Council for Crime Prevention in Sweden to the second author at the University of Massachusetts Lowell. We are extremely grateful to Jan Andersson, Director General of the Council, for his longstanding commitment to evidence-based crime prevention and his interest in our on-going research on the effects of improved street lighting on crime.

We benefited from excellent research assistance by Katherine Harrington at the University of Massachusetts Lowell. We would also like to thank the following individuals for assistance in trying to locate new evaluation studies: Professor Ross Homel (Griffith University), Professor Kenna Quinet (Indiana University), Dr. Kate Painter (University of Cambridge), and Deborah Friedman (University of Massachusetts Lowell).

May 2007

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Introduction

Improved street lighting serves many purposes, one of them being the prevention of crime. While street lighting improvements may not often be implemented with the expressed aim of preventing crime – pedestrian safety and traffic safety may be viewed as more important aims – and the notion of lighting streets to deter lurking criminals may be too simplistic, its relevance to the prevention of crime has been suggested in urban *centers*, residential areas, and other places frequented by criminals and potential victims.

Explanations of the way street lighting improvements could prevent crime can be grouped into two main perspectives:

1. As a situational crime prevention measure that focuses on reducing opportunity and increasing perceived risk through modification of the physical environment (Clarke, 1995), such as Crime Prevention Through Environmental Design (Jeffery, 1977).

2. As a method of strengthening informal social control and community cohesion through more effective street use (Angel, 1968; Jacobs, 1961) and investment in neighborhood conditions (Taub et al., 1984; Taylor and Gottfredson, 1986).

The situational approach to crime prevention suggests that crime can be prevented by environmental measures, which directly affect offenders' perceptions of increased risks and decreased rewards. This approach is also supported by theories, which emphasize natural, informal surveillance as a key to crime prevention. For example, Jacobs (1961) drew attention to the role of good visibility combined with natural surveillance as a deterrent to crime. She emphasized the association between levels of crime and public street use, suggesting that less crime would be committed in areas with an abundance of potential witnesses.

Other theoretical perspectives have emphasized the importance of investment to improve neighborhood conditions as a means of strengthening community confidence, cohesion, and social control (Kelling and Coles, 1996; Skogan, 1990; Wilson and Kelling, 1982). As a highly visible sign of positive investment, improved street lighting might reduce crime if it physically improved the environment and signalled to residents that efforts were being made to invest in and improve their neighborhood. In turn, this might lead them to have a more positive image of the area and to have increased community pride, optimism, and cohesion. It should be noted that this theoretical perspective predicts a reduction in both daytime and nighttime crime. Consequently, attempts to measure the effects of improved lighting should not concentrate purely on nighttime crime.

The relationship among visibility, social surveillance, and criminal opportunities is a consistently strong theme to emerge from the literature. A core assumption of both opportunity and informal social control models of prevention is that criminal opportunities and risks are influenced by environmental conditions in interaction with resident and offender characteristics. Street lighting is a tangible alteration of the built environment, but it does not constitute a physical barrier to crime. However, it can act as a catalyst to stimulate crime reduction through a change in the perceptions, attitudes, and behavior of residents and potential offenders.

It is also feasible that improved street lighting could, in certain circumstances, increase opportunities for crime. It may bring greater numbers of potential victims and potential offenders into the same physical space. Increased visibility of potential victims may allow better judgments of their vulnerability and attractiveness (e.g., in terms of valuables). Increased social activity outside the home may increase the number of unoccupied homes available for burglary. Increased illumination may make it easier to commit crimes and to escape.

The effects of improved street lighting are likely to vary in different conditions. In particular, they are likely to be greater if the existing lighting is poor and if the improvement in lighting is considerable. They may vary according to characteristics of the area or the residents, the design of the area, the design of the lighting, and the places that are illuminated. For example, improved lighting may increase community confidence only in relatively stable homogeneous communities, not in areas with a heterogeneous population mix and high residential mobility. The effects of improved lighting may also interact with other environmental improvements, such as closed circuit television (CCTV) cameras or security patrols.

The main aim of this report is to present the results of an updated systematic review on the effects of improved street lighting on crime. Six years have elapsed since we completed the first systematic review on the subject (Farrington and Welsh, 2002a; see also Farrington and Welsh, 2002b; Welsh and Farrington, 2004). This report is divided into five chapters. The second chapter provides some background on the use of improved street lighting to prevent crime. The third chapter, on research methods, reports on the criteria for inclusion of lighting studies in this review and the methods used to search for new evaluation studies. The fourth chapter reports on the key features of the studies that were included and the results of a meta-analysis. The final chapter provides some concluding comments and explores implications for policy and research.

