# Effectiveness of Safety Measures Recommended for Prevention of Workplace Homicide

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**Context** Homicide is the second leading cause of death on the job for US workers. Government agencies recommend that employers prevent violence against workers by adopting interventions originally designed to prevent robbery, but the effectiveness of these interventions is unknown.

**Objective** To investigate the effectiveness of existing administrative and environmental interventions recommended for preventing workplace homicide.

**Design, Setting, and Participants** Population-based case-control study of North Carolina workplaces where a worker had been killed between January 1, 1994, and March 31, 1998, identified through a statewide medical examiner system (cases; n=105) and an industry-matched random sample of workplaces at risk during the same period, selected from business telephone listings (controls; n=210).

**Main Outcome Measure** Risk of death of a worker due to homicide.

**Results** Among environmental interventions, strong and consistent reductions in the risk of a worker being killed on the job were associated with bright exterior lighting (odds ratio [OR], 0.5; 95% confidence interval [CI], 0.3-1.0). Among administrative interventions, the largest beneficial effect was for staffing practices that prevented workers from being alone at night (OR, 0.4; 95% CI, 0.2-0.9). Keeping doors closed during working hours was also associated consistently with substantially reduced risk (OR, 0.4; 95% CI, 0.1-1.1) but was not statistically significant. Combinations of 5 or more administrative measures were associated with significantly lower levels of risk (OR, 0.1; 95% CI, 0.0-0.5).

**Conclusions** We found evidence suggesting that eliminating solo work at night could reduce the risk of homicide for workers. Keeping doors closed and using bright exterior lighting or combinations of administrative interventions also appear to be beneficial, but there was no evidence of effectiveness for a number of other recommended measures.

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HOMICIDE IS THE SECOND LEADing cause of death on the job for US workers,[1] with an average of 20 fatal assaults each week.[2] A large proportion of all workplace homicides result from robberies in retail businesses.[1] The strategies government agencies have recommended to prevent homicide in the workplace[3-5] consequently draw largely on descriptive epidemiologic studies[6-10] and research on robbery by social scientists and industry consultants.[11] The recommended measures focus primarily on retail businesses where money transactions take place[3,4,12] and include both environmental design measures, such as increasing the visibility of persons inside the workplace or installation of alarms and surveillance devices,[13] and administrative or behavioral measures, like training workers to respond in threatening situations.[14] These strategies are based on those adopted by retailers to make robbery less attractive to potential perpetrators, and which some studies indicate are effective for that purpose.[11,13]

Cook[15] hypothesized that robbery-prevention measures should also prevent many workplace homicides. However, very few subsequent studies have examined this hypothesis or assessed the effectiveness of measures that have been recommended to prevent workplace homicides. To investigate the value of these robbery-prevention measures for preventing workplace homicide, we conducted a case-control study of homicides in North Carolina workplaces during 1994-1998.

## METHODS

The study population and data collection methods have been described in detail elsewhere.[16] Briefly, the units of study were workplaces, rather than workers, because we sought to investigate features of workplaces, like staff-

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ing policies and security devices, rather than behaviors or attributes of individual persons. Cases were North Carolina businesses or agencies where an employee or proprietor was killed on the job between January 1, 1994, and March 31, 1998, identified through North Carolina's statewide medical examiner system. Employers and work locations were identified from the medical examiner's report or follow-up telephone calls with law enforcement officers. Workplaces in all industry categories except agriculture, law enforcement, and the armed forces were included in the study.[16] Procedures pertaining to human subjects were reviewed and approved by the institutional review board of the University of North Carolina School of Public Health.

Controls were workplaces sampled from North Carolina businesses and agencies contained in a compilation of business telephone listings, American Business Lists.[17]The risk set for a given case included all establishments in this database that were in operation in the month of the case event (the index month). Controls were interviewed at the ratio of 2 per case, but to counter anticipated losses due to nonworking telephone numbers, ineligibility, and refusals, we randomly selected 10 potential controls for each case, individually matched by broad sector of industry using 1-digit Standard Industrial Codes.[18]

## Data Collection

After sending an introductory letter, we attempted to contact the manager, operator, or owner of each workplace by telephone to arrange an interview; oral agreement to participate was accepted as consent. The owner or manager in the index month was the preferred informant for both cases and controls, but if that person could not be interviewed and the workplace was a case, we followed all available leads to locate a knowledgeable informant, including coworkers of the victim or police officers who had investigated the homicide.[16] For controls, whose numbers were large, we made 6 attempts to conduct an interview for each workplace. If we could not reach a qualified informant in that number of attempts or consent was refused, we skipped to the next potential control.

