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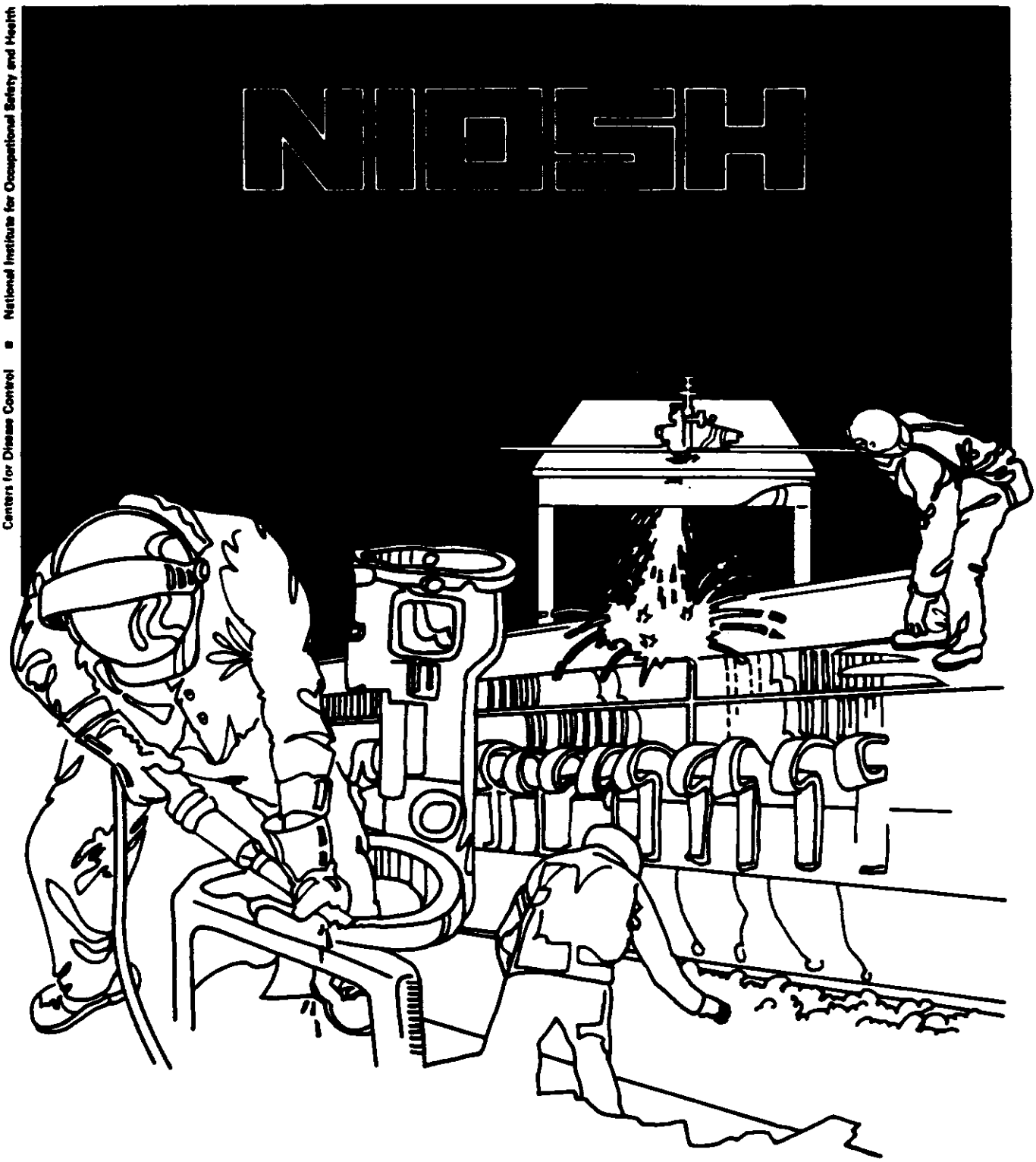


# Health Hazard Evaluation Report

## HETA 88-344-2092
## SHOPRITE SUPERMARKETS
## NEW JERSEY-NEW YORK

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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## I. SUMMARY

In August 1988, Local 1262 of the United Food and Commercial Workers Union requested NIOSH to investigate whether supermarket checkers had an increased prevalence of cumulative trauma disorders. In response, a cross-sectional study was conducted in four supermarkets. In July, 1989, an ergonomic assessment was conducted including videotaping and analysis of job tasks of checkers and non-checkers in the four stores. In October and November, 1989 a medical/epidemiological survey was conducted which included a detailed questionnaire and physical examinations of all workers in the four supermarkets.

The epidemiological analysis compared the prevalence of upper extremity cumulative trauma disorders in the checkers to the prevalence in the non-checkers. Of a total of 119 female checkers, the prevalences of disorders were: neck 16%, shoulder 15%, elbow 8%, hand 29%, and carpal tunnel syndrome 11%. Of the 56 female non-checkers the prevalences were: neck 10%, shoulder 4%, elbow 4%, hand 19%, carpal tunnel syndrome 4%.

Multiple logistic regression (MLR) analysis found elevated odds ratios for checkers compared to non-checkers for all parts of the upper extremities; however, only the associations for shoulder and hand were statistically significant at a $p<.05$ level. MLR analysis of the checkers alone found a statistically significant dose-response relationship between checking and disorders for all parts of the upper extremities. Differences were also found between prevalences of disorders in those using different checkstand designs, however, most of these were not statistically significant.

The ergonomic analysis examined repetitiveness, posture, and efficiency of movements for the different checkstand designs. The total repetitions per hour based on normal customer orders ranged from 1432 to 1782 for the right hand and 832 to 1260 for the left hand. Average forces were estimated to be low, and peak forces to be medium. Multiple awkward postures were found involving all parts of the upper extremities and are described in detail. Recommendations are given for both an ergonomically improved checkstand design as well as temporary alterations for the existing checkstand designs.

On the basis of this investigation, NIOSH investigators concluded that an upper extremity CTD hazard existed at this chain of supermarkets. Recommendations for redesign of the supermarket checkstand are included in this report.

KEY WORDS: SIC 5411 (Grocery stores), supermarkets, cumulative trauma disorders, carpal tunnel syndrome, tendonitis, cashiers.

## II. INTRODUCTION

In August 1988, Local 1262 of the United Food and Commercial Workers Union in Clifton, N.J., requested that the National Institute for Occupational Safety and Health, NIOSH, conduct a complete study to determine the nature of the problem of cumulative trauma disorders (CTDS) at Shoprite Supermarkets and make design suggestions which could resolve the problem. To answer this request NIOSH conducted an investigation that consisted of both a medical/epidemiological and an ergonomic component. The goal of the medical investigation was to compare the prevalence of upper extremity CTDs in the cashiers to other supermarket workers. This part of the investigation included a detailed questionnaire and a physical examination to assess whether current workers have a potentially work-related CTD. The ergonomic investigation consisted of direct observation and video analysis to determine the degree of repetitive motion, forceful motions, and awkward postures required by current workstation designs. The results of this analysis formed the basis for specific recommendations for redesign of the checkstands. An interim report of the results of this study was sent to the management and union on June 13, 1990.

