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Closed-Circuit TV Surveillance Evaluation: Statistical Analysis of the Effects on Rates of Crime

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Technical Report

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Abstract

This paper reports on the statistical analysis conducted on crime data provided by the Toronto Police Services in order to assess the impact on crime after implementing the Closed Circuit Television (CCTV) pilot initiative. Over the period May 2007 to October 2008, the Toronto Police Services installed CCTV cameras in a number of selected areas for periods of time between six months and one year. This report documents the results of the application of standard statistical techniques to determine the effectiveness of surveillance cameras in reducing crime, and compares them with findings from previous research studies. The analysis is based on data derived from the Toronto Police Services call-for-service ACCESS database, a comprehensive, geo-coded database that includes all records of demands for policing services involving events of a violent nature from 1995. This report addresses questions related to crime reduction in the targeted areas and diffusion of benefits beyond the targeted areas, and makes some general considerations about displacement and dispersion.

Résumé

Le présent rapport expose lanalyse statistique des données sur la criminalité fournies par le Service de police de Toronto qui a été faite en vue d'évaluer l'effet que la mise en œuvre du projet pilote de système de télévision en circuit fermé a eu sur la criminalité. De mai 2007 à octobre 2008, le Service de police de Toronto a mis en place, pour une durée de six mois à un an, des caméras de télévision en circuit fermé dans certaines zones sélectionnées. Le rapport documente les résultats des techniques statistiques courantes qui ont été appliquées dans le but de déterminer dans quelle mesure les caméras de surveillance sont efficaces pour réduire la criminalité et présente une comparaison de ces résultats avec les résultats de recherches antérieures. L'analyse est fondée sur les renseignements tirés de la base de données ACCESS sur les demandes d'intervention du Service de police de Toronto. Il s'agit d'une vaste base de données géomatiques, qui comprend les dossiers de toutes les demandes d'intervention policière impliquant des événements à caractère violent enregistrées depuis 1995. Le rapport traite de la réduction de la criminalité dans les zones visées et des avantages observés en dehors de ces zones, et comprend quelques observations générales sur le déplacement et la dispersion.

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Executive summary

Closed-Circuit TV Surveillance Evaluation

Simona Verga; DRDC CSS TR 2010-09; Defence R&D Canada – Centre for Security Science; December 2010.

Background: The Toronto Police Services have commissioned Canadian Police Research Centre (CPRC) to perform an independent Program Impact Review focusing on results from the Toronto Police Services Closed Circuit Television (CCTV) pilot initiative. Over the period May 2007 to October 2008 they installed CCTV cameras in a number of selected areas for periods of time between six months and one year. CCTV is a surveillance technique thought to prevent crime because of the deterrent effect on potential offenders, when they are aware that the cameras may be watching their activities. Cameras, located at predetermined points to ensure optimal coverage, collect images that are transferred to a monitoring station or are stored for subsequent analysis and review. Also, other presumed benefits of CCTV cameras are efficient deployment of police resources, reduced fear of crime in the community, and facilitating follow-on investigation. At the same time, the presence of cameras might raise concerns about privacy and civil liberties, and such concerns must be addressed by careful design and implementation under strict guidelines.

Principal results: This report includes a literature review, to capture the existing knowledge in terms of study design, existing methodology, and trends in results. The literature review paints a mixed picture of the effectiveness of CCTV surveillance on reducing crime, providing evidence to support crime reduction effects for some types of offences but not for others. Property crime and disorder crime registered the most substantial declines. For violent crime, the results reported were more inconclusive. The literature review also highlighted CCTV implementation design issues that limited the ability to draw general conclusions about CCTV effectiveness.

The main objective of this technical report is to document the results of the application of standard statistical techniques to Toronto crime data, in order to determine the effectiveness of surveillance cameras in reducing crime. This report addresses questions related to crime reduction in the targeted areas and diffusion of benefits beyond the targeted areas, and makes some general considerations about displacement and dispersion. The analysis is based on crime data provided by the Toronto Police Services in its call-for-service ACCESS database, a comprehensive, geo-coded database that includes all records of demands for policing services involving events of a violent nature from 1995. The results of the analysis are compared with findings from previous research studies on CCTV effectiveness.

Significance of results: The results presented and discussed in this report indicate that, after the implementation of the CCTV camera systems, the level of crime decreased in three out of the five areas analyzed, and remained largely unchanged in the remaining two. These findings are supported by time series data done over the entire period of time for which records exist (1995 to 2008). While the author tried to support these findings with calculated summary statistics, where crime levels over the implementation period were compared with crime levels during the same

period in the previous year, the latter calculations, while agreeing with time series results, did not pass statistical significance tests. These results were consistent with observations derived from the review of previous literature. Based on the above findings, as well as findings from the literature review, one might conclude that the implementation of CCTV camera systems can be effective, but further analysis is necessary. Any future implementation of CCTV systems would benefit greatly if such implementation is preceded by careful project design.

Future work: Based on existing data, additional time series analysis could be done for identified buffer areas around the target areas. Crime analysis in the selected areas prior to implementation might help identify trends, crime evolution, unexpected external changes that may have influenced the results, existing mitigating measure and other characteristics and separate them from the effects of CCTV surveillance. Also, future work would address other questions such as community impact and perceptions of safety. These aspects have not been addressed at the time the work documented in this report was performed because of unresolved issues about the data available, lack of capacity and lack of time.

Sommaire

Closed-Circuit TV Surveillance Evaluation

Simona Verga ; DRDC CSS TR 2010-09 ; R & D pour la défense Canada – Centre des sciences pur la sécurité ; décembre 2010.

Contexte : Le Service de police de Toronto a demandé au Centre canadien de recherches policières de mener un examen indépendant en vue de déterminer les répercussions de son projet pilote de système de télévision en circuit fermé. De mai 2007 à octobre 2008, le Service de police de Toronto a mis en place, pour une durée de six mois à un an, des caméras de télévision en circuit fermé dans certaines zones sélectionnées. La télévision en circuit fermé est une technique de surveillance censée prévenir la criminalité en raison de son effet dissuasif sur les délinquants potentiels lorsqu'ils savent que leurs activités peuvent être captées par des caméras. Les caméras, situées stratégiquement en vue d'assurer une couverture optimale, captent des images qui sont ensuite transférées à une station de surveillance ou stockées pour être examinées et analysées par la suite. Les caméras de télévision en circuit fermé auraient aussi pour avantages de favoriser le déploiement efficient des ressources policières, de réduire la crainte de la criminalité dans la collectivité et de faciliter la tenue d'enquêtes ultérieures. Par contre, la présence de caméras peut soulever des préoccupations quant au respect de la vie privée et des libertés civiles. Pour tenir compte de ces préoccupations, il faut concevoir soigneusement le système et encadrer sa mise en œuvre de lignes directrices rigoureuses.

Principaux résultats : Le rapport comprend un examen de la littérature, qui permet de bien cerner l'état des connaissances sur la conception des études, les méthodologies actuelles et les tendances qui se dessinent. D'après cet examen, l'efficacité de la surveillance par télévision en circuit fermé est mitigée lorsqu'il s'agit de réduire la criminalité : les données semblent confirmer une diminution effective de la criminalité dans le cas de certains délits, mais pas pour d'autres. Les infractions contre les biens et les cas de désordre public seraient les délits dont la fréquence diminue le plus. Du côté des crimes avec violence, les résultats signalés sont moins concluants. L'examen de la littérature fait également ressortir des problèmes de conception touchant la mise en œuvre de systèmes de télévision en circuit fermé, problèmes qui ont limité la capacité de tirer des conclusions générales sur l'efficacité de ces systèmes. Ce rapport technique vise principalement à documenter les résultats des techniques statistiques courantes qui ont été appliquées aux données sur la criminalité à Toronto dans le but de déterminer dans quelle mesure les caméras de surveillance sont efficaces pour réduire la criminalité. Le rapport traite de la réduction de la criminalité dans les zones visées et des avantages observés en dehors de ces zones, et comprend quelques observations générales sur le déplacement et la dispersion. L'analyse est fondée sur les renseignements tirés de la base de données ACCESS sur les demandes d'intervention du Service de police de Toronto. Il s'agit d'une vaste base de données géomatiques, qui comprend les dossiers de toutes les demandes d'intervention policière impliquant des événements à caractère violent enregistrées depuis 1995. L'organisation du projet de télévision en circuit fermé de Toronto et les résultats de l'analyse sont comparés aux constatations tirées d'études antérieures sur l'efficacité des systèmes de télévision en circuit fermé.

Portée des résultats : Les résultats présentés et discutés dans le rapport indiquent que, après la mise en œuvre du système de caméras de télévision en circuit fermé, le niveau de criminalité a diminué dans trois des cinq zones étudiées, mais n'a pratiquement pas bougé dans les deux autres. Ces résultats sont étayés par des données chronologiques couvrant toute la période pour laquelle des dossiers existent (de 1995 à 2008). Bien que l'auteur ait tenté de corroborer ces résultats à l'aide de statistiques sommaires calculées, les niveaux de criminalité pendant la période du projet étant comparés aux niveaux de criminalité observés à la même période de l'année précédente, ces derniers calculs, même s'ils concordaient avec les résultats obtenus des données chronologiques, n'ont pas passé les tests de signification statistique. Ces constatations vont dans le même sens que les observations tirées de l'examen de la littérature. D'après les résultats de la présente analyse et ceux dégagés par l'examen de la littérature, on pourrait conclure que la mise en œuvre d'un système de caméras de télévision en circuit fermé est peut-être efficace, mais qu'une analyse plus approfondie s'impose. Dans l'avenir, il pourrait être très profitable de concevoir soigneusement au préalable la mise en œuvre de tout système de télévision en circuit fermé.

Recherches futures : À l'aide des données existantes, d'autres analyses des séries chronologiques pourraient être faites pour des zones tampons autour des zones visées. L'analyse de la criminalité dans les zones sélectionnées avant la mise en œuvre du projet pourrait aider à définir les tendances, l'évolution de la criminalité, les changements externes imprévus qui ont pu influer sur les résultats, les mesures d'atténuation existantes et autres caractéristiques, et à isoler leurs effets de ceux de la surveillance par système de télévision en circuit fermé. De futures recherches devraient aussi s'intéresser à l'effet sur les collectivités et au sentiment de sécurité, aspects qui n'ont pas été traités au moment où l'étude présentée dans ce rapport a été réalisée en raison de problèmes non résolus concernant la disponibilité des données, le manque de capacité et les contraintes de temps.

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1 Introduction

1.1 Closed Circuit Television (CCTV) Surveillance - Basic Concepts and Theory

CCTV is a surveillance technique that aims to prevent crime by increasing the perceived risks of potential offenders in engaging in criminal acts [1]. Cameras, located at predetermined points to ensure optimal coverage, collect images that are transfered to a monitoring station or are stored for subsequent analysis and review. Cameras can be static (i.e, focusing on a single view), or can pan, tilt and zoom (either moved by operators during live monitoring, or pre-programmed and placed on 'tours' to survey a succession of scenes).

The theory behind CCTV's aim to reduce crime makes a number of assumptions about the mechanisms under which CCTV works, which are discussed below.

Generally, the main objective of CCTV surveillance implementation is deterrence. The presence of the cameras is thought to have a deterrent effect on potential offenders, as long as they are aware that the cameras may be watching their activities. When the locations of the cameras are advertised, potential offenders may perceive that the increased risk of being caught by police outweighs the benefits of the intended crime. Crime prevention is therefore a feature of offender perception, which might produce a self-discipline in which such individuals control their acts.

Also, CCTV cameras allow for efficient deployment of police resources, by monitoring the scene to determine whether police assistance is required. This ensures that police resources are called upon only when necessary.