The questionnaire developed for the study was designed to elicit detailed information about workplaces and an array of factors potentially related to workers' risk of being killed on the job. Following a classic industrial hygiene model, preventive measures were divided into environmental control measures related to workplace design and administrative-control measures related to work practices and policies. In addition to inquiring about measures to prevent robbery and violence, the instrument covered operational and physical aspects of the workplace, its surroundings, and the demographic characteristics of the workforce. For cases, we requested information about workplace characteristics in the month the homicide event occurred (the index month). For controls, we requested the same information for the index month of the matched case. The instrument was pretested with a sample of potential controls and workplace homicide cases not included in the study.

Interviews were conducted by telephone by trained, experienced interviewers and lasted 23 minutes, on average. The goal was to collect data as soon as possible after identification of a case and its controls, but because the subject matter was sensitive and the cases were subject to medical and legal investigation, there was always a lag of at least 3 months between the case event and the interview.

To supplement the interviews, we obtained information on county size and urbanization from the 1990 US Census.[19] For county-level crime statistics, we obtained data from the North Carolina Uniform Crime Reporting Program, 1993-1997.[20]

## Data Analysis

Analysis of the data sought to quantify the protective effect of interventions that have been recommended to reduce the risk of homicide in workplaces. Logistic regression was used to estimate the association of each intervention with the occurrence of homicide in the workplace via the exposure odds ratio (OR) and its 95% confidence interval (CI). Variables were coded so that ORs less than 1.0 indicated a beneficial effect of the intervention.

Each measure was initially examined in isolation using a simple logistic model. To control for the influence of other workplace and community characteristics, we also used multiple logistic models to estimate ORs adjusted for potentially confounding factors that were strongly associated with homicide risk in a previous analysis of the data. Briefly, the factors from 9 groups of variables related to workplace location, employer characteristics, and workforce characteristics that were most strongly associated individually with the risk of homicide[16] were entered into a multivariable predictive model before adding indicators for interventions. The factors considered for control included the following: (1) being located in an urban county or a county with high crime rates, (2) belonging to an industry associated with high risk in previous studies[21] (taxicab services, bars and nightclubs, restaurants and prepared food vendors, grocery and convenience stores, and gasoline stations), (3) being located in a residential or industrial area, (4) being open Saturdays, (5) having a high proportion of male or minority workers, and (6) having moved or opened within 2 years. County characteristics did not significantly improve the fit of the models and were deleted from the model, but the other predictors remained. Indicator variables for the presence of interventions were then added singly to this model, which was used for all adjusted analyses.

Despite efforts to obtain complete data for each workplace, some missing values were present and were treated as missing in the analysis. Analyses were conducted using both unconditional logistic regression and conditional logistic regression, which preserves the individual matching of

cases and controls. Egret analytical software (Cytel Software Corp, Cambridge, Mass) was used to fit both classes of models. The results were essentially identical regardless of the method, but some multivariable models failed to converge in conditional form because of the smaller cell sizes imposed by matched analysis. As a result, we report only the results from unconditional logistic models.

## RESULTS

Interviews were completed for 105 of the 119 workplaces that were eligible to be included as cases according to medical examiner's records. Five of the 119 eligible cases were used for a pilot test of the questionnaire and were excluded from the study, however, and 9 of the 114 workplaces remaining were dropped from the analysis because no informant could be interviewed.

We initiated attempts to contact 505 potential control workplaces and succeeded in reaching 344, of which 311 were found to be eligible. Of these eligible workplaces, interviews were completed for 210 (68%), while respondents at 101 workplaces (32%) refused. There was no significant difference in response by industry among cases or controls. The median interval between the homicide and the interview was 13 months, with a minimum of 82 days; and 4 interviews required 4 years to complete.

Informants reported preventive measures in almost all workplaces: 99% had administrative-control measures and 96% had environmental-control measures, while only 1 workplace had neither type.

