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Robbery-Related Injury in Convenience Stores: Estimating Lifetime Risk and Identifying High-Risk Populations

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ABSTRACT

Robbery-related injuries constitute a major risk for convenience store workers in the United States. Studies that focus on the injury outcomes associated with convenience store robbery are extremely limited in number. This is a prospective study of 1271 convenience stores in three metropolitan areas of Virginia between February 1, 1995 and September 30, 1996. The study quantifies the lifetime risk for an occupational robbery-related injury occurrence and determines the relative importance of various types of factors in the classification of high risk stores. Lifetime risk was estimated by calculating the probability in convenience stores for having one or more employee(s) sustain at least one robbery-related injury over a range of years that a store could be in operation. Results indicate that knowledge of the circumstances of the robbery are needed to maximize the identification of high risk stores. Estimated lifetime risk reaches 567 stores with an occupational robbery-related injury occurrence per 1,000 stores in operation after 45 years. This study addresses limitations of previous research by including information on clerk resistance and the number of robbers in its analysis. These two circumstantial characteristics of robbery have been previously hypothesized to be associated with robbery-related injury.

Key Words: resistance, classification, occupational and risk assessment.

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INTRODUCTION

Robbery-related injuries constitute a major risk for convenience store workers in the United States. In 1990, reports show that the convenience store industry experienced between 23,000 and 38,000 robberies (Schreiber, 1991). This research suggests that potentially tens of thousands of convenience store workers are directly placed at risk for robbery-related injuries each year. Based on survey responses of the National Association of Convenience Stores (NACS) member companies, approximately 1 out of every 5 convenience stores in the United States is robbed each year (Schreiber, 1991). In a study of 1835 convenience store robberies across selected metropolitan areas in seven eastern states in the U.S., Amandus et al. (1997) demonstrated that approximately 1 out of every 8 robberies was associated with an injury to at least 1 employee and 2 out of every 100 robberies were associated with a severe injury to at least 1 employee. Schreiber (1991) reported that homicide incidence rates in convenience stores were 1 incident per 953 stores in 1989 and 1 per 731 stores in 1990. Sexual assault incidence rates were reported as 1 incident per 472 stores in 1989 and 1 incident per 401 stores in 1990. Other violent crime (excludes homicide, robbery, and sexual assault) incident rates, including assault, abduction, and intentional injuries were 1 incident per 61 stores in 1989, and 1 incident per 46 stores in 1990. Although homicides and rapes in convenience stores are not always associated with robbery, Erickson (1991) showed that approximately two-thirds of homicides and one-third of rapes are robbery related. These results imply that thousands of convenience store workers sustain robbery-related injuries and hundreds of convenience store workers sustain severe robbery-related injuries each year.

Numerous studies have evaluated risk factors for convenience store robbery (Hunter, 1988; Amandus *et al.*, 1995; Hunter and Jeffery, 1991). Such studies have consistently indicated that the store's environmental designs (*e.g.*, escape routes, lighting, visibility, and other factors) affect the probability of robbery. Characteristics of the surrounding environment and population (*e.g.*, the degree of social disorganization, presence of gasoline service, and the amount of vehicular traffic) have also been identified as significantly associated with robbery occurrence (Duffala, 1976; D'Alessio and Stolzenberg, 1990). However, these studies only address factors associated with convenience store robbery. Conclusions concerning risk for occupational injury, based on these studies, require the assumption that inferences based on risk for robbery also hold for robbery-related injury. While recommendations for robbery interventions are designed to lower a convenience store's risk for robbery, their relative effectiveness in reducing a convenience store's risk of robbery-related injury is unclear. Until there exists conclusive research showing which factors protect against robbery-related injuries or until robbery interventions are proven overwhelmingly successful such that robbery no longer occurs in convenience stores, fewer robberies may not necessarily imply fewer violent robberies.