Another objective of CCTV surveillance is to reduce fear of crime (i.e., increase feeling of safety) in communities where such systems are implemented. The presence of the cameras may encourage the public to frequent the surveilled area more. In addition to the direct desired benefit of the community feeling more safe and secure, this might lead to an increase in the natural surveillance, thus reinforcing the increased perceived risk of being caught for potential offenders. On the other hand, potential victims are reminded of the 'risk' of crime, therefore altering their behaviour accordingly.

Finally, the ability to store images enables post-incident analysis, facilitating follow-on investigation. CCTV cameras capture images of offences taking place. In some cases this may lead to punishment and the removal of the offenders' ability to offend (either due to incarceration, or increased monitoring and supervision).

At the same time, the presence of cameras might raise concerns about privacy, and public interest has been focused on whether CCTV systems pose threats to civil liberties. For that reason, such surveillance systems implementation is normally done under strict guidelines in regard to camera location and orientation.

While such concerns are legitimate and must be addressed by careful design and implementation, CCTV surveillance systems have become an important crime prevention and security measures, and continuous technical advances, leading to improved systems and reduced costs, are bound to improve system performance and lead to more and more such systems being deployed.

1.2 Toronto Project Background

The Toronto Police Services have commissioned Canadian Police Research Centre (CPRC) to perform an independent Program Impact Review (PIR) focusing on results from the Toronto Police Services (TPS) Closed Circuit Television (CCTV) pilot initiative. Over the period May 2007 to October 2008 they installed CCTV cameras in a number of areas for periods of time between six months and one year; these installations are described in Annex A. Data are available from the TPS calls-for-service (CFS) database on the numbers of various crimes committed, along with their dates, times, locations and types of crime; a detailed description of the database can be found in the CCTV Evaluation Project charter [2] and is summarized in Annex B.

CPRC has requested the assistance of the Operational Research Team in the Centre for Security Science to perform the analysis of these data, with the emphasis on applicable statistical techniques, and to assess thereby the effectiveness of surveillance cameras in reducing crime.

1.3 Outline

Section 2 reviews previous major studies on the effectiveness of CCTV surveillance on reducing crime. It discusses main findings of those studies, as well as the methods used to establish effectiveness.

Section 3 describes the analysis conducted on the crime data provided by the Toronto Police Services up to November 28, 2008, in order to assess the impact of their CCTV pilot initiative. This section describes the methods of analysis and their application to determine the effectiveness of surveillance cameras in reducing crime, and it reports results for five areas with implemented surveillance cameras for which before and after implementation data was available at the time of the analysis.

Section 4 draws conclusions and makes recommendations for future implementations of CCTV cameras based on the results of the analysis discussed in Section 3.

2 Effectiveness of CCTV Surveillance on Reducing Crime - Previous Research Studies

Continuous improvement of CCTV technology and cost reductions in video-monitoring equipment have contributed to a steady increase in CCTV deployment. As a situational crime prevention intervention, video surveillance of public places has steadily increased, registering a tremendous growth in recent years, particularly in Britain [3] and especially in London [4]. The use of CCTV surveillance by law enforcement agencies to fight crime in the United States is less common, although federal grants to aid local law enforcement in fighting terrorism after the terrorist attacks of September 11, 2001 have contributed to an appreciable increase in CCTV deployment in the United States more recently [5]. Based on the review of the literature in open source searches during the work documented in this report, in Canada, the employment of video surveillance systems that are monitored by law enforcement has been rather small scale, although one could expect that to change, given the increased availability, improving performance of such systems and decreasing costs, as well as the general global trend.

The remainder of this section will review previous major studies on the effectiveness of CCTV surveillance on reducing crime, as well as the methods used to establish effectiveness.

2.1 The Home Office CCTV Research Studies

2.1.1 The Home Office CCTV Review 2002

The first systematic review of the effects of CCTV in preventing crime was carried out by Welsh and Farrington [6]. Systematic reviews have explicit objectives, explicit criteria for including or excluding studies, extensive searches all over the world for eligible evaluations, careful extraction and coding of key features of studies, a structured and detailed report of the methods used for locating, appraising, and synthesizing evidence, and explicit conclusions about effect sizes [7]. In their systematic review, Welsh and Farrington only included evaluations with before-and-after measures of crime in experimental and comparable control areas. This was regarded as the minimum standard of methodological quality that was adequate for drawing conclusions about effectiveness in evaluation research [8].

The study by Welsh and Farrington [6] reviews the findings of forty six relevant previous studies from both the US and UK on the effectiveness of CCTV in crime reduction. Of the 46, only 22 were considered to be rigorous enough for inclusion in their meta-analysis, according to strict methodological criteria:

1. CCTV was the main intervention studied. For evaluations involving one or more other interventions, only those evaluations were considered in which either the author identified CCTV as main intervention or, if the author did not do this, the importance of CCTV relative to the other interventions was clear. This was done because in other cases it is impossible to disentangle the effects of CCTV from the effects of other interventions.

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

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

4. The studies included a comparable control area.

5. 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 crime rates between the before and after time periods. It was considered that a measure of change based on an N below 20 was potentially misleading. Also, any study with fewer than 20 crimes before would have insufficient statistical power to detect changes in crime. In fact, the author of the current paper found that a criterion of 20 is too low, but Welsh and Farrington [6] did not want to exclude studies unless their numbers were clearly inadequate.

Welsh and Farrington [6] stressed the importance of criterion 3. Ideally, one would like to be able to use the 'gold standard' of the randomised experiment [8]. The key feature of randomised controlled trials, which are widely used in medical evaluations, is that the experimental and control groups are equated before the experimental intervention on all possible extraneous variables. Hence, any subsequent differences between them must be attributable to the intervention. Technically, randomised experiments have the highest possible internal validity in unambiguously attributing an effect to a cause. The randomised experiment, however, is only the most convincing method of evaluation if a sufficiently large number of units is randomly assigned to ensure that the experimental group is equivalent to the control group on all possible extraneous variables (within the limits of statistical fluctuation). As a rule of thumb, at least 50 units in each category are needed. This number is relatively easy to achieve with individuals but very difficult to achieve with larger units such as areas, as in the evaluation of CCTV schemes. For larger units such as areas, the best and most feasible design usually involves before-and-after measures in experimental and control conditions together with statistical control of extraneous variables. The use of a control condition that is comparable with the experimental condition is necessary in order to exclude threats to internal validity.

The review draws conclusions on the effectiveness of CCTV generally and on its effectiveness in terms of specific settings (e.g., car parks, public transport or city centres). Welsh and Farrington concluded that 11 showed a desirable effect on crime, five an undesirable effect, that the apparent positive effect was not supported by clear evidence in an additional five, and that in one study it was simply hard to distinguish whether there was any effect.

The location and focus of the CCTV implementation were found to be important. Studies of the city centre and public housing showed that CCTV had a small overall positive effect; approximately two per cent better in experimental areas than in control areas. On public transportation there was again a mixed message; overall there was a reduction in crime in experimental areas, but it was not significant, and of the four studies, one found no effect and another an undesirable effect. In car parks the findings were clearer; CCTV had a statistically significant effect, in that there was a 41% reduction in vehicle crimes, although in all the studies other measures, such as street lighting, were in operation alongside CCTV. Based on these findings, Welsh and Farrington suggest that a package of interventions focused on a specific crime type made the CCTV-led projects in car parks effective.

With the caveat that Welsh and Farrington's work [6] focused on a narrow range of studies and did not include qualitative work, their review of previous work did not offer conclusive evidence that CCTV on its own impacts positively on crime levels.

2.1.2 The Home Office CCTV Review 2005

The most frequently cited review in the CCTV literature was authored by Gill and Spriggs [9]. This study is comprehensive and nuanced, providing details on operation, technology used, cost effectiveness and it breaks down effectiveness by types of crimes.

In their report, Gill and Spriggs [9] evaluate 13 CCTV projects (comprising 14 separate systems) implemented in a range of contexts, including town centres, city centres, car parks, hospitals and residential areas. The main objective of the crime data analysis was to measure the impact of the CCTV projects on crime and fear of crime. For the analysis, the authors adopted a quasi-experimental model aimed to achieve as far as possible Level 3 of the Maryland Scientific Methods Scale [8]. This requires a measurement of change in the incidence of crime before and after the installation of CCTV in both an intervention, or 'target', area, and a control area. The analysis aimed to measure change for a significant length of time following implementation, though implementation delays and failures, the lack of a suitable control, and limited access to data in some cases reduced the planned robustness of the analysis to some extent.

Gill and Spriggs [9] used police recorded crime statistics to measure changes in levels of crime in the intervention areas and in comparable control areas before and after the CCTV systems were installed. Where appropriate, changes in crime patterns in the surrounding areas were also assessed, in order to measure any displacement or diffusion of benefit effects. Researchers identified other crime reduction initiatives operating within the intervention and control areas, so that it could be assessed to what extent these offered alternative explanations for changes in crime levels. Also documented was the process by which the project designers chose CCTV, and the extent to which CCTV was evaluated as a means of addressing local problems.

All the systems had the broad objective of reducing crime. Out of the 13 systems evaluated, six showed a relatively substantial reduction in crime in the target area compared with the control area, but only two showed a statistically significant reduction relative to the control, and in one of these cases the change could be explained by the presence of confounding variables. Crime increased in seven areas but this could not be attributed to CCTV. The findings in these seven areas were inconclusive as a range of variables could account for the changes in crime levels, including fluctuations in crime rates caused by seasonal, divisional and national trends and additional initiatives.

Gill and Spriggs have found that systems installed in a mixed category of areas (e.g. car parks, a hospital and various other areas covered by one system) displayed the most encouraging results in terms of reduction in crime, particularly in car parks, while town centre and residential systems showed varied results, with crime going down in some areas and up in others. Residential redeployable schemes appeared to show no long-term reduction in crime levels, however, the cameras were dealing with short-term problems, which require sensitive measures to detect the impact of the cameras.

They have also found that certain types of offences were affected more than others. Impulsive crimes (e.g. alcohol-related crimes) were less likely to be reduced than premeditated crime (e.g. theft of motor vehicles). Violence against the person rose and theft of motor vehicles fell in the target areas in accordance with national trends in recorded crime.

Some system attributes had more effect than others. For example, camera coverage was positively correlated to effect size, although this was not statistically significant. Increased camera density (numbers of cameras installed per unit area) was related to effect size, but only up to a density level where the number of cameras installed in an area had reached saturation point. CCTV seemed more effective in sites with limited and controlled access points, such as entrances and exits to the area.

Spatial displacement of crime was not common but did occur. One system showed evidence of displacement of overall crime into the surrounding area, while a second system showed displacement of burglary into the surrounding area, and a third showed displacement of vehicle crime into the gaps in coverage between cameras. None of the factors outlined above determine exactly how well a system will work, but they suggest what combinations of factors can work together to reduce crime.

Public attitude surveys were conducted, to assess changes in public perceptions of CCTV in the intervention areas and comparable control areas before and after the installation of CCTV. These included residential in-home surveys and town/city centre in-street surveys. Public attitude surveys were carried out before and after the installation of CCTV in 12 different areas: nine residential estates and three city/town centres. The surveys covered a number of important issues, summarized below.