## III. BACKGROUND

Cumulative trauma disorders of the musculoskeletal system occur in workers whose jobs require repetitive exertion, most often of the upper extremities. These disorders are usually diagnosed as tendinitis, synovitis, tenosynovitis, bursitis, ganglionic cysts, strain, or other specifically described disorders, such as carpal tunnel syndrome (CTS) and DeQuervain's disease. CTDs affect the tendons, tendon sheaths, and nerves of the involved area. Studies have shown that these disorders can be precipitated or aggravated by activities associated with repetitive exertion, particularly if the tasks require application of force in an awkward posture.[1-14] The postures most often associated with upper extremity CTDs are extension, flexion, and ulnar and radial deviations of the wrists, open-hand pinching, twisting movements of the wrists and elbows, and shoulder abduction and flexion. These type of postures and movements are frequently necessitated in many manufacturing and assembly jobs in industry. Occupations with a high incidence of CTDs include electronic components assembly, garment manufacturing, small appliance manufacturing and assembling, meat processing and packing, fish filleting, and buffing and filing of metal or plastics parts. As many as 44 cases per 100 workers per year have been reported in a meat packing plant.[15]

Motion-related, but non-occupational, risks for CTDs include hobbies and recreational activities, such as woodworking, tennis, weight-lifting, knitting, and sewing. All of these pastimes could impose physical demands on the musculotendinous system similar to those of the jobs mentioned previously.

One of the most disabling CTDs is carpal tunnel syndrome (CTS). It was reported as a clinical entity as early as 1854. However, not until 1927 was this median nerve disorder fully described and recognized as a syndrome in medical literature.[16] It is caused by compression of the median nerve (and the surrounding arterioles) inside the carpal tunnel at the wrist. Its clinical manifestation includes pain and paresthesia (numbness, burning, and tingling sensation) in the hand and fingers along the distribution of the median nerve.[17-20] These symptoms are frequently experienced while asleep, and also may include possible radiation of pain to other locations of the involved hand/arm. In the advanced stage, atrophy (wasting) of the thenar muscle (at the base of the thumb) may occur.

CTS may be associated with non-exertional conditions such as diabetes mellitus, hormonal factors (use of oral contraceptives, pregnancy, and gynecological surgery), rheumatoid arthritis, acromegaly, and gout.[21] Since many of these conditions are unique to women, their risk of CTS may be elevated. Previously, it was thought that women were at higher risk than men for work-related CTS)[12], although this study did not compare the rate of CTS between men and women performing similar jobs. Based on a series of studies encompassing several different manufacturing plants, women and men were found to be at essentially the same risk for CTS if performing identical job activities.[22,23]

There are several factors which precipitate occupational CTDs. Among these are excessive muscular force, high frequency of movements (short length of task cycles), and awkward hand/wrist postures. One study found that workers performing jobs with force levels of 4 kilograms (8.8 lbs) or more were four times as likely to develop hand/wrist CTDs as those whose jobs required muscular exertions of 1 kilogram (2.2 lbs) or less.[24] Job tasks with cycle times lasting 30 seconds or less were found to be associated with an incidence of upper extremity CTDs three times greater than with those jobs where the cycle time was greater than 30 seconds.[24] In studies reporting an increased incidence of CTDs, where the number of hand movements were recorded, the range was from 5000 to 50,000 repetitions per day.[5, 25-31] The work activities were varied and included cutting poultry, keystroking, hand sanding/filing, and packing tea.

Because of the complexity of repetitive motion patterns, it has been difficult to establish a critical frequency factor for a CTD risk. Recently, however, guidelines for using frequency of movement as a method for assigning risk to repetitive tasks were developed and applied in a study of a meat processing and packing plant.[15] Low risk was defined as fewer than 10,000 movements per eight-hour day (less than 1250 per hour), medium risk as 10,000 to 20,000 movements per eight-hour day (1250-2500 per hour), and high risk as 20,000 or more movements per eight-hour day (greater than 2500 per hour). These frequency-of-movement criteria are intended merely as

guidelines for judging the relative risk of a hand intensive job task. It is also important to note that other factors associated with the performance of a work activity, such as levels of muscular force exerted and awkward upper extremity postures, would reduce the number of movements defining each of the described risk levels.[32]

Literature Review of Epidemiological Studies on Supermarket Checkers

In the 1970s, two Japanese studies evaluated the ergonomic stresses and the prevalence of CTDs in checkers.[33,34] One of these, O'Hara et. al., found that 31% of 371 checkers had physical examination evidence of an upper extremity CTD. A 1979 German report by the Federal Institute for Occupational Protection and Accident Research assessed the ergonomic stresses of checkers.[35] Twenty-six percent of 72 checkers complained of lower extremity problems and 17% of spinal column problems. Electromyographic analysis identified the trapezius and deltoid muscles as the most severely stressed during the peak work hours. Elias, et al., in a 1981 French study which evaluated 88 cashiers, assessed ergonomic stresses and measured work load through telemetric measures of heart rate and dynamometric measures of muscle fatigue. They documented awkward postures and a significant decrease in left hand strength before and after work.[36]

In British Columbia, Canada, in 1982, a local union of the United Food and Commercial Workers Union conducted a questionnaire survey of its membership.[37] They found that 30.3% of 957 checkers reported a physician-diagnosed upper extremity CTD and some missed days of work. An additional 19% reported experiencing symptoms at work but did not seek medical attention. This study was limited by the use of questionnaire data and by potential selection bias due to a response rate of only 56%. Following this study, the same local union designed an ergonomically-improved checkstand.[38]

A NIOSH Health Hazard Evaluation was conducted in 1984 by Rosenstock et al. that compared the prevalence of disorders among checkers with that of bakers in a Seattle area UFCW local union.[39] This study used questionnaires, physical examinations, and nerve conduction velocities to diagnose carpal tunnel syndrome (CTS). No significant difference in symptom rates between checkers and bakers was found; however, checkers did have more physical examination evidence of CTS. Both groups had increased mean median sensory nerve latencies, and the checkers had a mean left median nerve latency that was statistically significantly higher than that of the bakers. This study was limited by potential selection bias, since the response rate was only 16% among the checkers and 8% among the bakers. Additionally, it was limited by the use of a comparison population that also is exposed to ergonomic stresses. These same investigators reviewed 943 patient records from an occupational medicine clinic and found that 8 out of 26 cases of CTS had worked as grocery checkers.[40]

Margolis et al. conducted a questionnaire survey in 1986 of 1,345

checkers in a single UFCW union local in the Los Angeles area. Sixty-four percent of women aged 18-49 and 76% of women aged 35-49 had complaints the researchers defined as consistent with CTS.[41] They found statistically significant associations with use of laser scanners and increased years of work as a checker. This study was limited by the use of questionnaire data alone resulting in a case definition for CTS that probably overestimated the true prevalence of the disorder.

The California Department of Health Services conducted a cross-sectional survey in a single supermarket in the Los Angeles area in 1987.[42] It examined the rate of CTS using a questionnaire, physical examination, and nerve conduction velocities. The population included 10 checkers and compared a group with high exposure to ergonomic risk factors (including the checkers) to a low exposure group. This study found a higher rate of symptoms of CTS and abnormal nerve conduction velocities in checkers compared to the lower exposure group; however, these differences were not statistically significant because of the small sample size. This study was also limited by potential selection bias with only 48% of the current employees participating in the physical examination and nerve conduction portion of the study.

## IV. METHODS

Three corporations in the Shoprite chain agreed to participate in this study: Fooderama, Big V, and Wakefern. These three corporations owned 28 stores. The managers of these stores were surveyed to determine the variation in checkstand design and store size. Four of these stores were chosen to be included in our investigation because they utilized different types of checkstand designs (Table 1). Three of the stores used laser scanners. One of these stores, Fooderama's Shoprite in Bricktown, New Jersey, had the take-off belt to the right of the checker (Figure 1a). Two stores, Big V's Shoprite in Middletown, New York, and Wakefern's Shoprite in Clark, New Jersey, had designs where the take-off belt was to the left of the checker (Figure 1b). The fourth store, Fooderama's Shoprite in Sayreville, New Jersey, had no laser scanner (Figure 1c). All four of the stores had scales above the level of the conveyor and scanner. The Middletown store used baggers most of the time, while at the other three stores the checkers did all of the bagging.

