STREET LIGHTING AND CRIME: DIFFUSION OF BENEFITS IN THE STOKE-ON-TRENT PROJECT

by

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Abstract: *Using a victim survey, the prevalence and incidence of crime were measured 12 months before and 12 months after the installation of improved street lighting in an experimental area of Stoke-on-Trent, U.K.; and at the same times in adjacent and control areas where the street lighting remained unchanged. The prevalence of crime decreased by 26% in the experimental area and by 21% in the adjacent area, but increased by 12% in the control area. The incidence of crime decreased by 43% in the experimental area and by 45% in the adjacent area, but decreased by only 2% in the control area. Police-recorded crimes in the whole police area also decreased by only 2%. It is concluded that the improved street lighting caused a substantial decrease in crime in the experimental area, and that there was a diffusion of these benefits to the adjacent area (which was not clearly delimited from the experimental area). Furthermore, the benefits of improved street lighting, in terms of the saidngs to the public from crimes prevented, greatly outweighed its costs*$_x$

The main aim of the present research was to assess the effect of improved street lighting on crime, using before and after victimization surveys in experimental, adjacent and control areas. This quasi-experimental design makes it possible to control for many threats to valid inference. It also permits the investigation of displacement and diffusion of benefits from experimental to adjacent areas. In many

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ways, the study resembles a "double-blind" clinical trial, since neither respondents nor interviewers knew about its purpose.

INTRODUCTION

Previous Research on Street Lighting and Crime

Contemporary interest in the relationship between street lighting and crime began in North America during the dramatic rise in crime that took place in the 1960s. Many towns and cities embarked upon major street lighting programmes as a means of reducing crime, and initial results were encouraging (Wright et al., 1974).

The proliferation of positive results across North America led to Tien et al.'s (1979) detailed review of the effect of street lighting on crime funded by the federal Law Enforcement Assistance Agency. The final report describes how 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, the authors found that as many projects reported an increase or no change as a reduction in crime. 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); insufficient appreciation of the impact of lighting on different types of crime; and inadequate measures of public attitudes and behaviour.

Obviously, the Tien et al. (1979) review should have led to attempts to measure the effects of improved street lighting using alternative measures of crime, such as victim surveys, self-reports or systematic observation. Unfortunately, it was interpreted as showing that street lighting had no effect on crime and, thereafter, the topic was neglected.

In the United Kingdom, very little research was carried out on street lighting and crime until the late 1980s. There was a resurgence of interest in the issue between 1988 and 1990, when three small-scale street lighting projects were implemented and evaluated in different areas of London: Edmonton, Tower Hamlets and Hammersmith/Fulham (Painter, 1994). In each location, crime, disorder, and fear of crime declined and pedestrian street use increased dramati-

cally after the lighting improvements (see Painter, 1996, for a review of U.K. projects).

In contrast to these generally positive results, a major 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, publicised simultaneously, also asserted that "better lighting by itself has very little effect on crime" (Ramsey and Newton, 1991:24). The Atkins et al. (1991) evaluation appeared to be well-designed, since it was based on before and after measures of police statistics and victimization reports in relit (experimental) and control areas. However, in analyzing police statistics, crimes were dubiously classified into those "likely" or "unlikely" to be affected by street lighting. For example, robbery and violence, which decreased significantly in the Wright et al. (1974) project, were thought *unlikely* to be affected by street lighting (Atkins et al., 1991:10). Interestingly, while the "likely" crimes decreased by only 3% after the improved lighting, the "unlikely" crimes decreased by 24% (Atkins et al., 1991). Unfortunately, the response rates in the victimization surveys were very low (37% before and 29% after). Only 39 crimes were reported in the before survey in the experimental area and only 13 in the control area, suggesting that the research had insufficient statistical power to detect changes in crime rates.

The best-designed previous evaluation of the effect of improved street lighting on crime was the Dudley project (Painter and Farrington, 1997), which was the forerunner of the present project. Before and after victimization surveys were carried out in experimental and control areas. The areas were adjacent to each other but clearly defined and physically separated. Large samples were interviewed (about 440 before and 370 after in each area). In general, the experimental and control respondents were closely comparable, except that more of the control respondents were aged over 60 and more of them in the before survey said that they had seen a police officer on foot on their estate in the previous month.

The prevalence and incidence of crime decreased significantly on the experimental estate after the relighting compared with the control estate. This result held not only after controlling for initial levels of crime, but also after controlling for the respondent's age and for the visibility of police officers on the estate. There was no sign of crime displacement from the experimental to the control estate. The percentage of crimes committed after dark was about 70% before and after in both estates. Therefore, the reduction in crime in the experi-

mental estate applied equally to crimes committed in the day or night.

The experimental sample noticed that the lighting had improved and became more satisfied with their estate afterwards. Also, they were more likely than the control sample to say that their estate was safe after dark in the after survey. Pedestrian counts showed that the number of women out on the streets after dark increased significantly in the experimental area compared with the control area; the number of men also increased in the experimental area, but less markedly. It was concluded that the improved street lighting had caused a decrease in crime, and that this was probably mediated by increased community pride and informal social control deterring potential offenders.

Street Lighting: Mechanisms of Crime Reduction

Explanations of the way street lighting improvements could prevent crime can be found in "situational" approaches which focus on reducing opportunity and increasing perceived risk through modification of the physical environment (Clarke, 1992). Explanations can also be found in perspectives that stress the importance of strengthening informal social control and community cohesion through more effective street use (Jacobs, 1961; Angel, 1968), and investment in neighbourhood conditions (Taub et al., 1984; Fowler and Mangione, 1986; Lavrakas and Kushmuk, 1986; Taylor and Gottfredson, 1986). The situational approach to crime prevention suggests that crime can be prevented by environmental measures that directly affect offenders' perceptions of increased risks and decreased rewards. This approach is also supported by theories that 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 emphasised the importance of investment to improve neighbourhood conditions as a means of strengthening community confidence, cohesion and social control (Wilson and Kelling, 1982; Taub et al., 1984; Taylor and Gottfredson, 1986; Skogan, 1990). 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 neighbourhood. In turn, this

might lead them to have a more positive image of the area and 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 between 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 behaviour of residents and potential offenders.

There are several possible ways in which improved lighting might reduce crime:

(1) Lighting reduces crime by improving visibility. This deters potential offenders by increasing the risks that they will be recognized or interrupted in the course of their activities (Mayhew et al., 1979).

(2) Lighting improvements encourage increased street usage, which intensifies natural surveillance. The change in routine activity patterns works to reduce crime because it increases the flow of potentially capable guardians. From the offender's perspective, the proximity of other pedestrians acts as a deterrent increasing the risks of being recognised or interrupted when attacking personal or property targets (Cohen and Felson, 1979). From the potential victim's perspective, perceived risks and fears of crime are reduced.

(3) Enhanced visibility and increased street usage combine to heighten possibilities for informal surveillance. Pedestrian density and flow and surveillance have long been regarded as crucial for crime control since they can influence offenders' perceptions of the likely risks of being caught (Jacobs, 1961; Newman, 1972; Bennett and Wright, 1984).

(4) The renovation of a highly noticeable component of the physical environment, combined with changed social dynamics, acts as a psychological deterrent. Offenders judge that the image of the location is improving and that social control, or-

der, and surveillance have increased (Taylor and Gottfredson, 1986). They may deduce that crime in the relit location is riskier than elsewhere, and this can influence behaviour in two ways. First, offenders living in the area will be deterred from committing offences or escalating their activities. Second, potential offenders from outside the area will be deterred from entering it (Wilson and Kelling, 1982). Crime in the relit area is reduced though it may be displaced elsewhere.

(5) Lighting improves community confidence. It provides a highly noticeable sign that local authorities are investing in the fabric of the area. This offsets any previous feelings of neglect and stimulates a general "feel-good" factor. Fear is reduced.

(6) Improved illumination reduces fear of crime because it physically improves the environment and alters public perceptions of it. People sense that a well-lit environment is less dangerous than one that is dark (Warr, 1990). The positive image of the nighttime environment in the relit area is shared by residents and pedestrians. As actual and perceived risks of victimization lessen, the area becomes used by a wider cross-section of the community. The changed social mix and activity patterns within the locality reduce risks of crime and reduce fear.

It is feasible that lighting improvements could, in certain circumstances, increase opportunities for crime by bringing greater numbers of potential victims and potential offenders into the same physical space. It is also likely that more than one of the preventive mechanisms may operate simultaneously or interact.

The Stoke-on-Trent and Dudley projects represent the most thorough attempts to develop a coherent theory linking street lighting, the urban environment and resident dynamics with the incidence of crime. The methods of measurement were designed empirically to test whether street lighting could facilitate informal surveillance and pedestrian use of an area in ways that promote the capacity and willingness of residents to protect the community from potential offenders. These are theory-based evaluations.