- Awareness of cameras: Individuals were usually aware of cameras in their area, and were highest in small residential areas. Public awareness increased with the number of cameras per unit area increased (though the positive correlation was not statistically significant).
- Worry about being a victim of crime: Members of the public worried less about becoming victims of crime in the intervention area following the installation of CCTV, but this was statistically significant in only three areas (the effect was significant in the target area compared with the control area in just two areas). These changes in levels of worry about crime did not appear to be affected by type of area. Respondents who were aware of the cameras actually worried more often about becoming a victim of crime than those who were unaware of them. Knowing that cameras were installed in an area did not necessarily lead to a reinforced feeling of security among respondents.
- Feelings of safety: Feelings of safety increased in all but one of the areas surveyed following CCTV installation (in three areas the effect was greater in the target than in the control area), however, none of the results were statistically significant.
- Reported victimisation: In eight CCTV implementation schemes, a reduction in the percentage of respondents who reported having been victims of crime was reported after the installation of the system (four of these eight recorded a larger reduction in the target than the control area), however, none of the data were statistically significant. In six residential areas the number of reported incidents increased or decreased in line with changes in recorded crime levels

generally, so tending to confirm the reliability of the recorded crime data. Victimisation did not appear to be affected by the type of area the CCTV system was installed in. Worry about being a victim of crime declined in seven areas in step with a reduction in reported victimisation. This suggests that worry about being a victim of crime was directly related to crime levels, rather than the mere presence of the cameras.

- Changes in behaviour: Respondents rarely changed their behaviour following the installation of CCTV. Across the areas surveyed, only from two to seven per cent visited places they had previously avoided. This is substantially fewer than the 15 per cent of pre-implementation respondents who thought that CCTV would encourage them to visit places they avoided. Also, the presence of CCTV did not discourage people from visiting places. Only one per cent of respondents said they avoided places once CCTV had been installed.

- Support for CCTV: The proportion of respondents happy or very happy about having cameras in their area declined in nine areas following their installation; in five of these the reduction was statistically significant. However, the level of support of CCTV remained high at over 70% of the sample in all but one area. At the same time, concerns regarding the implication for civil liberties decreased slightly following the implementation of CCTV. Whereas 17% of respondents expressed such concern prior to its installation, this declined from two to seven percentage points post CCTV installation.

- Perceived effectiveness of CCTV: In residential areas, the proportion of those who perceived the impact of CCTV to be positive decreased following its installation in all the areas surveyed. Respondents were less likely to think that people reported more incidents to the police once CCTV was installed, although in all cases over a third of respondents thought that this was the case before implementation. They were less likely to think that the police responded more quickly to incidents following CCTV installation, although the proportion of respondents who thought that this occurred varied from 12% to 60%. They were less likely to think that crime had got lower following installation of CCTV, although 27 to 70% thought that it had.

In addition to the aspects discussed in the above paragraphs, Gill and Spriggs [9] also looked at the technical specification and design as well as the process of implementing and installing the CCTV systems. Also, control room operations and control room management were assessed, including working relationships with external agencies such as the police. Overall, they concluded in their report that the use of CCTV needs to be supported by a strategy outlining the objectives of the system and how these will be fulfilled. This needs to take account of local crime problems and prevention measures already in place.

2.2 US CCTV Research Studies

Fewer studies of video surveillance have been conducted in the United States, where cameras have been erected in a piecemeal manner, and have not undergone an extensive process of networking. However, Welsh and Farrington's meta-analysis [6], summarized in 2.1.1, compared UK and US sites, and the two authors revisited this comparison in a 2004 follow-up [10]. In their review, Welsh and Farrington found that none of the five evaluations of CCTV conducted in the United States

found a statistically significant crime reduction. In what follows, findings from a few more recent independent studies of small-scale systems are reviewed, offering a preliminary view of the impact of video surveillance on crime in US cities.

2.2.1 Temple University Philadelphia Case Study 2008

Ratcliffe and Taniguchi at Temple University, Department of Criminal Justice, have studied the crime reduction effects of public CCTV cameras in the city of Philadelphia, using two different evaluation techniques [11].

The first technique, Hierarchical Linear Modeling (HLM), was used to evaluate the general impact of all of the cameras. This technique allows for different camera implementation dates, any seasonal variation in crime, and any general trends in crime at each site. HLM finds that the introduction of CCTV cameras is associated with a 13% reduction in all crime (both serious crime and disorder crime, according to definitions shown in the Appendix A of the study [11]) after the implementation of the cameras, with the most significant impact of the cameras being on disorder crime count, 16% lower for the target areas following implementation, after controlling for the days per month, the average temperature that month, and the crime trend at each target location. The frequency of serious crimes around each camera location was generally too low to detect a measurable impact in serious crime alone. The authors of the study did not interpret this as meaning that serious crime was not impacted, just that the levels of serious crime were too low to detect a statistically significant effect.

The second technique, Weighted Displacement Quotient (WDQ) is employed to determine whether or not differences between the target areas and buffer areas are a result of displacement from the target area or a diffusion of benefits from the use of CCTV surveillance in the target area. The determination of a WDQ first requires the researcher to determine three operational areas; the target area where the crime reduction strategy has been deployed (in this case, CCTV camera viewsheds), a buffer area that is estimated to be the most likely location that crime would be displaced to, and a control area that acts as a check on general crime trends that are affecting the region in general. Based on WDQ analysis, the introduction of CCTV was associated with considerably different impacts on crime at each site. At half of the sites, crime did not reduce in the target area. At four sites, serious crime reduced and there was even evidence of a diffusion of positive benefits to surrounding streets. At some sites, crime reduced in the target area but there was apparent displacement to surrounding streets. Therefore the 13% reduction in overall crime was comprised of very different behaviors at CCTV evaluation sites.

2.2.2 The University of California, Berkeley, San Francisco Case Study 2008

Jennifer King and colleagues at Centre for Information Technology Research in the Interest of Society (CITRIS) and the Samuelson Clinic at the University of California, Berkeley, studied the effectiveness of San Francisco's small video surveillance system. In their final report [12], based on aggregate statistics on serious violent crime and serious property crimes before and after installation of cameras in high-crime neighbourhoods, King's group found a statistically significant and substantial declines in property crime within view of the cameras. Within 100 feet of camera locations, the decline was 24% percent. No corresponding declines were observed in the immediately

adjacent areas, neither were increases in property crime observed in these areas. When incidents occurring in public and incidents occurring in private places were analyzed separately, statistically significant and substantial declines were observed near the cameras for crimes occurring in public only, and no relationship between distance from the camera and the change in crime for property crime occurring in private locations. No corresponding relative changes in crime near the cameras for areas in the control area were found. Thus, all three tests point to a significant deterrent effect of the cameras on property crime.

Regarding violent crime, King and colleagues did not find evidence of an impact of the cameras. Violent incidents did not decline in areas near the cameras relative to areas further away, there was no decline in violent crimes occurring in public places, and no statistically significant differences in the relationships between the before-after change in crime and the distance from the camera locations for target sites and comparison (control) sites. When violent crimes were disaggregated, analysis of specific violent crime rates reveals a decline in overall homicides in areas near the cameras but an increase in areas far from the cameras, suggestive of a displacement effect. However, disaggregating the data into homicides occurring in public as opposed to private areas yields little evidence of a decline in homicides near the cameras or a significant increase in homicides far from the cameras. Thus homicide patterns in the areas surrounding the cameras during the time period before, during, and after camera installation were consistent with random variation. The researchers did not find evidence of an effect of the cameras on other types of incidents (e.g., drug incidents, prostitution, vandalism, and other incidents described as suspicious occurrences).

Finally, King and colleagues performed analysis to investigate the effectiveness of the Community Safety Camera program in investigating crime that occur within view of the cameras and assisting in the prosecution and defence of charged crimes. The researchers note that despite poor image quality, camera footage has been useful for criminal investigations; while there are occasional instances where suspects or witnesses can be identified, more often footage is helpful in establishing a sequence of events for a crime or placing witnesses at a scene. Camera footage has assisted police in laying charges against a suspect, but has also contributed to charges against suspects being dropped or amended by the District Attorney's office in a few cases. There has been limited success with the cameras acting as a 'silent witness', with footage standing in for witness testimony.

2.2.3 The University of Southern California Los Angeles Case Study 2008

Aundreia Cameron and colleagues at the University of Southern California School of Policy, Planning and Development released a report to the California Research Bureau in May 2008, on the effects of video surveillance on crime in two areas of Los Angeles [5]. The group used a quasi-experimental research design to analyze the effectiveness of video surveillance and looked at five out of 14 cameras along a high-traffic section of Hollywood Boulevard and six cameras at the Jordan Downs Public Housing Project in Watts.

Statistical analysis of crime and arrest data before and after implementation found that:

- Neither cameras in Jordan Downs nor Hollywood Boulevard had any statistically significant effect in reducing the overall monthly crime rates within the target areas.

- The monthly rate of violent crimes fell in both the Jordan Downs and Hollywood target areas but the results were not statistically significant.
- The monthly rate of property crimes decreased in Hollywood and increased in Jordan Downs, but the results were not statistically significant.
- The evidence on the displacement of crime is mixed; in both locations, some crimes increased at a faster rate in buffer areas (between 500 and 1000 feet), while other crimes decreased at a faster rate in these same areas; however, the results were not statistically significant.
- CCTV had no statistically significant effect on monthly arrest rates for misdemeanour 'quality of life' infractions in either Jordan Downs or Hollywood Boulevard.

The study [5] notes that local implementation and operations were found to be critical to CCTV effectiveness, and complemented their statistical findings through interviews with the Los Angeles Police Department, community groups and business interests as well as through related documents and media reports. Base on these efforts, the researchers found that the types of crimes being targeted by the Los Angeles Police Department, and the dynamism of the areas under study, may limit the ability to draw general conclusions about CCTV effectiveness based on their results. They did, however, state a number of lessons that can be learnt from their experience:

- CCTV is a tool for law enforcement, not a panacea.
- Effective and sustainable CCTV systems require adequate training, leadership and resources.
- Deterrence and enforcement are strongly intertwined.
- Additional research is needed into how local program operations affect program implementation, as well as the detection, apprehension and prosecution of criminal suspects.

2.3 Summary of Previous Studies

The literature review presented in this section paints a mixed picture of the effectiveness of CCTV surveillance on reducing crime. While some crime reduction effects have been supported by evidence, the underwhelming extent to which this could be done does not seem to be proportionate with the rapid growth of crime prevention initiatives relying on video surveillance of public places.

Most of the studies discussed here found that the effectiveness of CCTV surveillance was dependant on the location of cameras, as well as the type of crime. For example, a reduction of crime in car parks in the presence of surveillance cameras was a fairly consistent finding across many studies. Also, a reduction in property crimes was observed consistently, and so was a reduction in disorder crime. Generally, the effects were most pronounced on the types of crimes that imply premeditation, and in areas where the CCTV implementation was supplemented with other interventions (e.g., improved street lighting). For violent crime offences, the results reported were more inconclusive. Most studies reviewed here did not find declines in violent crime; those that did, found that the effect was small and, in most cases, not statistically significant.

More definite conclusions can be drawn from this review section about experimental design. Many studies seem to agree that the observed effects depended on particular characteristics of the targeted areas, and thus may be hard to replicate elsewhere. The importance of understanding the implementation setting and thoughtful target selection are emphasized in virtually all of the studies reviewed. When evaluating effectiveness of video surveillance on reducing crime, one has to consider, at the very least, the availability of *before* and *after* measures of crime in experimental areas, and of suitable control measures. Ideally, when designing a CCTV surveillance evaluation project, a number of suitable areas, free from other interventions that might confound CCTV effects, should be identified. Some of these areas would then be randomly selected for CCTV implementations, with the remaining areas used for control measures. Surrounding areas should also be identified, and the corresponding crime data analyzed, in order to capture any diffusion of benefits or displacement of crime effects. Trends in crime rates, seasonal effects, and other relevant variables should be captured for all these areas.