### A. Medical

A mobile medical trailer was brought to each of the four stores during the weeks of October 15, and November 5, 1989. The medical evaluation was offered to all workers during their normal working hours and included a questionnaire which asked if the workers had experienced pain, aching, stiffness, burning, numbness or tingling during the past year in the neck, shoulder, elbow, hand or back. Other questions elicited more detailed

information about their work history, hobbies, working a second job, history of acute injuries, and other medical problems associated with musculoskeletal disorders.

Each participant was also given a standardized physical examination by one of two physician examiners who were not aware of the worker's job title and questionnaire results. The criteria for defining a physical examination as positive for a CTD are listed in Table 2.

Although all workers in these four stores were allowed to participate in the medical evaluation, only those who were represented by Local 1262 were actively encouraged by union field representatives to participate. This occurred because in some of the stores there was a misconception that the evaluation was only for Local 1262 members. Therefore, this report will not include the results from any of the meat, deli, and fish workers who were evaluated. Additionally, since workers under 18 years of age could not participate without parental consent, many of those workers were not evaluated. Therefore, workers under 18 will also not be included in this report. Finally, since pregnancy has been associated with CTDs, pregnant women will also not be included.

We considered a worker to have a work-related CTD if she/he had both complaints on questionnaire and a positive physical examination of a particular part of the body. Specifically, the worker had to give a history on the questionnaire of discomfort in a particular body part which lasted at least one week or occurred at least once a month during the past year. The discomfort had to begin after starting work at that supermarket and while the worker was employed on the current job. In addition, a case of work-related CTD had to have a positive physical examination involving that body part and no history of acute injury to that body part. If a worker had an acute injury to a particular body part, or the pain began before working in that store or while working on another job, he or she was excluded from analysis of that particular body part. Since some studies suggest that night-time discomfort is characteristic of carpal tunnel syndrome (CTS), workers were considered to have CTS only if their hand discomfort awakened them from sleep. Since there are not adequate objective physical examination screening tests for the lower back, a case of lower back CTD was defined by questionnaire results alone.

The influence of working a second job and hobbies were evaluated as potential confounders. Working on a second job was categorized as a simple yes/no variable without regard to the potential repetitiveness of the second job. Hobbies, however, were categorized either as being associated or not being associated with upper extremity CTDs. This determination was

made by a physician, trained in occupational medicine and experienced with the literature on CTDs, who was blinded to the exposure and disease status of the individuals. A hobby was considered to be a potential confounder if it has been associated with CTDs and the individual engaged in it at least five hours per week.

Selected phone interviews were done after the field study so that the questionnaire could be administered to workers who did not participate in the field survey. This was done in order to determine whether those who participated were representative of the entire workforce in those four stores.

Statistical analysis of these data compared the prevalence of CTDs among the checkers to the prevalence among all other workers combined. Unconditional logistic regression using the PC program Epidemiological Graphics, Estimation, and Testing package (EGRET) was used to determine the effect of both work-related factors and potential confounders. Logistic regression analysis was also used to determine the major predictors of disorders among the checkers alone. This analysis focused both on evaluating the effects of different workstation designs and examining a potential dose-response relationship between hours and years of checking and the rate of CTDs. An alpha level of 0.05 was used as a criterion for statistical significance for all analyses.

B. Ergonomic

Site visits to four Shoprite grocery store locations were conducted July 11-13, 1989, for collection of ergonomic data. During these site visits, videotape was taken of cashier and non-cashier workers at all four of the stores. Three sets of videotapes were taken at each store: (1) a standard cart order; (2) "customer" orders; and (3) non-cashier jobs in other departments. A list of all the analyzed jobs is found in Table 3.

Standard Cart Orders

The manager of each of the participating stores provided a standard cart of groceries consisting of 33 items of various sizes, shapes, and textures which were specified in a list provided by the NIOSH project officer. The purpose of the standard cart was to evaluate differences among the various checkstand designs while controlling for the number and types of items being processed through the various checkstand designs. Seven standard cart orders were processed, consisting of one full-chute order at each of the four stores and one express lane order at each store, except the Sayreville location, which did not have an express lane. All cashiers processing the standard cart orders were females. The standard-cart orders were

processed as usual, including bagging (except at the Middletown store full-chute lane, where a bagger was present). However, there was no tender exchange or coupons handled in the standard cart orders.

Customer Orders

Customer orders were videotaped while actual customers were processed through the checkstands. Eighteen of the customer orders were processed through full-chute checkstands, and nine customer orders were processed through express-lane checkstands.

Non-Cashier Jobs

Forty-six non-cashier job activities were analyzed for the same data as for the cashier jobs, with the exception of the job-specific data, such as numbers of scans and key-ins. Non-cashier jobs included general stocking, produce, bakery, salad bar preparation, pharmacy and courtesy counters, and horticulture. The videotaping of these jobs was limited to the portions of the jobs that were being performed at the time of the site visit.

Job Analysis Methodology

Cashier jobs were analyzed for cycle time, number of items, number of scans, and number of key-ins. Cycle time for cashiers was the amount of time elapsed between reaching for the first item in an order and completing the last movement associated with that same order, including cash tendering and bagging, where applicable.

Worker data for both cashier and non-cashier jobs included the total numbers of movements for the left and right hands individually, the presence of awkward postures, and a catalog of the job activities most associated with these awkward postures. Awkward postures (Figure 2) included: flexion, extension, and ulnar/radial deviations of the wrists; supination and pronation of the forearms; abduction and flexion of the shoulders; and flexion (bending) and rotation of the trunk.

The job cycle was broken into seven tasks for the express lane orders and eight tasks for the full-chute orders. The seven tasks were the following: (1) Reaching for items located on the initial conveyor belt, (2) scanning, (3) keying, (4) reaching to the scale, (5) opening the bags (including placing plastic bags on the bag frames), (6) bagging the groceries, and (7) lifting the bags into the cart or to the customer. The additional task present in the full-chute orders was manually placing items in the bagging area after scanning or keying.

Estimates of average and peak forces were made for the cashier

and non-cashier jobs based on observed postures, estimated weight of items, and subjective evaluation of exertion. In order to compare the repetition rates of these workers with values seen in other industries, the number of movements was expressed as number of movements made per hour of work. The risk level based solely on the repetition rates was considered low for persons making less than 1250 movements per hour, medium for those making 1250 to 2500 movements per hour, and high for persons completing 2500 movements or more per hour of work. The overall risk level was determined by considering the risk levels based on both estimated force and repetition rates (see Table 4).

In addition to the total number of repetitions per order, the number of movements required per item was calculated. This measure was intended to provide an indication of efficiency among the various checkstand designs.

During a second visit, a video camera was focused on the scanner portion of full-chute checkstands at three of the same stores. (The Sayreville store was not included since no scanners were present there.) Data from these tapes were used to calculate missed scan rates. Three portions of the tapes from each store with laser scanners (Bricktown, Clark, and Middletown) were randomly selected. The number of attempts required to scan 100 items was counted in each portion of tape, and the missed scan rate was determined.

## V. RESULTS

### A. Medical

#### Participants

In the four stores combined, a total of 319 workers completed questionnaires and had physical examinations. Of these 319 workers, 38 were excluded from the analysis because they either worked in deli, meat or fish (20), they were under 18 years old (16), or they were pregnant (2). The distribution of participants by department is shown in Table 5. An additional 41 questionnaires were completed by telephone interviews. All those workers who were not checkers were grouped together as a comparison population. The demographics of the 281 field participants included in the study are shown in Table 6. The checkers were almost exclusively female (96%),while the non-checkers were only 36% female.