Crime Displacement

The main theoretical criticism of Crime Prevention Through Environmental Design (Jeffery, 1971) and situational approaches is that blocking opportunities for crime in one place will merely result in it being displaced to a different time, place or target, or cause the of-

fender to change tactics or commit different types of offences (Reppetto, 1976; Gabor, 1983). The assumption underpinning the displacement hypothesis is that making one offence more difficult to accomplish does not eliminate the motivation to offend, and that the rational criminal will simply seek out alternative opportunities.

Rational choice theory, while accepting the possibility that displacement occurs, holds that it will only happen to the extent that alternative crimes offer the same reward without greater costs in terms of risk or effort. From this perspective, displacement is not seen as an inevitable outcome of situational measures but as conditional upon the offender's assessment of the ease, risk and appeal of other criminal opportunities.

Recent reviews of the evidence on crime displacement suggest that empirical evidence in support of the phenomenon is hard to come by (Bannister, 1991; Barr and Pease, 1992; Clarke, 1992, 1995; Hesseling, 1994). Nonetheless, displacement has been found in a number of studies. For example, evidence of spatial displacement of burglary was noted in a study of Neighbourhood Watch in Vancouver, Canada (Lowman, 1983); spatial and functional displacement occurred following a target-hardening project in Newcastle, UK (Allatt, 1984) and spatial displacement has been observed following property marking schemes in Ottawa, Canada (Gabor, 1983, 1990).

There are so many methodological difficulties associated with measuring displacement that Barr and Pease (1990) questioned whether the issue could ever be resolved by empirical research. A recent study of the use of slugs (false coins) on the London underground demonstrated how an uncritical acceptance of displacement could mean that increases in crime, which might have occurred in the absence of any preventive measure, might be wrongly interpreted as evidence of displacement (Clarke et al., 1994).

Clarke (1992, 1995) cites numerous examples of successful situational measures that did not lead to displacement, and other research has shown that, depending on the nature of the offence, there may be no point in looking for displacement effects. For example, the likelihood of crime displacement occurring from the introduction of random breath testing (Homel, 1993) or of speed cameras in Australia (Bourne and Cook, 1993) is minimal because people are not normally predisposed and determined to commit drunk driving and speeding offences.

Research focussing on the "choice structuring properties" of different offence types has demonstrated the contingent nature of crime displacement and explained why it is not an inevitable outcome of

situational preventive measures (Clarke and Mayhew, 1988; Mayhew et al., 1989; Clarke and Harris, 1992a, 1992b). Even where displacement has been observed, it has rarely been total (Gabor, 1990). It might be benign if offenders were deflected from more serious to less serious offences, or from offending against a repeatedly victimized vulnerable group of the population to offending against a group that is better able to resist and withstand antisocial and criminal events (Painter, 1991; Pease, 1991; Barr and Pease, 1992). Arguing that displacement symbolises pessimism about crime prevention, Barr and Pease (1990) prefer the term "deflection," which indicates success in moving a crime from its intended- target.

Diffusion of Benefits

A considerable number of studies have observed the reverse of displacement, whereby the effects of a preventive action led to a reduction in crimes not directly targeted by the measure (see Clarke, 1992, 1995, for a summary). For example, Miethe (1991) used the term "free-rider" effect to refer to the benefits to unprotected residents whose neighbours had taken preventive actions. Sherman (1990) noted the "bonus effects" of prolonged preventive effects after the period during which police crackdowns took place. Scherdin (1986) observed a "halo" effect, when a library book detection system prevented not only electronically protected material from being stolen but also unprotected items.

Poyner and Webb (1992) noticed that measures designed to reduce thefts in indoor markets in the Birmingham city centre also appeared to reduce thefts in other markets. Poyner (1991) found that a closed circuit television (CCTV) system, aimed at reducing thefts of cars in a university car park, also led to a reduction in a nearby car park not covered by the cameras. Poyner (1992) showed that CCTV on buses not only reduced vandalism on the five targeted vehicles but extended to the entire fleet of 80 buses, simply because schoolchildren were unsure which buses did, or did not, have cameras. Painter (1991) also found a reduction in crime in two unlit roads adjacent to a relit area following a street lighting initiative, and Pease (1991) noted a "drip-feed" effect to other households that were not targeted by a burglary prevention scheme, so that the burglary rate across the entire estate declined.

This phenomenon has been termed "diffusion of benefits." This is defined as the "spread of the beneficial influence of an intervention beyond the places which are directly targeted, the individuals who are the subject of control, the crimes which are the focus of the inter-

vention or the time periods in which an intervention is brought" (Clarke and Weisburd, 1994:169). Diffusion through deterrence works by affecting offenders' perceptions of risk, as illustrated by Poyner's (1992) study of CCTV on buses, which appeared to bring a widespread benefit because the children were unsure about which buses had cameras. Diffusion through discouragement works by changing offenders' assessments of the relative effort and reward involved in committing offences. For example, Pease (1991) explained the "drip-feed" effect in the Kirkholt burglary project as a consequence of the removal of prepayment meters from burgled households, which meant that burglars could no longer count on finding a meter containing cash in a house. Ekblom (1988) also noted that the introduction of anti-bandit screens in London post offices brought about a reduction not only in over-the-counter robberies but also in other robberies of staff and customers. He considered that potential robbers had been discouraged by the general message that something was being done to increase security at post offices.

Possible displacement and diffusion effects have implications for evaluation designs. On the one hand, displacement of crime from the target area to a nearby control area may lead to "double counting" and an exaggeration of the impact of the intervention. On the other hand, as Ekblom and Pease observed (1995:9): "...diffusion of benefits from the action to the control area (occasioned, for example by offenders giving the action area a wider berth than strictly necessary) may lead to an underestimate of impact. In effect, the more successful a programme is in spreading benefits beyond its boundaries, the less success may be attributed to it." Clarke (1995:42) commented that it was likely that in the 1990s, diffusion of benefits might supersede displacement as "the principal focus of theoretical debate about the value of situational measures."

RESEARCH DESIGN

The Stoke-on-Trent evaluation employed a non-equivalent control group design with before and after measures of crime in experimental (relit), adjacent and control areas. Using a victim survey, the prevalence and incidence of crime were measured 12 months before and 12 months after the installation of improved street lighting in the experimental area and, at the same times, in adjacent and control areas where the street lighting remained unchanged. The questions on crime were identical in all surveys. The adjacent and control areas selected were located near the experimental area for two reasons.

First, it was envisaged that the people living in them would be similar in many respects to those in the experimental area, and second, to facilitate the investigation of spatial and temporal displacement of crime or diffusion of benefits. Hence, demographic factors that might influence crime rates should be equivalent in all areas at the outset. It becomes more plausible, therefore, that any change in crime between the relit and non-relit areas can be attributed to the street lighting programme rather than to preexisting differences between the samples. This design controls for the major threats to internal validity (history, maturation, testing, instrumentation, regression and mortality).

Research Hypotheses

The main research hypotheses were as follows:

(1) Improved street lighting will decrease crime after dark in the experimental area (e.g., either because the increased risk of offenders being seen and identified acts as a deterrent, potential victims can more easily avoid potential offenders, or it is harder for potential offenders to hide and surprise their victims).

(2) Improved street lighting will decrease crime both in the dark and the light in the experimental area (e.g., because the improved lighting signals an improving neighbourhood and leads to increased community confidence and community pride, which, in turn, leads to increased informal social control, which then deters potential offenders).

(3) Improved street lighting will displace crime to the adjacent area, so that crime in the adjacent area increases.

(4) Improved street lighting will cause a diffusion of benefits to the adjacent area (e.g., because potential offenders are deterred not only from the experimental area but also from adjacent areas), so that crime in the adjacent area decreases.

(5) Improved street lighting will lead to a decreased fear of crime after dark.

(6) Improved street lighting will lead to an increased number of people outside on the streets after dark.

(7) Improved street lighting will lead to a more favourable assessment of the quality of the neighbourhood.

Selection and Description of the Experimental Area

Stoke-on-Trent is a city in the North Midlands of England, which has been formed around the six towns of Burslem, Fenton, Hanley, Longton, Stoke and Tunstall. The towns lie in close proximity to one another, within a single metropolitan area about eight miles in diameter. The city has been dominated by two industries, mining and pottery. Though the area was badly hit by unemployment throughout the 1980s, Stoke-on-Trent remains a flourishing and vibrant place. The large project area lies to the north of the city, and is surrounded by open land. It offers few social amenities. The northern part is bounded by a main arterial road, which contains the usual mixture of neighbourhood public houses, small shops, a snooker (pool) club, a church, fish-and-chip shops, and take-away food outlets. Within the large project area, experimental, adjacent and control areas were studied.