In real life situations, often the perceived urgency to intervene in 'problem' areas makes experimental design an after-the-fact consideration. Since ideal experimental conditions are a luxury that usually researchers in this field do not have, one has to be careful to present any findings in context and with appropriate caveats. This may limit the ability to draw general conclusions about CCTV effectiveness, and this limitation is a recurring theme in the studies reviewed here.

3 Statistical Analysis of the Toronto Police Service Call-for-Service Data

This section describes the analysis conducted on the crime data provided by the Toronto Police Services up to November 28, 2008, in order to assess the effectiveness of surveillance cameras in reducing crime. It describes the methods of analysis and their application to address some of the questions posed in the design of the pilot project, described in the Project Charter [2] and summarized in Section 1.2. Results are compared with findings and lessons learned from previous studies, summarized in Section 2.3.

This paper addresses only those questions in Ref. [2] related to crime reduction in the targeted areas and diffusion of benefits beyond the targeted areas; some general considerations about displacement and dispersion are also discussed. However, because of unresolved issues about the data available, lack of capacity and lack of time, addressing the other questions in Ref. [2] (e.g., community impact and perceptions of safety, and unexpected external changes that may have influenced the outcome) has been deferred.

3.1 Data Provided and Data Reconciliation

There were six areas targeted for the implementation of the CCTV pilot initiative discussed in this report, and they are described in Annex A. The analysis presented in this section covers the five areas for which data were available at the time the work presented here was done. They include one target area in North York (31 Division), two target areas in Scarborough (42 Division), one target area in the Entertainment District (52 Division), and one target area in the 51 Division.

The data were provided by the Toronto Police Service in two lots:

- An ACCESS database of incidents in the period 1 Jan 1995 to 26 Aug 2008, inclusive; and
- An EXCEL spreadsheet of locations of surveillance cameras.

More details on the data are presented in Annex B. In the ACCESS database, the map location of each incident was given in an ‘easting’ and a ‘northing’, i.e., in units of metres from the zero point for the grid zone for Toronto. See Ref. [13] for details of this system. For each descriptive location, such as ‘2739 VICTORIA PARK AVE’, the grid locations were exactly the same throughout the database; this supports the inference that the grid references were consistently copied from some central standard for each descriptive location, instead of being measured for each incident. The imprecision introduced by this practice could not be assessed.

The EXCEL spreadsheet provided the map location of each camera, given in coordinates from GPS measurements, in degrees and minutes of angle, with the minutes specified to three decimal places.

The angular locations were converted to grid references using two different programs from the Internet; these yielded consistent results for their conversions. The descriptive locations of camera locations and of incident locations were then compared. When a camera location and an incident

location had the same descriptive location, their grid references were compared, as shown in Figure B.2. The eastings for the camera locations were, with two exceptions, less than 28 metres smaller than the eastings for the incident locations. The northings for the camera locations were, with one exception, between 205 and 261 metres smaller than the northings for the incident locations.

While unknown, the imprecision arising from the use of standard locations for incidents, instead of measured locations for each incident, is unlikely to exceed the discrepancies found between the two systems of measurement - the eastings and northings recorded for the incidents and the angular references of the GPS reading for the camera locations.

Because of these inexactitudes, the determination, for each incident, of its location within or outside a surveilled area often cannot be done with certainty. The areas used for the statistical analysis are therefore areas that can be specified readily in the database of incidents and that are approximations to the areas of surveillance. For the purposes of this trial, perpetrators are unlikely to know the surveilled areas more precisely than that.

3.2 Data Analysis Methods

3.2.1 Data Selection

The first step in the analysis was to define 'target areas' and select all the incidents in those areas before, during and after the implementation of the CCTV camera systems. The cameras were on a 360 degree programmed tour, and they were designed to zoom in and out as they sweep areas of particular importance. The cameras were positioned to cover areas within 100 - 200 metres from their location.

'Target areas' were given by the overlapping coverage of a 'cluster' of cameras installed at the same general location. 'Buffer areas' are areas directly adjacent to target areas, obtained by extending a further 200 metres beyond the boundaries of each target area. Boundaries for both target and buffer areas were chosen with factors such as major roads, natural boundaries and other topographical features in mind. More details about boundary selection and calculations involved are presented in Annex C.

For the entertainment district (Divisions 52) and Division 51 efforts were made to select control areas that were similar to the targeted areas. Control areas were selected in the same general zone and with as similar features to the targeted areas as possible. In a truly randomized experiment, a number of areas with similar attributes (e.g., general location, physical features, and crime levels) are identified beforehand, and the systems whose impact one wants to evaluate are assigned randomly to some of the identified areas. This was not the case with the current project, and because of significant limitations in control area selection, the author decided to compare any effects on crime that the implementation of CCTV systems might have had in the target areas with the crime records for the whole city, as the level of crime in the city seems to have been fairly constant over the period of time for which records exist (1995-2008). The approach used in this work is consistent with best practices in the field, as discussed in Section 2.

In order to assess the impact of CCTV system implementation, the author has looked at levels of crime in the selected areas during the implementation period and during the same time period in each of the years with records prior to the implementation. For example, if the pilot project ran from May to November 2007, summary statistics were calculated for the implementation period and for the period May to November 2006, as well as time series for the months from May to November each year since the records started until implementation (1995 to 2007). This data selection attempts to eliminate any seasonal effects that might alter the conclusions (e.g., the number of crime during the winter months might be different than the number of crimes during the summer months). Ideally, one would prefer to have data for a full year after implementation and at least a full year before. However, in only one of the areas evaluated was the CCTV system kept for a full year, while in an additional area the system was operational for seven months and for the remaining areas the cameras were installed for a period of six months.

3.2.2 Summary Statistics

For each target area considered, summary statistics were calculated - the total and the average monthly number of recorded incidents and associated standard deviation - for the selected areas during the implementation period and during the selected period before implementation (as discussed in the previous section). Simple percentage changes in the average monthly number of incidents before/after implementation were calculated, with positive values indicating a decrease in crime after implementation (desired effect) and negative values indicating the opposite effect (a value of zero indicating unchanged level of crime).

To determine whether any observed changes are statistically significant, the author calculated the Relative Effect Size (RES) between the number of recorded offences in the target areas and buffer areas, control areas (where identified) and citywide. This calculation measures the effect of the intervention in the target area and is based upon the odds ratio (sometimes also called a contingency table [14]). To construct this statistic, the following information is required:

Table 1: *Information for relative effect size (RES) calculation*

	Crime count in the set number of months (preferable 12 months) *before* implementation	Crime count in the set number of months (preferable 12 months) *after* implementation
Target Area	a	b
Comparison Area (e.g., buffer, control)	c	d

Given the information in Table 1, the RES is then calculated as:

$$RES = \frac{a/b}{c/d} \tag{1}$$

Values of the RES over one indicate a relative decrease in crime levels in the target area compared with the buffer, control area or citywide, respectively. To test the significance of the RES values and construct confidence intervals, the associated standard error has also been calculated. 95%

confidence intervals have been used to assess statistical significance. While one might be tempted to accept a weaker confidence level, weaker levels might lead to conclusions based on findings that could plausible have arisen by chance, especially given the lack of true randomization in the experimental setup.

In calculating RES values and the associated standard errors, the author has followed the techniques described in Ref. [15], including adjusting the calculations to account for temporal fluctuations in the variance of monthly records of crimes. In order to do that, variance over a 12-month period was estimated as the maximum of either 12 multiplied by (monthly standard deviation)^2 associated with the mean number of crimes over a year, or the actual number of crimes in the year. For example, with respect to the number of crimes in the target area before implementation, a, the variance of crime is either a or $12 \times (\text{S.D.}(a))^2$. Where only six months of pre- and post-data was used to calculate the RES, the square of the standard deviation was multiplied by 6 rather than 12. The standard error was calculated as:

$$\sigma^2 = (\text{var}(a)/a^2 + \text{var}(b)/b^2 + \text{var}(c)/c^2 + \text{var}(d)/d^2). \tag{2}$$

The associated 95% confidence interval (CI) was estimated from the following formula:

$$\text{CI} = \text{effect size} \pm (\text{effect size} \times 2 \times \sigma^2), \tag{3}$$

with negative limits set to zero. For justification in using these formulae, please see Ref. [15] (particularly footnote 2).

3.2.3 Time Series

A second technique used in the analysis was based on time series. For this part, the number of incidents in each target area during the implementation months (see discussion in section 3.2.1) and for all years with records was plotted over time. For each target area, it was possible to identify temporal trends in the data before implementation and use regression techniques to predict values for the implementation period if no CCTV system had been implemented. Predicted values for the number of incidents and calculated 95% confidence intervals were compared with data after CCTV system implementation. The results of the comparison enabled the author to assess the effects of implementation without worrying about possible effects of other confounding factors that might have had an effect during the implementation period.

3.3 Results of Analysis and Discussions

3.3.1 Entertainment District - Division 52

Target area: within Division 52 (entertainment district), the target area was defined, as described in 3.2.1 and detailed in C, as the area covered by the cluster of cameras located at the following intersections:

- Pearl Street, east of Duncan Street;

- Duncan Street/Adelaide Street West;
- Duncan Street/Richmond Street West;
- Richmond Street West, east of Duncan Street;
- Richmond Street West/Widmer Street;
- Richmond Street West/Peter Street;
- Adelaide Street West/Peter Street; and
- Richmond Street West/John Street.

Implementation period: 01/05/2007-31/04/2008.

Discussion

A superficial evaluation of the tabulated percentage change results shown in Fig. 1 shows a decrease in the total number of violent crime incidents reported in the implementation period compared to the same period the year before implementation in the target area. Similar effects are also seen in the buffer area and the control area, while the level of crime citywide remained virtually unchanged. The calculated RES values seem to indicate a stronger impact on crime in the buffer area than in the target area, virtually as strong an effect in the control area as in the target area and a reduction in crime in the target area compared to citywide data. This would indicate a diffusion of benefits not only in the immediate buffer area, but also in a larger zone around the target. However, in all these cases the RES value of one falls within the calculated 95% confidence intervals (which was calculated taking into account temporal fluctuations in the data over the observed periods of time). Thus, none of the above results withstand scrutiny when subjected to statistical significance tests. In other words, these results cannot be used to draw conclusions about the effectiveness of the implementation of CCTV cameras in reducing crime.

The time series results shown in Fig. 2 and 3, however, show that the implementation of the CCTV system significantly reduced the number of incidents in the implementation period, leading to a value in the implementation period below the calculated value (and 95% confidence interval) based on the trend in crime evolution over the years. Overall, the time series in Fig. 2 shows a steep increase in crime levels over time in the target area, and the implementation of the CCTV system leads to a break in this trend.