Studies that focus on the injury outcomes associated with convenience store robbery are extremely limited in number. Previous studies of selected metro-

politan areas have evaluated risk factors for injury conditional on robbery and provided annual estimates for injury conditional on robbery, but did not address the overall probability of robbery-related injury (Amandus *et al.*, l996; Amandus *et al.*, 1997). The purpose of this study is to estimate the lifetime risk for an occupational robbery-related injury occurrence in convenience stores and to determine the relative importance of various types of factors in the classification of high-risk stores.

METHODS

The dynamic study population included all convenience stores, N = 1271, in the Virginia Commonwealth from the following counties and cities: Arlington County, Alexandria, Chesapeake, Chesterfield County, Fairfax County, Hampton, Henrico County, Newport News, Norfolk, Portsmouth, Prince William County, Richmond, Suffolk, and Virginia Beach. All convenience store robberies, including those reoccurring in the same convenience store, were prospectively identified through police reports between February 1, 1995 and September 30, 1996. Data collected included staff and store characteristics, distance to various police focal points for criminal activity, and the circumstances of the robbery. Data concerning the occurrence and circumstances of robbery were abstracted from police reports by the Virginia Department of Criminal Justice Services. Examples of the circumstantial information include: number of robbers, type of weapon used, time of the robbery, clerk resistance, and injury status. Trained interviewers administered clerk and manager questionnaires and completed store evaluation forms. Clerks provided information on the following staff and store characteristics: the number of clerks on duty, presence of cash limit policies, employee demographics including age, gender, and race, permission to use a weapon in the event of robbery, whether weapons have been kept in the store during the previous year, whether a weapon was being kept on the premises, and whether they had received training in robbery prevention. Clerks also provided circumstantial information, including whether customers were present in the store during the robbery and information on the amount of money that was stolen. Managers provided information on staff characteristics, including their date of birth, gender, and race. Managers also provided the following store information: store name and address, size of the company, store type (e.g. corporate, franchise, independent or dealer), store age, and the store size. Retired police officers completed store evaluations, determining the presence of cash limit signs, drop safes, bullet resistant shields and video security systems. They also noted whether the drop safe was visible and whether the security system included a video monitor that could be seen by customers and robbers. Information on the surrounding area was also collected. This data included the distance (in miles) between the store and the following focal points for high crime activity: known drug trafficking activity, loitering youth and gangs, subsidized public housing projects, privately owned multifamily dwellings, and areas with broken windows, graffiti, and abandoned cars on empty lots. Census

data provided information on the surrounding population of each store. Each store was assigned longitudinal and latitudinal coordinates according to its address. Then each store was matched with 1990 census-tract data. Although all the stores in the study participated, one store chain representing 39% of the robbed stores did not allow interviewers to administer questionnaires to their clerks. Instead, the company provided information on their cash handling policies, number of clerks on duty, demographics of employees, and the details on the circumstances of the robbery.

Robberies in the convenience stores were defined as any taking or attempt of taking goods or money from the store that involved the "threat of" or the "use of" force. An occupational robbery-related injury occurrence was defined as an event in which a store has one or more employee(s) sustain at least one robbery-related injury. Robbery-related injuries included all injuries sustained by employees from acts of intimidation or physical assault experienced during the robbery. The injuries varied in their degree of severity and were both fatal and nonfatal. Injuries ranged from bruises and scratches to traumatic stress, cuts, gunshots, and other types of wounds resulting from being struck. Severe injuries were defined as those injuries that required any medical treatment, prohibited the employee from returning to work, or resulted in death. Cases that required medical treatment included injuries that resulted from either being struck on the head with a blunt object (such as a baseball bat or bottle), being punched in the face, being shot on the side of the neck with a gun, getting sprayed in the face with pepper gas, or being cut on the hand with a knife.