The experimental area comprises what was originally a council estate containing 365 properties. The majority of houses are still rented from the council, although approximately 17% have been sold to tenants. The estate is characteristic of many others built in the early 1950s. It is made up of low-rise, short-terraced and semi-detached houses that have gardens back and front. The adjacent areas were located to the west and east of the experimental area, and were not clearly differentiated from it. Some roads continued from the experimental area into the adjacent areas with no obvious boundary, making it difficult for respondents to know where one area ended and another began. The adjacent area to the east was primarily council-owned property, whereas the adjacent area to the west was primarily privately owned property. The control areas were located further away from the experimental area, to the north and south. They were physically separate from and clearly demarcated from the experimental and adjacent areas, and were primarily council-owned property.

The Nature and Implementation of the Street Lighting Programme

Details of the street lighting programme and the way and the time it was implemented are important; the type, level and uniformity of lighting will affect the likelihood of preventing crime. If, for instance, the level or uniformity of the lighting is inadequate, or if the lighting is obscured by other environmental features such as shrubbery, then the potential mechanisms suggested earlier may not be induced. Each of the improved lighting schemes in the programme was de-

signed to meet British Standard, BS 5489, Part 3. This lists three categories of lighting levels — from 3/1 (the best) to 3/3 (the worst). These categories are based on levels of traffic, pedestrian use and perceived levels of crime. Thus, an area with high traffic flow, high pedestrian flow and high crime should be illuminated to the 3/1 standard. The preexisting street lighting in the experimental, adjacent and control areas did not even achieve the minimum standard of 3/3. Consequently, the lighting upgrade constituted a very noticeable alteration of the nighttime environment in the experimental area.

The experimental area was chosen for relighting by the council on the basis of its perceived need. Between mid-December 1992 and mid-January 1993, 110 high-pressure sodium (white) street lights (lantern type) were installed over 1,000 metres of roadway. These lights replaced the older, domestic-type tungsten lamps. Detached footpaths that were previously unlit were also illuminated. The area was illuminated in accordance with category 3/2 of BS 5489, giving an average illuminance of 6 lux and a minimum of 2.5 lux. Maintenance and energy costs doubled as a consequence of reducing the large spacing of up to 50 metres pre-test to approximately 38 metres post-test. However, the amount of useful light increased fivefold and the efficient use of electricity doubled.

THE BEFORE AND AFTER VICTIMIZATION SURVEYS

The timing of data collection was the same in all the areas. The before survey was carried out from the last two weeks of October to mid-November 1992. The lighting installation commenced in December 1992 and was completed by the second week in January 1993. The after surveys were undertaken 12 months later, from mid-November to mid-December 1993. In investigating the impact of street lighting on crime, the 12-month period prior to street lighting installation (November 1991-November 1992) was compared with the 12 month period after, including the installation period (December 1992-December 1993).

The before and after surveys measured household victimization and respondents' perceptions, attitudes and behaviour. The majority of questions on victimization, fear of crime and quality of life were similar to those used in successive British Crime Surveys (e.g., Mayhew et al., 1993; Mirrlees-Black et al., 1996). Respondents were only asked about crimes that had occurred *on their estate* during the previous 12 months, and supplementary questions ensured that the same criminal event did not generate reports of two categories of

crime. Additional questions on public reactions to the new lighting and travel behaviour after dark were included at the end of the after survey, as part of a process evaluation of programme implementation. Other crime prevention strategies, such as Neighbourhood Watch and policing strategies, were monitored through closed and open-ended questions and interviewer fieldwork sheets, as were other possible extraneous historical influences that might have caused a change in outcomes within and between the project areas.

Interviewing Procedures

The household face-to-face interviews took between 45 and 90 minutes, depending on the extent of victimization. Prior to an interviewer calling, households were sent a leaflet explaining that a crime survey was taking place, but no mention was made of the proposed street lighting initiative. To minimize any unwitting interviewer bias, interviewers were *not* told about the true purpose of the survey, and were therefore unaware of the lighting improvements that were to take place. They were also unaware that there were experimental and control areas. The same interviewing team, consisting of 19 interviewers, was employed in each of the study areas, both before arid after the initiative. For the after survey, every effort was made to match interviewers to their before respondents. The research was carried out by a company with previous experience in undertaking community surveys. A 20% quality control check was undertaken. Each week the fieldwork supervisor visited 10% of respondents to check that interviews had been conducted, and a further 10% of respondents were mailed a self-completion questionnaire that asked whether the interview had been conducted in a satisfactory manner.

The type of local authority dwelling ensured that only one household lived at each address. A "household" was defined as "people who are catered for by the same adult(s) and share the same meals." An individual over the age of 18 years was selected for interview by a random procedure, which involved the interviewer listing, in alphabetical order, the first names of household members. Selection of the interviewee was based on a pre-assigned random number between one and nine, depending on the number of persons living in the household. The initial cross-sectional target samples can therefore be considered as representative of people living in the areas.

In the before survey, interviewers were instructed to make unlimited callbacks to contact the selected individual and no substitution was allowed. In the after survey, interviewers were instructed to contact the same individual from the same household. After six call-

backs, another member of the household could be selected for interview, using the same randomized procedures described above. New tenants who had moved in were interviewed in the after survey, but no attempt was made to trace individuals who had moved from one address on the estate to another.

Selection of Samples

The electoral register was used as the sampling frame for the experimental, adjacent and control areas. Field enumeration was used to identify missing addresses and void properties. It would be more accurate to describe the Stoke-on-Trent survey, carried out in the experimental area, as a census because every household on the electoral register was included. The reason for this was to ensure that there were sufficient numbers of criminal incidents for statistical analysis. In the adjacent and control areas, every third household on the electoral register was selected for inclusion. The intention was to produce a sample size approximately comparable to that in the experimental area.

Of the issued sample of 756 addresses (drawn from a sampling frame of 1,580 addresses in all areas), 79 were void (vacant). The response rate in the before survey was 89% in the experimental area (317 completed interviews from 357 addresses) and 80% in the adjacent and control areas (255 completed interviews from 320 addresses). There were originally three control areas, but one was dropped from the design because it was being extensively renovated by the council, and many of the houses were boarded up because tenants had temporarily moved out during the renovation. Many of the void addresses were in this area. Excluding this area, there were 88 completed interviews in the before survey in the two remaining control areas, and 135 completed interviews in the two adjacent areas. For ease of exposition, the two adjacent areas will in future be termed the adjacent area, and the two control areas will be termed the control area.

In the after survey, the aim was to complete interviews only at houses where interviews had been completed in the before survey. The follow-up response rates were 88% (278 out of 317) in the experimental area, 90% (121 out of 135) in the adjacent area, and 92% (81 out of 88) in the control area. In 92% of cases, the respondent was the same in the after survey as in the before survey; in 6% of cases, a different respondent from the same household was interviewed in the after survey; and in 2% of cases, a different respondent from a different household living at the same address was interviewed

in the after survey. Unfortunately, it was not possible to link up before addresses with after addresses in order to carry out longitudinal analyses, with each address acting as its own control. Hence, the before and after surveys had to be treated as repeated cross-sectional surveys.

In the Dudley project, it was estimated that samples of 325-400 people before and after were required to have sufficient statistical power to detect a reasonably likely and practically important magnitude of change in crime rates, from a 50% to a 40% overall victimization rate (Painter and Farrington, 1997). Hence, the small sample sizes in the adjacent and control areas are a limitation of the Stoke-on-Trent project. These small sample sizes mean that changes in crime rates (or in other variables) between the before and after surveys would have to be quite large in the adjacent and control areas in order to be statistically significant. Roughly speaking, a reduction in the victimization rate from 50% to 40% in the experimental area would be significant, but the reduction would have to be from 50% to 35% in the adjacent and control areas in order to be significant.

Victimization surveys have many limitations. Respondents may experience memory decay, especially in relation to less important events that have occurred within the previous 12 months. "Telescoping" is also a possible distorting factor, in that respondents may recall events from outside this 12-month period as occurring within it. However, the comparison of experimental, adjacent and control areas, and before and after surveys, largely controls for these kinds of measurement limitations, which should be similar in all surveys and all areas.

