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John J. McNesby, President **Robert B. Ballentine, Jr., Recording Secretary**

#3048

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IRRC
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Independent Regulatory Review Commission
David Sumner, Executive Director
333 Market Street, 14th Floor
Harrisburg, PA 17101

Re: Regulation #126-8 (IRRC #3048)
Taxicab Safety Cameras

Dear Mr. Sumner:

I write today to extend my full support and that of the Philadelphia Chapter of the Fraternal Order of Police Lodge#5 to Philadelphia Parking Authority Regulation 126-8 (IRRC #3048) Taxicab Safety Cameras.

Use of safety cameras by law enforcement agencies whether authorized and installed by governmental entities or by private institutions and citizens has become more and more common and proven to be quite valuable in investigations of crimes, accidents and a number of other situations. Clear posting of signs indicating the presence of cameras have proven to be an effective deterrent to would be criminals or other would be violators of reasonable rules regulations and other standards.

Not only will the PPA's proposed camera system insure a much higher level of safety for taxicab drivers but will significantly enhance the safety of first responders to emergency calls for assistance from the Philadelphia Police Department who would have real time information regarding the events to which they are responding. For instance, in the case of a shooting or robbery by gun, the police would have an idea of who is armed, the descriptions of assailants and other significant information which would not otherwise be afforded without the system proposed.

In closing, I've attached a recently published study by the National Institute of Occupational Safety and Health (NIOSH) which concludes that cameras installed in taxicabs save taxicab drivers' lives. The researchers looked at records of murders of taxicab drivers in many cities across the United States (including Philadelphia) and compared rates of murders in cities mandating safety cameras with cities that require only safety shields and those requiring neither safety measure. Those cities requiring safety cameras had significantly lower taxi driver murder rates than cities requiring safety shields as well as cities with neither requirement.

In view of the above information, I strongly but respectfully urge your approval of Regulation #126-8 (IRRC #3048).

Sincerely,

John J. McNesby, President
Philadelphia Lodge 5
Fraternal Order of Police

Crime Science
a SpringerOpen Journal

SHORT CONTRIBUTION Open Access

Cities with camera-equipped taxicabs experience reduced taxicab driver homicide rates: United States, 1996–2010

Cammie Chaumont Menéndez[1*], Harlan Amandus[1], Parisa Damadi[2], Nan Wu[3], Srinivas Konda[1] and Scott Hendricks[1]

Abstract

Background: Driving a taxicab remains one of the most dangerous occupations in the United States, with leading homicide rates. Although safety equipment designed to reduce robberies exists, it is not clear what effect it has on reducing taxicab driver homicides.

Findings: Taxicab driver homicide crime reports for 1996 through 2010 were collected from 20 of the largest cities (>200,000) in the United States: 7 cities with cameras installed in cabs, 6 cities with partitions installed, and 7 cities with neither cameras nor partitions. Poisson regression modeling using generalized estimating equations provided city taxicab driver homicide rates while accounting for serial correlation and clustering of data within cities. Two separate models were constructed to compare (1) cities with cameras installed in taxicabs versus cities with neither cameras nor partitions and (2) cities with partitions installed in taxicabs versus cities with neither cameras nor partitions. Cities with cameras installed in cabs experienced a significant reduction in homicides after cameras were installed (adjRR = 0.11, CL 0.06-0.24) and compared to cities with neither cameras nor partitions (adjRR = 0.32, CL 0.15-0.67). Cities with partitions installed in taxicabs experienced a reduction in homicides (adjRR = 0.78, CL 0.41-1.47) compared to cities with neither cameras nor partitions, but it was not statistically significant.

Conclusions: The findings suggest cameras installed in taxicabs are highly effective in reducing homicides among taxicab drivers. Although not statistically significant, the findings suggest partitions installed in taxicabs may be effective.

Keywords: Taxicab driver homicides; Workplace violence; Public health; Robberies; Safety equipment; Intervention; Ecological study; Generalized estimating equations; Retrospective time series

Introduction

Taxicab drivers work in one of the most violent occupations in the United States (Richardson and Windau 2003). In 2010, the homicide rate for taxicab drivers was 7.4 per 100,000 workers, higher than the rate for police officers, 6.7 per 100,000 workers; the overall work-related homicide rate was 0.37 per 100,000 workers Bureau of Labor Statistics, (2010). Risk factors for homicides among taxicab drivers include working alone, working late hours, interacting with the public, and working with cash (NIOSH 1995; OSHA 2000). The taxicab industry and transportation regulators have relied heavily on the use of partitions or security cameras installed in taxicabs as effective deterrents against robbery. In the absence of city ordinances mandating the use of security cameras or partitions, some large companies require specific safety equipment as a company policy. Two reports have provided important, yet limited, insight into the potential effectiveness of security cameras and partitions in reducing taxicab driver robberies and assaults (Stone and Stevens 1999; Taxicab Advisory Group Committee 2004). Together, the reports provide summaries of decreased taxicab driver homicides and assaults across several cities equipping taxicabs with cameras ten years ago

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and findings on reduced assaults among taxicab drivers driving taxicabs equipped with partitions in one city 15 years ago. There remains scant scientific evidence supporting the effectiveness of either deterrent in reducing workplace violence outcomes among taxicab drivers.