Store populations at high risk for having an occupational injury during robbery were identified using logistic regression. Risk for injury conditional on robbery were modeled using data from all the robberies that occurred during the 20-month period. Classification results, including percent correctly classified, sensitivity, and specificity, were examined using a range of predicted probabilities as the cutoff value for high risk. Based on classification accuracy, sensitivity, and specificity for a range of predicted probabilities, robbery occurrences with a predicted probability of injury greater than 0.1 were classified as high risk. Potential risk factors for injury occurrence during robbery were grouped into three levels of data: (1) population and surrounding area characteristics, (2) staff and store characteristics, and (3) robbery circumstances. The number of variables that could be evaluated at each level needed to be restricted because there were only a small number of outcomes in which a robbery resulted in an occupational injury occurrence. Variables that were eligible for entry into the model selection process included those with a p-value less than or equal to 0.20 at the univariate level. The final model for each of the three levels of data included those variables listed in Table 1. These variables were chosen using a backward-selection procedure in logistic regression. Further details of the selection methods will be discussed elsewhere in a manuscript currently being written for the purposes of risk factor identification. Classification results were calculated using five different models: (1) population and surrounding area characteristics alone, (2) staff and store

Table 1. Predictors of occupational injury given robbery.

1. Characteristics of the surrounding store population and store area	A. High percent of population 15 to 24 years old
	B. Low per capita income
	C. High percentage of vacant buildings
	D. Close proximity to graffiti, broken windows, and abandoned cars on empty lots
2. Characteristics of the store procedures and staff demographics	A. Cash limit policy
	B. Younger age of manager
3. Characteristics specific to the circumstances of the robbery	A. Resistance of clerk during robbery
	B. Robber's type of force/weapon used
	C. Time of the crime
	D. Number of robbers

characteristics alone, (3) staff and store characteristics in addition to population and surrounding area characteristics, (4) robbery circumstances alone, and (5) robbery circumstances in addition to population and surrounding area and staff and store characteristics. These results were used to assess the level of detail needed to accurately identify stores at high risk for occupational injury during robbery.

Health hazards associated with working in a particular environment can accumulate over many years of exposure. Otherwise known as working lifetime risk (WLTR), these cumulative estimates of risk over time are useful in setting priorities for developing interventions in a particular industry. Although traditionally evaluated at the worker level, the WLTR formula was utilized in this study in order to quantify the store-level risk in the convenience store industry over a range of years that a store could be in operation. The risk for having an occupational robbery-related injury occurrence in convenience stores was assessed by calculating the lifetime risk (LR) using the following equation (Fosbroke, Kisner, and Myers, 1997).

$$LR = \left[1 - \left(1 - R\right)^{y}\right] * 1000$$

This study presents only point estimates of risk. 'R' represents the average annual risk for having an occupational robbery-related injury occurrence; '1-R' is the average annual risk of a store not having an occupational robbery-related injury occurrence, and 'y' represents the number of years that a store could be exposed to having an occupational robbery-related injury occurrence. The lifetime risk represents the average risk in convenience stores for having an occupational robbery-related injury occurrence over 'y' years of operation.

The lifetime risk formula assumes that R, the average annual probability in convenience stores for having an occupational robbery-related injury occurrence, remains constant over the years that a store is in operation. This formula also assumes that exposure to having a robbery-related injury occurrence remains constant over the years that a store is in operation. Lifetime risk presents an average risk among convenience stores, even though the risk may vary between individual stores. In this study, y was set from 6 months to 45 years, covering a long range of possible exposures. An individual employee's lifetime risk could not be estimated since the total number of clerks at risk was unknown.

R (in the life time risk formula) was estimated using the following formula:

$$R = \text{Probability(Injury \{year\})} = \{1 - [1 - \text{Probability(Injury \{day\})}]^{365}\}$$

The Probability (Injury {day}) represents the average daily probability of having an occupational robbery-related injury occurrence. The Probability (Injury {year}) represents the average annual probability of having an occupa-

tional robbery-related injury occurrence. The Probability (Injury {day}) was estimated using the formula.