During the field study, 85% of the female checkers and 55% of the female non-checkers participated. Following the telephone interviews, 91% of the female checkers and 85% of the female non-checkers had completed the questionnaire.

Prevalence of CTDs

The prevalence of CTDs in checkers and non-checkers is shown in Table 7. The checkers had a higher rate of disorders for all parts of the body. CTDs of the hand and wrist were the most common problem found on examination for both checkers and non-checkers. A higher prevalence of CTDs was found in females non-checkers than in male non-checkers. The limited ergonomic analysis of the non-checker group does not allow us to determine whether this difference is due to work-related factors. Therefore, since the prevalence of disorders was higher in female non-checkers than in male non-checkers, and the small number of male checkers made stratification by gender impossible, we chose to confine our statistical analysis to the 119 female checkers and the 56 female non-checkers.

To better characterize the effect of these disorders on the checker's ability to continue working, we calculated the rate of missed workdays and visits to a health care provider for each category of CTD. Table 8 shows the self-reported rate of missed workdays and visits to a health care provider due to these CTDs. Those with carpal tunnel syndrome had the highest rates of missed work and visits to a medical provider. In general the rates for missed work ranged between 12% and 23%, and the rate of visits to a medical provider ranged between 6% and 38%.

We examined which side of the body was affected by these CTDs based on the results of the physical examination. Table 9 shows the frequency of right-sided, left-sided, and bilateral involvement among those with disorders. The prevalence of each disorder was similar for both sides of the body although slightly more common on the right for the shoulder and hand. This finding is consistent with videotape analysis showing that checkers used the right hand more frequently for tasks such as bagging and keying.

Comparison of Checkers to Non-Checkers

In order to determine if checking was associated with CTDs, a statistical analytic method (multivariate logistic regression) was used to examine the relationship between checking and CTDs, while taking into account several work-related and non-work-related factors which potentially could also cause CTDs (Table 10).

The results of this statistical analysis is shown in Table 11. These results are in the form of odds ratios (OR) which indicate for each CTD the odds of being a checker compared to the odds of being a non-checker. An odds ratio above 1.0 indicates an association between being a checker and the CTD. The 95% confidence interval (CI) indicates the probable range within which the odds ratio actually falls. If the confidence interval

includes 1.0, the association between checking and a CTD could have occurred by chance alone and the elevated odds ratio is not considered statistically significant. The odds ratio is an estimate of the risk for a checker developing a CTD compared to the risk for a non-checker. It provides a more accurate estimate if the prevalence of the condition is low, a circumstance which does not apply to most of the CTDs found in this study.

There was a statistically significant association between checking and having a CTD ("any CTD" in Table 11). Statistically significant associations were also found between checking and CTDs involving either the shoulder or the back alone. There was a higher prevalence of neck CTDs, elbow CTDs, and CTS in checkers compared to non-checkers, but these associations were not statistically significant. Those with hand CTDs were statistically more likely to be checkers, but this was found only in those workers who had been checkers for at least 10 years (Figure 3).

To determine the effect of the low participation rate of the non-checkers in the field, we compared the odds ratios from data collected only in the field to those calculated from data collected both in the field and by telephone interviews. (Figure 4) The association between checking and disorders was similar when participation among non-checkers was raised to 85%.

The ergonomic analysis of the non-checkers showed that these workers performed work requiring repetitive motions and awkward postures (see discussion section below). Therefore, comparing checkers to non-checkers probably resulted in lower odds ratios than would have been observed if the comparison group had been truly unexposed to ergonomic stresses. Thus, these odds ratios probably underestimate the actual risk of CTDs in the checkers.

Evaluation of Risk Factors Among Checkers

In order to explore further the potential work-related risk factors for CTDs among checkers, we analyzed the data for checkers alone to look for a dose-response relationship between checking and disorders (i.e., increased risk of disorders with more time spent checking). We used two measures of dose: months working as a checker adjusted for age, and hours per week working as a checker adjusted for working a second job. Figure 5 shows the relationship between the length of employment as a checker and neck CTDs, hand CTDs, and CTS. There was a statistically significant association between longer employment as a checker and these CTDs, but not for shoulder, elbow or back CTDs.

Figure 6 shows the relationship between the number of hours per week of checking and shoulder CTDs, elbow CTDs, and CTS. The

number of hours working as a checker was statistically significantly related to shoulder and elbow CTDs and of borderline significance for CTS (p=.09). The relationship with hours working was not significant for neck, hand, or back CTDs.

We also evaluated the effects of several design features of the checkout stand, including left versus right takeoff belt designs, and the use of a laser scanner versus no scanner. The prevalence of disorders in each of the four stores is shown in Table 12. We were not able to look at differences among all of the four stores because of the small number of checkers at any one store. Instead, we chose to examine several major design characteristics found in these stores. As with the previous analyses, we used multivariate analysis to adjust for all significant factors listed in Table 10.

First we examined the effect of the use of the laser scanner. The prevalences of CTDs in the stores using scanners and the store not using a scanner are found in Table 13. The store with no scanner was small, with only 15 checkers, and had no cases of CTS or shoulder disorders that were confirmed on physical examination. Our statistical analysis cannot be done when there are no cases in one of the two groups. Therefore, for statistical analysis, we used cases defined by questionnaire alone. Table 14 shows that there was a higher prevalence of CTDs by questionnaire among checkers using a laser scanner, than among those not using a laser scanner. The only statistically significant association was between shoulder CTDs and using a laser scanner.

We next looked only at the three stores with laser scanners. Two stores had a design with a takeoff to the left (Figure 1b) and a third had the takeoff belt to the right (Figure 1a). Besides the difference in the side of the takeoff belt, there were also differences in the orientation of the checker relative to the laser scanner. In the right-sided design, the checker stands behind the scanner while with the left-sided design the checker stands to the side of the scanner. Table 15 shows the prevalence of CTDs in checkers using these two designs and the results of the statistical analysis. There were higher prevalences among workers using the left-sided design for all types of CTDs, except elbow and back; however, none of these relationships was statistically significant.

Finally, we examined the effects of the cashier's height. Although checkers vary in size, the checkstands are not adjustable. We compared short individuals (defined as 5 feet 2 inches or less) to all other checkers. Table 16 shows the prevalences of CTDs and statistical analysis for short checkers versus others. The prevalences of CTDs of the shoulder, elbow, and hand, and CTS were higher in short checkers, while the prevalences of CTDs of the neck and back were lower. This

pattern suggests that short workers have more problems related to reaching because of their shorter arm span. However, since they are closer to the register and checkstand surface they may not stoop and bend as much, which could explain their lower rates of neck and back disorders. These findings would suggest the need for adjustable workstations to accommodate workers of varying sizes.

## VI. Ergonomic

### A. Standard Cart

#### 1. Full-Chute Lanes

Checkstand Design

The variations in full-chute checkstand design characteristics are outlined in Table 1, including: (1) position of the second conveyor belt (chute) in relation to the workstation (right chute or left chute); (2) presence/absence of a bagger; and (3) presence/absence of a scanner. All scanners were mounted horizontally and presented a vertical beam. The variations and dimensions are shown in Figure 1a, 1b, and 1c for the Bricktown, Clark/Middletown, and Sayreville stores, respectively. The checkstand design was the same at the Clark and Middletown stores, although the operation differed since a bagger was present at the Middletown store.