### Environmental Measures

Workplaces with a physical barrier between workers and the public were 40% less likely to experience a homicide (OR, 0.6; 95% CI, 0.3-1.3) relative to workplaces without such features. However, few other environmental control measures were associated with noteworthy reductions in the risk of homicide when considered without adjustment for other factors (TABLE 1).

After adjustment for high-risk industries, location, Saturday hours, workforce composition, and recent changes in location, bright lighting outside (OR, 0.5; 95% CI, 0.3-1.0), security alarms (OR, 0.5; 95% CI, 0.2-1.0), and cash drop boxes that workers could not open (OR, 0.5; 95% CI, 0.2-1.3) were also associated with notable reductions in risk (Table 1).

Although most individual environmental-control measures were not associated with reduced risk of homicide, workplaces with at least 5 of these measures were less likely to have had a homicide than those with none of the measures (Table 1).

### Administrative Measures

In general, administrative control measures were more consistently associated with reductions in the risk of homicide, compared with environmental measures (TABLE 2). When considered without taking other factors into account, keeping entrances locked or closed during working hours, making special arrangements with a law enforcement agency, psychological screening of job applicants, depositing cash proceeds in a bank daily, having more than 1 worker on duty, and workers not being alone at night were all associated with noteworthy reductions in risk, with ORs ranging from 0.3 to 0.6. The protective effects of more than 1 worker being present (OR, 0.4; 95% CI, 0.2-0.7) and workers not being alone at night (OR, 0.3; 95% CI, 0.1-0.5) were statistically significant.

Adjustment for the array of external factors considered previously did not produce major changes in the ORs for most administrative measures (Table 2). The adjusted ORs for closed entrances (OR, 0.4; 95% CI, 0.1-1.1) and worker training programs (OR, 0.6; 95% CI, 0.3-1.3) suggested slightly stronger protective effects of these measures, however, while the beneficial effects of arrangements with a law enforcement agency and having multiple workers on duty were somewhat diminished (Table 2).

Signs advertising limited cash on hand and, after adjustment, sign-in procedures for visitors and the use of

**Table 1.** Effect of Environmental Control Measures on the Risk of Homicide in North Carolina Workplaces

| Control Measure | No. Exposed/ No. Unexposed | | Odds Ratio (95% Confidence Interval) | |
|---|---|---|---|---|
| | Cases (n = 105) | Controls (n = 210) | Unadjusted | Adjusted* |
| Lighting and visibility | | | | |
| Bright lighting outside building | 28/71 | 70/139 | 0.8 (0.5-1.3) | 0.5 (0.3-1.0) |
| Bright lighting inside during work hours | 58/43 | 135/74 | 0.7 (0.5-1.2) | 0.7 (0.3-1.3) |
| Bright lighting inside before/after hours | 36/61 | 86/123 | 0.8 (0.5-1.4) | 0.9 (0.4-1.7) |
| Workers visible from outside | 62/39 | 126/84 | 1.1 (0.7-1.7) | 1.0 (0.5-1.9) |
| Access | | | | |
| Barrier between workers and public | 68/14 | 113/16 | 0.6 (0.3-1.3) | 0.6 (0.2-1.8) |
| Security and surveillance devices | | | | |
| Video cameras | 25/75 | 33/175 | 1.8 (1.0-3.2) | 1.3 (0.6-2.8) |
| Alarms | 19/79 | 54/151 | 0.7 (0.4-1.2) | 0.5 (0.2-1.0) |
| Mirrors | 30/70 | 44/166 | 1.6 (0.9-2.8) | 0.8 (0.4-1.8) |
| Other devices | 24/75 | 51/155 | 1.0 (0.6-1.7) | 0.8 (0.4-1.7) |
| Cash storage | | | | |
| Drop box | 16/59 | 31/114 | 1.0 (0.5-2.0) | 0.5 (0.2-1.3) |
| Safe with worker access | 33/39 | 70/75 | 0.9 (0.5-1.6) | 1.3 (0.6-2.9) |
| ≥5 Environmental control measures | 36/69 | 83/127 | 0.8 (0.5-1.3) | 0.5 (0.2-1.0) |

*Adjusted for a priori high-risk industry, residential or industrial location, open Saturdays, workforce race and sex, relocated or opened in last 2 years.

guards were associated with notable increases in risk.