Probability(Injury {day}) = Probability(Injury|Robbery)*Probability(Robbery {day})

The Probability(Robbery {day}) represents the average daily probability of robbery. The Probability(Injury|Robbery) represents the conditional probability of injury given robbery, which was calculated as the number of occupational robbery-related injury occurrences divided by the total number of robberies.

Since annual risks may vary between individual stores, separate calculations of lifetime risk for subsets of the population were made. A range of the predicted probabilities of injury conditional on robbery were determined using the logistic model which included store and staff characteristics, population and surrounding area variables, and circumstances of the robbery. To quantify the effect of the variability in these predicted values on the annual probability of injury, the extreme values for predicted probability of injury conditional on robbery were also used to estimate lifetime risk.

RESULTS

Four hundred and sixty convenience store robberies were identified among the dynamic study population of 1271 convenience stores during the 20 month study period. These 460 robberies occurred in 299 of the convenience stores, or 24% of the total study population. Seven percent, N = 94, of all the convenience stores in the study population represent 55% of all the robbery events because these stores were robbed repeatedly, between two and seven times. Sixteen percent, N = 205, of all the convenience stores in the study population were robbed only once and represent 45% of all robbery events. Forty-one of the 460 robberies resulted in an occupational robbery-related injury occurrence, yielding a 0.089 probability of injury given robbery. Ten of the 460 robberies resulted in a severe occurrence of occupational robbery-related injury, yielding a 0.022 probability of severe injury given robbery.

Results concerning the identification of high-risk stores are listed in Table 2. Classification accuracy ranged between 63.2 and 80.8%, depending on which model was used. Model sensitivity ranged between 50.0 and 71.8%, while specificity ranged between 63.5 and 82.6%. The models which included circumstantial variables led to the highest classification percentage, the highest sensitivity and specificity, and the lowest percentages of false negatives and false positives. The remaining models achieved comparable results in terms of each of these statistics. False positives rates for all models were very high (between 72.4 and 86.7%), while false negative rates were very low (between 3.3 and 7.3%). The models were also rerun with the deletion of all observations with missing values for any variable in the model. Results were nearly identical. Details on the significant predictors for robbery-related injury will be discussed elsewhere in a manuscript currently being written for the purposes of risk factor identification.

Table 2. Classification: high risk robberies for occupational injury.

Model	No. Injuries	N	Accuracy	Sens	Spec	FPR	FNR
1. Population and surrounding area	36	380	64.5	50.0	66.0	86.7	7.3
2. Store and Staff[a]	35	375	63.2	60.0	63.5	85.5	6.1
store and staff[b]	34	358	70.9	50.0	73.1	83.7	6.7
3. Circumstances[a]	39	442	79.2	71.8	79.9	74.3	3.3
Circumstances[c]	33	349	80.8	63.6	82.6	72.4	4.4

Note: FPR = False-positive rate.
FNR = False-negative rate.

[a] Model includes only those characteristics indicated.

[b] Model includes characteristics of population and surrounding area characteristics.

[c] Model includes characteristics of store and staff and population and surrounding area.

The daily probability of robbery and the daily probability of occupational robbery-related injury occurrence were calculated as approximately 0.00057 and 0.00005, respectively. Assuming the average risk remains constant across time, the annual probability for having an occupational robbery-related injury occurrence was calculated as approximately 0.018. The logistic model was used to calculate the range of predicted probabilities for injury conditional on robbery using the 460 robbery events. Results varied between 0.005 and 0.874. These results were used to calculate a range of predicted probabilities for occupational robbery-related injury occurrence over the course of a year. The results of the annual risk for occupational robbery- related injury occurrence varied between 0.001 and 0.166.