The theoretical basis behind the installation of bullet-resistant partitions or security cameras is that decreasing the opportunity for the desired reward and/or increasing the probability of a perpetrator being caught would decrease robberies and assaults among taxicab drivers (Jeffrey 1971). Moreover, the tenets described in Crime Prevention Through Environmental Design (CPTED) and widely utilized for stationary business environments can be adapted for a mobile business environment (taxicabs) using the framework provided by Situational Crime Prevention which focuses on the opportunities and challenges for crime reduction in specific settings (Jeffrey 1971; Clarke 1992). In addition to the dearth of scientific evidence supporting safety equipment in taxicabs in reducing crime among taxicab drivers, the theoretical basis describing the effect of safety equipment as a crime deterrent for this population is often not described.

The primary objective of this study is to evaluate the effectiveness of security cameras in reducing taxicab driver homicides. The secondary objective is to evaluate the effectiveness of partitions in reducing taxicab driver homicides.

Methods

Study design

An ecological study design evaluated the impact of the two widely-used types of safety equipment designed to reduce robberies and homicides among taxicab drivers. A retrospective longitudinal time series analysis spanning 1996 through 2010 evaluated annual citywide taxicab driver homicide rates from 20 major cities representing the largest metropolitan areas. Using a population-based ranking of the metropolitan areas (Census 2000), industry regulators helped identify all camera and partition cities followed by eligible control cities.

Data elements

The outcome, taxicab driver homicide rates, was aggregated at the city level and constructed from crime reports obtained from police departments (numerator) and the number of licensed taxicabs from municipal transportation regulators (denominator). A standardized search strategy tailored for municipal police crime departments was used to locate taxicab driver homicides using any one of the following criteria: (1) crime premise designated as 'vehicle', (2) name of licensed taxicab companies, (3) keywords 'cab', 'taxi' or 'driver' in the crime report or (4) news clippings reporting taxicab driver homicides. Each crime report provided by each municipal police department was reviewed for relevance by the first author. Information on installation year of camera or partition (or neither) was obtained directly from city transportation regulators. A city was designated annually as a "camera city" or "partition city" if >70% of the cabs had cameras or partitions during the study period; a cut point of 70% was decided *a priori* as it reflected the observed distribution across cities during early stages of study planning. Camera cities and partition cities were mutually exclusive as ordinances/company policies historically required either cameras or partitions (personal communication with industry regulators). Two covariates were included in the statistical analysis: the concurrent decline in homicide rates in the United States since 1990 (Hendricks et al. 2007) and the city-specific annual (background) homicide rates as provided by the Uniform Crime Reports (FBI 2010). These covariates were chosen as homicide rates among workers (in addition to taxicab drivers) were declining for reasons that were not necessarily associated with safety equipment use (Hendricks 2007) and homicide rates varied annually both within and across cities.

Statistical analysis

Generalized estimating equations accounted for serial correlation and clustering of data within cities. Annual taxicab driver homicide rates were modeled on installation status (camera or partition) compared to control cities in two separate models adjusting for covariates. A separate model restricted to camera cities only compared post-installation versus pre-installation homicide rates. The Wald test statistic determined the significance of installation status. The natural logarithm of the number of licensed taxicabs by city per year was used as an offset variable. The taxicab driver homicide counts were assumed to follow a Poisson distribution; the offset variable provided the denominator used to calculate the homicide rates. The data were tested for dispersion and found to be slightly under-dispersed (scale = 0.92). Therefore, all confidence intervals were considered conservative in their range.

Findings

Taxicab driver homicides

Police crime report data were analyzed for 7 cities where cameras were installed in taxicabs, 6 cities where partitions were installed in taxicabs and 7 cities where neither partitions nor cameras were installed in taxicabs. From 1996 through 2010, 95 taxicab driver homicides were investigated by law enforcement authorities (Table 1). In camera cities there were 19 homicides pre-installation (occurring in 6 cities), and only seven homicides post-camera installation (occurring in 2 cities). The homicides occurring post-camera installation occurred in cities where

Table 1 Number of taxicab driver homicides, average number of licensed cabs and average taxicab driver homicide rate

	Number of Taxicab Driver Homicides															Average Number of Licensed Cabs	Average Taxicab Driver Homicide Rate[§]
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		
Cameras																	
City 1[¶]					1			1								382	0.35
City 2[¶]		1	1	1				1	1							1422	0.33
City 3		1	1			1			1						2	2092	0.19
City 4		1	1	1				1				1			1	1861	0.22
City 5[†]																669	0.00
City 6[¶]		1	1	1			1									1353	0.22
City 7[¶]		1					1		1							648	0.31
Partitions																	
City 8	3	2	1	1						1	2		N/A	N/A	N/A	1400	0.60
City 9		2														1685	0.09
City 10	2	5	1		2	2	2	2	1	1	1					6646	0.19
City 11				1					1	1						750	0.27
City 12				2	1	2	1	1	1		1					2169	0.28
City 13		2			1	1	1	3			1		1		1	1650	0.44
Control																	
City 14			1			1		1				1		1		1548	0.22
City 15				1					1						2	462	0.60
City 16			1				1		1							821	0.28
City 17[†]																250	0.00
City 18																332	0.00
City 19			2	1												915	0.23
City 20[†]	N/A	N/A	N/A													577	0.00

[§]per 1,000 cab drivers.
[¶]Cities with ordinance mandating taxicab cameras.
[†]These cities did not experience any taxicab driver homicides during the timespan studied.
N/A indicates crime reports not available for this time period.

one company had a policy requiring cameras rather than a citywide ordinance mandating camera installation in taxicabs. Six camera cities experienced a decrease in the taxicab driver homicide rate post-installation (the remaining camera city had no homicides during the entire study period).