The majority of workplaces (81 cases and 203 controls) had at least 5 administrative-control measures. This number of measures was associated with a substantial and statistically significant reduction in the risk of homicide (OR, 0.1; 95% CI, 0.0-0.5 after adjustment). Data for workplaces with 1 to 5 administrative measures could not be analyzed separately because of small numbers.

### Robbery-Related Homicide

Because many of the interventions considered here were initially developed with the intention of preventing robbery rather than worker injuries, we also conducted an exploratory analysis that took the circumstances of the case events into account. Cases and their controls were subdivided according to whether the homicide that defined the case occurred in the course of a robbery (n=60) or in association with another kind of event (n=42). All of the nonrobbery homicides were related to disputes, and 3 cases with unknown circumstances were excluded.

For environmental measures, there was no consistent evidence of a stronger beneficial effect in robbery-related incidents (TABLE 3). Administrative measures appeared more successful in preventing robbery-related homicides (TABLE 4). The ORs for dispute-related homicides, however, were greater than 1.0 for several administrative measures. Because these analyses were based on subgroups, CIs for the ORs were noticeably wider than when all workplace homicides were considered together.

**Table 2.** Effect of Administrative Control Measures on the Risk of Homicide in North Carolina Workplaces

| Control Measure | No. Exposed/ No. Unexposed | | Odds Ratio (95% Confidence Interval) | |
|---|---|---|---|---|
| | Cases (n = 105) | Controls (n = 210) | Unadjusted | Adjusted* |
| Public access | | | | |
| Entrances closed during business hours | 9/93 | 33/177 | 0.5 (0.2-1.1) | 0.4 (0.1-1.1) |
| Entrances closed before/after hours | 56/16 | 147/32 | 0.8 (0.4-1.5) | 0.6 (0.2-1.3) |
| Entrances locked | 6/95 | 22/187 | 0.5 (0.2-1.4) | 0.5 (0.1-1.6) |
| Identification badges for employees | 15/86 | 38/172 | 0.8 (0.4-1.5) | 1.0 (0.5-2.3) |
| Sign-in procedures for visitors | 15/84 | 29/181 | 1.1 (0.6-2.2) | 2.0 (0.9-4.8) |
| Guards and law enforcement | | | | |
| Protected by security guards | 12/89 | 20/190 | 1.3 (0.6-2.7) | 1.8 (0.7-4.5) |
| Arrangements with law enforcement agency | 16/83 | 64/144 | 0.4 (0.2-0.8) | 0.7 (0.3-1.5) |
| Warning signs | | | | |
| Area restricted to visitors | 35/61 | 77/133 | 1.0 (0.6-1.6) | 1.1 (0.5-2.1) |
| Limited cash on hand | 5/75 | 2/145 | 4.8 (0.9-25.5) | 3.8 (0.5-26.6) |
| Worker training | | | | |
| Any training for violent situations | 55/30 | 144/66 | 0.8 (0.5-1.4) | 0.6 (0.3-1.3) |
| Training for robbery | 44/34 | 100/108 | 1.4 (0.8-2.4) | 1.0 (0.5-2.0) |
| Training for other situation | 48/37 | 128/82 | 0.8 (0.5-1.4) | 0.7 (0.2-1.3) |
| Preemployment screening | | | | |
| Psychological tests | 5/78 | 24/184 | 0.5 (0.2-1.3) | 0.5 (0.1-1.7) |
| Ask about or check felony convictions | 42/44 | 119/85 | 0.7 (0.4-1.1) | 0.6 (0.3-1.2) |
| Cash-handling procedures | | | | |
| Daily bank deposits | 36/23 | 103/39 | 0.6 (0.3-1.1) | 0.6 (0.2-1.3) |
| No night deposits | 17/45 | 95/48 | 1.3 (0.7-2.6) | 1.4 (0.6-3.5) |
| Staffing | | | | |
| More than 1 worker usually on duty | 65/31 | 176/33 | 0.4 (0.2-0.7) | 0.6 (0.3-1.4) |
| Employees never work alone | 26/72 | 73/136 | 0.7 (0.4-1.1) | 0.7 (0.3-1.4) |
| Never work alone evenings | 65/18 | 138/61 | 1.6 (0.9-2.9) | 1.2 (0.6-2.6) |
| Never work alone nights | 49/34 | 168/31 | 0.3 (0.1-0.5) | 0.4 (0.2-0.9) |
| Never work alone in isolated areas | 79/18 | 156/54 | 1.5 (0.8-2.8) | 1.0 (0.5-2.2) |
| Usually not working outside business hours | 68/27 | 146/64 | 1.1 (0.6-1.9) | 1.1 (0.5-2.2) |
| ≥5 Administrative measures | 81/24 | 203/7 | 0.1 (0.1-0.3) | 0.1 (0.0-0.5) |