QUANTITATIVE RESULTS

Comparability of the Experimental, Adjacent and Control Areas

Table 1 shows the extent to which the experimental, adjacent and control areas were comparable in the before surveys. For example, 55.2% of respondents in the experimental area were female, compared with 63.7% of those in the adjacent area and 56.8% of those in the control area, a non-significant variation on the 3 x 2 chi-squared test. The variation in age was nearly significant (p=.O61). The local authority did not permit a question about ethnic origin, but the vast majority of respondents were white. Most had lived in the area for 10

Table 1: Comparability of Experimental, Adjacent and Control Areas Before Improved Lighting

	Experimental % (N=317)	Adjacent % (N=135)	Control % (N=88)	p value
Demographics				
Female	55.2	63.7	56.8	ns
Age 45+	54.9	64.4	65.9	ns
On Estate 10+ years	56.5	61.5	58.0	ns
Employed	28.4	31.1	25.0	ns
Opinion of Estate				
Talk to most/all neighbours	72.6	80.0	71.6	ns
Friendly area	74.1	75.6	73.9	ns
Well kept	39.1	50.4	46.6	ns
Unsafe to walk in dark	66.2	68.9	60.2	ns
Risks for women alone after dark	88.1	90.3	88.9	ns
Risks for elderly alone after dark	93.7	94.6	88.2	ns
Youth hang around	81.1	76.3	68.2	.033
Quality of life worse last year	60.3	56.3	44.3	.028
Quality of life better last year	3.5	4.4	17.0	.0001
Saw police in last month	21.1	25.9	58.0	.0001
Estate Lighting				
Badly lit	73.5	57.0	62.5	.002
Too dull	72.2	64.4	64.8	ns
Creates shadows	55.2	51.9	46.6	ns
Worry about Crime				
Burglary	75.7	80.0	68.2	ns
Street robbery	30.5	37.0	36.4	ns
Street assault	36.2	38.5	34.5	ns
Vandalism to home	63.4	67.4	59.1	ns
Car stolen/damaged	53.3	68.4	59.5	.020
Avoid going out after dark	33.1	38.6	34.1	ns
Feel unsafe in own home	52.7	53.3	46.6	ns
High fear of crime	54.3	58.5	48.9	ns
Prevalence of Crime				
Burglary	24.3	20.0	12.5	ns
Outside theft/vandalism	20.5	30.4	17.0	.030
Vehicle crime	25.9	18.5	11.4	.008
Property crime	53.0	52.6	31.8	.001
Personal crime	12.6	16.3	6.8	ns
All crime	57.7	55.6	34.1	.0004
Increased last year	83.0	87.4	65.9	.0002
% Outside in dark	70.3	72.3	48.9	.009
% Reported to police	56.7	48.1	59.6	ns

p values based on chi-squared from 3 x 2 tables

or more years, and over 40% had lived in the area for 20 or more years. Less than one-third of respondents were employed full-time or part-time. Generally, the respondents in the different areas were comparable on these demographic factors.

About three-quarters of respondents in all areas said that they talked to most or all of their neighbours, and about three-quarters said that their area was friendly. The experimental respondents were somewhat less likely than the remainder to say that their area was well kept, but this was not quite statistically significant (p=.O67). About two-thirds of all respondents said that it was unsafe to walk in the dark in their area, and about 90% in all areas said that there were risks for women and elderly people out alone after dark.

Respondents in the control area were somewhat less likely to say that groups of youths hung around their area. They were also less likely to say that their environment and quality of life had become worse, and more likely to say that things had become better, in the last year (although very few respondents thought that their environment and quality of life had improved). Respondents in the control area were also much more likely to say that they had seen a police officer on foot in their area in the last month.

In response to questions about street lighting, most people said that their area was badly lit, and those in the experimental area were most likely to say this. However, there was no significant variation among area respondents in saying that the street lighting was too dull or that it created shadows. About three-quarters of respondents in all areas worried "a lot" or "quite a bit" about burglary. There was no significant variation among the areas in worries about burglary, being robbed in the street, being attacked in the street, or having one's home damaged by vandals. However, respondents in the adjacent area were most worried about having their car stolen or damaged. There were no significant differences among the areas in avoiding going out after dark (always or often), feeling unsafe in one's own home, or having a very or fairly high fear of crime.

Crimes were divided into four types:

(1) burglary (including attempts),

(2) theft from outside the home, vandalism of the home or bicycle theft,

(3) theft of or from vehicles or damage to vehicles, and

(4) personal crime against any member of the household, including street robbery, snatch theft, assault, threatening behaviour or sexual pestering of females.

Categories (1), (2) and (3) together constitute property crime. Table 1 shows that the experimental and adjacent area were generally comparable on the reported prevalence of victimization in the last year, but the control area had a lower victimization rate. Similarly, whereas 83% of those in the experimental area and 87.4% of those in the adjacent area thought that crime had increased in the last year, this was true of only 65.9% of those in the control area. About 70% of all crimes were committed during the hours of darkness outside or in a public place in the" experimental and adjacent areas, but this was true of only about 50% of crimes committed in the control area. There was no significant variation among the areas in the probability of reporting a crime to the police.

None of the variables measured in this project and shown in Table 1 can explain the significant before differences in crime among the experimental, control and adjacent areas. The variations in youths hanging around and in the perceived quality of life are similar to the variations in crime. It is possible that more police on foot in an area might correlate with lower crime rates. However, as also found in the Dudley project, there was no correlation whatever between seeing police on foot in the area and the prevalence of any type of crime. The non-comparability of the before crime rates in the three areas will be controlled in regression analyses.

Changes in the Prevalence of Crime

Table 2 shows changes in the prevalence of crime (the percentage of households victimized in the last year) between the before and after surveys. For all crime categories except burglary, prevalence decreased significantly in the experimental area after the street lighting was improved. For example, the percentage who were victims of any crime decreased by a quarter, from 57.7% to 42.8%. The greatest percentage decreases were in personal crime (52%), outside theft/vandalism (40%) and vehicle crime (37%).

The prevalence of crime also decreased in the adjacent area. None of the decreases was statistically significant, but the decreases in all crime ($p=.080$) and in property crime ($p=.070$) were not far off. The decreases in vehicle crime (37%), personal crime (34%) and outside theft/vandalism (27%) were substantial. Crime did not change consistently in the control area. Overall, the prevalence of all crime increased slightly, from 34.1% before to 38.3% after.

The extent to which changes in prevalence in one area were significantly different from changes in prevalence in another was tested

using the interaction term in a logistic regression equation (Farrington, 1997):

$$LOG [P/(1-P)] = b_0 + b_1 PREPOST + b_2 CONEXP + b_3 PREPOST*CONEXP$$

Where

LOG = Natural logarithm
P = Probability of crime
PREPOST = Dichotomous before/after variable
CONEXP = Dichotomous control/experimental variable
PREPOST*CONEXP = Interaction term

This method of analysis controls for preexisting differences in crime rates between areas. It showed that the change in all crime in the experimental area was significantly different from the change in all crime in the control area (LRCS=4.69, p=.030). Similarly, the change in property crime in the experimental area was significantly different from the change in property crime in the control area (p=.O44). It can be concluded that the prevalence of crime decreased significantly in the experimental area compared with the control area, but decreased similarly in the experimental and adjacent areas.

Changes in the Incidence of Crime

Table 3 shows changes in the incidence of crime (the average number of victimizations per 100 households, allowing a maximum of 10 per household in each crime category). For all crime categories except burglary and outside theft/vandalism, incidence decreased significantly in the experimental area after the street lighting was improved. For example, the incidence of all crimes decreased by 43%, from 173.8 to 99.3 crimes per 100 households. The greatest percentage decreases were for personal crime (68%) and vehicle crime (46%).

The incidence of crime also decreased in the adjacent area, and the decreases were significant for property crime (38%), personal crime (66%) and all crime (45%). However, crime did not change consistently in the control area. Overall, the incidence of all crime decreased marginally, from 69.3 to 67.9 crimes per 100 households.

The extent to which changes in incidence in one area were significantly different from changes in incidence in another was tested using the interaction term in a Poisson regression equation. (This was carried out using the GLIM computer package to specify a Poisson distribution of incidence and a logarithmic link to the right hand side

Table 2: Changes in the Prevalence of Victimization

	Experimental			Adjacent			Control		
	Before (317)	After (278)	% Change	Before (135)	After (121)	% Change	Before (88)	After (81)	% Change
Burglary	24.3	21.2	-13	20.0	18.2	-9	12.5	16.0	+28
Outside theft/vandalism	20.5	12.2	-40*	30.4	22.3	-27	17.0	16.0	-6
Vehicle crime	25.9	16.2	-37*	18.5	11.6	-37	11.4	8.6	-25
Property crime	53.0	39.2	-26*	52.6	40.5	-23	31.8	35.8	+13
Personal crime	12.6	6.1	-52*	16.3	10.7	-34	6.8	4.9	-28
All crime	57.7	42.8	-26*	55.6	43.8	-21	34.1	38.3	+12

* Change significant on chi-squared test ($p<.05$, two-tailed)
Change in experimental area significantly different from change in control area:
Property crime, LRCS=4.05, p=.044
All crime, LRCS=4.69, p=.030
LRCS = Likelihood Ratio Chi-Squared = Interaction term in logistic regression

Table 3: Changes in the Incidence of Victimization

	Experimental			Adjacent			Control		
	Before (317)	After (278)	% Change	Before (135)	After (121)	% Change	Before (88)	After (81)	% Change
Burglary	38.5	32.7	-15	31.1	24.8	-20	15.9	16.0	+1
Outside theft/vandalism	43.8	27.0	-38	65.2	38.8	-40	26.1	34.6	+33
Vehicle crime	47.6	25.5	-46*	34.8	18.2	-48	17.0	11.1	-35
Property crime	130.0	85.3	-34*	131.1	81.8	-38*	59.1	61.7	+4
Personal crime	43.8	14.0	-68*	48.9	16.5	-66*	10.2	6.2	-39
All crime	173.8	99.3	-43*	180.0	98.3	-45*	69.3	67.9	-2

Note: Mean offence rate per 100 households

*Change significant on t-test ($p<.05$, two-tailed)

Change in Experimental area significantly different from change in Control area:

Outside theft, LRCS=5.91, p=.015

Property crime, LRCS=4.69, p=.030

All crime, LRCS=7.17, p=.007

Change in Adjacent area significantly different from change in Control area:

Outside theft, LRCS=5.74, p=.017

Property crime, LRCS=4.82, p=.028

All crime, LRCS=7.19, p=.007

LRCS = Likelihood Ratio Chi-Squared = Interaction term in Poisson regression

of the equation.) This showed that the change in all crime in the experimental area was significantly different from the change in all crime in the control area (LRCS=7.17, p=.007). Similarly, the changes in outside theft/vandalism and property crime were significantly different in the experimental and control areas. Also, the changes in outside theft/vandalism, property crime and all crime in the adjacent area were significantly different from the corresponding changes in the control area. Once again, these tests show that crime decreased in the experimental and adjacent areas compared to the control area.