Statistical models of homicide rates

Modeling annual citywide taxicab driver homicide rates among camera cities post-installation compared with pre-installation revealed a statistically significantly reduced homicide rate ($RR_{unadj} = 0.22$; 95% CL 0.10, 0.52) (Table 2, Model 1). This reduction is more pronounced ($RR_{adj} = 0.11$; 95% CL 0.06, 0.24) after controlling for pre-existing annual changes in city taxicab driver homicide rates ("year") and the background city homicide rate. A sub-analysis exploring changes in taxicab driver homicide rates among cities with only a company policy (rather than cities with an ordinance for which there were no homicides occurring post-installation) found a statistically significant reduction in rate ($RR_{unadj} = 0.53$; 95% CL 0.29, 0.99) that persisted ($RR_{adj} = 0.40$; 95% CL 0.13, 0.81) after covariate adjustment. Modeling annual citywide taxicab driver homicide rates on camera installation in camera cities compared with control cities post-installation versus pre-installation revealed a statistically significant reduction in homicide rate ($RR_{unadj} = 0.31$; 95% CL 0.14, 0.72) (Model 2) that persisted ($RR_{adj} = 0.32$; 95% CL 0.15, 0.67) after controlling for covariates. A sub-analysis exploring changes in taxicab driver homicide rates in cities where camera installation is not citywide but due to a company policy found a reduced rate compared to control cities in both unadjusted and adjusted models [($RR_{unadj} = 0.63$; 95% CL 0.46, 0.88); ($RR_{adj} = 0.58$; 95% CL 0.38, 0.87)]. Modeling annual citywide taxicab driver homicide rates on partition installation in partition cities compared with control cities revealed a slightly higher rate ($RR_{unadj} = 1.11$; 95% CL 0.59, 2.09) which, after controlling for declining homicide rates and background crime rates, presented a reduction in taxicab driver homicide rate that was not statistically significant ($RR_{adj} = 0.78$; 95% CL 0.41, 1.47).

Discussion

To our knowledge, this is the first study to conduct a large-scale evaluation of the effectiveness of a widely adopted type of taxicab safety equipment. Our findings suggest cities with camera-equipped taxicabs experience reduced rates of taxicab driver homicides post-installation and compared with cities that do not use cameras. Furthermore, those cities where camera-equipped taxicabs were mandated by ordinance experienced no taxicab driver homicides post-installation whereas the two cities that experienced taxicab driver homicides post-installation, although fewer, were in cities where the dominant (>70% of market) taxicab company implemented a policy of camera-equipped taxicabs. Findings suggest that cities with partition-equipped taxicabs may experience reduced taxicab driver homicide rates compared to nonpartition-equipped other cities.

The observance of a significant reduction in taxicab driver homicides in cities where taxicabs are equipped with cameras, and the more pronounced effect in cities where taxicabs are equipped with cameras as mandated by a city ordinance, was an encouraging one. Based on anecdotal evidence from transportation regulators in cities already mandating cameras by ordinance, transportation regulators are currently considering promulgating city ordinances for their cities that will mandate the use of security cameras in taxicabs. Our findings suggest cities where taxicabs are equipped with cameras could result in fewer taxicab driver homicides particularly in cities with an ordinance mandating taxicabs are equipped with cameras. Furthermore, these findings are consistent

Table 2 Statistical models describing intervention effects on city-wide taxicab driver homicide rates: United States, 1996—2010

	*Model 1**		*Model 2†*		*Model 3§*	
	Unadjusted RR (95% CL)	**Adjusted RR (95% CL)**	**Unadjusted RR (95% CL)**	**Adjusted RR (95% CL)**	**Unadjusted RR (95% CL)**	**Adjusted RR (95% CL)**
Variables						
Cameras installed	0.22 (0.10, 0.52)	0.11 (0.06, 0.24)	0.31 (0.14, 0.72)	0.32 (0.15, 0.67)	—	—
Partitions installed	—	—	—	—	1.11 (0.59, 2.09)	0.78 (0.41, 1.47)
Year¶	—	1.09 (1.00, 1.19)	—	0.98 (0.92, 1.04)	—	0.88 (0.83, 0.94)
City homicide rate**	—	1.10 (1.01, 1.20)	—	1.12 (1.03, 1.23)	—	1.12 (1.06, 1.19)

*Rate ratio of taxicab driver homicide rates post-installation versus pre-installation of cameras.
†Rate ratio of taxicab driver homicide rates in camera cities compared to control cities.
§Rate ratio of taxicab driver homicide rates in partition cities compared to control cities.
¶The rate ratio represents an associated change in taxicab driver homicide rate for every increase of 1 year.
**The rate ratio represents an associated increase in taxicab driver homicide rate for every 1 unit increase in city homicide rate.

with a previous analysis examining news clippings to identify homicides (Chaumont Menéndez et al. 2013). Specifically, results of the news clippings analysis were concordant with the current study with respect to an observed effect of cameras in possibly reducing citywide taxicab driver homicide rates, but inconclusive for the effect of partitions.

Nearly all of the cities studied had installed partitions in taxicabs by 1996, which limited the data available to examine the pre-post differences in homicide rates. However, 15 years' worth of homicide rates in partition cities compared to control cities, after adjusting for city homicide rates and temporal patterns in taxicab driver homicide rates, revealed no statistically significant difference.

The primary limitations to the study are due to the ecological study design: (1) we could not estimate individual risk of homicide for taxicab drivers across safety equipment types and (2) the lack of uniform data in the crime reports on homicide circumstances precluded more detailed analyses. Significant strengths of this study are the 15-year time span, systematic collection of data in 20 major US cities, pre-post design that includes use of comparison cities with neither camera-equipped nor partition-equipped taxicabs, and statistical analysis that accounts for serial correlation of data that adjusts for two crucial covariates. Additionally, in working with city regulators and counting only licensed drivers, we were able to assume the drivers were in taxicabs installed with required safety equipment. The study and its findings make a significant contribution to understanding the possible effect of taxicab safety equipment on taxicab driver homicides.