*Adjusted for a priori high-risk industry, residential or industrial location, open Saturdays, workforce race and sex, relocated or opened in last 2 years.

## COMMENT

Several administrative measures involving work practices or operations appeared to be beneficial for preventing worker homicides: keeping entrances closed or locked, depositing cash daily, psychological screening or criminal background checks of prospective employees, and having more than 1 worker present, especially at night, were all associated with 30% to 70% reductions in the odds of a workplace experiencing a homicide in both crude and adjusted analyses. Environmental changes in workplace design were generally not associated with reduced risk of fatal violence as actually implemented. After statistical adjustments to take other workplace characteristics into account, however, beneficial effects were indicated for bright lighting, alarms, and secure cash storage devices.

A recent review of research evaluating workplace robbery-prevention programs identified 26 pertinent studies, the collective results of which suggest that, overall, these interventions are effective in preventing robbery.[13] None of the studies directly evaluated the risk of employee injury or death in relation to the presence of work interventions, however. Our study, which did examine the success of interventions for preventing fatal violence against workers, suggests mixed success for interventions that have been recommended to prevent violence against workers.

Our findings that the risk of homicide in workplaces may be reduced by having at least 2 workers on duty are relevant to current public policy. The state of Florida mandated environmental and administrative control measures in selected convenience stores

through legislation adopted in 1990 and 1992[22]; the 1992 law required stores open at night to have at least 2 clerks on duty and institute environmental safety measures. The "2-clerk" provision has been controversial because of the additional cost to employers and inconsistent empirical support based on earlier, ecological studies.[13,23,24] Our findings suggest that having more than 1 worker present may be an effective strategy for preventing robbery-related worker fatalities. However, we also observed increased risk of non–robbery-related homicides in workplaces where informants reported more than 1 worker "usually" on duty. The numbers of nonrobbery homicides were not sufficient to investigate these incidents in detail, but explanations should be sought in appropriately designed studies.

The federal Occupational Safety and Health Administration (OSHA)[4] and California's OSHA program (CalOSHA)[12] have also issued safety guidelines for late night retail businesses that combine elements of the Florida laws with other environmental and administrative control measures. Among the measures recommended by these agencies, our findings indicate some benefits for bright outdoor lighting, limiting nonemployees' access with barriers or closed or locked doors, and safe cash-handling procedures, including drop safes and frequent bank deposits. In this study, security guards, which the Florida law requires for some businesses, and inquiring about job applicants' criminal records also appeared to be beneficial, but only in preventing robbery-related violence.

Several other recommended or legally required interventions, including improved visibility of the work area from outside, video surveillance cameras, observation mirrors, posted notices of limited cash on hand, and training to prepare workers for robberies, did not appear to be effective in preventing robbery-related homicides, however. Odds ratios for several of these measures were greater than 1.0, an observation that may be explained by inability to completely control for characteristics of the workplace, such as neighborhood quality or prior experience with crime, which are related to the risk of homicide and also influence employers' decisions to implement interventions. It is also possible, however, that some interventions may be counterproductive if they advertise the presence of valuable assets but do not constitute a credible deterrent from robbers' perspective.

Epidemiologic research on workplace violence generally has not differentiated homicides due to robbery and other causes,[6-10,25] and some agencies have issued recommendations for prevention that do not take the full range of circumstances into account.[3] Our data suggest, however, that different strategies may be needed to control workplace violence that is not related to robbery.