Changes in the Prevalence of Known Victims

Respondents were asked whether they, personally, knew anyone else from their estate who had been a victim of specified crimes in the last year. Table 4, modelled on Table 2, shows changes in the prevalence of known victims in the experimental, adjacent and control areas. For all crime categories except vandalism to the home (outside theft and bicycle theft were not asked), prevalence decreased significantly in the experimental area after the street lighting was improved. For example, the prevalence of known victims of any crime decreased from 86.8% to 78.4%. The greatest percentage decreases were in personal crime (33%) and vehicle crime (27%).

In the adjacent area, the prevalence of known victims also decreased for vehicle crime (by 20%, significantly) and personal crime (by 26%). The prevalence of known victims generally increased in the control area. The increases were greatest, and almost significant, for vandalism (by 42%, p=.060) and vehicle crime (by 51%, p=.O65).
Changes in known victims in the experimental area were significantly different (according to the interaction term in logistic regressions) from changes in known victims in the control area for burglary, vandalism, vehicle crime and property crime. Also, differences were nearly significant for all crime (p=,079). In all cases, the prevalence of known victims decreased in the experimental area and increased in the control area. For vehicle crime, changes in known victims in the adjacent area were significantly different from changes in known victims in the control area. Also, differences were not far off significance for property crime (p=.O94). For burglary, changes in the experimental area were not far off statistically different from changes in the adjacent area (p=.O98). Generally, the prevalence of known victims decreased in the experimental area, decreased less in the adjacent area, and increased in the control area.

Table 4: Changes in the Prevalence of Known Victims on Estate

	Experimental			Adjacent			Control		
	Before (317)	After (278)	% Change	Before (135)	After (121)	% Change	Before (88)	After (81)	% Change
Burglary	77.9	66.2	-15*	76.3	76.0	0	62.5	69.1	+11
Vandalism	49.5	42.8	-14	50.4	50.4	0	37.5	53.1	+42
Vehicle crime	57.5	42.1	-27*	65.9	52.9	-20*	29.5	44.4	+51
Property crime	86.4	76.3	-12*	88.1	81.8	-7	72.7	79.0	+9
Personal crime	27.4	18.3	-33*	28.9	21.5	-26	34.1	27.2	-20
All crime	86.8	78.4	-10*	88.1	82.6	-6	76.1	79.0	+4

* Change significant on chi-squared test ($p<.05$, two-tailed)

Change in experimental area significantly different from change in control area:

Burglary, LRCS=5.60, p=.018

Vandalism, LRCS=6.61, p=.010

Vehicle crime, LRCS=12.50, p=.0004

Property crime, LRCS=6.02, p=.014

Change in adjacent area significantly different from change in control area:

Vehicle crime, LRCS=8.39, p=.004

LRCS = Likelihood Ratio Chi-Squared = Interaction term in logistic regression

Changes in the Prevalence of Witnessed Crimes

Respondents were also asked whether they, personally, had seen or heard specified incidents happening on their estate in the last year. Interviewers were asked to check that these incidents were different from those reported elsewhere on the questionnaire. Incidents were classified as vandalism or vehicle crime (which together comprised property crime; burglary was not asked about here), personal crime, and a further category of "incivilities" (drunk, rowdy or abusive people, or someone vomiting or urinating).

Table 5 shows changes in the prevalence of crime witnesses in the experimental, adjacent and control areas. The prevalence of crime witnesses decreased significantly in the experimental area after the street lighting was improved, for all crime categories. For example, 77.3% of respondents witnessed a crime in the before period, compared with 59.7% in the after period, a decrease of 23%. The greatest percentage decreases were in personal crime (51%), incivilities (34%) and vehicle crime (31%).

The prevalence of crime witnesses also decreased in the adjacent area. These decreases were significant for vehicle crime (29%) and property crime (23%) and not far off significance (p=.090) for vandalism (24%). The prevalence of crime witnesses increased in the control area for vandalism (22%) and incivilities (25%), but decreased for personal crime (31%). For all crime, the prevalence of crime witnesses increased in the control area from 63.6% to 70.4%.

Changes in crime witnesses in the experimental area were significantly different from changes in the control area, for vandalism, property crime, incivilities and all crime. Also, the comparison was not far off significance for vehicle crime (p=.O91). Changes in crime witnesses in the adjacent area were significantly different from changes in the control area for vandalism, and nearly significantly different (p=.O76) for property crime. Changes in crime witnesses in the experimental area were significantly different from changes in the adjacent area for personal crime, and nearly significantly different for incivilities (p=.O84) and all crime (p=.O64). Generally, the prevalence of crime witnesses decreased in the experimental area, decreased less in the adjacent area, and increased in the control area.

Table 5: Changes in the Prevalence of Crime Witnesses

	Experimental			Adjacent			Control		
	Before (317)	After (278)	% Change	Before (135)	After (121)	% Change	Before (88)	After (81)	% Change
Vandalism	50.2	37.8	-25*	45.9	34.7	-24	46.6	56.8	+22
Vehicle crime	61.8	42.8	-31*	58.5	41.3	-29*	48.9	44.4	-9
Property crime	68.1	52.5	-23*	64.4	49.6	-23*	58.0	60.5	+4
Personal crime	27.8	13.7	-51*	24.4	23.1	-5	25.0	17.3	-31
Incivilities	49.5	32.7	-34*	43.0	38.8	-10	30.7	38.3	+25
All crime	77.3	59.7	-23*	68.9	63.6	-8	63.6	70.4	+11

* Change significant on chi-squared test ($p < .05$, two-tailed)

Change in experimental area significantly different from change in control area:

Vandalism, LRCS=6.81, p=.009

Property crime, LRCS=4.60, p=.032

Incivilities, LRCS=8.03, p=.005

All crime, LRCS=9.23, p=.002

Change in adjacent area significantly different from change in control area:

Vandalism, LRCS=4.79, p=.029

Change in experimental area significantly different from change in adjacent area:

Personal crime, LRCS=4.99, p=.025

LRCS = Likelihood Ratio Chi-Squared = Interaction term in logistic regression

Comparison of the Estates after the Intervention

Table 6, modelled on Table 1, shows differences between the estates after the improved street lighting on the experimental estate. Not surprisingly (in light of the high response rates), the demographic characteristics of the respondents in the after survey were similar to those in the before survey, and there were no significant differences among the estates on gender, age, length of tenure or employment.

As in the before survey, about three-quarters of respondents in each area said that their estate was friendly. However, there was a significant increase in the experimental area in the percentage who said that their estate was well kept (from 39.1% to 57.2%; $p<.0001$). This large increase in the experimental area was almost significantly greater ($p=.O61$) than the small increase (from 50.4% to 54.5%) in the adjacent area, and was significantly different ($p=.002$) from the decrease (from 46.6% to 37.0%) in the control area.

As in the before survey, most respondents in all areas said that it was unsafe to walk in the dark in their area, and that there were risks for women and elderly people out alone after dark. There were no significant differences between the areas in these statements. However, there was a significant change over time: respondents in the experimental area were less likely to say that it was unsafe to walk in the dark in the after survey (66.2% before, 56.5% after; $p=.018$).

Respondents in all areas were equally likely to say that groups of youths hung around their area. However, there was a significant decrease in the percentage of respondents saying this in all areas in the after survey compared with the before survey. Similarly, although there was no significant difference among the areas in the after survey in saying that the environment and quality of life had become worse in the last year, significantly fewer respondents said this in all areas in the after survey compared with the before survey. Unlike the adjacent and control areas, there was a significant increase in the experimental area in the percentage of respondents saying that the environment and quality of life had become better in the last year (from 3.5% to 22.7%; $p<.0001$). Respondents in all areas were equally unlikely to say that they had seen a police officer on foot in their area in the last month. The probability of this decreased significantly in all areas between the before and after surveys.