Taxicab driver personal safety in Seattle and King County, Final report and recommendations. The report of the Taxicab Advisory Group Committee on Driver Safety to the Director of the Department of Executive Administration for the city of Seattle. June 18, 2004.

Competing interests
None of the authors has any competing interests.

Authors' contributions
CCM and HA conceived and designed the study. CCM and PD acquired the data. CCM and SH analyzed and interpreted the data. CCM drafted the article and all other authors revised it critically. All authors provided approval of the version to be published.

Acknowledgments
The authors sincerely thank Dr. Corinne Peek-Asa, Dr. Carri Casteel and Dr. Kristin Cummings for early reviews of the manuscript. There are no conflicts of interest to report for any of the authors.
This work was funded by an intramural grant within the National Institute for Occupational Safety and Health at the Centers for Disease Control and Prevention.

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Received: 19 December 2013 **Accepted:** 9 April 2014
Published online: 09 May 2014

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doi:10.1186/s40163-014-0004-3
Cite this article as: Chaumont Menéndez *et al.*: **Cities with camera-equipped taxicabs experience reduced taxicab driver homicide rates: United States, 1996–2010.** *Crime Science* 2014 **3**:4.

AMERICAN JOURNAL OF
Preventive Medicine

VOLUME 45(1) www.ajpmonline.org JULY 2013

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A Journal of the
ACPM American College of Preventive Medicine & APTR Association for Prevention Teaching and Research
ELSEVIER

Effectiveness of Taxicab Security Equipment in Reducing Driver Homicide Rates

Cammie K.C. Menéndez, PhD, Harlan E. Amandus, PhD, Parisa Damadi, BS, Nan Wu, MS, Srinivas Konda, MPH, Scott A. Hendricks, MS

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Background: Taxicab drivers historically have had one of the highest work-related homicide rates of any occupation. In 2010 the taxicab driver homicide rate was 7.4 per 100,000 drivers, compared to the overall rate of 0.37 per 100,000 workers.

Purpose: Evaluate the effectiveness of taxicab security cameras and partitions on citywide taxicab driver homicide rates.

Methods: Taxicab driver homicide rates were compared in 26 major cities in the U.S. licensing taxicabs with security cameras (n=8); bullet-resistant partitions (n=7); and cities where taxicabs were not equipped with either security cameras or partitions (n=11). News clippings of taxicab driver homicides and the number of licensed taxicabs by city were used to construct taxicab driver homicide rates spanning 15 years (1996–2010). Generalized estimating equations were constructed to model the Poisson-distributed homicide rates on city-specific safety equipment installation status, controlling for city homicide rate and the concurrent decline of homicide rates over time. Data were analyzed in 2012.

Results: Cities with cameras experienced a threefold reduction in taxicab driver homicides compared with control cities (RR=0.27; 95% CI=0.12, 0.61; p=0.002). There was no difference in homicide rates for cities with partitions compared with control cities (RR=1.15; 95% CI=0.80, 1.64; p=0.575).

Conclusions: Municipal ordinances and company policies mandating security cameras appear to be highly effective in reducing taxicab driver deaths due to workplace violence.

(Am J Prev Med 2013;45(1):1–8) Published by Elsevier Inc. on behalf of American Journal of Preventive Medicine

Introduction

Workplace violence remains a leading source of occupational fatalities and injuries[1] with taxicab drivers historically experiencing one of the highest homicide rates of any occupation.[2] Since the mid-1990s, workplace homicides have declined in the general working population.[3] However, homicide rates among taxicab drivers continue to rank among the highest of any occupation.[2] Despite a tremendous need for effective safety advances in this occupation, there is a paucity of research focused on evaluating the effectiveness of safety equipment in taxicabs.

Two safety publications[4,5] that summarized risk factors for work-related homicides have guided the taxicab industry and its regulators in the use of safety equipment to prevent workplace violence. In the past 20 years, the use of safety equipment in taxicabs occurred through ordinances promulgated by municipal transportation regulators or policies issued by large companies. Bullet-resistant partitions were the dominant safety equipment in use in the early 1990s. Currently, cameras are in greater use and have become the security equipment of choice for industry regulators and taxicab fleet operators.

Although a comprehensive evaluation of interventions designed to reduce robberies in the retail industry has been undertaken,[6] there have been to date only two reports examining the effectiveness of taxicab safety equipment in reducing workplace violence outcomes.[7,8]

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0749-3797/$36.00

http://dx.doi.org/10.1016/j.amepre.2013.02.017

(In 1999, transportation researchers reported a 56% decrease in assaults after 12 months of mandatory partition installation in a pilot group of taxicab drivers.[7]) Further, taxicab drivers with partitions experienced fivefold fewer assaults than taxicab drivers without partitions.[7]

Subsequently, a comprehensive report in 2004 presented case studies for two cities using cameras in taxicabs and claimed the use of cameras resulted in decreases in both robberies and assaults.[8] Although both reports presented data supporting the use of partitions and security cameras as effective in reducing assaults, the findings were based on a short time period and a single city's experience. Evaluating workplace violence incidents among taxicab drivers in multiple cities over a shared, longer time span would contribute to this limited body of research and provide stronger conclusions and generalizability of the findings.