Forty percent of the deaths defining the case population in this study were associated with disputes. These events include both work-related disputes between the victim and a coworker, manager, or client, and disputes involving domestic partners or family members. Measures intended to make workplaces unattractive targets for robbery[4] generally had little effect in preventing other kinds of violence. However, closed and locked doors, which control access by nonemployees, and bright lighting, visibility from outside, and alarms, all of which increase the chance that an assailant would be observed, did offer some protection against dispute-related violence. These findings support CalOSHA guidelines that recommend limiting nonemployee access and use of alarms to prevent nonrobbery violence against workers.[12]

This study had several limitations. Among them is that the data were collected retrospectively through interviews that, because of ongoing legal investigations and the sensitivity of the subject matter, were typically conducted 1 to 2 years after the events of interest had taken place. It is probable that informants' recall of past events was imperfect. They may, for example, have been unable to recall all the safety measures that existed at the time of the case event, and some measures they did report might not have been functional or present at that time. While the duration

**Table 3.** Effect of Environmental Control Measures on the Risk of Workplace Homicide Among Cases by Type of Incident*

| Control Measure | Odds Ratio (95% Confidence Interval)† | |
|---|---|---|
| | Robbery (60 Cases) | Nonrobbery‡ (42 Cases) |
| Lighting and visibility | | |
| Bright lighting outside building | 0.5 (0.2-1.2) | 0.4 (0.1-1.4) |
| Bright lighting inside during work hours | 0.9 (0.3-2.2) | 0.4 (0.1-1.2) |
| Bright lighting inside before/after hours | 0.9 (0.4-2.3) | 0.8 (0.3-2.2) |
| Workers visible from outside | 1.2 (0.5-3.1) | 0.6 (0.2-1.7) |
| Access | | |
| Barrier between workers and public | 0.5 (0.1-1.9) | 1.4 (0.1-18.4) |
| Security and surveillance devices | | |
| Video cameras | 0.9 (0.3-2.5) | 3.1 (0.8-12.2) |
| Alarms | 0.8 (0.3-2.3) | 0.2 (0.0-0.7) |
| Mirrors | 1.3 (0.5-3.4) | 0.7 (0.2-3.2) |
| Other devices | 0.9 (0.3-2.5) | 0.9 (0.3-2.7) |
| Cash storage systems | | |
| Drop box | 0.5 (0.1-1.7) | 0.5 (0.1-3.1) |
| Safe with worker access | 0.8 (0.3-2.3) | 12.0 (1.1-134.2) |
| ≥5 Environmental measures | 0.7 (0.3-1.6) | 0.4 (0.1-1.3) |

*Effect of environmental control measures unknown for 3 cases.
†Adjusted for a priori high-risk industry, residential or industrial location, open Saturdays, workforce race and sex, relocated or opened in last 2 years.
‡Nonrobbery cases were associated with work-related disputes (n = 20), family or domestic disputes (n = 16), and disputes of unknown nature (n = 6).

of recall was similar for cases and controls, it is possible that the quality of recall differed for cases, which had experienced a traumatic criminal event, and controls, which had not. Differential reporting of exposure could have resulted if informants for case workplaces tended to overreport the presence of safety measures, relative to control informants, because of heightened recall of events associated with the homicide, or out of desire to avoid blame for the event. Such a tendency would be most likely to produce bias toward the null. This hypothetical source of bias, if it were indeed present, might be partially offset by an unplanned feature of the data collection methods. We interviewed investigating police officers as proxies for 40% of cases because no other informant was available.[16] Officers were generally quite familiar with the circumstances of the homicides, including preventive measures that were present, but would presumably not have any motivation to overstate the use of interventions. The duration of recall was similar for police officer proxies and workplace informants, but officers sometimes could not provide information on operational details of the workplace, such as the business hours or the number and sex of employees, which were treated as covariates in adjusted analyses.

While we attempted to differentiate interventions that were useful for preventing robbery-related and non–robbery-related violence, the study design was not ideal for this purpose. We classified cases according to the circumstances that led to the fatal event, but did not have parallel information for controls, which could only be subdivided according to the circumstances of their matched cases.

Despite having included all the cases available in a large state over 5 years, our ability to evaluate some aspects of workplace violence prevention was still limited by small numbers. Some recommended interventions, such as bulletproof partitions and comprehensive robbery-prevention packages, were encountered too infrequently for meaningful statistical analysis. Small numbers also made effectiveness difficult to evaluate when multiple interventions were present simultaneously.