Table 6: Comparisons of Experimental, Adjacent and Control Areas After Improved Lighting

	Experimental % (N = 278)	Adjacent % (N = 121)	Control % (N=81)	p value
Demographics				
Female	54.0	65.3	58.0	ns
Age 45+	59.4	62.8	66.7	ns
On estate 10+ years	60.8	62.0	64.2	ns
Employed	29.9	34.7	23.5	ns
Opinion of Estate				
Friendly area	78.8	81.0	77.8	ns
Well kept	57.2	54.5	37.0	.006
Unsafe to walk in dark	56.5	61.2	59.3	ns
Risks for women alone after dark	86.4	83.6	81.3	ns
Risks for elderly alone after dark	92.1	89.0	87.0	ns
Youths hang around	63.3	61.2	51.9	ns
Quality of life worse last year	22.7	24.8	13.6	ns
Quality of life better last year	22.7	9.9	21.0	.011
Saw police in last month	9.7	12.4	11.1	ns
Estate Lighting				
Badly lit	4.0	61.2	65.4	.0001
Too dull	5.8	62.8	54.3	.0001
Creates shadows	3.6	55.4	45.7	.0001
Experimental estate brighter	98.9	100.0	100.0	ns
Worry about Crime				
Burglary	73.4	74.4	71.6	ns
Street robbery	33.5	33.9	28.4	ns
Street assault	35.3	37.2	32.1	ns
Vandalism to home	67.3	66.1	66.7	ns
Car stolen/damaged	47.5	53.7	45.7	ns
Avoid going out after dark	33.1	35.9	37.0	ns
Feel unsafe in own home	49.3	43.0	34.6	ns
High fear of crime	51.4	47.1	39.5	ns
Prevalence of Crime				
Burglary	21.2	18.2	16.0	ns
Outside theft/vandalism	12.2	22.3	16.0	.037
Vehicle crime	16.2	11.6	8.6	ns
Property crime	39.2	40.5	35.8	ns
Personal crime	6.1	10.7	4.9	ns
All crime	42.8	43.8	38.3	ns
Increased last year	33.5	49.6	25.9	.0009
% Outside in dark	71.4	71.9	63.2	ns
% Reported to police	68.1	51.7	68.4	.024

p values based on chi-squared from 3 x 2 tables

There was no doubt that the improvement in street lighting was noticed by respondents in the experimental area. In the after survey, 96% of experimental respondents said that their area was well lit, and only 4% said that it was badly lit; in the before survey, 73.5% said that the experimental area was badly lit, compared with 26.5% who said that it was well lit (see Table 1). Of course, the percentage of experimental respondents who said that their area was badly lit decreased significantly ($p<.0001$). There was no significant change in the percentage of respondents in the adjacent area who said that their area was badly lit (from 57.0% before to 61.2% after), or in the corresponding percentage in the control area (from 62.5% before to 65.4% after). Similarly, there were dramatic decreases in the experimental area in the percentages who said that the street lighting was too dull or that it created shadows.

In the after survey, respondents in the adjacent and control areas were asked if they had walked through the experimental area after dark. Of those in the adjacent area, 25% said that they had walked through the experimental area very often or regularly, and a further 21% said that they had walked through the experimental area occasionally (not shown in Table 6). Of those in the control area, 12% had walked through the experimental area very often or regularly, and a further 6% had walked through the experimental area occasionally. Virtually all respondents in all areas noticed that the lighting on the experimental estate had become brighter (Table 6).

On most questions on worries about crime, there were no significant differences among respondents in the three areas in the after survey and no significant changes over time. However, there was a significant decrease in the percentage who said that they worried about their car being stolen or damaged in the adjacent area (from 68.4% to 53.7%; $p=.029$) and the difference was not far off significance in the control area (from 59.5% to 45.7%; $p=.10$). The decrease was less in the experimental area (from 53.3% to 47.5%). Similarly, there were marked (and in some cases near-significant) decreases in the adjacent and control areas in the percentages feeling unsafe in their own homes and the percentages with a high fear of crime. It seemed that fear of crime did not change in the experimental area but decreased in some cases in the adjacent and control areas.

In most cases, the prevalence of victimization did not differ significantly among the three areas in the after survey. However, outside theft/vandalism was lowest in the experimental area and highest in the adjacent area. There were significant ($p<.0001$) decreases in all three areas in the percentages of those who thought that crime had

increased in the last year. The decreases in this percentage were not significantly greater in any area compared with any other area. The percentage of crimes committed outside in the dark was very similar in the experimental and adjacent areas and in the before and after surveys. It increased significantly in the control area (from 48.9% to 63.2%; p=.005). The percentage of crimes reported to the police increased significantly in the experimental area (from 56.7% to 68.1%; p=.0l5) and increased non-significantly in the control area (from 59.6% to 68.4%).

Changes in Police-Recorded Crimes

The Staffordshire Police agreed to provide recorded crime figures for the police area that included the experimental, adjacent and control areas. Unfortunately, police force areas in Staffordshire were restructured in March 1992, making data before and after this date non-comparable. In comparing police-recorded crime before and after the improved street lighting, the most valid comparison is between April -December 1992 and April - December 1993 in police area JC22 (a wide geographical area including the project areas).

Table 7: Crimes Recorded in Police Area JC22

	Included Crimes	Excluded Crimes	Total Crimes
April - June 1992	177	42	219
July - September 1992	198	43	241
October - December 1992	210	59	269
Total 1992	585	144	729
April - June 1993	209	53	262
July - September 1993	159	34	193
October - December 1993	203	48	251
Total 1993	571	135	706
Change 1992 - 1993	-2%	-6%	-3%

Note: Excluded crimes: Non-residential burglary, going equipped to steal, shoplifting, fraud, receiving stolen property, drugs.

Table 7 shows that the total number of police-recorded crimes decreased by 3% between 1992 and 1993 in this police area. However, not all of these crimes would have been reported in the before and after victimization surveys, which focussed on offences against households and persons. In particular, non-residential burglaries, being equipped to steal, shoplifting, fraud, receiving and drug offences would not have been reported. When these crimes were excluded, comparable police-recorded crimes decreased by 2% between 1992 and 1993 in this police area. This was a negligible decrease.

Pedestrian Street Use

The number of pedestrians using the streets after dark was counted in the experimental, adjacent and control areas. Pedestrians were counted on a Thursday and Friday evening between 7:00 p.m. and 9:30 p.m. during the first week of December in 1992 and in **1993.**

In both years the weather conditions were similar (cold but dry). Table 8 shows that the number of male pedestrians increased by 72% in the experimental area and by 27% in the adjacent and control areas, a significant difference (chi-squared = 7.85, p= .005). The number of female pedestrians increased by 70% in the experimental area and by 41% in the adjacent and control areas, a non-significant dif-. ference.

Table 8: Nighttime Pedestrian Counts

	Before	After	% Change
Experimental Area			
Men	199	343	+72
Women	160	272	+70
All	359	615	+71
Adjacent Area			
Men	279	360	+29
Women	165	234	+42
All	444	594	+34
Control Area			
Men	255	320	+25
Women	196	276	+41
All	451	596	+32

QUALITATIVE RESULTS

Statements from Respondents

Respondents were asked a general question about whether their quality of life had improved, gotten worse or remained the same over the previous 12 months. They were not asked specifically about the effects of the improved lighting. Nevertheless, statements from respondents in the experimental area suggested that they thought the improved street lighting had decreased crime rates and improved their quality of life, especially because the improved illumination led to increased surveillance. Respondents' observations included:

"You can see everything that moves outside now."

"You can see more. It's like Blackpool Illuminations — they're the best I've seen — these lights."

"It's much brighter now than before and you can even see people coming to your door."

"You can see people more clearly. The lighting is just great. It was terrible before."

"If you hear a noise outside and you look outside, you can recognise who they are."

"Stronger light means less people hang around to be seen."

"It's safer because you can now recognise who is walking towards you."

"You can see where you are walking. You can see anybody. All the little walkways are lit up."

"You can see more of the area in the dark alleyways. Nobody can hide. You can see where you are walking now. You can see if anybody is loitering about."

"You can see people from a distance now and recognise them as well."

"Everywhere is illuminated. It's good. It's so bright and there's no shadows."

And finally, as one 69-year-old man commented: "It's cut out shadows, it deters people from lurking. There is less chance of being pounced on from dark corners and hedges. I've been out in the early hours to get into my car at my garage. Because of the lighting I felt quite safe. We feel happier to go out now."

