

## Homicide on the Job: Workplace and Community Determinants

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Homicide is the second leading cause of death on the job for workers in the United States. To identify workplace-level predictors of homicide risk, a case-control study of worker killings in North Carolina in 1994–1998 was conducted. Workplaces were the units of analysis: case workplaces ( $n = 105$ ) were those where a worker was killed during the study period, while controls ( $n = 210$ ) were a density sample of North Carolina workplaces, matched on time and industry sector. Potential risk and protective factors were assessed in telephone interviews with workplace managers. Associations were measured by the exposure odds ratio and 95% confidence interval, estimated via conditional logistic regression. Characteristics associated with notably higher risk included being at the current location for 2 years or less (odds ratio (OR) = 5.3, 95% confidence interval (CI): 2.2, 12.6), having only one worker (OR = 2.9, 95% CI: 1.2, 7.2), and having night (OR = 4.9, 95% CI: 2.7, 8.8) or Saturday (OR = 4.2, 95% CI: 1.9, 9.2) hours. Workplaces with only male employees (OR = 3.1, 95% CI: 1.5, 6.5) or with African-American or Asian employees were also more likely to experience a killing. While few of the preceding risk factors are directly modifiable through workplace interventions, it is important to identify them before developing or evaluating preventive measures. *Am J Epidemiol* 2001;154:410–17.

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Homicide is the second leading cause of death on the job for workers in the United States after motor vehicle crashes (1). Every week, on average, 20 workers are killed, and 18,000 are assaulted (2). It is only in the last decade, however, that violence against workers has become widely recognized as an occupational health problem.

A number of epidemiologic studies have used surveillance data to describe occupations, industries, and worker groups at high risk of injury from violence (3–6). On the basis of these early studies, researchers and government agencies have identified contact with the public; exchange of money; delivery of passengers, goods, or services; working alone or at night; and working in high-crime areas as important markers for situations that increase workers' risk of being killed on the job. Work settings identified as high risk include convenience stores, gasoline stations, grocery stores, bars, nightclubs, restaurants, and taxicab services

(7–9). Most research to date has been descriptive, however, and few analytic studies have been conducted to evaluate risk factors for workplace violence (7, 10–13).

To investigate potential risk factors and protective measures for workplace homicide in detail, we conducted a case-control study of homicides in North Carolina workplaces in the years 1994–1998. Because previous descriptive research has suggested a large number of possible risk factors, we examined a broad array of questions about workplaces and their environments. Here we report on the relation of homicide risk to characteristics of the workplace, the workforce, and the community.

## MATERIALS AND METHODS

### Study population

We sought to investigate workplace-level predictors of worker homicides, such as type of business and location, rather than person-level factors, such as worker or perpetrator attributes and behaviors. Workplaces, rather than individual workers, were the units of analysis. Case workplaces (cases) were those in North Carolina where someone was killed while at work between January 1, 1994 and March 31, 1998 and were identified through the statewide medical examiner system. State law requires that all injury deaths in North Carolina be investigated by a medical examiner and that a report be filed in the central Office of the Chief Medical Examiner. We reviewed the medical examiner's records for all homicide victims aged at least 10 years. A death was eligible for inclusion if the fatal event occurred in North Carolina, the victim was at work at the time of the

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Abbreviations: OR, odds ratio; CI confidence interval.

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injury, and death occurred within 365 days. Employers and work locations were identified from either the medical examiner's report or follow-up telephone calls with law enforcement officers.

Control workplaces (controls) were sampled from North Carolina businesses and agencies contained in *American Business Lists*, a compilation of business telephone listings. The risk set for a case included all workplaces listed in *American Business Lists* that were in operation at the time of the case event. Two controls were sought for each case, but to compensate for anticipated losses due to incorrect or out-of-date information, nonresponse, and refusals, we randomly selected 10 potential controls for each case, individually matched by one-digit Standard Industrial Classification code (14). Controls were selected with replacement. A workplace could be a control for more than one case or could be both a control and a case, but this did not occur in practice.