Background

Contemporary interest in the effect of improved street lighting on crime began in the U.S. during the dramatic rise in crime in the 1960s. Many towns and cities embarked upon major street lighting programs as a means of reducing crime, and initial results were encouraging (Wright et al., 1974). This proliferation of projects led to a detailed review of the effects of street lighting on crime by Tien et al. (1979), as part of the National Evaluation Program of Law Enforcement Assistance Agency (LEAA) funding. Their report described how the 103 street lighting projects originally identified were eventually reduced to a final sample of only 15 that were considered by the review team to contain sufficiently rigorous evaluative information. With regard to the impact of street lighting on crime, Tien et al. (1979) found that the results were mixed and generally inconclusive. However, each project was considered to be seriously flawed because of such problems as: weak project designs; misuse or complete absence of sound analytic techniques; inadequate measures of street lighting; poor measures of crime (all were based on police records); and insufficient appreciation of the impact of lighting on different types of crime.

The review by Tien et al. (1979) should have led to attempts to evaluate the effects of improved street lighting using more adequate designs and alternative measures of crime, such as victim surveys, self-reports, or systematic observation. It should also have stimulated efforts to determine in what circumstances improved street lighting might lead to reductions in crime. Unfortunately, it was interpreted as showing that street lighting had no effect on crime and effectively ended research on the topic in the U.S.

In the U.K., very little research was carried out on street lighting and crime until the late 1980s (Fleming and Burrows, 1986). There was a resurgence of interest between 1988 and 1990, when three small-scale street lighting projects were implemented and evaluated in different areas of London (Painter, 1994). In each location crime, disorder, and fear of crime declined and pedestrian street use increased dramatically after the lighting improvements.

In contrast to these generally positive results, a major British Home Office-funded evaluation in Wandsworth (Atkins et al., 1991) concluded that improved street lighting had no effect on crime, and a Home Office review, published simultaneously, also asserted that "better lighting by itself has very little effect on crime" (Ramsay and Newton, 1991:24). However, as further evidence has accumulated, there have been more signs that improved street lighting could have an effect in reducing crime. In a recent narrative review by Pease (1999, p. 68), he considered that "the capacity of street lighting to influence crime

has now been satisfactorily settled." He also recommended that the debate should be moved from the sterile "does it work or doesn't it?" to the more productive "how can I flexibly and imaginatively incorporate lighting in crime reduction strategy and tactics?" (p. 72).

Research methods

As noted above, this report presents a systematic review of the effects of improved street lighting on crime and follows closely the methodology of this review technique. Systematic reviews use rigorous methods for locating, appraising, and synthesizing evidence from prior evaluation studies, and they are reported with the same level of detail that characterizes high quality reports of original research. According to Johnson et al. (2000, p. 35), systematic reviews "essentially take an epidemiological look at the methodology and results sections of a specific population of studies to reach a research-based consensus on a given study topic." They have explicit objectives, explicit criteria for including or excluding studies, extensive searches for eligible evaluation studies from all over the world, careful extraction and coding of key features of studies, and a structured and detailed report of the methods and conclusions of the review. All of this contributes greatly to the ease of their interpretation and replication by other researchers. It is beyond the scope of this report to discuss all of the features of systematic reviews, but interested readers should consult key volumes on the topic (see Farrington and Welsh, 2001; Petticrew and Roberts, 2006; Welsh and Farrington, 2006).

Criteria for Inclusion of Evaluation Studies

In selecting evaluations for inclusion in this review, the following criteria were used:

1. Improved street lighting (or improved lighting) was the focus of the intervention. For evaluations involving one or more other interventions, only those evaluations in which improved lighting was the main intervention were included. The determination of what was the main intervention was based on the author identifying it as such or, if the author did not do this, the importance the report gave to improved lighting relative to the other interventions.

2. There was an outcome measure of crime. The most relevant crime outcomes were violent and property crimes.

3. The evaluation design was of high methodological quality, with the minimum design involving before-and-after measures of crime in experimental and comparable control areas.