Area	No. incidents before	No. incidents after	% change	Relative Efect Size (RES)	RES Lower limit (95%)	RES Upper limit (95%)	Statistical significance
Target area	853	765	10%	-	-	-	
Buffer area	475	411	13%	0.96	0.74	1.19	NS
Control area	363	329	9%	1.01	0.75	1.27	NS
Citywide	51037	51494	-1%	1.13	0.95	1.30	NS

Figure 1: *Summary statistics for entertainment district - Div. 52*

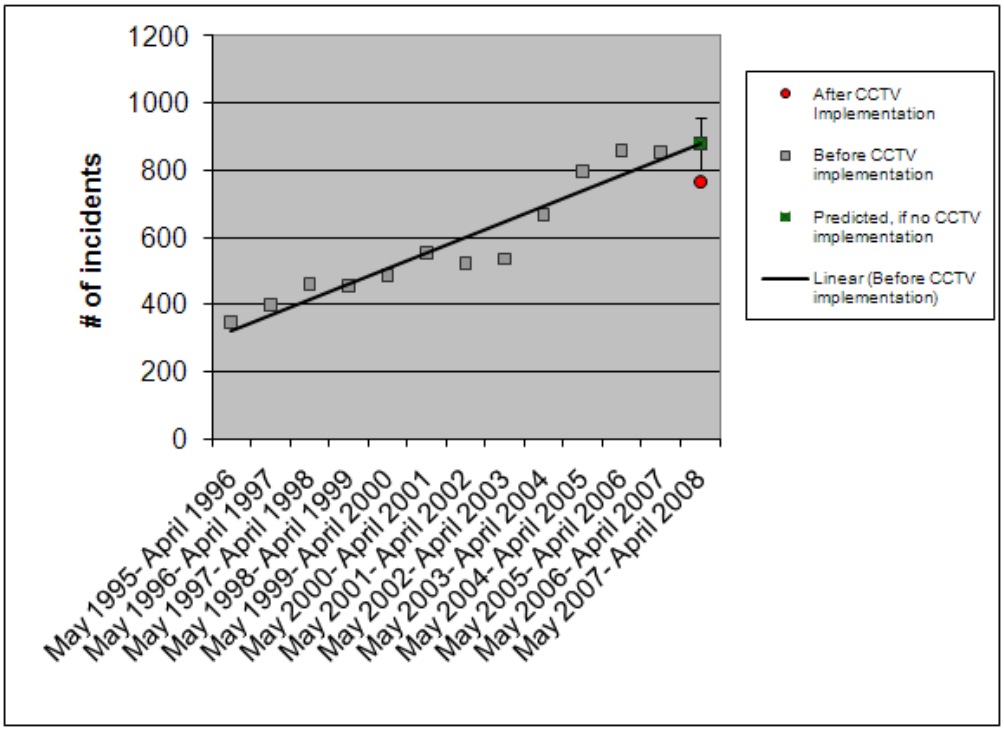

Figure 2: *Time series for entertainment district - Div. 52*

No. incidents after implementation	Predicted value, if no implementation	Lower limit (95%)	Upper limit (95%)	Observed effect
765	879	801	957	Reduction

Figure 3: *Regression results based on time series for entertainment district - Div. 52*

3.3.2 Division 51

Target area:

- Dundas Street/George Street;
- Gerrard Street/George Street;
- Pembroke Street/Dundas Street;
- Dundas Street/Sherbourne Street East;
- Dundas Street/Sherbourne Street West;
- Sherbourne Street/Shutter Street; and
- Queen Street/Sherbourne Street.

Implementation period: 01/11/2007-31/04/2008.

Discussion

Again, a superficial look at the tabulated percentage change results shown in Fig. 4 seem to show in this case a virtually unchanged level of crime in the target area reported in the implementation period compared to the same period the year before implementation, a unchanged level of crime in the buffer area, while a decrease is observed in the control area. The level of crime citywide seems to have increased slightly for the periods of time considered. The calculated RES values indicate virtually the same effect on crime in the buffer compared with the target area, a decrease in crime in the control area compared with the target area, and similar trends in the target area compared to citywide data. However, once again in all these cases the RES value of one falls within the calculated 95% confidence intervals, so none of the above results withstand scrutiny when subjected to statistical significance tests and cannot be used to draw conclusions about the effectiveness of the implementation of CCTV cameras in reducing crime.

The time series results shown in Fig. 5 and 6 show that the implementation of the CCTV system had no significant effect on the number of incidents in the implementation period, leading to a value in the implementation period within the calculated 95% confidence interval based on the trend in crime evolution over the years. Overall, the time series in Fig. 5 shows a slight decrease in crime levels over time in the target area, and the value after the implementation of the CCTV system follows the observed trend.

Area	No. incidents before	No. incidents after	% change	Relative Efect Size (RES)	RES Lower limit (95%)	RES Upper limit (95%)	Statistical significance
Target area	475	471	1%	-	-	-	-
Buffer area	384	385	0%	1.01	0.71	1.31	NS
Control area	178	151	15%	0.86	0.56	1.15	NS
Citywide	23137	23834	-3%	1.04	0.79	1.29	NS

Figure 4: *Summary statistics for target area - Div. 51*

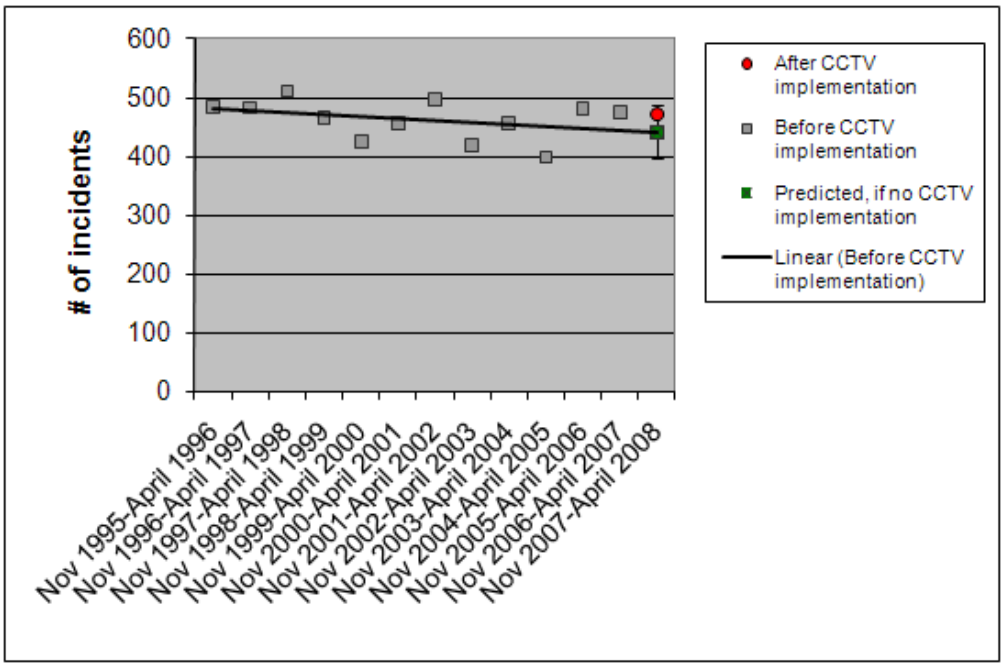

Figure 5: *Time series for target area - Div. 51*

No. incidents after implementation	Predicted value, if no implementation	Lower limit (95%)	Upper limit (95%)	Observed effect
471	441	396	486	No effect

Figure 6: *Regression results based on time series for target area - Div. 51*

3.3.3 North York - Division 31

Target area:

- Jane Street/Finch Avenue West;
- Jane Street/Yorkwood Gate; and
- Jane Street/Firgrove Crescent.

Implementation period: 01/05/2007-31/10/2007.

Discussion

The tabulated percentage change results shown in Fig. 7 seem to show a decrease in the total number of violent crime incidents reported in the implementation period compared to the same period the year before implementation in the target area. Similar effects are also seen in the buffer area. The author could not identify a suitable control area in this case. The level of crime citywide remained virtually unchanged. The calculated RES values seem to indicate a larger impact on crime in the target area than in the buffer area, and a reduction in crime in the target area compared to citywide data. This would indicate some diffusion of benefits in the immediate buffer area. But again, in all these cases the RES value of one falls within the calculated 95% confidence intervals, so the results do not pass statistical significant tests and cannot provide the base for any effectiveness conclusions.

The time series results shown in Fig. 8 and 9, however, show that the implementation of the CCTV system significantly reduced the number of incidents in the implementation period, leading to a value in the implementation period below the calculated value (and 95% confidence interval) based on the trend in crime evolution over the years. Overall, the time series in Fig. 8 shows a slight increase in crime levels over time in the target area, and the implementation of the CCTV system leads to a large decrease below the trend.

Area	No. incidents before	No. incidents after	% change	Relative Efect Size (RES)	RES Lower limit (95%)	RES Upper limit (95%)	Statistical significance
Target area	123	96	22%	-	-	-	-
Buffer area	104	94	10%	1.16	0.67	1.64	NS
Citywide	27900	27660	1%	1.27	0.92	1.62	NS

Figure 7: *Summary statistics for North York - Div. 31*

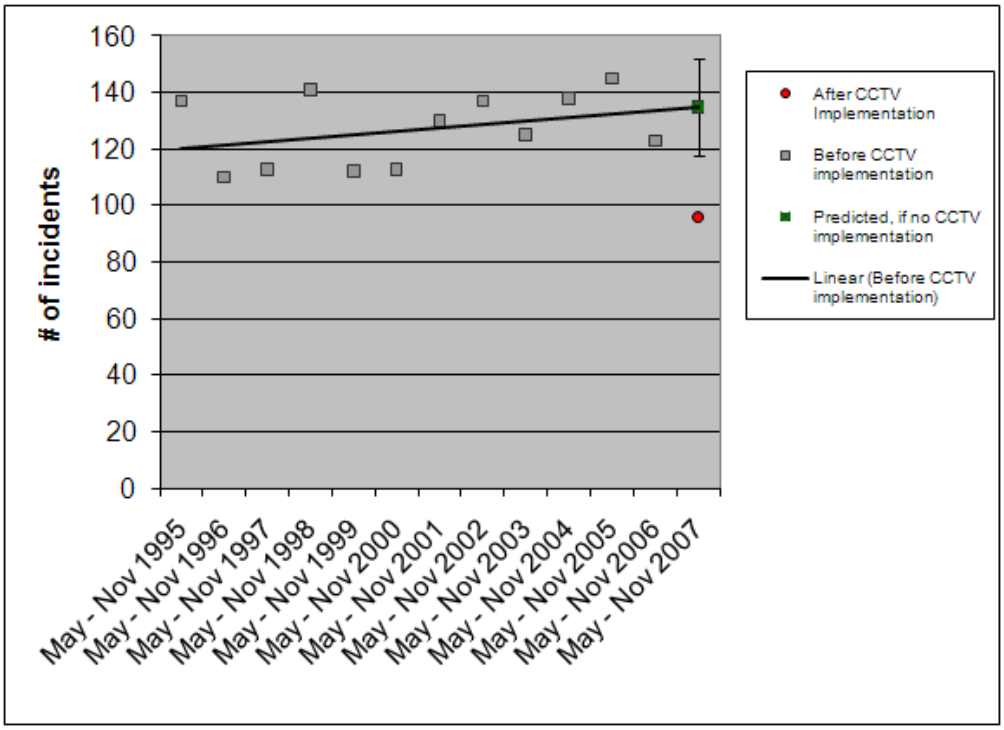

Figure 8: *Time series for North York - Div. 31*

No. incidents after implementation	Predicted value, if no implementation	Lower limit (95%)	Upper limit (95%)	Observed effect
96	135	118	152	Reduction

Figure 9: *Regression results based on time series for North York - Div. 31*

3.3.4 Scarborough - Division 42

Target area A1:

- Morcambe Gate/Victoria Park Avenue; and
- Morcambe Gate/Chester Le Boulevard.

Implementation period: 01/05/2007-31/10/2007.

Discussion

The tabulated percentage change results shown in Fig. 10, again, on a superficial examination, show a decrease in the total number of violent crime incidents reported in the implementation period compared to the same period the year before implementation in the target area. Opposite effects are seen in the buffer area, indicating a potential displacement of crime. The author could not identify a suitable control area in this case. The level of crime citywide remained virtually unchanged. The calculated RES values seem to indicate a larger impact on crime in the target area than in the buffer area, and a reduction in crime in the target area compared to citywide data. Again, in all these cases the RES value of one falls within the calculated 95% confidence intervals. It must be noted that because of low numbers of records over the observed time periods and large variations from month to month, as well as a reduced implementation period (only six months) the author has less confidence in the statistical calculations (this is also reflected in the very broad confidence interval). As was the case with all previous areas, the results do not pass statistical significance tests and cannot be used.