Agricultural workplaces were excluded from the study because there was no comprehensive sampling frame for farms. Law enforcement agencies and the armed services were also excluded because case workplaces from these sectors are etiologically distinct yet are not sufficiently numerous to analyze separately.

### Data collection

To characterize the environment of case and control workplaces, information on county size and urbanization was obtained from the 1990 census (15), and county crime statistics were obtained from the North Carolina Uniform Crime Reporting Program, 1993–1997 (16).

Information about the location and physical design of workplaces, their business activities, their hours of operation, and the demographic characteristics of their employees was collected by telephone interview. The items included in the interview were identified from the literature (3–11), a descriptive analysis of North Carolina workplace homicide cases (13), and observation of local businesses. For cases, we sought information about the workplace as it was during the month in which the homicide occurred (index month). The same information was requested for controls as of the index month of the case.

After sending an introductory letter, we attempted to contact each workplace by telephone to arrange an interview, with verbal agreement to the interview accepted as informed consent. Informants were selected according to a hierarchy: The owner or manager was the preferred informant, but large employers sometimes designated another official to respond. At some smaller businesses, where the victim was the owner, manager, or sole employee, we interviewed a surviving employee or a family member. For cases, whose numbers were limited, we pursued all available avenues to identify willing, knowledgeable informants. When no other informant was available, we interviewed investigating police officers as proxies.

We did not use proxies for controls because they would not necessarily have experienced a criminal event or police investigation and therefore did not have a source of comparable informants. If we could not reach a qualified informant

in six attempts or if consent was refused, we skipped to the next potential control. Control workplaces that were not in operation in the index month were replaced to ensure that controls were in the risk set of their matched case. When interviews were completed for two eligible control workplaces for a given case, any unused controls were replaced in the pool. The average duration of completed interviews was 23 minutes.

### Data analysis

Data were analyzed in stages, beginning with descriptive tabulations. Potential determinants of homicide risk were coded as categorical variables, using binary indicators when there were more than two categories. To preserve the individual matching by month of case occurrence and industry sector, conditional logistic regression was used to analyze the relation between potential determinants and case status. The association of homicide with a given predictor variable was expressed by the exposure odds ratio, obtained by exponentiating the logistic regression coefficient and its 95 percent confidence interval. Confidence intervals were interpreted as estimates of precision rather than as indicators of statistical significance. Conditional logistic regression models were fit using the SAS PHREG procedure (SAS Institute, Inc., Cary, North Carolina). In situations in which poor fit of conventional, asymptotic models suggested sparse data, regressions were reestimated by exact conditional methods (17), using LogXact software (Cytel Software Corp., Cambridge Massachusetts).

Although a number of the variables we evaluated are potentially correlated, we generally did not treat them as confounders in the classical sense. To treat a variable as a confounder implies a prior decision that it is a nuisance factor of secondary or no interest relative to some primary exposure. Rather, we sought to identify important empirical predictors among related variables, which does not require a prior judgment about which variable is of primary interest. To assess the extent to which associations of homicide risk with single variables might be attributable to other, correlated exposures, we developed a multivariable predictive model. Odds ratios adjusted for all terms in the model were estimated by conditional logistic regression as for single-variable models. Some predictors with several categories were collapsed when the numbers were small or the models would not converge.

### RESULTS

A total of 152 homicide deaths, representing 143 case workplaces, were identified during the study period. Five 1994 case workplaces used for a pilot study were excluded, as were 24 other case workplaces associated with excluded industry categories. Interviews were completed for 105 (92 percent) of the 114 remaining case workplaces. Police officers were interviewed as proxy informants for 43 (41 percent) case workplaces when the designated informant could not be reached ( $n = 22$ ) or refused to participate ( $n = 21$ ). We attempted to contact 505 potential controls. We could

not reach anyone at 161 of these workplaces, and among the 344 contacted, 33 were ineligible. Of the 311 eligible workplaces contacted, 210 (68 percent) completed the interview, and 101 refused. The response rate did not differ significantly by industry among cases or controls.