Finally, experience in North Carolina workplaces may not be applicable to some other areas. While North Carolina is the 11th largest state, its largest cities have fewer than a million inhabitants and some features of the politicolegal system are atypical. For example, although liquor stores have been a focal point for other research on robbery prevention, the sale of liquor is a state-controlled monopoly in North Carolina.

Our research provides evidence that restricting nonemployees' access to workplaces by keeping doors closed or locked and increasing visibility with bright exterior lighting are effective in preventing both robbery-related and non–robbery-related homicides in a wide range of industries. Eliminating solo work at night also appears to be strongly beneficial for preventing robbery-related violence. Otherwise, the study failed to provide a strong, unambiguous endorsement of any single safety measure among those that have been required or recommended by government agencies and industry groups for preventing workplace homicide.

**Table 4.** Effect of Administrative Control Measures on the Risk of Workplace Homicide Among Cases by Type of Incident*

| Control Measure | Odds Ratio (95% Confidence Interval)† | |
|---|---|---|
| | Robbery (60 Cases) | Nonrobbery‡ (42 Cases) |
| Public access | | |
| Entrances closed during business hours | 0.2 (0.0-1.6) | 0.5 (0.1-2.4) |
| Entrance closed before/after hours | 0.4 (0.1-1.4) | 1.1 (0.3-3.7) |
| Locked entrances | 0.2 (0.0-1.8) | 0.4 (0.1-2.6) |
| Identification badges for employees | 0.3 (0.1-1.2) | 4.9 (1.3-18.0) |
| Sign-in procedures for visitors | 1.0 (0.1-6.8) | 4.4 (1.3-14.8) |
| Guards and law enforcement | | |
| Protected by security guards | 0.3 (0.0.-3.4) | 4.0 (1.0-16.1) |
| Arrangements with law enforcement agency | 0.4 (0.1-1.4) | 0.9 (0.3-2.8) |
| Warning signs | | |
| Area restricted to visitors | 0.6 (0.2-1.7) | 1.8 (0.6-5.3) |
| Limited cash on hand | 2.4 (0.2-25.3) | 0.2 (0.0-∞)§ |
| Training | | |
| Any training for violent situations | 0.6 (0.2-1.8) | 0.9 (0.3-3.0) |
| Training for robbery | 1.5 (0.5-4.3) | 1.4 (0.4-4.9) |
| Training for other situation | 0.8 (0.3-2.0) | 0.8 (0.3-2.5) |
| Preemployment screening | | |
| Psychological tests | 0.8 (0.1-4.8) | 0.4 (0.1-2.3) |
| Ask about or check felony convictions | 0.2 (0.1-0.6) | 1.7 (0.5-5.8) |
| Cash handling procedures | | |
| Daily bank deposits | 0.5 (0.2-1.8) | 0.7 (0.1-3.0) |
| No night deposits | 1.4 (0.5-4.4) | 1.4 (0.2-8.3) |
| Staffing | | |
| More than 1 worker usually on duty | 0.3 (0.1-0.8) | 24.3 (1.2-509.7) |
| Employees never work alone | 0.3 (0.1-1.1) | 1.6 (0.6-4.7) |
| Never work alone evenings | 1.4 (0.5-3.9) | 1.1 (0.3-3.7) |
| Never work alone nights | 0.4 (0.1-1.3) | 0.9 (0.2-3.7) |
| Never work in isolated areas | 0.8 (0.2-2.4) | 1.6 (0.4-5.8) |
| Usually not working outside business hours | 1.8 (0.6-4.9) | 1.0 (0.3-3.1) |
| ≥5 Administrative measures | 0.1 (0.0-0.9) | 0.2 (0.0.-0.9) |

*Effect of administrative control measures unknown for 3 cases.
†Adjusted for a priori high-risk industry, residential or industrial location, open Saturdays, workforce race and sex, relocated or opened in last 2 years.
‡Nonrobbery cases were associated with work-related disputes (n = 20), family or domestic disputes (n = 16), and disputes of unknown nature (n = 6).
§Asymptotic multivariate model failed to converge; adjusted odds ratio estimated by exact logistic regression.

Having multiple administrative control measures was, however, associated with a significant reduction in risk.