The time series results in Fig. 11 and 12 show that the implementation of the CCTV system had no significant effect on the number of incidents in the implementation period, leading to a value in the implementation period within the calculated 95% confidence interval based on the trend in crime evolution over the years. Overall, the time series in Fig. 11 shows unchanged crime levels over time in the target area, and the value after the implementation of the CCTV system follows the observed trend.

Area	No. incidents before	No. incidents after	% change	Relative Efect Size (RES)	RES Lower limit (95%)	RES Upper limit (95%)	Statistical significance
Target area	44	39	11%	-	-	-	-
Buffer area	55	61	-11%	1.25	0.26	2.24	NS
Citywide	27900	27660	1%	1.12	0.37	1.87	NS

Figure 10: *Summary statistics for Scarborough - Div. 42 (target area A1)*

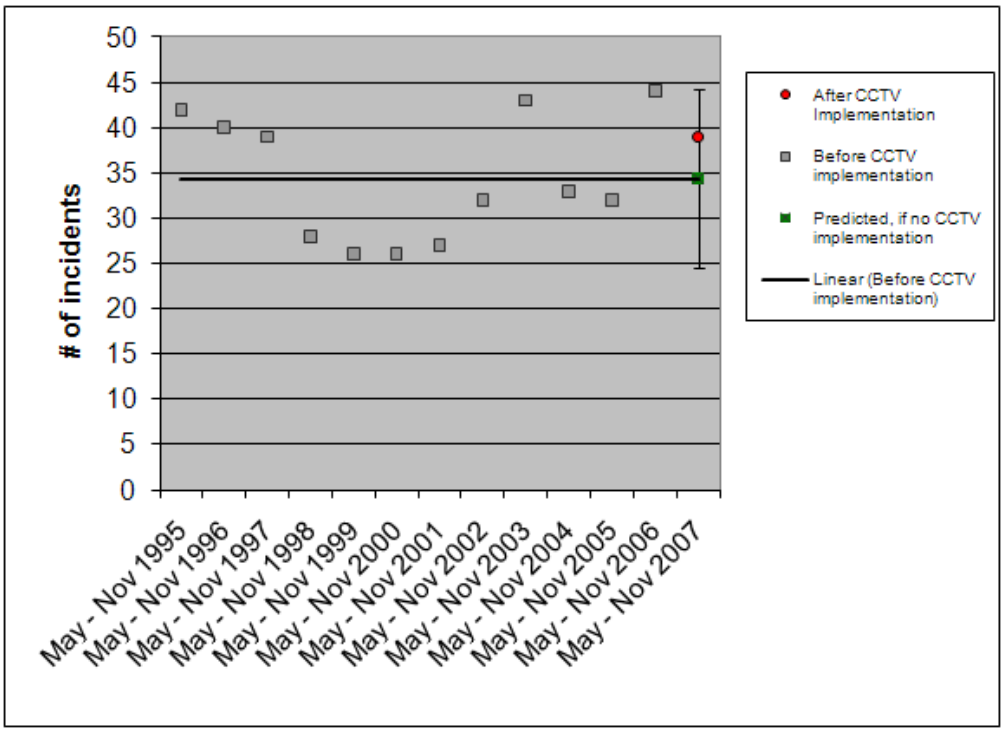

Figure 11: *Time series for Scarborough - Div. 42 (target area A1)*

No. incidents after implementation	Predicted value, if no implementation	Lower limit (95%)	Upper limit (95%)	Observed effect
39	34	24	44	No effect

Figure 12: *Regression results based on time series for Scarborough - Div. 42 (target area A1)*

Target area A2:

- Neilson Avenue/Sewells Road; and
- Brenyon Way, west of Sewells Road.

Implementation period: 01/05/2007-31/10/2007.

Discussion

The tabulated percentage change results shown in Fig. 13 seem to show a large decrease in the total number of violent crime incidents reported in the implementation period compared to the same period the year before implementation in the target area. A decrease in crime numbers could also be seen in the buffer area, indicating a potential diffusion of benefits. The author could not identify a suitable control area in this case. The level of crime citywide remained virtually unchanged. The calculated RES values seem to indicate a larger impact on crime in the target area than in the buffer area, and a large reduction in crime in the target area compared to citywide data. Again, in all these cases the RES value of one falls within the calculated 95% confidence intervals. As in Target Area A1, low numbers of records over the observed time periods and large variations from month to month, as well as a reduced implementation period (only six months) lead the author to have less confidence in the statistical calculations (this is again reflected in the very broad confidence interval). As was the case with all other areas, the results do not pass statistical significance tests and cannot be used.

The time series results shown in Fig. 14 and 15 show that the implementation of the CCTV system significantly reduced the number of incidents in the implementation period, leading to a value in the implementation period bellow the calculated value (and 95% confidence interval) based on the trend in crime evolution over the years. Overall, the time series in Figure 5 shows an increase in crime levels over time in the target area, and the implementation of the CCTV system leads a decrease below the trend, visible even with the scatter due to low numbers of records.

Area	No. incidents before	No. incidents after	% change	Relative Efect Size (RES)	RES Lower limit (95%)	RES Upper limit (95%)	Statistical significance
Target area	20	11	45%	-	-	-	-
Buffer area	20	15	25%	1.36	0.00	3.01	NS
Citywide	27900	27660	1%	1.80	0.23	3.38	NS

Figure 13: *Summary statistics for Scarborough - Div. 42 (target area A2)*

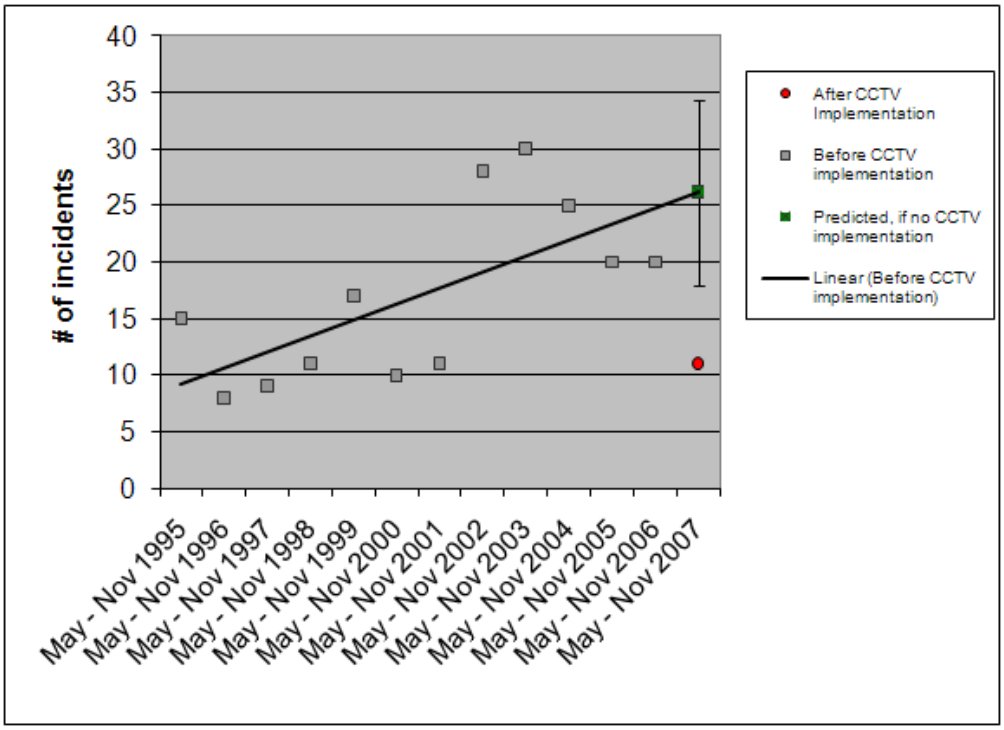

Figure 14: *Time series for Scarborough - Div. 42 (target area A2)*

No. incidents after implementation	Predicted value, if no implementation	Lower limit (95%)	Upper limit (95%)	Observed effect
11	26	18	34	Reduction

Figure 15: *Regression results based on time series for Scarborough - Div. 42 (target area A2)*

4 Conclusions and Recommendations

The results presented and discussed in Section 3 of this report indicate that the level of crime decreased in three out of five areas after the implementation of the CCTV camera systems, and remained largely unchanged in the remaining two. These findings are supported by time series data done over the entire period of time for which records exist (1995 to 2008). While the author tried to support these finding with calculated summary statistics, where crime levels over the implementation period were compared with crime levels during the same period in the previous year, the latter calculations did not stand scrutiny when they were subjected to statistical significance tests.

Based on the above findings, one might conclude the implementation of CCTV camera systems can be effective, but further analysis is necessary. Based on existing data, additional time series analysis could be done for identified buffer areas around the target areas (this was not done because of lack of time).

Analyzing the effectiveness of any future implementation of CCTV systems would benefit greatly if such implementation is preceded by careful design. Thus, earlier involvement of statistical advice on experimental design is recommended, especially concerning controls. Ideally, a large number of areas could be identified beforehand, and they would be randomly allocated to have cameras or not. Crime analysis in the selected areas prior to implementation might help identify trends, crime evolution, existing mitigating measure and other characteristics and separate them from the effects of CCTV surveillance. In addition, coverage of at least one year is recommended, in order to avoid seasonal effects. Also, longer implementation period, as well of extended target areas, might lead to larger numbers of records, and thus improved statistical results.

A fully randomized controlled trial is only rarely achieved in an operational setting. However, there are experimental designs that can yield quite a few of the benefits of a 'gold standard' design at a moderate increase in the burden of the trial. The possibility of using such designs should be examined before the trial. The benefits are so great that this is one of the strongest reasons for early involvement of statisticians in the trial design. Additionally, all maps and other geo-coded information should be brought into registration before the trial starts; there should be exactly ONE map used for camera locations and crime locations. The accuracy of location information should also be determined before starting to gather data. In this trial there was an almost consistent bias of less than 28 metres in eastings and another almost consistent bias of between 205 and 261 metres in northings. A small amount of pre-trial work could confirm these biases and accurately estimate them; they could then be eliminated in later analyses.

The findings presented in this report are consistent with what was learned from reviewing previous research studies. For violent crime types of offences, declines in violent crime were observed in some cases, but not present or not significant in others. Since the Toronto CCTV pilot initiative only targeted (and data were provided for) violent offences, the author could not investigate whether the effects on other types of offences, such as property crime or disorder offences, were more substantial. The limitations related to experimental setup were similar to many other video surveillance initiatives studied in the reports discussed in Section 2. The present work makes the argument for sorting out the design issues at the outset of any future project, before implementation,

to the benefit of both researchers trying to produce sound analyses, and law enforcement agencies, which ultimately want to implement interventions that are proven to produce results.

References

[1] Clarke, R. V. (1997), Situational Crime Prevention: Successful Case Studies, In Introduction, pp. 1–43, Guilderland, NY: Harrow and Heston.

[2] CCTV Evaluation: Project Charter and Scope Statement Version 2: April 2008, Prepared by Mark Barkley, Toronto Police Services.

[3] Fussey, P. (2007), An Uninterrupted Transmission? Processes of CCTV Implementation and the Impact of Human Agency, Surveillance & Society, *Special Issue on 'Surveillance and Criminal Justice'*, 4(3), 229–256. Available online at `www.surveillance-and-society.org`.

[4] Davenport, J. (2007, September 7), Tens of thousands of CCTV cameras, yet 80 percent of crime unsolved, *Evening Standard*.