There were 28 case workplaces in both 1994 and 1995, 27 in 1996, 25 in 1997, and six in the first quarter of 1998. The 105 case workplaces with interviews represented 10 major industry sectors: retail trade ( $n = 59$ ); transportation ( $n = 14$ ); manufacturing ( $n = 11$ ); banking and real estate ( $n = 5$ ); business services ( $n = 4$ ); and entertainment and recreation ( $n = 4$ ). The other eight cases occurred in construction, personal services, and public administration. The distribution of controls was identical because of the matched design.

### Workplace location and community characteristics

The risk of being the site of a killing was modestly increased for workplaces located in counties above the 75th percentile of population (odds ratio (OR) = 1.5, 95 percent confidence interval (CI): 0.9, 2.7) and in those with index crime rates above the 75th percentile (OR = 1.6, 95 percent CI: 0.9, 2.6). Location within city limits, in rural settings, or near interstate highway exits was not predictive of risk (table 1). Relative to those in other locations, however, workplaces located in shopping centers or malls had a lower risk of experiencing a killing (OR = 0.5, 95 percent CI: 0.2, 1.1), while workplaces in residential areas (OR = 2.0, 95 percent CI: 1.2, 3.2) or industrial zones (OR = 1.6, 95 percent CI: 0.6, 4.3) had higher risks. Workplaces that had opened or changed location within the previous 2 years had a fivefold excess risk (OR = 5.3, 95 percent CI: 2.2, 12.6), while there was no excess for those that had been in the same location for more than 2 years.

### Employer characteristics

Associations of workplace killings with selected characteristics of the employer and the work site are shown in table 2. Being open to the public and conducting cash transactions have both been identified as risk factors in previous studies, but workplaces with these characteristics had only moderately increased risks of being the site of a killing, and the confidence intervals included 1.0 (table 2). Workplaces associated with industries identified as high-risk settings in earlier research (table 2) were, however, six times as likely to experience a killing as those belonging to other industries (OR = 6.5, 95 percent CI: 3.4, 12.7). Among industries in the high-risk group (table 3), odds ratios were particularly high for taxicab services, grocery stores, convenience stores, restaurants, and bars.

Workplaces with small numbers of workers were more likely to be the site of a homicide, with the highest risk for locations with only one worker (OR = 2.9, 95 percent CI: 1.2, 7.2). Markedly higher risks were also found for sites where work was carried out at night or on Saturdays (table 2). Workplaces with operations on Friday nights had the highest risk (OR = 5.1, 95 percent CI: 2.8, 9.1). In contrast, worksites that operated only during the day or only from Monday to Friday had markedly lower homicide risks (table 2).

### Workforce characteristics

The likelihood of a workplace experiencing a homicide also varied with the predominant sex and ethnicity of the workers employed there. Locations that employed only men were three times as likely to experience a killing as those

**TABLE 1. Association of workplace homicide with characteristics of the community and the workplace location, North Carolina, 1994–1998**

	Exposed cases	Exposed controls	OR*	95% CI*
<b>Community characteristics</b>				
Metropolitan county	64	122	1.1	0.7, 1.9
County population >75th percentile	25	35	1.5	0.9, 2.7
Index crime rate >75th percentile	33	47	1.6	0.9, 2.6
<b>Workplace location</b>				
Inside city limits	81	167	1.0	0.6, 1.7
Rural area	30	59	1.0	0.6, 1.7
Within 0.5 mile† of interstate highway exit	18	41	0.9	0.5, 1.7
Shopping center or mall	8	31	0.5	0.2, 1.1
Business district or commercial area	73	148	1.0	0.6, 1.8
Residential area	66	97	2.0	1.2, 3.2
Industrial area	8	11	1.6	0.6, 4.3
>50 yards‡ from nearest building	26	66	0.7	0.4, 1.2
Nearest building occupied during work hours	95	196	1.3	0.5, 3.8
>5 years in current location	60	157	1.0	
>2–5 years in current location	15	36	0.9	0.4, 1.7
2 years in current location	21	12	5.3	2.2, 12.6

\* OR, odds ratio; CI, confidence interval. Estimated by conditional logistic regression with matching on calendar time and industry sector.