Measures for preventing workplace violence require further evaluation. Because of the diversity of the settings in which workers may be subjected to threats of violence, future studies should consider a range of industries and geographic areas. Further methodological improvements, including randomized prospective trials and consideration of different types of violent events, should be incorporated to improve the quality of measurement and control for other determinants of crime.

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## REFERENCES

**1.** Bureau of Labor Statistics. *National Census of Fatal Occupational Injuries, 1998.* Washington, DC: US Dept of Labor; 1999.
**2.** National Institute for Occupational Safety and Health. *Violence in the Workplace: Risk Factors and Prevention Strategies.* Cincinnati, Ohio: NIOSH Publications; 1996.
**3.** National Institute for Occupational Safety and Health. *NIOSH Alert: Preventing Homicide in the Workplace.* Cincinnati, Ohio: NIOSH Publications; 1995.
**4.** Occupational Safety and Health Administration. *Recommendations for Workplace Violence Prevention Programs in Late-Night Retail Establishments.* Washington, DC: Occupational Safety and Health Administration; 1998.
**5.** Occupational Safety and Health Administration. *Workplace Violence.* Washington, DC: Occupational Safety and Health Administration; 1999.
**6.** Kraus JF. Homicide while at work: persons, industries, and occupations at high risk. *Am J Public Health.* 1987;77:1285-1289.
**7.** Davis H. Workplace homicides of Texas males. *Am J Public Health.* 1987;77:1290-1293.
**8.** Davis H, Honchar PA, Suarez L. Fatal occupational injuries of women, Texas 1975-84. *Am J Public Health.* 1987;77:1524-1527.
**9.** Castillo DN, Jenkins EL. Industries and occupations at high risk for work-related homicide. *J Occup Med.* 1994;36:125-132.
**10.** Bell CA. Female homicides in United States workplaces, 1980-1985. *Am J Public Health.* 1991;81:729-732.
**11.** Erickson RJ. Retail employees as a group at risk for violence. *Occup Med.* 1996;11:269-276.
**12.** CalOSHA. Cal/OSHA guidelines for workplace security. California Division of Occupational Safety and Health; 1995. Available at: http://www.dir.ca.gov/DOSH/dosh_publications/worksecurity.html. Accessiblity verified January 23, 2002.
**13.** Casteel C, Peek-Asa C. Effectiveness of crime prevention through environmental design (CPTED) in reducing robberies. *Am J Prev Med.* 2000;18:99-115.
**14.** Runyan C, Zakocs R, Zwerling C. Administrative and behavioral interventions for workplace violence prevention. *Am J Prev Med.* 2000;18(4 suppl):116-127.
**15.** Cook PJ. Robbery violence. *J Criminal Law Criminol.* 1987;78:357-376.
**16.** Loomis D, Wolf S, Runyan C, Marshall S, Butts J. Homicide on the job: workplace and community determinants. *Am J Epidemiol.* 2001;154:410-417.
**17.** American Business Lists [database online]. Omaha, Neb: American Business Information Inc; 2001.
**18.** Executive Office of the President, Office of Management and Budget. *Standard Industrial Classification Manual, 1987.* Washington, DC: Office of Management and Budget; 1987.
**19.** Data User Services Division, Bureau of the Census, US Department of Commerce. *Census of Population and Housing, 1990: Public Use Microdata Sample, US Technical Documentation.* Washington, DC: US Dept of Commerce; 1992.
**20.** North Carolina State Bureau of Investigation. *Crime in North Carolina, 1997.* Raleigh: NC Dept of Justice; 1998.
**21.** Kraus JF, Blander B, McArthur DL. Incidence, risk factors and prevention strategies for work-related assault injuries: a review of what is known, what needs to be known, and countermeasures for intervention. *Annu Rev Public Health.* 1995;16:355-379.
**22.** Florida Statutes, §812.701 and 812.175, Convenience Business Security Act, 1990-1992.
**23.** Erickson RJ. *Convenience Store Security at the Millenium.* Alexandria, Va: National Association of Convenience Stores; 1998.
**24.** Nelson NA, Kaufman JD. Fatal and nonfatal injuries related to violence in Washington workplaces, 1992. *Am J Ind Med.* 1996;30:438-446.
**25.** Toscano G. Workplace violence: an analysis of bureau of labor statistics data. *Occup Med.* 1996;11:227-235.