[5] Cameron, A., Kolodinski, E., May, H., and Williams, N. (2008), Measuring the Effects of Video Surveillance on Crime in Los Angeles, (Technical Report CRB-08-007) California Research Bureau. Available online at `http://www.library.ca.gov/crb/08/08-007.pdf`.

[6] Welsh, B. C. and Farrington, D. P. (2002), Crime prevention effects of closed circuit television: a systematic review, (Technical Report Home Office Research Study 252) Home Office, London UK. Available online at `http://www.homeoffice.gov.uk/rds/pdfs2/hors252.pdf`.

[7] Farrington, D. P. and Petrosino, A. (2000), Systematic reviews of criminological interventions: The Campbell Collaboration Crime and Justice Group, *International Annals of Criminology*, 38, 49–66.

[8] Sherman, L. W., Farrington, D. P., Welsh, B. C., and (Eds.), D. L. M. (2002), Evidence-based crime prevention, Routledge, London.

[9] Gill, M. and Spriggs, A. (2005), Assessing the impact of CCTV, (Technical Report Home Office Research Study 292) Home Office, London UK. Available online at `http://www.homeoffice.gov.uk/rds/pdfs05/hors292.pdf`.

[10] Welsh, B. C. and Farrington, D. P. (2004), Evidence-based Crime Prevention: the Effectiveness of CCTV, *Crime Prevention and Community Safety: An International Journal*, 6(2), 21–33.

[11] Ratcliffe, J. and Taniguchi, T., CCTV Camera Evaluation, Technical Report.

[12] King, J., Mulligan, D. K., and Raphael, S., CITRIS Report: The San Francisco Community Safety Camera Program, Technical Report.

[13] The Universal Transverse Mercator Grid, by Natural Resources Canada (online), National Academy of Science, `http:maps.nrcan.gc.ca/topo101/utm_ref_e.php` (Access Date: December 2008).

[14] Crow, E. L., Davis, F. A., and Maxfield, M. W. (1960), Statistics Manual, Dover Publications Inc., New York.

[15] Gill, M., Spriggs, A., Argomaniz, J., Bryan, J., Waples, S., Allen, J., Kara, D., Kilworth, J., Little, R., Smith, P., Swain, D., and Jessiman, P. (2005), Technical Annex: methods used in assessing the impact of CCTV, (Technical Report Home Office Online Report 17/05) Home Office, London UK. Available online at
http://www.homeoffice.gov.uk/rds/pdfs05/rdsolr1705.pdf.

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Annex A: CCTV Camera Installations

This annex describes the installation of CCTV cameras in a number of areas in Toronto by the Toronto Police Services (TPS) over the period May 2007 to October 2008. The description is based upon details found in the CCTV Evaluation Project Charter [2] and supplemented by additional information provided by TPS in e-mail exchanges. As a component of their comprehensive crime management strategy, based on existing research into the use of Closed Circuit Television (CCTV) technology and under strict privacy guidelines set by City of Toronto Corporate Access and Privacy office, the Toronto Police Services (TPS) identified specific areas for deployment of CCTV camera systems as part of a pilot project. The areas targeted were identified as having elevated levels of crime comparative to the surrounding neighbourhoods and not responding well to other ongoing strategies. On April 30, 2007, the following cameras were deployed in North York (31 Division), Scarborough (42 Division), and the Entertainment District (52 Division) as part of the pilot project:

North York (31 Division):

- Jane Street/Finch Avenue West;
- Jane Street/Yorkwood Gate; and
- Jane Street/Firgrove Crescent.

Scarborough (42 Division):

- Morcambe Gate/Victoria Park Avenue; and
- Morcambe Gate/Chester Le Boulevard.

Scarborough (42 Division):

- Neilson Avenue/Sewells Road; and
- Brenyon Way, west of Sewells Road.

Entertainment District (52 Division):

- Pearl Street, east of Duncan Street;
- Duncan Street/Adelaide Street West;
- Duncan Street/Richmond Street West;
- Richmond Street West, east of Duncan Street;
- Richmond Street West /Widmer Street;
- Richmond Street West / Peter Street;
- Adelaide Street West/Peter Street; and
- Richmond Street West /John Street.

On October 31, 2007, the six-month pilot cameras in 31 and 42 Divisions were removed and re-deployed to 51 Division:

51 Division:

- Dundas Street/George Street;
- Gerrard Street/George Street;
- Pembroke Street/Dundas Street;
- Dundas Street/Sherbourne Street East;
- Dundas Street/Sherbourne Street West;
- Sherbourne Street/Shutter Street; and
- Queen Street/Sherbourne Street.

The 51 Division and Entertainment District (52 Division) cameras remained in place until April 30, 2008. After that they were removed and re-deployed to the 14 Division until Oct. 31, 2008.

14 Division:

- Queen Street/Bathurst Street, South East corner;
- Queen Street/Bathurst Street, North West corner;
- Bathurst Street/Queen Laneway East;
- Bathurst Street/Queen Laneway West;
- Queen Street/Ryerson Ave; and
- Queen Street/Markham Street.

The cameras were programmed to perform a 360 degree tour. There were no degree by degree distance markers to establish what was within view of the camera throughout its tour. As the camera made its tour, it zoomed in and out as designed for areas of particular importance. It was also focused down to the sidewalk at any point where a larger view could create privacy concerns for residences. Each camera was individually programmed with these factors in mind. The cameras were positioned to cover areas within 100 - 200 metres from their location, with overlapping coverage points in order to ensure the best coverage possible of the target area.

Annex B: Crime Data

This annex describes the data provided for analysis by the Toronto Police Service.

1. The call-for-service (CFS) ACCESS database includes all records of demands for policing services involving events of a violent nature, and each crime location is geo-coded. Violent CFS includes the following event types:

- Assault
- Assault Just Occurred
- Assist P.C. (Police Constable)
- Assault In Progress
- Indecent Exposure Just Occurred
- Fight
- Holdup
- Holdup Alarm
- Homicide
- Indecent Exposure
- Person with a Gun
- Person with a Knife
- Robbery
- Sexual Assault
- Shooting
- Sound of Gunshot
- Stabbing
- Unknown Trouble
- Wounding

The TPS CFS data is the most consistent, geo-coded data available to TPS for an extended period of time, 1 Jan 1995 to 26 Aug 2008. The map location of each incident was given in an 'easting' and a 'northing', i.e. in units of metres from the zero point for the grid zone for Toronto. See Ref. [2] for details of this system. For each descriptive location, such as '2739 VICTORIA PARK AVE', the grid locations were exactly the same throughout the database; this supports the inference that the grid references were consistently copied from some central standard for each descriptive location, instead of being measured for each incident. A sample of the database table is provided in Figure B.1 below.

AD_TS	Year	Month	Time	EVENT_TYPE	ZONE	MAPINFO_ADDRESS	EASTING	NORTHING	DISPOSITION	DISPOSITION_CODE
01/01/1995 12:06:27 AM	1995	01	00:06:27	Unknown Trble	4204	2739 VICTORIA PARK	634841.17	4848376.71	Report Taken	REP
01/01/1995 12:12:18 AM	1995	01	00:12:18	Snd Of Gunsho	5513	14 RAINSFORD RD	636444.46	4836310.83	Gone on Arriva	GOA
01/01/1995 12:16:09 AM	1995	01	00:16:09	Assault	5111	30 ST LAWRENCE ST	632543.28	4834696.26		ADV
01/01/1995 12:23:06 AM	1995	01	00:23:06	Unknown Trble	5102	260 WELLESLEY ST E	631272.33	4836050.26		ADVEVNT
01/01/1995 12:24:10 AM	1995	01	00:24:10	Assault	4107	2155 LAWRENCE AVE	638048.35	4845015.84		ADV
01/01/1995 12:28:28 AM	1995	01	00:28:28	Assault	1414	AUGUSTA AVE && QU	629049.09	4833807.57		ADV
01/01/1995 12:30:05 AM	1995	01	00:30:05	Person W A G	2310	DIXON RD && ROYAL	618092.68	4839355.41	Report Taken	REP
01/01/1995 12:34:29 AM	1995	01	00:34:29	Fight	2101	171 DELTA ST	618079.29	4828864.53	Gone on Arriva	GOA
01/01/1995 12:35:07 AM	1995	01	00:35:07	Assault I/Prog	4115	29 PARKCREST DR	643467.99	4843807.75	No Action Req	NA
01/01/1995 12:39:53 AM	1995	01	00:39:53	Fight	5212	JOHN ST && QUEEN	629733.84	4834024.21		ADV
01/01/1995 12:41:04 AM	1995	01	00:41:04	Assault J/Occ	3112	8 JOHN ST	619430.56	4839528.34	Gone on Arriva	GOA
01/01/1995 12:46:36 AM	1995	01	00:46:36	Unknown Trble	2106	1 BIRCHLEA AVE	618842.92	4827480.86	Report Taken	REP
01/01/1995 12:48:50 AM	1995	01	00:48:50	Fight	5102	200 WELLESLEY ST E	631111.75	4835999.3	No Action Req	NA
01/01/1995 12:50:03 AM	1995	01	00:50:03	Fight	2207	1116-A THE QUEENS	619494.03	4830824.02	Gone on Arriva	GOA
01/01/1995 12:51:19 AM	1995	01	00:51:19	Fight	4105	188 SEDGEMOUNT D	642367.32	4847413.67	Gone on Arriva	GOA
01/01/1995 12:51:47 AM	1995	01	00:51:47	Snd Of Gunsho	2204	5005 DUNDAS ST W	618497.26	4833451.57		ADV
01/01/1995 12:52:48 AM	1995	01	00:52:48	Fight	2301	30 CARRIER DR	612195.51	4843601.49		ADV
01/01/1995 12:57:17 AM	1995	01	00:57:17	Assault	5206	ST JOSEPH ST && YO	630189.65	4835829.23	Gone on Arriva	GOA
01/01/1995 12:59:01 AM	1995	01	00:59:01	Stabbing	4115	45 PARKCREST DR	643334.42	4843856.05		ARR
01/01/1995 12:59:07 AM	1995	01	00:59:07	Assault		BATHURST && QUEE	0	0		ADV
01/01/1995 1:00:44 AM	1995	01	01:00:44	Assault	5215	99 BLUE JAYS WAY	629683.85	4833507.47		ADV
01/01/1995 1:00:50 AM	1995	01	01:00:50	Assault I/Prog	5516	29 BALSAM AVE	637909.32	4836492.78		ADV
01/01/1995 1:01:07 AM	1995	01	01:01:07	Fight	1413	732 QUEEN ST W	628247.32	4833579.55		ADV
01/01/1995 1:04:40 AM	1995	01	01:04:40	Fight	4114	5 DELANO PL	641217.8	4840293.8		ADV
01/01/1995 1:12:38 AM	1995	01	01:12:38	Assault	5509	39 DON MOUNT CRT	632846.03	4835328.5		ARR
01/01/1995 1:12:49 AM	1995	01	01:12:49	Fight	4103	ELLESMERE RD && M	642287.42	4848339.55	No Action Req	NA
01/01/1995 1:13:38 AM	1995	01	01:13:38	Shooting	3311	101 RAILSIDE RD	634938.41	4843704.79	No Action Req	NA
01/01/1995 1:16:03 AM	1995	01	01:16:03	Unknown Trble	5509	BROADVIEW AVE &&	632913.9	4835483.22	Gone on Arriva	GOA
01/01/1995 1:16:27 AM	1995	01	01:16:27	Fight	5215	14 DUNCAN ST	629946.3	4833777.29		ARR
01/01/1995 1:17:24 AM	1995	01	01:17:24	Fight	4114	2365 KINGSTON RD	640967.21	4840700.47		ADV
01/01/1995 1:22:59 AM	1995	01	01:22:59	Fight	4211	4140 LAWRENCE AVE	645527.08	4847453.13	Gone on Arriva	GOA
01/01/1995 1:25:28 AM	1995	01	01:25:28	Fight	1309	26 BEAVER AVE	625572.24	4836387.82		ADV
01/01/1995 1:26:24 AM	1995	01	01:26:24	Unknown Trble	3309	LYNVALLEY CRES &&	635908.89	4845042.71	No Action Req	NA

Figure B.1: *Sample page from the TPS CFS database*

2. The EXCEL spreadsheet with locations of surveillance cameras includes the map location of each camera, given in coordinates from GPS measurements, in degrees and minutes of angle, with the minutes specified to three decimal places.