† 1 mile = 1.6 km.

‡ 1 yard = 91.44 cm.

**TABLE 2. Association of workplace homicide with characteristics of the employer, North Carolina, 1994–1998**

	Exposed cases	Exposed controls	OR*	95% CI*
Type of employer				
Public-sector vs. private-sector employer	1	12	0.9	0.6, 1.5
Single site vs. larger organization	29	76	0.7	0.4, 1.2
Site open to the public	92	174	1.8	0.8, 4.2
Cash transactions conducted	89	182	1.4	0.6, 3.2
A priori high-risk industry†	54	40	6.5	3.4, 12.7
No. of workers				
≥6	44	119	1.0	
2–5	40	80	1.4	0.8, 2.3
1	12	10	2.9	1.2, 7.2
Working hours				
Monday–Friday only	9	60	0.2	0.1, 0.4
Any Saturday hours	90	149	4.2	1.9, 9.1
Any Sunday hours	59	88	1.9	1.2, 3.0
Days only (7 a.m.–6 p.m.)	20	92	0.3	0.2, 0.5
Any evening hours (6 p.m.–9 p.m.)	68	106	2.1	1.2, 3.5
Any night hours (9 p.m.–6 a.m.)	67	64	4.9	2.7, 8.8
Friday night	67	62	5.1	2.8, 9.1
Saturday night	60	50	4.6	2.7, 8.1

\* OR, odds ratio; CI, confidence interval. Estimated by conditional logistic regression with matching on calendar time and industry sector.

† A priori high-risk industries include taxicab services, bars and nightclubs, restaurants, eating places and prepared food vendors, grocery and convenience stores, and gasoline stations. Referent group, all other industries.

where women predominated (table 4). Sites with no European-American workers were at higher risk of experiencing a homicide (OR = 10.8, 95 percent CI: 3.5, 33.5) than were those where the workforce was of mixed races. Most of the non-European workers reported were African American. Relative to sites with European workers only, those with only African-American workers experienced a higher frequency of homicide (OR = 3.2, 95 percent CI:

0.9, 11.0). Workplaces that employed Asian workers also had higher risk (OR = 3.3, 95 percent CI: 1.3, 8.5).

### Multivariable models

A multivariable model was constructed by selecting the factors associated most strongly with the risk of homicide, whether in a positive or a negative direction, from each

**TABLE 3. Association of workplace homicide with selected primary business activities as described by the respondent, North Carolina, 1994–1998\***

	Exposed cases	Exposed controls	OR†	95% CI†
Taxicab industry	11	0	25.1‡	4.1, ∞
Trucking industry	2	4	4.8‡	0.4, ∞
Bars and nightclubs	6	0	9.3‡	1.2, ∞
Restaurants, eating places, and prepared food vendors	16	20	4.4	1.6, 12.4
Convenience stores	23	12	9.9	2.9, 33.4
Grocery stores	5	2	10.6‡	1.3, ∞
Gasoline stations	11	13	3.3	1.0, 10.7
Pawnshops	3	0	5.1‡	0.5, ∞
Video rental stores	2	3	2.9	0.2, ∞
Game rooms and arcades	3	1	4.3‡	0.4, ∞

\* Referent group: all industries not listed.

† OR, odds ratio; CI, confidence interval. Estimated by conditional logistic regression with matching on calendar time and industry sector.

‡ OR and 95% CI estimated by exact methods.