4. The total number of crimes in each area before the intervention was at least 20. The main measure of effect size was based on changes in numbers of crimes between the before and after time periods. It was considered that a measure of change based on an *N* below 20 was po-

tentially misleading. Also, any study with less than 20 crimes before would have insufficient statistical power to detect changes in crime. The criterion of 20 is probably too low, but we were reluctant to exclude studies unless their numbers were clearly inadequate.

Search Strategies

In order to locate studies meeting the above criteria, four search strategies were employed:

1. Searches of electronic bibliographic databases (see below).

2. Searches of reviews of the literature on the effects of improved lighting on crime. Two new reviews were identified and assessed: Beyer et al. (2005) and Cozens et al. (2003). (Appendix 1 lists all of the literature reviews that we consulted for our first systematic review on improved street lighting and the present update.)

3. Searches of bibliographies of evaluation reports of improved lighting studies.

4. Contacts with leading researchers (see Acknowledgments).

Both published and unpublished reports were considered in these searches. Furthermore, the searches were international in scope and were not limited to the English language. These searches were completed in March 2007 and reflect material published or reported over a six-year period, between January 2001 and December 2006.

The following ten electronic bibliographic databases were searched:

- Criminal Justice Abstracts
- National Criminal Justice Reference Service (NCJRS) Abstracts
- Sociological Abstracts
- Educational Resources Information Clearinghouse (ERIC)
- Government Publications Office Monthly Catalogue (GPO Monthly)
- Psychology Information (PsychInfo)
- Dissertation Abstracts
- Social, Pyschological, Educational, and Criminological Trials Register (C2-SPECTR)
- Google Scholar
- Medline

These electronic databases were selected on the basis of the most comprehensive coverage of criminological, criminal justice, and social and behavioral science literatures. They are also among the top databas-

es recommended by the Campbell Collaboration Crime and Justice Group. Three databases, Social Science Abstracts (SocialSciAbs), Public Affairs Information Service (PAIS) International, and the Australian Criminology Database (CINCH), which were used in the initial systematic review, were not used here because they were no longer available to the researchers. In their place, two new electronic databases were searched: Google Scholar and Medline.

The following terms were used to search the ten databases noted above: street lighting, lighting, illumination, and natural surveillance. When applicable, "crime" was then added to each of these terms (e.g., street lighting and crime) to narrow the search parameters.

These search strategies did not result in the collection of one new evaluation of improved street lighting that met our inclusion criteria. Two new evaluations of improved street lighting were identified and analyzed (Tseng et al., 2004; Willis et al., 2005). In each case they did not meet our inclusion criteria and hence were excluded. The evaluation by Tseng et al. (2004) was excluded because there was no control area. The evaluation by Willis et al. (2005) was excluded because crime was not measured; instead, residents' attitudes and values about improved lighting were measured.

Prior to the commencement of the search strategies reported here, we received an evaluation report on the effects of improved street lighting on crime that we had previously been unsuccessful in obtaining. The scheme took place in Cleveland, U.K., and is reported in a published paper by Vamplew (1991). The evaluation did not meet the inclusion criteria and so was excluded. This was because there was no control area and no measure of crime.

Previous search strategies (up to December 2000) produced 13 improved street lighting evaluations that met the inclusion criteria. The results reported here are based on these 13 high quality evaluations, but with new analyses.

Results

To assess the effectiveness of improved street lighting in reducing crime, meta-analytic techniques were used. A meta-analysis is essentially a statistical summary of comparable effect sizes reported in each evaluation. In order to carry out a meta-analysis, a comparable measure of effect size and an estimate of its variance are needed in each program evaluation (Lipsey and Wilson, 2001; Wilson, 2001). In the case of street lighting evaluations, the measure of effect size had to be based on the number of crimes in the experimental and control areas before and after the intervention. This is because this was the only information that was regularly provided in these evaluations. Here, the odds ratio is used as the measure of effect size. For example, in the Atlanta improved street lighting evaluation (Atlanta Regional Commission, 1974; see below), the odds of a crime after given a crime before in the control area were 431/234 or 1.842. The odds of a crime after given a crime before in the experimental area were 151/114 or 1.325. The odds ratio, therefore, was 1.842/1.325 or 1.39, which was substantial but not statistically significant.