The angular locations were converted to grid references using two different programs from the internet; these yielded consistent results for their conversions. The descriptive locations of camera locations and of incident locations were then compared. The EXCEL spreadsheet in Figure B.2 below shows the GPS coordinates received from TPS, the grid reference conversions of those GPS coordinates, the grid references for those same locations found in the incident database and the discrepancy between the converted and CFS database eastings and northings.

PS CCTV Camera Location	Date Active	Date De-active	GPS Location	Converted Easting	Converted Northing	From the database	Easting	Northing	Discrepancy Easting	Discrepancy Northing
52 Division - Entertainment District										
01.Duncan & Pearl	5/1/2007		43.64790763911025, -79.38723921775818	**630064**	**4834031**	DUNCAN ST && PEARL ST	629959	4833770	105	261
02.Adelaide & Duncan	5/1/2007		43.648163828519095, -79.38851594924927	**629961**	**4834058**	ADELAID && DUNCAN	629939	4833839	22	219
03.Richmond (West of Duncan)	5/1/2007		43.64944087760613, -79.38963174819946	**629868**	**4834198**					
04.Richmond (East of Duncan)	5/1/2007		43.649712586674774, -79.38833355903625	**629972**	**4834230**					
05.Richmond & John	2/6/2007		43.64908377238948, -79.39063489437103	**629788**	**4834156**	JOHN ST && RICHMOND ST W	629763	4833940	25	216
06.Richmond & Widmer	5/1/2007		43.64881594208366, -79.39199209213257	**629679**	**4834125**	RICHMOND ST W && WIDMER ST	629659	4833907	20	218
07.Richmond & Peter	5/1/2007		43.64838896376419, -79.39310252666473	**629590**	**4834075**	PETER ST && RICHMOND ST W	629564	4833854	26	221
08.Adelaide & Peter	5/1/2007		43.64720505345751, -79.3928986787796	**629609**	**4833944**	ADELAIDE ST W && PETER ST	629601	4833735	8	209
09.Richmond and Duncan	5/1/2007		43.649380713289, -79.38904166221618	**629916**	**4834192**	DUNCAN ST && RICHMOND ST W	629893	4833978	23	214
10.John & Nelson	2/6/2007		43.648402549484764, -79.3905919790268	**629793**	**4834081**	JOHN ST && NELSON ST	629786	4833869	7	212
11.John and Adelaide	2/6/2007		43.64774460891751, -79.3903398513794	**629814**	**4834008**	JOHN N && O ADELAIDE	630625	4834504	811	496
12.Peter North of Richmond - Cooper La	5/1/2008		43.64879265243541, -79.39362287521362	**629547**	**4834119**					
14 Division										
23.Queen & Bathurst South East Corner	5/1/2008	10/31/2008	43.64716526590258, -79.40381795167923	**628729**	**4833923**	BATHURST ST && QUEEN ST W	628701	4833703	28	220
24.Queen & Bathurst North West Corner	5/1/2008	10/31/2008	43.64730500744266, -79.4041197001934	**628704**	**4833938**	BATHURST ST && QUEEN ST W	628701	4833703	3	235
25.Queen & Willis	5/1/2008	10/31/2008	43.64773878640247, -79.40410226583481	**628705**	**4833986**					
26.Bathurst & Queen Laneway - West	5/1/2008	10/31/2008	43.64676738890375, -79.40397083759308	**628717**	**4833878**					
27.Bathurst & Queen Laneway - East	5/1/2008	10/31/2008	43.64676835933866, -79.40396547317505	**628718**	**4833878**					
28.Queen & Ryerson	5/1/2008	10/31/2008	43.64746900925213, -79.40232396125793	**628849**	**4833959**	QUEEN ST W && RYERSON AVE	628863	4833754	14	205
29.Queen & Markham	5/14/2008	10/31/2008	43.6469081018021, -79.4050906598568	**628627**	**4833892**					
31 Division										
31 Div - Jane and Finch	5/1/2007	10/31/2007	43.75717013288185, -79.51733708381653	**619355**	**4845971**	FINCH && JANE	619314	4845759	41	212
31 Div - Jane and Yewtree/Firgrove Cres	5/1/2007	10/31/2007	43.75490732486154, -79.51725125312805	**619366**	**4845719**	JANE ST && YEWTREE BLVD	619369	4845492	3	227
31 Div - Jane and Firgrove/Yorkwoods Ga	5/1/2007	10/31/2007	43.75132307884019, -79.51631247997284	**619449**	**4845323**	JANE ST && YORKWOODS GT	619458	4845036	9	287
42 Division										
42 Div - Victoria Park and Morecambe Ga	5/1/2007	10/31/2007	43.79806221884824, -79.3333911895752	**634072**	**4850794**	MORECAMBE GT && VICTORIA PA	634041	4850570	31	224
42 Div - Chester Le Blvd and Morecambe	5/1/2007	10/31/2007	43.798424244997285, -79.33181405067444	**634198**	**4850836**	CHESTER LE BLVD && MORECAM	634192	4850625	6	211
42 Div - Neilson Rd and Sewells Rd	5/1/2007	10/31/2007	43.80662054944689, -79.21843975782394	**643299**	**4851937**	NEILSON RD && SEWELL'S RD	643270	4851705	29	232
42 Div - Brenyon Way and Sewells Rd	5/1/2007	10/31/2007	43.807630974871216, -79.21626448631286	**643471**	**4852053**	BRENYON WAY && SEWELL'S RD	643511	4851852	40	201
51 Division										
23.Dundas & George	11/1/2007	5/31/2008	43.6573859195024, -79.37356665730476	**631146**	**4835105**	DUNDAS ST E && GEORGE ST	631143	4834875	3	230
24.Gerrard & George	11/1/2007	5/31/2008	43.66071868162696, -79.37483131885528	**631037**	**4835473**	GEORGE ST && GERRARD ST E	631024	4835244	13	229
25.Pembroke & Dundas	11/1/2007	5/31/2008	43.658242655931644, -79.37248840928077	**631231**	**4835202**	DUNDAS ST E && PEMBROKE ST	631228	4834973	3	229
26.Dundas & Sherbourne EAST	11/1/2007	5/31/2008	43.65840953861541, -79.37095552682876	**631355**	**4835223**	DUNDAS ST E && SHERBOURNE	631337	4834988	18	235
27.Dundas & Sherbourne WEST	11/1/2007	5/31/2008	43.65842409231586, -79.37114596366882	**631339**	**4835224**	DUNDAS ST E && SHERBOURNE	631337	4834988	2	236
28.Sherbourne and Shuter	11/1/2007	5/31/2008	43.65629727415106, -79.37007710337639	**631430**	**4834990**	SHERBOURNE ST && SHUTER ST	631415	4834753	15	237
29.Queen and Sherbourne	11/1/2007	5/31/2008	43.65442460272831, -79.36933413147926	**631494**	**4834783**	QUEEN ST E && SHERBOURNE	631472	4834572	22	211

Figure B.2: *TPS CCTV camera locations*

Annex C: Selection of Target, Buffer and Control Areas

This annex discusses the process of boundary selection for target and buffer areas, and the selection of control areas.

The first step in the analysis was to define 'target areas' and select all the incidents within the target area boundaries before, during and after the implementation of the CCTV camera systems. 'Target areas' were given by the overlapping coverage of a 'cluster' of cameras installed at the same general location. Initially, the author had looked at each camera individually and selected 100-200 metres (depending on the physical features) around it, because the cameras were on 360 degree tour and 'reached' as far as 100-200 metres from where they were mounted. A closer look at all camera locations on the map, and e-mail exchanges with TPS, led to the realization that a number of cameras were designed to survey an extended area (e.g., Peter St - Adelaide St - Simcoe St - Richmond St in Div. 52). Thus, the 'target area' was defined as an area that extended 50-100 metres beyond the polygon that contained all the cameras at the same general location, again, depending on such factors as major roads, natural boundaries, tall or low buildings and other similar features. There was a slight complication introduced by the fact that streets do not run perfectly north-south or east-west, which was 'fixed' by some vector calculations (rotating the reference system) to define appropriate boundaries. For boundary definition, the camera location coordinates used were those found in the database for incidents reported at the camera locations (see Table B2), because the northing coordinates obtained from the GPS conversions were systematically about 200 metres smaller (between 205 and 261 metres) compared to the database northing coordinates for the same locations. Some of the camera intersections were not found in the database, but because the cluster of cameras was considered, rather than individual locations, it did not matter, as long as those cameras were 'boundary cameras'. 'Buffer areas' were areas directly adjacent to target areas, obtained by extending a further 200 metres beyond the boundaries of each target area. Boundaries for both target and buffer areas were chosen with such factors as major roads, natural boundaries, tall or low buildings, zoning and other physical features in mind. For two target area (Division 52 and 51), the analysts attempted to select control areas. They were selected in the same general location as the target areas, between 500-1000 metres away, and they were mainly selected based on similar physical characteristics. This is far from ideal, since the selection does not include crime analysis; moreover, in regards to the entertainment district (Division 52), it has been pointed out by TPS that: 'There is no comparative area anywhere else in the city. It is an anomaly that the Toronto Police Service struggles with every weekend. The mass influx of people creates a population greater than that of many cities in Canada. A control area for the Entertainment District is simply impossible in the City of Toronto'. For these reasons, while comparisons with the 'control areas' selected by analysts were included, the comparison with citywide data as a control measure (also included) is considered more useful.

List of symbols/abbreviations/acronyms/initialisms

CCTV	Closed-Circuit Television
CFS	Call-for-Service
CITRIS	Centre for Information Technology Research in the Interest of Society
CORA	Centre for Operational Research and Analysis
CPRC	Canadian Police Research Centre
CSS	Centre for Security Science
DND	Department of National Defence
DRDC	Defence Research and Development Canada
HLM	Hierarchical Linear Modeling
OR	Operational Research
PIR	Program Impact Review
RES	relative effect size
S&T	Science and Technology
TPS	Toronto Police Services
UK	United Kingdom
US	United States
WDQ	Weighted Displacement Quotient

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This paper reports on the statistical analysis conducted on crime data provided by the Toronto Police Services in order to assess the impact on crime after implementing the Closed Circuit Television (CCTV) pilot initiative. Over the period May 2007 to October 2008, the Toronto Police Services installed CCTV cameras in a number of selected areas for periods of time between six months and one year. This report documents the results of the application of standard statistical techniques to determine the effectiveness of surveillance cameras in reducing crime, and compares them with findings from previous research studies. The analysis is based on data derived from the Toronto Police Services call-for-service ACCESS database, a comprehensive, geo-coded database that includes all records of demands for policing services involving events of a violent nature from 1995. This report addresses questions related to crime reduction in the targeted areas and diffusion of benefits beyond the targeted areas, and makes some general considerations about displacement and dispersion.

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CCTV
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