Local Hearsay and Community Confidence as a Means of Diffusing Benefits

The qualitative data also indicated that the relighting scheme was a topic of general discussion throughout the project area, and this may be an important mechanism of diffusion. The area most affected was the adjacent area, where respondents showed a general optimism about the future of their neighbourhood. The proposition that the benefits of relighting increased optimism about future investment, and reduced crime and fear in the adjacent area untouched by lighting improvements, can be illustrated by remarks made by residents. A councillor in the adjacent area commented: "We are targeting this area for improvements, and as the local councillor I feel optimistic and confident that the area is about to improve even further."

Another respondent in the adjacent area observed: "We need better lighting. People in [the experimental] area have now a greater respect for the area they live in... getting it more done up."

It also appeared that residents in the adjacent area, especially those closest to the new lighting scheme, felt resentful that their roads had not been lit, and this galvanised them into lobbying for improvements. As one interviewer put it, "This respondent [in the adjacent area] complained that the street lights are not continued up...Road. Have got up a petition with other residents...for the new lighting to come further up."

There were also indications that the effects of relighting one part of the neighbourhood had an effect on perceptions of crime and safety in the adjacent and control areas. The following comments are indicative of this process.

"Since the new lighting was put in it's been very quiet around here [adjacent area]... there used to be loads of trouble but now it's quietened down."

"I think the street lighting improvements should be carried on throughout this area. This would greatly improve things, along with more police patrols." [adjacent area]

"People would feel safer with lights, like in the [experimental] area. A lot more people feel safer. My mum does who lives there, and there's been less break-ins." [control area]

"The general quality of life around here has improved. Why? The street lighting. Things have quietened down recently with crime." [control area]

"I feel safer because of the new street lights further up the road." [adjacent area]

Though not conclusive, these personal accounts support the idea that relighting the experimental area was taken as a sign that the adjacent area was about to improve. If so, the relighting served to promote community confidence in the adjacent area because residents detected that the local authority was willing to invest in the physical environment. It certainly led to an increase in nighttime street use. These attitudinal and behavioural changes in themselves may have had an impact on offender and resident perceptions of the neighbourhood, in ways that reduced actual and perceived opportunities for crime and increased actual and perceived risk.

Street Lighting and Crime from a Police Perspective

In addition to household surveys and pedestrian traffic counts, an in-depth survey of local police patrol officers was undertaken. Seven officers who regularly patrolled the area were interviewed, and they generally thought that relighting had reduced fear of crime in the experimental area. One officer said: "People have commented on the lighting and they feel safer, especially the elderly. They are glad it's been put in." From talking to people in the area about the lighting, these officers said that the locals were "over the moon about it." The officers thought that the lighting had reduced crime because the visibility was so much better on the streets. As one officer put it: "Street lighting has reduced crime, fear of crime, improved visibility in the back alleys and improved the confidence of those using the area. The police can patrol slowly in cars and get a good view of who is around, and recognise them. The locals also say the lighting [has] improved their sense of security."

The three beat officers believed that the street lighting had "warned off the villains" because the police were getting increased calls from the public about prowlers, to which they were responding. This finding is consistent with the increased reporting of crime noted in the household survey. The officers welcomed this increase and said that a partnership between them and the community was developing. One officer said that he was much more willing to get out of his car and patrol on foot. Another officer commented: "The burglars don't need to carry torches now. If they do, they stick out like a sore thumb and if they don't their activities are highly visible."

The sergeant thought that the street lighting made the work of the police easier after dark. When called to suspicious events, officers now drove to a nearby point and got out of the cars and approached on foot. This was quieter and gave them the element of surprise.

All seven officers were convinced of the deterrent effects of good lighting. One commented: "Improved lighting is viewed positively from a police perspective. The [experimental] area is very well lit now but we need to get the same standard of street lighting throughout the [project] area. Criminals are deterred by good street lights."

There was also support for the proposition that street lighting improved community confidence through aesthetically enhancing the environment: "The lighting is very pleasing to look at and the young people are less willing to climb up the columns. It has greatly increased the sense of pride in the area and has encouraged public respect for the place. The improved lighting has increased people's confidence in using the area due to the decrease in crime."

This was a small sample, yet all seven police officers surveyed were very supportive of the view that street lighting deterred crime, improved the quality of life, increased police efficiency when patrolling the area after dark, and increased the willingness of the public to report offences to the police.

ESTIMATING BENEFITS AND COSTS OF IMPROVED STREET LIGHTING

The capital cost of the improved street lighting scheme on the experimental estate was £77,071. The annual maintenance costs of the lighting increased from £286 to £443, and the annual cost of electrical energy increased from £935 to £1,880. Hence, the annual costs were £1,102 greater after the improvement. As the improved street lighting was expected to last at least 20 years, it would be reasonable to pay off the capital cost over a 20-year period (Safe Neighbourhoods

Unit, 1993). Assuming an annual interest rate of 8%, annual payments at the end of each year of £7,850 would clear the debt in 20 years. Therefore, it would be reasonable to translate the cost of the improved street lighting into an annual cost of £8,952.

In attempting to assess whether these increased annual costs might be outweighed by the benefits of reduced crimes, what is needed is an estimate of the cost of each type of crime. This is available, for the U.S., in 1993 dollars. Miller et al. (1996) took account of property loss and damage, medical and mental health costs, police and fire services (but not other criminal justice) costs, social and victim services costs, and lost productivity in estimating the tangible costs of different types of crimes. They also attempted to calculate intangible costs such as pain, suffering and a reduced quality of life, but these costs are more controversial. For example, it was estimated that each U.S. robbery, on average, involved tangible costs of $2,300 and intangible quality-of-life costs of $5,700, making the total cost $8,000. Because of the controversial nature of intangible quality-of-life costs, we will not consider them.

Unfortunately, no estimates of the costs of all types of crimes are available for the U.K. Indeed, there have only been seven previous attempts to assess costs and benefits of U.K. situational crime prevention programmes where the primary victim was a person or a household (see Welsh and Farrington, 1999, for a review). Since we wanted 1993 estimates of the costs of different types of crimes, we began with the average value of stolen property published in the 1993 Criminal Statistics (U.K. Home Office, 1994). For example, its Table 2.18 shows a total value of stolen property in residential burglaries of £537 million, with £50.8 million recovered, and a total number of residential burglaries (including attempts) of 727,276. Dividing £486.2 million of stolen (and not recovered) property by the total number of offences reveals an average property loss in each burglary of £668.

Of course, burglaries recorded by the police may involve a greater property loss than unrecorded burglaries. Based on the British Crime Survey, Mirrlees-Black et al. (1996, Table A5.5) estimated the average net loss in each 1995 burglary (including attempts) as £370. However, this figure was net of insurance repayments, which might be excluded in assessing the cost of a burglary to the victim but should surely be included in assessing the cost of a burglary to society (which is our interest). The gross loss per burglary in 1995 was £676 (Mayhew, 1998), a number very similar to the Criminal Statistics figure for 1993.

Of course, property loss is only one of many types of costs of crime. For example, Ekblom et al. (1996) estimated that each completed residential burglary cost victims about £900 and caused criminal justice (e.g., police, courts and prisons) costs of about £300, making the total (property loss plus criminal justice) cost of a completed burglary £1,200. We estimated the tangible costs of each crime using the figures of Miller et al. (1996, Table 2). Unfortunately, these exclude criminal justice costs other than the police. Nevertheless, they show that the average U.S. burglary (including attempts) in 1993 involved property loss or damage of $970 and total tangible losses of $1,100 (13.4% greater). In order to estimate the average tangible loss of a 1993 U.K. burglary, we scaled up the Criminal Statistics property loss figure of £668 by 13.4% (to £758).

All other estimates of the cost of different property crimes were obtained in the same way, by obtaining a property loss figure from the 1993 Criminal Statistics and scaling it up to a tangible loss figure using the estimates of Miller et al. (1996). There were two main exceptions. First, to estimate the cost of outside theft/vandalism, we combined the average loss in household vandalism of £116 according to the 1993 British Crime Survey (Budd, 1998) with the average loss in theft from vehicles of £239 according to the 1993 Criminal Statistics. Second, because we had no available costs for personal crimes, we had to use the U.S. costs of Miller et al. (1996). For example, they estimated the total tangible loss of an assault as $1,550 (principally caused by lost productivity of $950 and medical costs of $425), and we translated this into £939 at the current rate of exchange of 1.65 dollars to the pound.

Table 9 shows the results of the calculations. Beginning with the Stoke experimental area, the total number of before burglaries (including attempts) of 122 reported by 317 respondents was scaled up to an estimate of 137.4 for the 357 occupied houses. This assumes that the non-respondents had the same burglary rate as the respondents. Similarly, the total number of after burglaries of 91 reported by 278 respondents was scaled up to an estimate of 116.8 for the 357 occupied houses. This led to the estimate that 20.6 burglaries had been prevented by the improved street lighting. At £668 per burglary, this yielded a total savings of £13,761 in property loss alone, or a total savings of £15,615 when all tangible losses were included.