Using the estimated annual probability for occupational robbery-related injury occurrence of 0.018, lifetime risk was calculated for a convenience store operating over a range of 6 months to 45 years. Additionally, lifetime risk was calculated with consideration for the variability in predicted probabilities of injury conditional on robbery, using the minimum and maximum risk estimates of 0.001 and 0.166, respectively. In order that lifetime risk might be clearly displayed for both small increments over the first 5 years, and for larger increments over the next 45 years, separate graphs were created for each interval. Figure 1 illustrates that empirical lifetime risk ranges between 9 and 80 stores with an occupational robbery-related injury occurrence per 1000 stores over 6 months to 4.5 years of store operation. Figure 2 illustrates that empirical lifetime risk reaches 567 stores with an occupational robbery-related injury occurrence per 1000 stores over 45 years of store operation. These

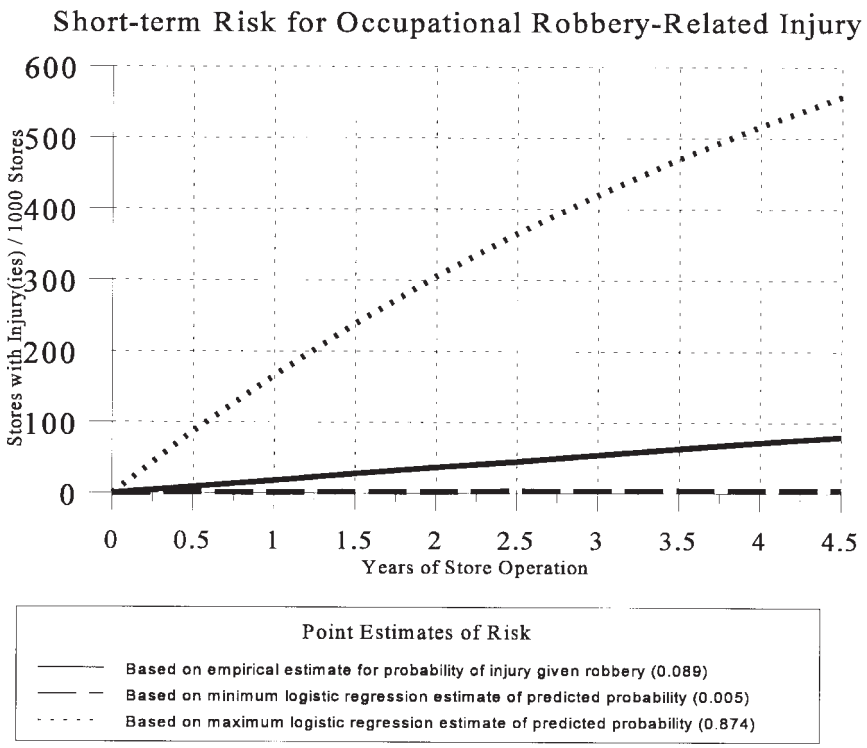

Figure 1. Lifetime risk in convenience stores for having an occupational robbery-related injury occurrence in which one or more employee(s) sustain at least one injury.

figures also show the lifetime risk using the minimum and maximum predicted probabilities. Figure 1 illustrates that lifetime risk for occupational robbery-related injury occurrences ranges between 1 and 5 per 1000 stores using the minimum predicted probability of injury conditional on robbery, and between 87 and 559 per 1000 stores using the maximum predicted probability of injury conditional on robbery. Figure 2 illustrates that lifetime risk for occupational robbery-related injury occurrences ranges between 5 and 48 per 1000 stores using the minimum predicted probability of injury conditional on robbery, and between 597 and 1000 per 1000 stores using the maximum predicted probability of injury conditional on robbery. Lifetime risk, based on the empirical risk estimate, shows the average risk of this population of convenience stores over a range of years that a store could be in operation. The estimates for lifetime risk, based on the minimum predicted probability, are representative of a subset of robbed stores in the population which had covariate values corresponding to the lowest prediction of injury risk given robbery. The lifetime risk estimated from the maximum predicted