**TABLE 4. Association of workplace homicide with characteristics of the people employed at the site, North Carolina, 1994–1998**

	Exposed cases	Exposed controls	OR*	95% CI*
Sex				
Majority women	37	108	1.0	
Majority men	36	81	1.2	0.7, 2.2
Men only	23	20	3.1	1.5, 6.5
Age (years)				
Any employees >65	30	62	1.1	0.7, 1.9
Any employees <18	11	41	0.5	0.2, 1.0
Ethnicity				
European (White) only	39	105	1.1	0.7, 2.0
Mixed			1.0	
Non-European only	22	7	10.8	3.5, 33.5
Detailed ethnicity				
No African-American, Latino, or Asian workers	46	111	1.0	
Any Asian workers	14	12	3.3	1.3, 8.5
Any Latino workers	11	16	1.6	0.6, 4.4
Any African-American workers	43	92	0.8	0.4, 1.4
Only African-American workers	7	7	3.2	0.9, 11.0
Tenure				
Majority part-time	33	64	1.0	0.6, 1.7
Annual turnover >25%	20	49	1.1	0.6, 2.2

\* OR, odds ratio; CI, confidence interval. Estimated by conditional logistic regression with matching on calendar time and industry sector.

group of variables in tables 1, 2, and 4. These factors were entered simultaneously with the county population and crime rate.

With the exception of county population and crime rate, the direction and relative magnitude of the predictors were similar to single-variable models (table 5). Belonging to a high-risk industry, having been in the current location for 2 years or less, operating on Friday or Saturday nights, and having a non-European workforce or a workforce in which men predominated were all strongly and positively associated with the risk of a workplace experiencing the killing of a worker. County crime was more strongly associated with risk after other variables were controlled for, while the association of county population with homicide risk became negative (table 5). Deleting nonsignificant predictors did not substantially improve the fit of the models or the precision of the odds ratios for the remaining variables.

### Homicide circumstances

In the 105 case workplaces, 60 homicides were associated with robbery of the workplace, 39 with disputes (20 work related, 16 partner or family disputes, and three other or unknown) and six with other or unknown circumstances. To investigate whether robbery-related killings tend to occur in different kinds of work settings than do other types of homicides, we repeated the analysis, stratifying on the circumstances of the case homicide (robbery vs. other) and

looking for evidence of effect modification. Interactions involving three factors were significant. Workplaces that conducted cash transactions had odds ratios of 8.2 (95 percent CI 1.2,  $\infty$ ) for robbery-related killings and 0.6 (95 percent CI: 0.2, 1.8) for others. For having working hours on

**TABLE 5. Multivariable logistic regression model for association of workplace homicide with community, employer, and workforce characteristics, North Carolina, 1994–1998**

	Adjusted OR*	95% CI*
County population >75th percentile	0.4	0.1, 1.9
Index crime rate >75th percentile	4.3	1.2, 15.7
Residential or industrial location	2.0	0.9, 4.8
≤2 years in current location	14.2	3.2, 62.9
A priori high-risk industry	4.2	1.3, 14.2
Only 1 worker	3.8	0.6, 22.8
Friday or Saturday night operation versus weekdays only	3.5	1.1, 11.8
Workforce >50% men	2.0	0.9, 4.9
Workforce 100% European ethnicity vs. mixed	1.9	0.7, 5.3
Workforce 100% non-European ethnicity vs. mixed	10.7	2.2, 52.7

\* OR, odds ratio; CI, confidence interval. Estimated by conditional logistic regression with matching on calendar time and industry sector.

Saturday, the odds ratio was 20.2 (95 percent CI: 2.7, 152.41) for robbery and 1.8 (95 percent CI: 0.7, 4.7) for other circumstances, while workplaces with evening work hours had odds ratios of 5.0 (95 percent CI: 2.2, 11.5) and 0.7 (95 percent CI: 0.3, 1.6) for robbery and other circumstances, respectively.

## DISCUSSION

Previous studies based on analyses of surveillance data have suggested that contact with the public; exchange of money; and working alone, at night, or in high-crime areas are risk factors for workplace homicide (7, 10, 18). Several studies also report high rates of homicide associated with taxicab services, grocery stores, convenience stores, bars, nightclubs, and gasoline stations (5, 19, 20).