The study objective was to evaluate the effectiveness of safety equipment in reducing taxicab driver homicide rates. Specifically, it was hypothesized that installing cameras in taxicabs resulted in a reduction in citywide taxicab driver homicide rates (1) post-installation and (2) in comparison to cities without cameras. Second, it was hypothesized that cities with partitions installed in taxicabs experienced reduced taxicab driver homicide rates compared with cities without partitions.

Methods

A city was selected for inclusion in the analysis based on the following criteria: (1) being the most populated city within a metropolitan statistical area (MSA) with a population >250,000 and (2) maintaining taxicab licenses or playing a formal role in taxicab regulation. A list of the most-populated metropolitan statistical areas in the U.S. was generated from the U.S. Census Bureau.[9] One major city within each MSA was identified for every MSA on the list. If there was only one city for an MSA, data for that city were collected. Cities meeting Criteria 1 and 2 that did not have a substantial taxicab presence as determined by the city regulator were excluded in the evaluation.

Homicide data were retrieved by conducting a Lexis-Nexis Boolean search designed to locate electronically published newspaper reports during 1996 through 2010 describing taxicab driver homicides, using the following algorithm: 'cabdriver or cab driver or cabbie or (taxi w/2 driver) or livery driver or (limo! w/2 driver)' w/15 dead or death or die or died or dies or slay! or slain or kill! or murder! or fatal! or mortal!) and 'and not compiled by or obit! or subject (jury trial or mistrial or testimony or sentencing or verdict or decisions rulings or settlements or decisions)'. The *and not* section was designed to exclude articles on ongoing litigation. Each article was reviewed for duplication by trained data extractors. Data extracted on each taxicab driver who was ascertained to be a homicide victim were recorded for subsequent aggregation. To check for completeness, the name and date of each taxicab driver homicide was compared with a comprehensive list (www.taxi-library.org) memorializing the drivers created and maintained by a taxicab driver[10] in addition to verifying each city's homicides with the city transportation regulator.

Taxicab driver homicide rates consisted of the number of taxicab driver homicides (news clippings) divided by the number of licensed taxicabs (provided by municipal transportation regulators). Licensed taxicabs included medallions, liveries, and paratransit but excluded shuttles. Unauthorized taxicabs or taxicabs with expired vehicle licenses were excluded to the extent possible. Transportation regulators also described the type of security equipment installed in taxicabs (cameras, partitions, or neither) and provided the year most city taxicabs, if any, were installed with the security equipment. City homicide rates per 100,000 population were obtained from the annual Uniform Crime Reports published by the U.S Federal Bureau of Investigation (FBI) and represented the background crime rates for each MSA.[11]

All data elements were recorded annually by city, spanning the years 1996 through 2010. Safety equipment was indicated by two mutually exclusive dichotomous variables—safety cameras or partitions—and was recorded annually according to installation status in the majority of taxicabs. A city was considered a "camera city" if more than 70% of the taxicabs were equipped with cameras. Similarly, a city was considered a "partition city" if more than 70% of the taxicabs were equipped with partitions. A "control city" was defined as having less than 10% of the taxicabs equipped with either a camera or a partition. These cut-points were used as they represent the distribution of safety equipment implemented as a company policy for cities without ordinances mandating safety equipment.

A retrospective longitudinal time-series analysis was employed to evaluate the association of safety equipment type with taxicab driver homicide rates. The outcome variable was city taxicab driver homicide rate. The main effect independent variables were safety equipment type. Safety equipment status for each dichotomous variable representing safety equipment type was designated "1" beginning in the first full year safety equipment was implemented. In each city, the use of safety cameras or partitions was mutually exclusive. There were no lag periods created, as it was not expected that there would be a delayed effect of security equipment on taxicab driver homicide rates. A variable designating calendar year was included to control for the declining trend in homicide rates among taxicab drivers that began prior to 1996.[3]

All data were collected and analyzed in 1-year increments, with city being the analytic unit. Analyses were conducted in 2012 using PROC GENMOD in SAS, version 9.2. Generalized estimating equations were used to account for the serial correlation of the time series and allow for the clustering of data within cities. The natural logarithm of the number of licensed taxicabs by city each year was used as an offset variable.

The taxicab driver homicide counts were assumed to follow a Poisson distribution; the offset variable provided the denominator used to calculate the homicide rates. The data were tested for dispersion and found to be slightly under-dispersed (scale=0.9), so that all reported CIs can be considered conservative in their range. Annual city-specific taxicab driver homicide rates were modeled on camera installation status to test the hypothesis that cities with cameras experienced a decline in taxicab driver homicide rates compared to cities with neither cameras nor partitions. The Wald test statistic determined significance.

The same statistical model, restricted to camera cities, was used to test for the reduction in taxicab driver homicide rates

Table 1. Distribution of safety equipment by study cities: U.S., 1996–2010

Camera cities (year installed)	Partition cities[b] (year installed if after 1996)	Control cities
Austin TX (2005)	Baltimore MD (1999)[c]	Atlanta GA
Dallas TX (1999)	Boston MA	Cincinnati OH
Houston TX (1999)	Chicago IL	Columbus OH
Las Vegas NV (2005)[a]	Detroit MI	Denver CO
Orlando FL (2009)	Los Angeles CA	Honolulu HI
Portland OR (2004)[a]	New York City NY	Miami FL
San Francisco CA (2003)[a]	Philadelphia PA	New Orleans LA
Seattle WA (2006)[a]		Reno NV
		Sacramento CA
		San Diego CA
		Tampa FL

[a]Citywide camera installation per ordinance requirement
[b]All partition cities have citywide installation.
[c]Baltimore is the only partition city that did not have partitions installed before 1996.

post-installation compared with pre-installation. Taxicab driver homicide rates were modeled on partition installation status to test whether the hypothesis cities with partitions experienced lower taxicab driver homicide rates compared to cities with neither cameras nor partitions. The timing of the partition installations relative to the years examined precluded analysis of homicide rates post-installation versus pre-installation.