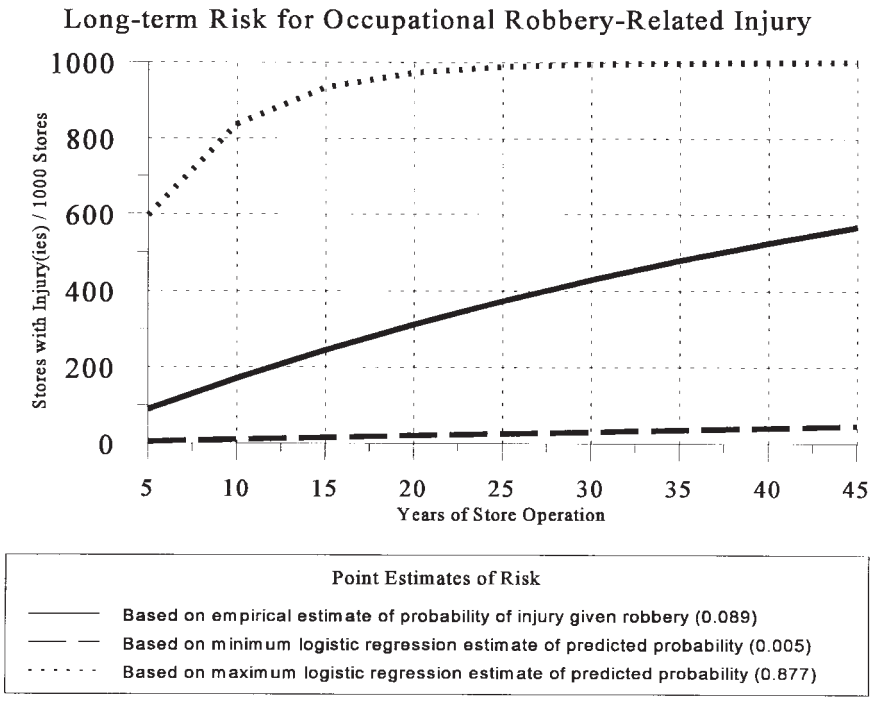

Figure 2. Lifetime risk in convenience stores for having an occupational robbery-related injury occurrence in which one or more employee(s) sustain at least one injury.

probability of injury conditional on robbery are representative of a subset of robbed stores in the population which had covariate values corresponding to the highest prediction of injury risk given robbery.

DISCUSSION

This study investigated the level of detail needed to accurately identify store populations at high-risk. Classification results indicate that high-risk convenience stores can usually be correctly identified using information concerning only the surrounding population and area and store and staff characteristics. However, in order to maximize classification accuracy, sensitivity, and specificity, and to minimize false positive and false negative rates of the model, circumstantial characteristics of the robbery need to be considered in the analysis. This limits the ability of investigators to identify populations at high risk for occupational robbery-related injury occurrence, since information on circumstances of robbery can only be collected after the robbery occurs.

This study also estimates a convenience store's lifetime risk over a range of years that a store could be in operation. The use of different logistic models to predict the probability of injury conditional on robbery leads to a wide variety of estimates for the probability of injury conditional on robbery. The results imply that, depending on individual characteristics of a store and the circumstances of robbery, the lifetime risk may vary tremendously. Empirical results indicate that convenience stores are, on average, at significant risk to experience an occupational robbery-related injury occurrence over any substantial amount of time in operation. After only 10 years of operation, for instance, convenience stores have a 17% probability for having an occupational robbery-related injury occurrence. The probability increases to 57% after 45 years. These results imply that for a population of a thousand stores operating from 10 to 45 years, the approximate range of convenience stores that will experience an occupational robbery-related injury occurrence is between 170 and 567.