Our findings are generally supportive of earlier observations about the kinds of workplaces where the threat of homicide may be heightened. We observed that the risk of homicide was elevated, although not strongly, for workplaces that were open to the public or that conducted money transactions. Being located in a county with a high crime rate was modestly associated with risk in single-variable models and more strongly associated after adjustment for other factors. Workplaces with only one worker had a somewhat larger increase in risk, while those that were open at night and on weekends had notably higher risks of experiencing a homicide than those that were not, with odds ratios near 5.0 for work on Friday and Saturday nights. We also observed a higher risk of experiencing a killing in several industries, including taxicab services, bars and nightclubs, convenience stores, and grocery stores.

We found, however, that some of the strongest predictors of the likelihood that a workplace would be the site of a killing were not descriptors of the employer's business or physical features of the workplace but, rather, were features of the social environment. Workplaces that employed primarily men, those with only workers of non-European ethnicity, and those that had moved or opened within the previous 2 years all had markedly higher risks of experiencing a killing. These associations persisted in multivariable models, but confidence intervals for some variables were very wide, suggesting a need for cautious interpretation of the multivariate odds ratios.

While neither the sex nor the ethnicity of people employed at a work site (as opposed to the victims themselves) is likely to affect the risk of homicide directly, they may be indicators of social interactions within the workplace or between the workplace and the community. Workplaces where the demographic makeup diverges widely from typical patterns are likely to have few employees. Sites employing African-American, Latino, or Asian workers may also be located more often in disadvantaged areas or have other characteristics associated with increased risk. Residential instability and concentration of disadvantage in neighborhoods have been found to predict the overall risk of homicide, particularly for African Americans (21, 22).

Other research has examined predictors of workplace robbery, focusing on convenience stores (7, 11, 23–25). Findings about predictors of risk of robbery are potentially relevant because about half of workplace homicides, both in North Carolina (13) and nationally (23), are associated with such crimes.

A higher risk of robbery does not necessarily increase the risk of homicide, but we found that several workplace characteristics that have been identified as risk factors for robbery in previous studies, including being in a populous county or a county with a high crime rate (11), being in business a short time (25), having a residential location (11, 24, 25), and having only White employees (25), were associated with increased risk of homicide. From previous studies of robbery (11, 24, 25), we had also expected to find that urban workplaces, workplaces in isolated locations, and those near interstate highways were more likely to experience a killing, but the data did not support these expectations. In addition, we observed higher risks of homicide in locations where most or all of the workers were of non-European ethnicity, whereas the only study to examine risk of robbery in relation to workforce ethnicity found that increased risk of robbery was restricted to stores with only White employees (25).

None of the preceding factors was stronger for killings that resulted from robbery at the workplace than for those that arose from disputes and or events. The risk of robbery-related homicide was heightened, however, where work was carried out in the evening or on Saturdays.

This study constitutes a significant step forward relative to previous research on workplace homicide. No other published study of which we are aware has examined employer- or community-level risk factors for workplace homicide. Previous studies of the problem have been based on analysis of data obtained from records, such as death certificates (4, 5, 20, 26), medical examiner or coroner reports (13, 27), or other kinds of routinely collected data (28, 29). As a result, most studies were able only to describe the occurrence of deaths or injuries by characteristics whose distribution can be estimated from population statistics, such as industry; occupation; and worker age, sex, and ethnicity. By identifying cases through the North Carolina statewide medical examiner system and assessing exposures through detailed interviews, we were able to combine the breadth of earlier studies with a deeper examination of potential causes.

The design of the study offers several advantages relative to earlier research. Matching on calendar time helps to control for secular trends in crime and other unmeasured risk factors, while prospective identification of cases should improve data quality. In addition, the North Carolina medical examiner system's statewide reporting, coding, and retrieval methods enhance the quality of the data (30–32). Homicides in the state are under medical examiner jurisdiction and are routinely investigated, regardless of motive or legal outcome. The enumeration of cases through this system is therefore likely to be the most complete available; the medical examiner system identifies more homicides than law enforcement agencies report to the Federal Bureau of



Investigation (33). We did not rely on the medical examiners' judgment of the work-relatedness of the deaths, however, because the consistency of such determinations has been a concern in previous methodological research (32, 34, 35).