Results

Taxicab Driver Homicide Distribution

News clippings data on the annual number of taxicab driver homicides, the annual number of licensed taxicabs, and city homicide rate were obtained for 26 cities. Taxicabs in eight cities were equipped with security cameras, taxicabs in seven cities had partitions installed, and 11 cities served as controls as they had neither partitions nor cameras installed. The camera and partition cities included in the analysis represent all of the cities eligible for the study. Table 1 presents the cities included in the analysis, their primary safety equipment designation, and, if applicable, the year and circumstance of widespread camera or partition installation. Cameras were installed in four of the camera cities due to a company policy, and four cities passed an ordinance mandating camera installation. Only one of the partition cities installed partitions during the time period evaluated in the study.

During the 15-year study period, news clippings identified 216 taxicab driver homicides in the 26 cities included in the analysis. The average number of taxicab driver homicides was 14 per year, with the minimum being three homicides (2007) and the maximum 24 (1997, 1998). Table 2 delineates the number of taxicab driver homicides per city and year, classified according to safety equipment status. Also included are the average number of licensed taxicabs per city, the average taxicab driver homicide rate per city, and the average homicide rate per city.

Figure 1 depicts the annual rate of taxicab driver homicides according to safety equipment type (neither cameras nor partitions is indicated as "control"). The taxicab driver homicide rates for partition cities and control cities were very similar for almost every year examined, peaking in 1998 and 2010. In general, the camera cities pre-installation experienced lower homicide rates than the partition cities, although for 2002 through 2004, homicide rates in camera cities were the highest of any of the groups. Finally, homicide rates in camera cities post-installation appeared to be lower for the majority of years than rates in camera cities pre-installation for comparable years.

Examining only the camera cities allows for a pre- and post-installation comparison of the number of taxicab driver homicide rates for each city (Figure 2). For every city, the taxicab driver homicide rate decreased post-installation. All of the cities with ordinances mandating cameras had no taxicab driver homicides after installation of cameras.

Effect of Cameras on Taxicab Driver Homicide Rates

Model 1 in Table 3 tests Hypothesis 1a that taxicab driver homicide rates post-installation of cameras were lower than those pre-installation. The unadjusted effect of camera installation in reducing taxicab driver homicide rates was significant (RR=0.18, 95% CI=0.08, 0.43). After controlling for an annual change in taxicab driver homicide rates ("year") and city homicide rate, the effect of camera installation remained significant (RR=0.14, 95% CI=0.07, 0.29). Model 2 describes the effect of camera installation compared to control cities (Hypothesis 1b). Both the unadjusted and adjusted effects of camera installation compared to

Table 2. Distribution of taxicab driver homicides by city and per year, U.S., 1996–2010

	Number of taxicab driver homicides															Average number of licensed taxicabs	Average taxicab driver homicide rate[a]	Average city homicide rate[b]
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010			
Cameras																		
City 1[c]	—	—	—	—	1	—	—	1	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	382	0.35	2.7
City 2	—	—	—	—	—	—	—	—	1	—	—	—	—	—[d]	—[d]	449	0.16	5.5
City 3[c]	—	—	1	1	—	—	—	1	1	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	1,422	0.25	10.2
City 4	—	1	1	—[d]	—[d]	1[d]	—[d]	—[d]	1	—[d]	—[d]	—[d]	—[d]	—[d]	2[d]	2,092	0.19	8.7
City 5	—	1	2	1	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	1[d]	—[d]	—[d]	1[d]	1,861	0.21	8.0
City 6	—	—	1	—	—	—	—	—	—	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	669	0.10	3.7
City 7[c]	—	1	1	1	—	—	1	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	1,353	0.22	5.6
City 8[c]	1	—	—	—	—	—	1	—	1	—	—[d]	—[d]	—[d]	—[d]	—[d]	648	0.31	3.3
Partitions																		
City 9	3	2	1	1[d]	2[d]	2[d]	—[d]	1[d]	1[d]	1[d]	2[d]	1[d]	—[d]	2[d]	1[d]	1,400	0.95	14.4
City 10	—[d]	2[d]	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	—[d]	1[d]	—[d]	—[d]	—[d]	—[d]	—[d]	1,685	0.12	3.8
City 11	1[d]	5[d]	4[d]	—[d]	3[d]	2[d]	—[d]	2[d]	1[d]	3[d]	1[d]	—[d]	—[d]	—[d]	—[d]	6,646	0.22	7.1
City 12	—[d]	—[d]	—[d]	1[d]	—[d]	—[d]	—[d]	—[d]	1[d]	1[d]	—[d]	—[d]	—[d]	—[d]	—[d]	750	0.27	16.7
City 13	—[d]	—[d]	—[d]	3[d]	1[d]	3[d]	1[d]	1[d]	—[d]	—[d]	1[d]	—[d]	—[d]	—[d]	—[d]	2,169	0.31	10.2
City 14	14[d]	5[d]	4[d]	4[d]	11[d]	4[d]	5[d]	2[d]	3[d]	4[d]	1[d]	—[d]	3[d]	3[d]	2[d]	12,517	0.35	6.6
City 15	—[d]	2[d]	—[d]	—[d]	1[d]	1[d]	1[d]	3[d]	—[d]	—[d]	1[d]	—[d]	1[d]	—[d]	1[d]	1,650	0.44	10.4
Control																		
City 16	—	—	1	1	1	1	—	1	—	—	2	1	—	1	1	1,548	0.43	8.8
City 17	—	—	—	1	—	—	—	—	1	1	—	—	—	—	2	462	0.76	5.8
City 18	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	500	0.27	6.5
City 19	—	—	1	—	—	—	1	—	1	—	—	—	—	—	—	821	0.28	4.7
City 20	—	—	—	2	—	—	—	—	—	—	1	—	—	—	1	2,000	0.13	2.3