The odds ratio (OR) has a very simple and meaningful interpretation. It indicates the proportional change in crime in the control area compared with the experimental area. In this example, the OR of 1.39 indicates that crime increased by 39% in the control area compared with the experimental area. An OR of 1.39 could also indicate that crime decreased by 28% in the experimental area compared with the control area, since the change in the experimental area compared with the control area is the inverse of the OR, or 1/1.39 here. The OR is calculated from the following table:

	Before	**After**
Experimental	a	b
Control	c	d

Where a, b, c, d are numbers of crimes

$$OR = ad/bc$$

The variance of OR is calculated from the variance of LOR (the natural logarithm of OR). The usual calculation of this is as follows:

$$V(LOR) = 1/a + 1/b + 1/c + 1/d$$

In order to produce a summary effect size in a meta-analysis, each effect size is weighted according to the inverse of the variance. This was another reason for choosing the OR, which has a known variance (Fleiss, 1981, pp. 61–67).

The estimate of the variance is based on the assumption that total numbers of crimes (a, b, c, d) have a Poisson distribution. Thirty years of mathematical models of criminal careers have been dominated by the assumption that crimes can be accurately modeled by a Poisson process (Piquero et al., 2003). However, the large number of changing extraneous factors that influence the number of crimes may cause overdispersion; that is, where the variance of the number of crimes VAR exceeds the number of crimes N.

$$D = VAR/N$$

specifies the overdispersion factor. Where there is overdispersion, V(LOR) should be multiplied by D. Farrington et al. (2007) estimated VAR from monthly numbers of crimes and found the following equation:

$$D = .0008 \times N + 1.2$$

D increased linearly with N and was correlated .77 with N. The mean number of crimes in an area in the lighting studies was about 445, suggesting that the mean value of D was about 1.56. However, this is an overestimate because the monthly variance is inflated by seasonal variations, which do not apply to N and VAR. Nevertheless, in order to obtain a conservative estimate, V(LOR) calculated from the usual formula above was multiplied by D (estimated from the above equation) in all cases. This adjustment corrects for overdispersion within studies but not for heterogeneity between studies. (For a more detailed discussion of the variance in this case, see Farrington and Welsh, 2004.)

Each of the included evaluations was rated on their effectiveness in reducing crime. Each evaluation was assigned to one of the following four categories: desirable effect (marked decrease in crime), undesirable effect (marked increase in crime), null effect (evidence of no effect on crime), or uncertain effect (unclear evidence of an effect on crime).

Also important to this review were the issues of displacement and diffusion of benefits. Displacement is often defined as the unintended increase in targeted crimes in other locations following from the introduction of a crime reduction scheme. (For a discussion of "benign" or desirable effects of displacement, see Barr and Pease, 1990.) Reppetto (1976) identified five different forms of displacement: temporal (change in time), tactical (change in method), target (change in victim), territorial (change in place), and functional (change in type of crime). Diffusion of benefits is defined as the unintended decrease in crimes following from a crime reduction scheme, or the "complete reverse" of displacement (Clarke and Weisburd, 1994).

In order to investigate these topics, the minimum design should involve one experimental area, one adjacent area, and one non-adjacent comparable control area. If crime decreased in the experimental area, increased in the adjacent area, and stayed constant in the control area, this might be evidence of displacement. If crime decreased in the experimental and adjacent areas and stayed constant or increased in the control area, this might be evidence of diffusion of benefits. Only two of the included evaluations (Portland and Stoke-on-Trent) had both adjacent and non-adjacent but comparable control areas. Two others (Harrisburg and Fort Worth) had an adjacent control area and the remainder of the city as another (non-comparable) control area.

Pooled Effects

From the 13 evaluations, it was concluded that improved street lighting had a significant desirable effect on crime, with a weighted mean odds ratio of 1.27 (95 per cent confidence interval 1.09–1.45), which was highly significant ($p = .002$). This means that crimes increased by 27 per cent after improved lighting in control areas compared with experimental areas, or conversely crimes decreased by 21 per cent in experimental areas compared with control areas.

Because the 13 effect sizes were significantly heterogeneous ($Q = 37.13$, 12 df, $p = .0002$), a random effects model was used here. Fixed effects models were used when the heterogeneity was not significant. The fixed and random effects models, and the other models used by Jones (2005), all produced very similar weighted mean effect sizes.