Nevertheless, this study has several limitations. Because workplaces, rather than workers, were the units of observation, we could not assess the contribution of personal characteristics or behaviors to the risk of homicide on the job. These individual-level factors would be challenging to investigate; proxy respondents would be required for all cases, and there is no single sampling frame for comparable controls.

The results of this study may be affected by nonresponse and by the use of proxy informants. The only alternative to proxy interviews would have been exclusion of cases without other informants, but this would have substantially reduced power and might have introduced bias because lack of a workplace informant is likely to be related to study factors such as workforce size.

Deficiencies in the absolute validity of the data obtained from proxy informants and the possibility of differential data quality for cases and controls are potential liabilities associated with this approach. Because no other source of information was available for the case workplaces that had required proxy respondents, however, we could not directly assess the effect, if any, of proxy responses on the study results. Controlling for respondent type through matching is sometimes recommended on the presumption that data that are imperfect but comparable produce less serious bias than do imperfect but noncomparable data (36), but the validity of this assumption is questionable on theoretical and practical grounds (37). Consequently, we made no attempt to match on the type of respondent and tried to obtain the best information available for each workplace, which dictated proxy respondents for some cases but direct interviews for all controls.

We matched case workplaces and controls on industry sector as well as on calendar time to enhance efficiency. Our estimates of the association of homicide with specific industries should therefore be interpreted in light of this feature of the study design. It is probable that the impact of matching on the odds ratios for individual industries is slight and toward the null because the matching was on broad industry sectors and high-risk business activities are typically located within high-risk industry sectors.

Although the cases included both workplaces where workers had been killed in the course of a robbery and those with homicides that had occurred under other circumstances, the study was not designed for a detailed inquiry into risk factors for distinct kinds of killings. The power of subgroup analyses was limited and, more important, precipitating circumstances could be defined only for case workplaces because controls were a sample of all workplaces at risk and need not have experienced a potentially lethal event. The factors contributing to different types of killings should be investigated in studies using case workplaces and controls matched to have comparable preinjury events.

The statewide setting of this study should facilitate generalization of the results to much of the nation. North Carolina is the eleventh largest state and is representative of rapidly growing areas of the South and West that are becoming major centers of population and economic activity. The findings may be less relevant to areas with established urban concentrations and large immigrant populations. North Carolina has no cities with more than a million inhabitants, and the immigrant population remains relatively small despite rapid growth in the 1990s.

Some of the risk factors for workplace homicide that emerged from this study, including the type of industry, the workplace location, the number of years in business, and the number of employees and their sex and ethnicity, are not in themselves likely to be modified in order to protect workers from violence. We also identified a strong relation between a workplace's risk of experiencing a homicide and operating at night and on weekends, which existed regardless of whether the workplace was part of a high-risk industry. Hours of operation are modifiable, but such changes might not be acceptable to employers whose business is defined by providing services outside of traditional hours. These factors are important to identify, despite limited ability to modify them, because the knowledge can be used to plan other interventions.

At-risk workplaces might implement environmental design and administrative changes such as those recommended by the National Institute for Occupational Safety and Health (8) or the Occupational Safety and Health Administration (9). These recommendations have not been thoroughly and rigorously evaluated in controlled studies, however, so their effectiveness in preventing worker injury is not known (38). Successful evaluation of preventive measures also depends on the ability to account for the kinds of risk factors considered here.

The association of homicide with worker sex and ethnicity requires further study. It seems likely that these workforce attributes are markers for other determinants of risk, although we could not identify those factors in this study. Further research is needed on individual-level attributes and behaviors that influence workers' risk of homicide while on the job and on the links between the occurrence of workplace robberies and subsequent injuries. Prevention of violence against workers will also require an understanding of the social and economic causes of violence, beyond the confines of the workplace.

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