Repetitiveness

Table 17 shows the job and worker data from the standard cart analyses. Cycle time within the full-chute lanes ranged from 155 seconds at the Middletown store to 295 seconds at Sayreville. The number of items varied from 32 to 35, even though each store manager had received the same list describing the types of items to include in the order. The number of scans exceeded the number of items at all three stores with laser-scanners. In all stores except Middletown, the right hand was used more than the left during the cycle. The Middletown cashier (who did not bag) distributed movements almost equally between hands and had a lower repetition rate (67% and 57% lower for the right and left hands, respectively) than the cashiers at the stores without baggers.

Medium repetition rates (based on the movements per hour data) were determined for both hands, except for the left hand at the Sayreville full-chute lane and both hands at the Middletown store. The repetition rates for these three exceptions were in the "low" category.

Postures

The awkward postures noted in the standard cart orders for each of the four stores (Bricktown (B), Clark (C), Middletown (M), and Sayreville (S)) are listed in Table 18. Although not noted in the tables, similar postural patterns were observed during the analysis of customer orders. The laterality (right (R), left (L), or both (2)) of each awkward posture observed is indicated for the activities noted.

In general, cashiers assumed awkward wrist, forearm, shoulder, and trunk postures as they reached for items on the conveyor belt. The Bricktown cashier reached for items with both hands, resulting in bilateral shoulder flexion and trunk flexion and rotation. The cashier at Clark faced the scanner and reached to her right side for items. Various awkward wrist and forearm postures, trunk flexion, and trunk rotation were observed in this cashier. The Middletown cashier faced the initial conveyor belt and pulled items towards the scanner at her left side. Awkward postures during reaching for items were right forearm supination and trunk flexion. The cashier at the Sayreville store stood in front of the register to key items which she reached with her left hand. Awkward postures of the Sayreville cashier's left wrist, forearm, and shoulder were observed.

The awkward postures associated with scanning were concentrated at the wrist. Using both hands, the cashier at Bricktown often extended both wrists. The Clark cashier, facing the scanner, extended the left wrist while scanning average and large sized items and flexed either wrist when handling small items. The Middletown cashier tended to use both hands equally in scanning. Although no awkward wrist postures were observed while the Middletown cashier reached for items, various awkward wrist postures were observed during the initial portion of the scanning motion, due to the cashier standing with the scanner to her side. Left wrist flexion was observed in the Middletown cashier during the final stage of almost every scan. No scanner was present at the Sayreville store.

Some postural patterns observed during keying appeared to be influenced by the individual working style of the cashiers. For example, a tendency for wrist extension while keying was noted during several customer orders at the various stores, but was not detectable during the standard cart orders. During the standard cart order, left wrist flexion was observed in the Bricktown cashier as she held items in the left hand while keying with the right hand.

While reaching to the scale at all of the full-chute

checkstands, the cashiers had either to abduct or flex the shoulder, as well as occasionally rotate the trunk.

The awkward postures observed while cashiers placed items into the bagging area included wrist flexion, shoulder extension/flexion, and/or shoulder abduction, and trunk rotation. The particular pattern observed depended on where in the bagging area the item was placed and the size of the item.

Opening the bags resulted in several awkward wrist postures at the Bricktown and Clark stores. Wrist rotation was observed as the cashiers placed the plastic bags onto the metal frames. Due to the routine presence of a bagger, the Middletown cashier did not bag groceries for the standard-cart order. The Sayreville cashier chose not to place the plastic bags onto the metal frame and demonstrated no awkward postures while opening bags.

While bagging the groceries, several awkward postures were assumed at the wrists, shoulders, and trunk. The wrist postures included both wrist flexion and extension while grasping the items. The cashier at Sayreville showed bilateral shoulder abduction and left shoulder flexion due to placing the bag on top of the bagging area. Some combination of trunk flexion or rotation was observed at each of the three stores at which bagging was performed by the cashier.

While cashiers lifted plastic bags into the cart, wrist extension and ulnar deviation were observed. Placing the bags into the cart or handing them to the customer often resulted in shoulder abduction and/or flexion. Trunk flexion was observed at Sayreville while the cashier leaned over the bagging area to place the bags into the cart. Trunk rotation was observed in the Bricktown cashier while she placed the bags into the cart beside her.

2. Express Lanes

Workstation Design

The design of the three express lanes was similar except that the register was placed to the right of the conveyor belt at the Clark and Middletown stores and to the left of the belt at the Bricktown store. Two metal bag frames (for plastic bags) were placed at the end of the conveyor belt at the Bricktown and Middletown stores. The Clark express lane, where plastic bags were not used, had a shelf on which paper bags were placed for bagging. The variations in the express-lane designs are shown in Figures 7a, 7b, and 7c for the Bricktown, Middletown, and Clark stores respectively.

The Sayreville store had no express lane.

Repetitiveness

The job and worker data for the express-lane standard cart orders are listed in Table 17. Cycle time for the three standard cart orders ranged from 163 to 207 seconds. The total number of scans and key-ins was greater than the number of items at all three checkstands. The total number of movements within the cycle ranged from 75 to 105 for the right hand and 57 to 73 for the left hand. Calculated movements per hour indicated medium repetition rates for each hand at all three checkstand designs, except for the left hand at the Clark express lane, where the repetition rate was low.

Postures

The awkward postures noted in the express-lane standard cart orders are listed in Table 19 for each of the three stores with express lanes (Bricktown (B), Clark (C), and Middletown (M)). Although not noted in any of the tables, similar postures were observed in the analysis of the customer orders. The laterality (right (R), left (L) or both (2)) of each noted posture is indicated for each of the activities noted.

As the cashiers reached for items on the conveyor belt, they tended to pick up the items while extending one or both wrists. Shoulder abduction was observed in the Middletown cashier as she reached to the side. Shoulder flexion was noted for all cashiers when they reached forward. Trunk flexion was observed in all three cashiers and trunk rotation was noted for the Bricktown and Middletown cashiers as they turned to fit between the two bag frames. Wrist flexion occurred while the cashiers pulled the items towards the scanner.

The awkward postures associated with scanning were concentrated at the wrist. Often, wrist flexion and ulnar deviation occurred simultaneously. Shoulder abduction, noted in the Middletown cashier, occurred while she scanned items located close to the register. Trunk flexion during scanning was due to the need for the cashier to lean over the bag frame. The Bricktown cashier was constantly in trunk flexion except when keying or placing bags into the cart.

During the keying activity, awkward wrist postures were noted at two stores. The cashier at the Bricktown store extended her wrist while keying. Ulnar deviation of the left hand of the Middletown cashier occurred as she held

items in the left hand while keying the price with the right hand. Trunk rotation resulted occasionally when the Clark cashier turned only the trunk to reach the register rather than repositioning the whole body.

Two approaches were used by the cashiers to reach the scale. The first was to face the scale and flex both the trunk and the shoulder. The other observed posture was to reach from the side of the scale and rotate the trunk, abduct the shoulder, and supinate the forearm. Often some combination of these styles was used while reaching to and from the scale. Postural analysis of this activity could not be completed for the Bricktown express lane since no produce was included in the order.

Doubled paper bags were used at the Clark store and plastic bags were used at the other two stores. Opening the bags resulted in several awkward wrist postures. The opening of the plastic bags on the metal frames required wrist rotation progressing from an extended wrist posture to ulnar deviation and wrist flexion. The awkward wrist postures of the left hand of the Clark cashier were seen while she held one paper bag and opened a second paper bag. Trunk flexion was only seen when the Bricktown cashier needed to reach small bags for particular items, such as frozen foods.