Interestingly, both night time and daytime crimes were measured in all five British studies and four of the eight U.S. studies. The nine night/day studies also showed a significant desirable effect of improved lighting on crime (OR = 1.43, CI = 1.19–1.71, $p < .0001$).

Table 1 summarizes the results of all 13 studies. This shows the odds ratio for total crime in each study plus its 95% confidence interval and statistical significance. It can be seen that only three studies (Portland, New Orleans, and Indianapolis) had odds ratios less than 1, meaning that improved street lighting was followed by an increase in crime, and in no case was this increase significant. The other 10 studies had odds ratios greater than 1, meaning that improved street lighting was followed by a decrease in crime, and in six cases this decrease was significant (or nearly so). Therefore, the hypothesis that more lighting causes more crime can be firmly rejected.

Table 1. Meta-Analysis of Improved Street Lighting Evaluations.

	Odds Ratio	Confidence Interval	P Value
American N Studies			
Portland	0.94	0.75 – 1.18	n.s.
Kansas City	1.24	0.90 – 1.71	n.s.
Harrisburg	1.02	0.72 – 1.46	n.s.
New Orleans	0.99	0.83 – 1.18	n.s.
American ND Studies			
Atlanta	1.39	0.99 – 1.94	.055
Milwaukee	1.37	1.01 – 1.86	.044
Fort Worth	1.38	0.92 – 2.07	n.s.
Indianapolis	0.75	0.45 – 1.25	n.s.
British ND Studies			
Dover	1.14	0.58 – 2.22	n.s.
Bristol	1.35	1.16 – 1.56	.0001
Birmingham	3.82	2.15 – 6.80	.0001
Dudley	1.44	1.10 – 1.87	.008
Stoke-on-Trent	1.71	1.10 – 2.67	.017
Summary Results			
4 US N Studies	1.01	0.90 – 1.14	n.s.
4 US ND Studies	1.28	1.06 – 1.53	.010
5 UK ND Studies*	1.62	1.22 – 2.15	.0008
8 US Studies	1.08	0.98 – 1.20	n.s.
9 ND Studies*	1.43	1.19 – 1.71	.0001
9 Violence*	1.10	0.91 – 1.34	n.s.
11 Property*	1.20	1.02 – 1.41	.024
All 13 Studies*	1.27	1.09 – 1.47	.002

Notes: N = only night crimes measured; ND = night and day crimes measured; * = random effects model used (fixed effects model used in other cases).

American Studies

Of the 13 improved street lighting evaluations in this review, eight were carried out in the United States. For the most part, residential neighborhoods were the setting for the intervention. Only four of the eight evaluations specified the degree of improvement in the lighting: by seven times in Milwaukee, four times in Atlanta, three times in Fort Worth, and two times in Portland (Table 2). However, the description of the lighting in other cases (e.g., "high intensity street lighting" in Harrisburg and New Orleans) suggests that there was a marked improvement in the degree of illumination. Only in Indianapolis was the improved street lighting confounded with another concurrent intervention, and it was sometimes possible to disentangle this.

The control area was often adjacent to the experimental area. Hence, similar decreases in crime in experimental and control areas could reflect diffusion of benefits rather than no effects of improved lighting. In most cases, the reports noted that the control area was similar to the experimental area in sociodemographic factors or crime rates. However, none of the evaluations attempted to control for prior noncomparability of experimental and control areas. Only one evaluation (Portland) included an adjacent area and a comparable non-adjacent control area.

The outcome measure of crime was always based on police records before and after the improved street lighting. The Indianapolis evaluation was based on calls for service to the police, many of which did not clearly involve crimes (e.g., calls for "disturbance"). Only the Atlanta and Milwaukee studies provided total, nighttime, and daytime crimes. The Portland, Kansas City, Harrisburg, and New Orleans studies measured only nighttime crimes, and the Fort Worth and Indianapolis studies reported only total crimes.

As shown in Table 2, improved street lighting was considered to have a desirable effect on crime in four evaluations: Atlanta, Milwaukee, Fort Worth, and Kansas City. In all four cases, the odds ratio was 1.24 or greater. In the other four evaluations, the improved street lighting was considered to have a null effect on crime. The results of the meta-analysis of the eight American studies confirm these conclusions. The average effect size was an odds ratio of 1.08, which was not significant. Overall, crime increased by 8 per cent in control areas compared with experimental areas, or conversely crime decreased by 7 per cent in experimental areas compared with control areas.