These results support the importance of interventions to reduce the occurrence of occupational robbery-related injury in convenience stores. Past research in this field has largely focused on reducing robbery, with an additional objective of reducing the risk of robbery-related injury to convenience store workers (Amandus, 1993). Reducing the risk for robbery, assuming the risk for injury conditional on robbery stays constant, will reduce the overall risk of injury. However, decreasing the risk for injury conditional on robbery, assuming risk for robbery stays constant, would also lead to a decline in injury risk. The relative effectiveness of these approaches is unclear. The lifetime risk estimates assume a constant product for the values of robbery probability and injury conditional on robbery probability, over time. If the product of these values decreases over time, the calculations of the lifetime risk presented here would overestimate risk. The literature seems to indicate the probability of robbery is decreasing, but the direction of the probability of robbery-related injury, over time, is unclear since research has not thoroughly investigated the topic of robbery-related injury.

Several limitations and technical clarifications are important in interpreting study results. Very different results for the estimates of annual probability for occupational robbery-related injury occurrence would lead to very different estimates of lifetime risk. Separate calculations of the probability of robbery by important covariates, such as time of day, could lead to different risk estimates. This analysis also assumes equal exposure, which may not be completely accurate since not all stores were open 24 hours a day. Sample size restrictions, due to a limited number of occupational robbery-related injury occurrences, prohibited a more detailed analysis of these study data.

Estimates of classification accuracy may be positively biased for the purposes of future prediction since cross-validation methods were not implemented due to the limited number of outcomes. The generalizability of the study results may also be an issue since our study population was limited to convenience stores in selected metropolitan areas of Virginia. However, the annual distribution of robbery for the study population of convenience stores in the

selected areas of Virginia over the first year is fairly consistent with 1990 national estimates, with only 17% and 20% of all stores, respectively, experiencing robbery (NACS, 1991). The annual distribution pattern of robbery for the selected areas in Virginia over the first year of the study also agrees with 1990 national estimates. Convenience stores experiencing only one robbery represent 13% of all convenience stores, both in the selected areas in Virginia over the first year and nationwide, while 11% of the stores in the selected areas in Virginia over the first year and 7% of the stores nationwide experience two or more robberies (NACS, 1991). Since researchers selected the eligible areas in Virginia such that both rural, suburban, and urban areas were included in the study, this may explain why the robbery distribution patterns seen in the study resembled the 1990 national estimates.

Future research in this area should attempt to collect a larger sample of robbery-related injury outcomes. Lifetime risk estimates could then be separately calculated for severe outcomes and different subgroups of convenience stores. Calculations of the probability for occupational robbery-related injury occurrence by time of day require a detailed analysis and knowledge of each store's hours of operation. This study lacked data on the hours of operation for many of the stores. Probability of robbery and probability of injury conditional on robbery are likely to vary by time of day (Amandus *et al.*, 1997).

Very few studies have analyzed the probability for occupational robbery-related injury occurrences in convenience stores. Amandus *et al.* (1996) and Schreiber (1991) both were able to calculate the probability of injury conditional on robbery, however a limitation of these studies is that the probability of robbery is unknown. This study makes an additional contribution to the convenience store robbery-related injury research by including two circumstantial factors: a clerk's resistance during robbery and the number of robbers. Amandus *et al.* (1997) and NACS (1987) previously suggested that circumstantial characteristics may heavily influence the risk of injury during a convenience store robbery. Classification results indicate that these circumstantial factors should be very carefully analyzed when considering opportunities for prevention programs.

This study examined two main topics: the lifetime risk for occupational robbery-related injury occurrence in convenience stores and the identification of store populations at high risk. Calculations of the risk for occupational robbery-related injury occurrence over a range of years that a store could be in operation indicate the large magnitude of this problem. These results underscore the importance of prevention methods in this setting. Identification of populations at high risk for injury given robbery should help guide researchers in selecting the appropriate study population. Future research, by expanding on the details of these analyses, will provide a valuable contribution to the risk assessment of occupational robbery-related injury occurrences in convenience stores.

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