Various awkward wrist postures were observed in all cashiers during bagging. Shoulder abduction occurred as the Clark and Middletown cashiers selected items from the bagging area, lifted large items from the conveyor belt, and placed items into each of the bags.

Wrist extension and shoulder abduction for the Bricktown and Middletown cashiers and ulnar deviation in the Bricktown cashier occurred as the cashiers placed the plastic bags into the cart. The Clark cashier showed no awkward postures when she lifted the paper bags during either the standard cart or customer orders.

3. <u>Comparison of Full-Chute and Express Lanes</u>

Since the numbers of items were approximately the same, a comparison can be made between full-chute and express lane standard cart orders (Table 17). In general, the cycle time and the number of movements per cycle were less for the express lanes than for the full-chutes, with the exception of the Middletown full-chute lane. The Middletown full chute had the shortest cycle time and the least number of movements per cycle compared to all other standard cart orders. This was due to the checkers not doing bagging activities. Within the Clark and Middletown stores, the shorter cycle time at the express checkstands resulted in a

greater number of movements being made per hour by express lane cashiers than full-chute cashiers, with the exception of left-hand rates at the Clark store. The highest hourly repetition rates for both right and left hands were calculated for the Bricktown express lane (2055 and 1591, respectively).

B. Standard Cart versus Customer Orders

Eighteen full-chute and nine express lane customer orders among the four stores were included in the analysis. The differences between customer orders and standard cart orders were the following: (1) No coupons nor tender exchange in the standard cart orders, and (2) occasional customer assistance with bagging during the full-chute customer orders.

1. Full-Chute Orders

Repetitiveness

The comparison of the ergonomic analyses of the full-chute standard cart to the full-chute customer orders are shown in Table 20. The average cycle time for the 18 full-chute customer orders was 91 seconds less than the average for the standard cart orders.

The within-store difference between the standard cart orders and customer orders in total number of movements per hour was greatest at the Middletown store for the right hand, where more movements were calculated for the customer orders (1545 movements per hour) than for the standard cart orders (951 movements per hour). The cashiers assisted in the bagging of items in the customer orders. Bagging by the cashier at the Middletown store was not included in the standard cart analysis.

Estimated Forces

The average and peak estimated forces were rated as low and medium, respectively, for each full-chute checkstand design. The overall risk was determined to be medium for the right hand at all workstations except the Middletown standard cart order, where the risk was low. The risk assessment for the left hand indicated low levels except for the Middletown customer orders and Bricktown and Clark standard cart orders, where the risk was determined to be medium. Therefore, a medium risk level for developing CTDs was noted for at least one hand at each checkstand design.

Efficiency of Movement

The Middletown store had the best efficiency rating (lowest number of movements per item) for both the standard cart and customer orders, with movements distributed evenly between hands. The other stores had various efficiency ratings, with more right-handed movements than left-handed movements for each item, regardless of the checkstand design.

Express Lanes

The results of the ergonomic analyses of the express-lane standard cart and customer orders are shown in Table 21.

Repetitiveness

Because of the large difference in the average number of items between the standard cart and customer orders (34 versus 6 items, respectively), no comparisons of cycle-related variables were made.

A larger number of total movements per hour was seen in customer orders than in standard cart orders for the right hand at the Bricktown store and for the left hand at the Middletown store. The only condition with more left-handed movements (1343 movements per hour) than right-handed movements (967 movements per hour), on average, was the Middletown express-lane customer orders.

Estimated Forces

The average and peak estimated forces were rated as low and medium, respectively, for each express-lane checkstand, with the exception of low peak force for the customer orders at Bricktown. The overall risk level (combination of force and repetitiveness) for the left hand of the Bricktown cashier was low during customer orders and medium during standard cart orders. The risk level based on right hand data, however, was high for the customer orders at Bricktown and medium for the standard cart orders. Except as noted above, all other risk levels were the same for a given hand when comparing the customer and standard cart orders within the same stores. Using the stated criteria for repetition and force, the data indicate that cashiers at the Middletown and Clark stores express lanes are at medium risk of developing CTDs, while the cashiers at the Bricktown store express lanes are at high risk.

Efficiency of Movement

At each store, the express-lane efficiency ratings for the standard cart orders were better than for customer orders. A greater number of right-handed than left-handed movements was seen for each item at all stores (both customer and

standard cart orders) except at the Middletown store. At the Middletown store, the efficiency was the same for both hands in the standard cart order. In addition, more left-handed movements per item were made than right-handed movements per item for the customer order. The greatest difference in efficiency between the right and left hands was seen at the Clark store, where the number of right handed movements was approximately two times the number of left-handed movements. The largest efficiency difference between the standard cart and customer orders was in the right hand at the Bricktown store, where more than twice the number of movements per item was made during customer orders (5.7 movements per item) than for the standard cart order (2.8 movements per item).

C. Missed Scans

The missed scan rates were determined to be 10.3%, 13.5%, and 44.8% for the Bricktown, Middletown, and Clark stores, respectively. No assessment was able to be done to determine whether this wide variability was due to scanner glass quality, checker technique variability, or any other factors.

D. Non-cashier Jobs

The videotaping and analysis of the non-cashier jobs were limited to a sample of the various tasks included in those jobs. As such, repetition rates and force estimates which are based on the entire range of activities typically performed by the non-cashiers studied are not available. Within these limitations, the repetition rates and estimated average and peak forces determined for the various non-cashier jobs are listed in Table 22.

This analysis showed that the non-cashiers were also exposed to ergonomic stresses. Since the analysis was limited to a small portion of their usual activities, this assessment should not be considered an overall ergonomic assessment of those jobs. Specifically, their risk level cannot be compared to the checkers' risk level which was based on a complete assessment of all of the tasks included in a checker's job. This analysis is useful, however, in establishing that the non-checker group is not an unexposed population, and thus any statistical tests comparing checkers to non-checkers may underestimate the relative risk of disorders in checkers compared to a population that is truly unexposed to ergonomic stresses.

## VII. DISCUSSION

In summary, the medical evaluation found that checkers have a higher rate of cumulative trauma disorders than non-checkers, and that there is a dose-response relationship between checking and these

disorders. Our analysis of checkstand design suggests that those who use a laser scanner have higher rates of CTDs than those who do not use laser scanners. Also, those who use a left takeoff belt have higher prevalences of neck CTDs, shoulder CTDs, and CTS than those who use a right takeoff belt. Finally, short checkers had higher prevalences of shoulder CTDs, elbow CTDs, hand CTDs, and CTS. Although most of the differences in the prevalences of disorders between designs were not statistically significant they were consistent in the associations they found. Because of the small number of checkers working at any one type of checkstand, the study had little power to detect statistically significant associations between CTDs and the checkstand design. The results of the ergonomic evaluation, discussed below, also suggest that all of the designs present ergonomic problems. This could also explain why none of the workstation designs was associated with significantly lower rates of CTDs. These limitations as well as others are discussed in Section VIII.

Cashiers perform a variety of unstructured activities during a job cycle, e.g., scanning/keying, bagging, and tender exchange, rather than a recurring pattern of structured movements, as is often seen in traditional industrial work tasks such as cutting, manufacturing, and assembly work. Another unique aspect of cashier work is the interaction with customers not normally seen in typical industrial tasks. Moreover, the pace of work by the cashier is largely dictated by the customer load at any particular time. However, the determination of job risk level based on repetitions per hour allows for a useful comparison of repetitiveness between cashiers and workers in other industries (even though cashiers typically work less than eight-hour days).