The key dimension on which the eight effect sizes differed seemed to be whether they were based on data for both night and day (Atlanta, Milwaukee, Fort Worth, and Indianapolis) or for night only (the other four studies). For the four night/day studies, the average effect size was a significant odds ratio of 1.28 (CI = 1.06 – 1.53, p = .010), meaning that crime increased by 28 per cent in control areas

Table 2. American Street Lighting Evaluations.

Author, Publication Date, Location	Context of Intervention and Increase in Lighting	Other Interventions	Outcome Measure	Follow-up Period	Results and Diffusion/ Displacement
Atlanta Regional Commission (1974), Atlanta, GA	City center; 4x	None	Crime (robbery, assault, and burglary)	12 months	Desirable effect; no displacement
DIFL (1974), Milwaukee, WI	Residential and commercial area; 7x	None	Crime (property and person categories)	12 months	Desirable effect; some displacement
Inskeep and Goff (1974), Portland, OR	Residential neighborhood (high crime); 2x	None	Crime (robbery, assault, and burglary)	6 or 11 months	Null effect; displacement and diffusion did not occur
Wright et al. (1974), Kansas City, MO	Residential and commercial areas; n.a.	None	Crime (violent and property offenses)	12 months	Desirable effect (for violence); some displacement
Harrisburg Police Department (1976), Harrisburg, PA	Residential neighborhood; n.a.	None	Crime (violent and property offenses)	12 months	Null effect; no displacement
Sternhell (1977), New Orleans, LA	Residential and commercial areas; n.a.	None	Crime (burglary, vehicle theft, and assault)	29 months	Null effect; no displacement
Lewis and Sullivan (1979), Fort Worth, TX	Residential neighborhood; 3x	None	Crime (total)	12 months	Desirable effect; possible displacement
Quinet and Nunn (1998), Indianapolis, IN	Residential neighborhood; n.a.	Police initiatives	Calls for service (violent and property crime)	7 to 10 months	Null effect; no displacement

Notes: DIFL = Department of Intergovernmental Fiscal Liaison; 4x = 4 times increase in lighting, and so forth; n.a. = not available.

compared with experimental areas, or decreased by 22 per cent in experimental areas compared with control areas. For the four night only studies, the odds ratio was 1.01 (n.s.), indicating no effect on crime. Therefore, the eight American studies could be divided into two blocks of four, one block showing that crime reduced after improved street lighting and the other block showing that it did not. Surprisingly, evidence of a reduction in crime was only obtained when both daytime and nighttime crimes were measured, although this feature may be a proxy for some other aspect of the different evaluation studies.

Unfortunately, all the American evaluations (except the Indianapolis one) are now rather dated, since they were all carried out in the 1970s. More recent American evaluations of the effect of improved street lighting need to be conducted. We now turn to the British evaluations, which were all published in the 1990s.

British Studies

The five British street lighting studies were carried out in a variety of settings, including a parking garage and a market, as well as residential neighborhoods (see Table 3). Three of the evaluations specified the degree of improvement in lighting: by five times in Stoke-on-Trent and by two times in Bristol (approximately) and Dudley. Control areas were usually located close to experimental areas. The outcome measure of crime was based on police records for three studies and on victim surveys in the other two cases (in Dudley and Stoke-on-Trent). Uniquely, the Dudley project also evaluated the impact of improved street lighting using self-reported delinquency surveys of young people. This project also included self-reports of victimization of young people and measures of fear of crime (Painter and Farrington, 2001a).

As shown in Table 3, improved street lighting was considered to be effective in reducing crime in four studies (Bristol, Birmingham, Dudley, and Stoke-on-Trent). In the fifth study (Dover), the improved lighting was confounded with other improvements, including fencing to restrict access to the parking garage and the construction of an office near the main entrance. On the basis of police records, Poyner (1991) concluded that the intervention had reduced thefts *of* vehicles but not theft *from* vehicles.

Results of the meta-analysis of the five British studies confirm these conclusions. Total crimes reduced significantly after improved lighting in Bristol, Birmingham, Dudley, and Stoke-on-Trent. When the odds ratios from the five studies were combined, crimes increased by 62 per cent after improved street lighting in control areas compared with experimental areas, or conversely crimes decreased by 38 per

Table 3. British Street Lighting Evaluations.