(continued on next page)

Table 2. *(continued)*

	Number of taxicab driver homicides															Average number of licensed taxicabs	Average taxicab driver homicide rate[a]	Average city homicide rate[b]
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010			
City 21	—	—	2	1	—	—	—	1	1	1	1	—	3	—	—	1,945	0.34	10.0
City 22	1	5	1	1	1	1	—	—	2	—	—	—	—	1	1	1,600	0.58	25.2
City 23[e]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	250	0.27	4.7
City 24	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	332	0.36	5.5
City 25	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	915	0.23	3.7
City 26[e]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	577	0.00	5.1

[a]Per 1000 taxicabs
[b]Per 100,000 city population
[c]Cities with ordinance mandating taxicab cameras
[d]Designate year of camera or partition implementation
[e]These cities did not experience any taxicab driver homicides during the time span studied.

control cities were significantly associated with reduced rate ratios: 4.8 times lower rates when unadjusted and 3.7 times lower rates after adjusting for annual taxicab driver homicide rate changes and city homicide rate (Table 3).

Effect of Partitions on Taxicab Driver Homicide Rates

The effect of partition installation compared to control cities (Hypothesis 2) found no significant association between citywide partition installation and taxicab driver homicide rates either before or after adjusting for annual taxicab driver homicide rate changes and city homicide rates (RR_{unadj}=1.01, 95% CI=0.64, 1.59; RR_{adj}=1.15, 95% CI=0.80, 1.64).

Discussion

These data support the hypothesis that installing cameras in taxicabs results in a reduction in citywide taxicab driver homicide rates post-installation (seven times lower homicide rate) and compared to cities with neither cameras nor partitions (three times lower homicide rate). The data do not support the hypothesis that cities with partitions installed in taxicabs experience lower taxicab driver homicide rates than cities with neither cameras nor partitions. This is the first study to methodically collect data from a nationally representative sample of the largest taxicab cities over a 15-year time span that allows for comparison of rates pre- and post-installation of cameras.

Cameras are effective to the extent that they are used to their optimal performance and publicized. The ordinance requirements in some cities mandate that a decal be posted on the passenger windows to make passengers aware that they are under surveillance. Consistent with Crime Prevention Through Environmental Design Theory, would-be perpetrators are less likely to commit a crime while under surveillance.[12]

Another crucial component to ensure optimal performance of security cameras is maintaining cameras according to manufacturer's instructions and not allowing security cameras to be intentionally disabled. Security cameras mandated by ordinance are checked for functioning at yearly inspections organized by city regulators, if not more frequently, when taxicab vehicles are checked for safety. Two of the three taxicab driver homicides that occurred in camera cities in 2010 had disabled cameras in their taxicabs (International Association of Transportation Regulators, personal communication, 2011). Specifically, the only city that experienced an increase in number of homicides after camera installation (City 4) was the city with the two murdered taxicab drivers whose cameras were disabled.

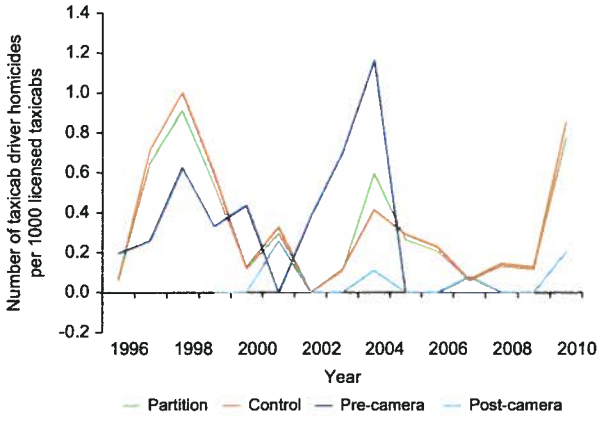

Figure 1. Distribution of taxicab driver homicide rates by safety equipment for cities included in analysis, U.S., 1996–2010

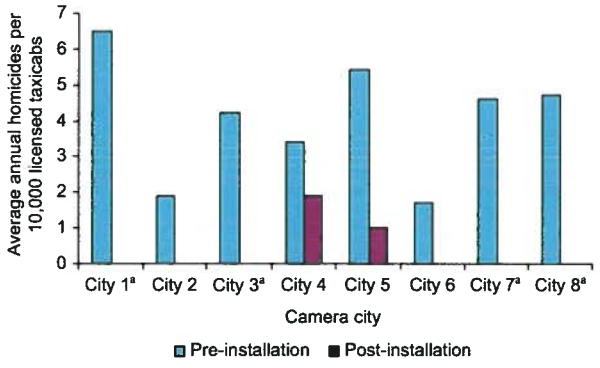

Figure 2. Taxicab driver homicide rates for camera cities pre- and post-installation, U.S., 1996–2010

Note: There were no fatalities post-installation for Cities 1, 2, 3, 6, 7, and 8. Actual number of homicides for each period are indicated above each column.