A. Workstation Design

The purpose of using a standard cart order was to compare the ergonomic characteristics of different checkstand designs. A variety of design differences was noted among the four full-chute checkstand designs, but these only accounted for minor differences in observed postures and movement patterns. Most of the variability noted was due to the unstructured nature of the task, which allowed the movement patterns to be chosen by the cashiers based on individual preferences. It was not possible to determine which checkstand might be considered a better ergonomic design due to the presence of problems common to each checkstand style.

Right versus Left Chute

The side to which the second conveyor belt (or chute) was located in relation to the cashier seemed to have only minor, if any, effect on repetition rates. The cashiers consistently performed more right-hand movements when bagging was included in the task. The risk levels and movement efficiencies were also

consistent between the right- and left-chute checkstands. A tradeoff in awkward postures was noted between right- and left-chute orientations when the checker reached for items and placed bags in the cart, but scanning and bagging also caused stress to similar body parts.

Reach Distance

In general, the reach distances to items on the conveyor belt were too long for both full-chute and express lanes. In the full-chute lanes, the cashiers were required to reach over the scanner and metal guards. Additionally, the cashier was required to reach around the cash register to grasp items from the initial conveyor belt in a left-chute lane and across a metal guard in the right-chute lane. In the express lanes, the cashier reached across a bag frame, the scanner, and a metal guard to reach items. The height and distance of the scales and receipt printers at both full-chute and express lanes also required extreme reaches.

Awkward postures, particularly of the wrist, were observed during scanning regardless of either the placement of the scanner or the cashier's location in relation to the scanner.

Bagging

The bagging aspect of the checker's job had an influence on both the repetition rates and awkward postures observed for the cashiers as seen in the store-by-store comparison of standard cart orders. The reduced number of repetitions by at least 67% and 57% for the right and left hands, respectively, when bagging was not done by the cashier (Middletown) indicates the major influence of bagging on the cashiers' task. The cycle time for the full-chute order at the Middletown store was shorter than at any of the other three stores, likely due to the presence of the bagger, since this was the only major difference between designs. The elimination of bagging also minimized the number of awkward postures assumed by the cashier. However, when the customer orders were compared to the standard cart order the Middletown checkers had repetition rates which were similar to the other stores due to their assisting with bagging. Therefore, the potential advantages of using baggers may not be seen among the Middletown checkers.

The immediate bagging of items (scan-and-bag) reduces the amount of repetitions per order as seen in the express lane orders versus the full-chute orders with the same number of items. Large orders through a full-chute lane, however, may require an option of allowing items to proceed into a bagging area. The ability to bag some items immediately would reduce the size requirements for the bagging area, and thus minimize reach distances.

For those cashiers who did bag, four major issues which influenced bagging were noted: (1) checkstand design characteristics; (2) use of metal frames for plastic bags; (3) use of plastic versus paper bags; and, (4) customer assistance with bagging.

The major design problem of the bagging task is that the large bagging area creates extreme reach distances to items which accumulate in the far end of the bagging areas in the full-chute checkstands. Trunk flexion and shoulder flexion/abduction are common awkward postures seen as a result of this excessive distance. The bagging area should be redesigned so that the reach distance for the cashier (or the bagger) is shortened. However, the bagging area must still be large enough to accommodate the space requirements of large orders processed through the checkstand.

The use of the metal frame for plastic bags resulted in rapid and repetitive awkward wrist postures while opening the bags. The purpose of the frame is to keep the bag open during bagging, although it is possible that this could be accomplished with another design. The alternative bagging method that was chosen by the Sayreville cashier was not to use the metal frame. Instead, the cashier held the bag open, which served to minimize awkward postures and movements while bagging. The disadvantage of this approach was that the cashier had to place the bag on top of the bagging area, resulting in shoulder abduction and flexion.

The use of paper bags at the Clark express lane demonstrated a possible solution to the problems believed to be associated with the use of plastic bags. Awkward wrist postures were noted in the cashier opening paper bags, while processing the standard cart order. However, it appeared that the speed of movement was less than that observed in cashiers opening and placing plastic bags on the metal frames. The awkward postures observed in cashiers opening paper bags did not appear to be necessary, and may be eliminated through training. The awkward postures observed in cashiers opening and attaching plastic bags to the metal frames seemed to be unavoidable. The analysis of only one cashier using paper bags is a recognized limitation of this study, but the difference between using paper bags and plastic bags was evident. Based on the limited data collected in this study, further investigations into the ergonomic stresses caused by the use of plastic versus paper bags would be important. The repetitions during customer orders at the full-chute lanes were influenced by customer assistance in bagging items. The total number of repetitions would be reduced if the customers always helped bag the groceries, but the intermittent pattern of customer assistance does not allow for an accurate determination of the overall effect.

B. Work Practices

Several of the stressful postures and movements performed by the cashiers did not appear to be required by the checkstand design, but rather were chosen for the convenience of either the customer or the cashier. Moreover, the cashier may not have been aware of the stress associated with the movements and postures assumed. Examples of these activities are tying plastic bags and handing them to the customer, and reaching over the conveyor to retrieve items from a customer's cart. It was not clear if the customer influenced the cashier's motion patterns in these instances, but these seemingly unnecessary movements and postures may be a consequence of dealing with the public, where restricting one's movements and motion patterns to the minimum and most efficient is not always possible.

The overall risk assessment for cashiers at the four stores evaluated was medium for most cases. Another similar NIOSH investigation in a meat packing plant found that those classified as medium risk had similar CTD rates as those classified as high risk, and both groups had significantly higher rates of CTDs than the low risk group.[18] When bagging was performed by a bagger (Middletown standard cart), the repetition rate was a low risk level, emphasizing the effect of rehandling items during bagging (first to scan, again to bag). The overall force levels were estimated to be relatively low, but the cashiers are required to exert more force during certain aspects of their job such as lifting and scanning heavy items and lifting filled bags, which were considered to involve medium or high force levels. These high peak forces may be important in the development of CTDs. In the study of the meat packing industry mentioned above, peak force was an important predictor of hand/wrist CTDs.[18] In addition, many of the activities judged to use low force involved quick movements of the hands or wrists. Examples are opening bags, scanning (and rescanning) items, and keying. It is possible that these movements result in acceleration levels high enough to impose an added stress to the musculoskeletal system. However, since limb acceleration levels (if any) were not measured, and cannot be judged visually, the subjective force levels assigned to jobs may underestimate the true forces exerted by the worker.

C. Missed Scans

Extra repetitions and awkward postures result due to missed scans. The reason for missed scans can include a dirty scanner window, poor contrast, and poor alignment between the items' bar codes and the laser beam. The new generation of scanners, which are able to scan more surfaces may increase the success rates of scans.

## VIII. LIMITATIONS

This investigation was limited by its cross-sectional design, which measures the prevalence of disorders at a particular point in time. There could be workers who developed problems and left work or moved to other jobs who would not be counted in this evaluation. This could result in the underestimation of the occurrence of CTDs. The study was also limited by the relatively small numbers of workers included in the final analysis, the lack of a truly unexposed comparison population, and by the limited choices of checkstand designs. Although this study was larger than any previous study of supermarket checkers that included physical examination data, it was difficult to compare checkers who worked at different checkstand designs since the number of checkers using any one design was small. The ergonomic analysis of the non-checker comparison population showed that they too were exposed to ergonomic stresses. Comparing checkers to a population that was exposed to similar stresses (though lesser in magnitude) would lead to an underestimation of the relative risk for CTDs in checkers. Finally, since the ergonomic analysis showed that all of the checkstand designs had ergonomic problems, it would be unlikely that cashiers working at any one of these designs would have resulted in substantially lower rates of CTDs than the others.