Author, Publication Date, Location	Context of Intervention and Increase in Lighting	Other Interventions	Outcome Measure	Follow-up Period	Results and Diffusion/ Displacement
Poyner (1991), Dover	Parking garage (in town center); n.a.	Fencing, office constructed	Crime (total and theft of and from vehicles)	24 months	Desirable effect (for theft of vehicles); no displacement
Shaftoe (1994), Bristol	Residential neighborhood; 2x	None	Crime (total)	12 months	Desirable effect; not measured
Poyner and Webb (1997), Birmingham	City center market; n.a.	None	Thefts	12 months (6 months in each of 2 years)	Desirable effect; no displacement and some diffusion
Painter and Farrington (1997), Dudley	Local authority housing estate; 2x	None	Crime (total and types of offenses)	12 months	Desirable effect; no displacement
Painter and Farrington (1999), Stoke-on-Trent	Local authority housing estate; 5x	None	Crime (total and types of offenses)	12 months	Desirable effect; diffusion, no displacement

Notes: 4x = 4 times increase in lighting, and so forth; n.a. = not available.

cent in experimental areas compared with control areas (OR = 1.62, CI = 1.22 – 2.15, p = .0008).

In conclusion, these more recent British studies agree in showing that improved lighting reduces crime. They did not find that nighttime crimes decreased more than daytime crimes, suggesting that a "community pride" theory may be more applicable than a "deterrence/ surveillance" theory.

Finally, the effects on different types of offenses were investigated. Violent crimes were measured in nine evaluations, and property crimes were measured in 11 evaluations. Table 1 shows that improved lighting was followed by a significant reduction in property crimes (OR = 1.20, CI = 1.02 – 1.41, p = .024) but not in violent crimes (OR = 1.10, CI = 0.91 – 1.34, n.s.).

Conclusions and Directions for Policy and Research

Evaluation research to measure the impact of improved street lighting on crime appears to have come to a standstill. This six-year update of the first systematic review on the subject (Farrington and Welsh, 2002a) did not find one new evaluation that measured the effect of lighting on crime. This lack of new studies does not, however, detract from the existing knowledge base on the crime prevention effects of improved street lighting.

Eight American evaluation studies met the inclusion criteria, and their results were mixed. Four studies found that improved street lighting was effective in reducing crime, while the other four found that it was not effective. Why the studies produced different results was not obvious, although there was a tendency for effective studies to measure both daytime and nighttime crimes and for ineffective studies to measure only nighttime crimes. However, all except one of these American evaluations date from the 1970s.

Five more recent British evaluation studies showed that improved lighting led to decreases in crime. Furthermore, in two studies (Dudley and Stoke-on-Trent), the financial savings from reduced crimes greatly exceeded the financial costs of the improved street lighting (Painter and Farrington, 2001b). Since these studies did not find that nighttime crimes decreased more than daytime crimes, a theory of street lighting focusing on its role in increasing community pride and informal social control may be more plausible than a theory focusing on increased surveillance and increased deterrence. The results did not contradict the hypothesis that improved street lighting was most effective in reducing crime in stable homogeneous communities.

While lack of systematic information on residential mobility made it difficult to draw clear conclusions about whether improved street lighting was more effective in reducing crime in stable homogeneous communities than in unstable heterogeneous communities, not one of the ten studies that could be included in this analysis clearly contradicted this hypothesis, and four studies (Dudley, Stoke-on-Trent, Harrisburg, and Fort Worth) were clearly concordant with it (the three studies that could not be included in this analysis were Indianapolis, Dover, and Birmingham; for more details, see Farrington and Welsh, 2002a).

An alternative hypothesis is that increased community pride comes first, causing improved street lighting on the one hand and reduced crime on the other, with no causal effect of improved lighting on crime. It is difficult to exclude this hypothesis on the basis of most

published evaluation reports. However, it can be excluded in the two evaluations (Dudley and Stoke-on-Trent) in which one of us (Farrington) was involved.

In Dudley, there had been no marked changes on the experimental estate for many years. The tenants on this and other local authority housing estates had complained about the poor lighting for some time, and this was why the local authority decided to improve the lighting on the experimental estate. The improvement in lighting was very obvious, and tenants thought that their quality of life had been improved (Painter and Farrington, 1997). This stimulated the Tenants' Association on the experimental estate to obtain £10 million (approximately $20 million) from the Department of the Environment for a program of neighborhood improvements in the next few years. The improvement in lighting on the experimental estate also stimulated the Tenants' Association on the control estate to petition the local authority to improve their lighting.