[a]Cities with an ordinance mandating cameras

All six taxicab driver homicides post-installation occurred in camera cities where cameras are required by company policy instead of by city ordinance. Although company policies for security camera installation may be effective, municipal ordinances requiring that all taxicabs be equipped with operating security cameras may be more effective. Such ordinances would ensure that individual owner–operated taxicabs and smaller businesses would use cameras, as do the nationally recognized taxicab companies that make up a large share of the market. Because deterrence through identification is one effect of camera installation, it is important that news reports mention the presence of a camera in the taxicab of a murdered driver, and post photos of potential suspects, so that potential perpetrators are aware of the possibility of being identified by surveillance cameras.

The lack of an observed reduction in taxicab driver homicides in partition cities was unexpected. Partitions were implemented citywide because of ordinance requirements before 1996 in six of the seven cities examined. These were typically the cities that were experiencing the highest number of taxicab driver homicides, and also the highest crime rates in the sample. The benefit of the bullet-resistant partition, consistent with Situational Crime Prevention Theory, is that it is designed to give more power to the driver than to the passenger in regard to control of physical space. Additionally, it separates the target (cash held by driver) from the perpetrator.[12,13]

The news reports provided only partial information on location of the shooting relative to the taxicab—on average, 30% of these data were missing. For those news reports that provided the information, on average, 75% of reported locations were *inside* the taxicab. Details about whether they occurred because of an open partition or through the back of the driver's seat are difficult to obtain, yet important for understanding the limitations of partitions.

One suggestion for improving the effect of partitions may be to incorporate complementary safety features, such as signage indicating that minimum amounts of cash are carried by the driver, accompanied by installation of a cashless system, and GPSs for driver location.[4,5] Although there was not an observed or significant reduction in taxicab driver homicides because of partitions alone, partitions could confer a protective effect in combination with additional safety measures. At this time, it is only speculation to decide which additional safety measures are needed, and further research evaluating additional safety measures for taxicab drivers is warranted.

Limitations

This study is limited by its ability to confer risk to individual taxicab drivers. Thus, because of the ecologic study design, the change in taxicab driver homicide rates (or lack thereof) in response to various types of safety equipment can be attributed only to citywide homicide rates. It is not possible to speak to the individual risks of taxicab drivers who have cameras versus partitions versus neither. However, this is a well-designed ecologic analysis that included all the major taxicab cities in the U.S. over a 15-year time span to allow for observed sustainable effects; it also incorporated a pre–post intervention with comparison group study design. The present study was conducted in response to a request by the International Association of Transportation Regulators, and the observations and findings of this research have implications for taxicab driver homicides in other countries where such homicide rates are considerably higher.

Another potential limitation is under-reporting when using news reports in constructing an outcome measure.

Table 3. Statistical models describing intervention effects on citywide taxicab driver homicide rates, U.S., 1996–2010

	Model 1[a]		Model 2[b]		Model 3[c]	
Variables	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Cameras installed	0.18 (0.08, 0.43)	0.14 (0.06, 0.29)	0.21 (0.09,0.52)	0.27 (0.12, 0.61)	—	—
Partitions installed	—	—	—	—	1.01 (0.64, 1.59)	1.15 (0.80, 1.64)
Year[d]	—	1.04 (0.97, 1.11)	—	0.96 (0.90, 1.07)	—	0.92 (0.89, 0.95)
City homicide rate[e]	—	1.05 (0.96, 1.16)	—	1.04 (1.02, 1.06)	—	1.05 (1.03, 1.08)

Note: Values are rate ratio (95% CI).
[a]Testing Hypothesis 1a, difference in taxicab driver homicide rates post-installation versus pre-installation of cameras
[b]Testing Hypothesis 1b, difference in taxicab driver homicide rates in camera cities compared to control cities
[c]Testing Hypothesis 2, difference in taxicab driver homicide rates in partition cities compared to control cities
[d]The rate ratio represents an associated increase in taxicab driver homicide rate for every increase of 1 year.
[e]The rate ratio represents an associated increase in taxicab driver homicide rate for every 1-unit increase in city homicide rate.

News reports on work-related homicides where police officers, convenience store clerks, and taxicab drivers are the victims tend to be well documented in electronic media. The search strategy used in the current study is methodologically rigorous and was conducted within a comprehensive electronic database. The results were validated by municipal taxicab regulators and were compared with data received from police departments for a separate phase of the overall study (covering 20 of the cities).

An additional limitation is the use of secondary safety equipment, such as GPS devices that geographically track the taxicab, and alert devices were not included as potential covariates. These data were very difficult to obtain in order to record them annually, as most regulators do not document when they install secondary safety equipment. However, most of the cities have taxicabs equipped with GPS devices and alerts, and the use of secondary safety equipment is not predominantly associated with camera or partition cities.

Conclusion

The data suggest that citywide installation of security cameras in taxicabs may result in a sustainable reduction of the homicide rate among taxicab drivers. The current results are likely generalizable to countries with similar issues of taxicab safety and similar taxicab driver robbery and assault risk factors. Current research is planned to evaluate the effect of cameras in reducing robbery and assault rates by interviewing individual drivers.

The authors thank the International Association of Transportation Regulators (IATR) for their partnership in this considerable endeavor. In particular, Craig Leisy, with the Consumer Affairs Unit in Seattle WA provided several invaluable critical reviews of the study during the proposal and writing phases. Malachi Hull and Matt Daus, Presidents of IATR, and Karen Cameron were crucial for building partnerships with municipal agencies. The authors also express gratitude to Charles Rathbone, taxicab driver and assistant fleet manager who maintains the Taxi Library website (www.taxi-library.org), who was the inspiration for this study.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

No financial disclosures were reported by the authors of this paper.

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Supplementary data

A pubcast created by the authors of this paper can be viewed at www.ajpmonline.org/content/video_pubcasts_collection.