The total savings in the Stoke experimental area in one year from 266 prevented crimes came to £65,892 in property loss alone and to £103,495 when all tangible losses were included. Thus, the tangible savings from crimes prevented paid for the full capital cost of the im-

proved street lighting (£77,071) and for the increased annual costs (£1,102) within one year. Including the full capital cost, the benefit-to-cost ratio was 1.3 to 1 after one year. More reasonably paying off the capital cost over 20 years, the benefit-to-cost ratio was 12 to 1 after one year (£103,495 divided by £8,952).

This calculation does not take account of crimes reduced in the adjacent area, which are calculated in Table 9 on the same basis as those in the experimental area. More crimes were prevented in the adjacent area because it was larger than the experimental area; thus, 42 before burglaries reported by 135 respondents in the adjacent area was scaled up to an estimate of 163.3 for the 525 occupied houses. The total savings in the adjacent area from 428.8 prevented crimes came to £77,003 in property loss alone and to £125,272 when all tangible losses were included.

The total tangible savings in the experimental and adjacent areas came to £228,747. Assuming that both were attributable entirely to the improved lighting, these savings more than paid for the full capital costs of the improved lighting in one year. Including the full capital cost, the benefit-to-cost ratio after one year was 2.9 to 1. More reasonably paying off the capital cost over 20 years, the benefit-to-cost ratio was 26 to 1 after one year. The control area was not included in these analyses because the incidence of crime did not change in it.

Clearly, better estimates of the costs of different types of crime are needed. Our estimates, based on national police-recorded crimes, may not apply very accurately to the particular housing estates studied. Nevertheless, even if our estimates were double or triple the true costs (which seems unlikely, especially since they do not include quality of life costs), it would still be clear that the crime-reduction benefits of the improved street lighting greatly outweighed the costs.

This is essentially because improving street lighting is relatively cheap compared with other environmental improvements. For example, Osborn (1994) reported that £856,000 was spent on putting fences all over the Kirkholt estate of 2,288 dwellings in Rochdale in 1986-90. Davidson and Farr (1994) reported that £1,400,000 was spent on improving security (to lifts, foyers, entrance doors and landings) in the Mitchellhill estate of 570 dwellings in Glasgow in 1989. Compared with many estate improvement projects funded by the Department of the Environment (Safe Neighbourhoods Unit, 1993, 1994) street lighting is inexpensive. Under any reasonable assumptions about the costs of crime, the benefits exceeded the costs in the Stoke project.

Table 9: Estimated Cost Savings from Reductions in Crime

	Estimated No. of Crimes			Property Savings		Tangible Savings	
	Before	After	Reduced	Per Crime £	Total £	Per Crime £	Total £
Experimental							
Burglary/attempts	137.4	116.8	20.6	668	13,761	758	15,615
Outside theft/vandalism	135.1	86.0	49.1	178	8,740	244	11,980
Cycle theft	21.4	10.3	11.1	213	2,364	292	3,241
Theft of vehicle	24.8	3.9	20.9	1,328	27,755	1,408	29,427
Theft from vehicle	145.3	87.4	57.9	239	13,838	328	18,991
Robbery/snatch theft	1.1	3.9	-2.8	202	-566	619	-1,733
Assault	16.9	1.3	15.6	0	0	939	14,648
Threats/pestered	138.5	44.9	93.6	0	0	121	11,326
Total	**620.5**	**354.5**	**266.0**	**248**	**65,892**	**389**	**103,495**
Adjacent							
Burglary/attempts	163.3	130.2	33.1	668	22,111	758	25,090
Outside theft/vandalism	318.9	173.5	145.4	178	25,881	244	35,478
Cycle theft	23.3	30.4	-7.1	213	-1,512	292	-2,073
Theft of vehicle	11.7	4.3	7.4	1,328	9,827	1,408	10,419
Theft from vehicle	171.1	91.1	80.0	239	19,120	328	26,240
Robbery/snatch theft	7.8	0	7.8	202	1,576	619	4,828
Assault	15.6	8.7	6.9	0	0	939	6,479
Threats/pestered	233.4	78.1	155.3	0	0	121	18,791
Total	**945.1**	**516.3**	**428.8**	**180**	**77,003**	**292**	**125,252**

CONCLUSIONS

Four measures of crime were derived from the before and after surveys: the prevalence and incidence of victimization, the prevalence of known victims, and the prevalence of witnesses of crime. Taking the results from all four measures together, there was a marked and significant decrease in crime in the experimental area, a somewhat lesser decrease in crime in the adjacent area, and no decrease or a slight increase in crime in the control area. The crime decreases in the experimental area were often significantly greater than in the control area but rarely significantly different from the decreases in the adjacent area. The benefits of improved street lighting, in terms of the savings to the public from crimes prevented, greatly outweighed the costs.

The percentage of crimes committed outside after dark was similar (about 70%) in the experimental and adjacent areas, and in the before and after surveys. It increased significantly in the control area. Hence, the number of crimes committed outside after dark decreased considerably in the experimental and adjacent areas compared with the control area, while the number of crimes committed at other times decreased somewhat in the experimental and adjacent areas compared with the control area. According to police statistics, there was no change in recorded household crime in the large police area that included the project areas. The probability of victims reporting crimes to the police increased significantly in the experimental area and non-significantly in the control area.

Respondents in all areas noticed the improvement in lighting in the experimental area. This was partly because respondents in the adjacent and control areas had heard about the improvement in lighting, and partly because they had walked through the experimental area themselves. People in the experimental area became more likely to say that their estate was well kept, and that their environment and quality of life had improved in the last year. Pedestrian counts showed that there were increased numbers of people on the streets after dark in the experimental area compared with the adjacent and control areas (which showed lower increases). Respondents in the experimental area became less likely to say that it was unsafe to walk after dark in their area. However, experimental respondents also said that they had the greatest fear of crime, and they were the most likely to say that they felt unsafe in their own homes in the after survey.

Qualitative data suggested that residents of the experimental area and police officers thought that the improved lighting had reduced crime and the fear of crime after dark, and that potential offenders were deterred by the increased visibility and surveillance. They also thought that it had increased community pride and the perceived quality of life, and had increased police effectiveness and the willingness of the public to report crimes to the police.

What is the most plausible explanation of these results? The null hypothesis that improved street lighting had no effect on crime seems implausible because of the marked decreases in crime in the experimental area after the improved lighting. Any argument in favour of the null hypothesis would have to suggest that some other factor, occurring at about the same time as the improved lighting, caused the decrease in crime in the experimental area. However, we are confident that no other factor could have influenced the experimental area but not the control area or the larger police area containing the project areas. A decrease in crime might conceivably have been caused by decreased unemployment, decreased poverty, increased prosperity, decreased police cautioning, tougher sentences, decreased drug and alcohol use, etc., but to the extent that any of these factors was important it would have affected not only the experimental area but also the control and wider police areas.

The most plausible explanation is that improved street lighting caused a decrease in crime in the experimental area. In absolute terms, the decrease in crime outside after dark was the same as the decrease in other types of crimes. However, relative to changes in crime rates in the control area, the decrease in crime outside after dark was greater than the decrease in other types of crimes.

It is plausible, therefore, to suggest that the effects of improved street lighting on crime operated via two different causal pathways. In the first pathway, improved street lighting caused increased visibility, street use and surveillance after dark, which, in turn, led to decreased perceived opportunities and rewards of crime and increased perceived risks by potential offenders, which in turn led to decreased crime. This pathway would especially explain a decrease in crime outside after dark. In the second pathway, improved street lighting led to increased community pride, community cohesion and informal social control, which deterred potential offenders. This pathway would explain decreases in crime at all times of the day. The operation of both pathways simultaneously would lead to large decreases in crime after dark and to smaller decreases in crime in the light. This prediction, and the hypothesized pathways, are concor-

dant with the quantitative and qualitative results obtained in the Stoke-on-Trent project. However, surveys of potential offenders are needed to verify the proposed causal pathways.

The research hypothesis that improved street lighting leads to an increased number of people outside on the streets after dark was also supported, as was the hypothesis that improved street lighting leads to a more favourable assessment of the quality of the area. However, the hypothesis that improved street lighting leads to a decreased fear of crime was supported only by the qualitative data. Apart from respondents in the experimental area saying that it became more safe to walk in the dark, no other quantitative results supported this hypothesis.

Interestingly, decreases in crime in the adjacent area were almost as great as in the experimental area. This suggests that there was no displacement of crime, but rather a diffusion of the benefits of improved street lighting. Conceivably, the improved lighting in the experimental area deterred potential offenders not only in this area but in the adjacent area as well, since the areas were not clearly delimited. The qualitative data showing how information about the areas was communicated, and how relighting led to increased community pride in the adjacent area, supported this hypothesis.

Summarizing, our main conclusion is that improved street lighting led to substantial and cost-effective decreases in crime in the experimental area, and that there was a diffusion of these benefits to the adjacent area.

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