In Dudley, it was clear that the improved lighting occurred first, led to increased community pride, and acted as a catalyst for further environmental improvements. A similar chain of events happened in Stoke-on-Trent. While we cannot be sure that the same causal ordering occurred in all other street lighting evaluations, it might be concluded that in at least some studies improved lighting caused increased community pride and decreased crime.

Future research should be designed to test the main theories of the effects of improved street lighting (i.e., community pride versus surveillance/deterrence) more explicitly. Surveys of youth in experimental and control areas could be carried out, to investigate their offending, their opinions of the area, their street use patterns, and factors that might inhibit them from offending (e.g., informal social control by older residents, increased surveillance after dark). Household surveys of adults could also be carried out, focusing on perceptions of improvements in the community, community pride, informal social control of young people, street use, and surveillance after dark.

Ideally, future research should measure crime using police records, victim surveys, and self-reports of offending. It is possible that one effect of improved street lighting may be to facilitate or encourage reporting of crimes to the police; for example, if victims get a better view of offenders. Therefore, police records may be misleading. Surveys of potential victims and potential offenders are necessary for testing key hypotheses about the effects of improved lighting.

Future research should ideally include several experimental areas and several comparable adjacent and control areas. Adjacent areas are needed to test hypotheses about displacement and diffusion of benefits. The comparability of experimental, adjacent, and control areas should be investigated. The use of several areas would make

it more possible to establish boundary conditions under which improved lighting had greater or lesser effects. The numbers of crimes recorded in each area in the before period should be sufficient to detect changes reliably. Ideally, large numbers of potential victims and potential offenders should be surveyed.

Crimes should be measured before and after the intervention in experimental, adjacent, and control areas. Ideally, a long time series of crimes should be studied to investigate pre-existing crime trends and also how far any effects of street lighting persist or wear off over time. Different types of crimes should be measured, and also crimes committed during daytime and the hours of darkness. The improvement in lighting in different areas should be carefully measured, including vertical and horizontal levels of illumination. Cost-benefit analyses of the impact of improved street lighting should be carried out (only 2 of the 13 studies conducted a cost-benefit analysis). Our previous work (Welsh and Farrington, 1999; 2000) has shown that situational crime prevention is an economically efficient strategy in preventing crime.

In testing hypotheses, it would be useful to investigate the effects of street lighting in conjunction with other crime prevention interventions. To the extent that community pride is important, this could be enhanced by other environmental improvements. To the extent that surveillance is important, this could be enhanced by other interventions, such as CCTV cameras. For example, one experimental area could have both improved street lighting and CCTV, a second could have only improved street lighting, and a third could have only CCTV. This kind of planned evaluation of interactions of crime prevention initiatives has rarely been attempted.

The policy implications of research on improved street lighting have been well articulated by Pease (1999). He pointed out that situational crime prevention involved the modification of environments so that crime needed more effort, more risk, and lower rewards. The first step in any crime reduction program required a careful analysis of situations and how they affected potential offenders and potential victims. The second step involved implementing crime reduction interventions. Whether improved street lighting was likely to be effective in reducing crime would depend on characteristics of situations and on other concurrent situational interventions. Efforts to reduce crime should take account of the fact that crime tends to be concentrated among certain people and in certain locations, rather than being evenly distributed throughout a community.

The British studies included in this review show that improved lighting can be effective in reducing crime in some circumstances. Exactly what are the optimal circumstances is not clear at present, and this needs to be established by future evaluation research. However, improved street lighting should be considered as a potential strategy

in any crime reduction program in coordination with other intervention strategies. Depending on the analysis of the crime problem, improved street lighting could often be implemented as a feasible, inexpensive, and effective method of reducing crime.

Street lighting has some advantages over other situational measures that have been associated with the creeping privatization of public space, the exclusion of sections of the population, and the move towards a "fortress" society (Bottoms, 1990). Street lighting benefits the whole neighborhood rather than particular individuals or households. It is not a physical barrier to crime, it has no adverse civil liberties implications, and it can increase public safety and effective use of neighborhood streets at night. In short, improved street lighting has few negative effects and clear benefits for law-abiding citizens.

Appendix

Literature Reviews Consulted

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