The ergonomic analysis was based on a limited amount of videotape taken during portions of a full work shift. For the standard cart orders, only one cashier was evaluated at each of the seven workstation designs. For the regular customer orders, the number of cashiers videotaped varied between stores. The analysis of the videotapes, however, did provide information on the postural demands of various checkstand designs. Although the sample size was not large, an indication of the cashiers' activities and job demands was obtained. The non-cashier analyses provided limited insight into a portion of the jobs performed by other workers within the grocery store environment.

The overall results of the ergonomic evaluations indicated that the cashiers performed repetitive work and that many non-neutral postures were used by the cashiers. Because only a few workers per workstation were analyzed, and because repeated observations were not made over time, we cannot precisely separate out differences in morbidity which result from differences in work practices and stature or other personal characteristics and those related to workstation factors. Because of our limitations in assessing both exposure and the cross-sectional nature of this study, it is not surprising that we did not find striking differences in the rates of CTDs by checkstand design. It would require a larger study to examine this important question in greater detail. Our results do suggest that each checkstand design may have ergonomic characteristics which contribute to the development of CTDs.

## IX. RECOMMENDATIONS

Analysis of the videotapes indicated that checkstand design and work practices were contributing factors to the observed postural stresses of cashier work. Presented below are the design characteristics of a recommended checkstand, examples of worker practices that should be eliminated, and suggested interim measures for modifying existing checkstand designs.

### A. Checkstand Design

The major components of the checkstand that influence the patterns of motion of the cashier are the placement of the scanner, the keyboard, the cash drawer, the scale, and the bagging area. The proper positioning of these components in the checkstand area will reduce the level of biomechanical stress experienced by cashiers, and ultimately should reduce the rate of cumulative trauma disorders for cashiers.

A list of guidelines for design of an ergonomically sound checkstand follow. Figure 8 has been provided as one example of the application of these ergonomic guidelines. This figure should not be interpreted as a blueprint for building a checkstand but rather as a visual illustration of our recommended guidelines. Other designs which incorporate the same guidelines should also reduce cumulative trauma disorders.

1. Locate the scale and the scanner in front of the cashier. The scale should be placed horizontally (mounted flush with the conveyor) to eliminate twisting and reaching to weigh produce. Two types of current technology accommodate this design. In the first, a scanner is mounted vertically and presents a horizontal beam toward the cashier (Figure 8). In the second, the scanner/scale, the scanner is located horizontally and the scale is mounted within the scanner. The choice between these two designs depends on which has greater efficiency in reading the bar codes and which minimizes the handling of scannable items. Since the checkstand designs in the Shoprite stores did not contain either of these designs this study could not assess the merits of the vertical scanner compared to the scanner/scale. Either design however, should include laser technology capable of reading a wide range of product surfaces thus minimizing handling of scannable items. The vertical scanner has the attribute of allowing minimal contact between the scanner glass and the grocery products thus avoiding the problems associated with dirty scanner glass.

   For a conveyor height of 34-36 inches, the reach to the far end of the scale and conveyor belt should be no more than 17 inches, provided that all items can be handled within 12

inches to the right or left of the cashier. If cashiers must reach more than 12 inches to the right or left, the conveyor width should be reduced to 14 inches.

2. Situate the keyboard in front of the cashier, above the scanner. The keyboard should have adjustment capabilities in all directions (up-down, right-left, toward-away from the cashier). The angle of the keyboard should also be adjustable. The height of the keyboard should be positioned so that the height of the hand does not exceed shoulder height while keying. For women the range of adjustability should be 47-57 inches. This range would accommodate women whose size falls within the first through the ninety-ninth percentile of all women. For men the similar range of adjustibility would be 51-63 inches. Therefore, if the keyboard is designed to accommodate both men and women it should have an adjustability range of 47-63 inches.

3. Locate a bag stand to the side of the cashier that permits each item to be immediately bagged after scanning. This arrangement would eliminate the rehandling and lifting of items that currently accumulate in the bagging area. The top of the empty bags should be positioned at a height even with the conveyor. Filled bags are delivered to the customer by either a belt or roller conveyor (Figure 8).

   For instances where "scan and bag" is not possible, practical, or chosen by the cashier, similar bag stands should be located at the end of the checkstand to allow bagging by another worker, the customer, or the cashier (after all items are scanned).

   The elimation of bagging by the cashier, as studied in the Middletown standard cart order, resulted in a large decrease in the number of repetitions and awkward postures. The incorporation of baggers may allow for micro-rest breaks which should decrease the overall ergonomic risk levels for the cashiers.

4. Locate the cash drawer to the side of the cashier (opposite the bag stand) at a height of 32-36 inches from the floor, with the near edge of the drawer no more than 18 inches from the cashier.

5. Provide an adjustable sit/stand bar in the checkstand area to allow for rest when possible during the job cycle, such as during customer check writing, waiting for customers, etc. Padded mats to stand on that are designed to reduce leg fatigue should also be considered for the checkstand floor area.

   Several elements of the recommended checkstand design

(scanner, keyboard, and scale) are being tested at a Shoprite store that was not included in this study. Review of videotapes of cashiers at this checkstand indicated that the flush-mounted scale eliminated excessive reaching to weigh produce, and the horizontal orientation of the scanner allowed for reduced handling during the scanning of heavy items such as liters of pop and gallons of milk. The keyboard was conveniently located in front of the cashier and could be operated with little wrist deviation. These features should be incorporated into all checkstands.

B. Cashier Work Practices

Many of the observed patterns of motion did not appear to be controlled by the design of the checkstand, but rather, were chosen by the cashiers to expedite the processing of an order, or to be helpful to the customer. Nonetheless, the cashiers should be aware that these extra movements add to the risk of the job and should be eliminated whenever possible. These activities include:

1. Reaching over the conveyor to unload or load grocery items from/to the customer's shopping cart.

2. Tying filled plastic bags before handing them to the customer.

3. Reaching for items to be scanned instead of waiting for the conveyor belt to bring items to the scanner. (This problem may be due to inconvenient location of the conveyor control mechanism.)

4. Scanning an item more than two or three times and not keying-in multiple purchases of a single item. Multiple scanning versus keying items is an issue of ergonomic trade-off that must be investigated further. It is possible that multiple scanning of items is a work practice chosen by some cashiers to avoid reaching to an inconveniently-located keyboard.

The supermarket industry should encourage the product manufacturers to adopt standard labeling practices which will minimize the need to reposition items for scanning and/or rescan items that were unsuccessfully scanned. This may require some investigation into which kinds of labels optimize the chance of a successful scan, especially for items known to be difficult to scan, such as frozen foods, silver-colored containers, and soft, deformable packages.

C. Interim Measures

There are some minor modifications that could be made to existing checkstands used at Shoprite stores that, if implemented, would minimize some biomechanical stress. The effectiveness of a partial checkstand redesign cannot be predicted, but these interventions could be introduced while major modifications are in progress.

1. All Checkstands

a. Weigh and price produce in the Produce Department rather than require the cashier to perform this step at the checkstand. This practice is not included in the recommended checkstand design discussed above because its implementation may not be in accordance with Shoprite management policy. However, if the need for a scale at the checkstand could be easily eliminated in all stores, it would provide more flexibility in the design of checkstands, even for the recommended design.

b. Provide baggers for all checkstands in all stores.

2. Full right chute (Bricktown)

Reduce the distance required to reach for and scan grocery items. The cashier stands at the end of the conveyor and reaches 25 inches over a metal barrier, the scanner, and a conveyor belt guard to scan grocery items. This distance can be reduced to the recommended 17 inches by reducing the distances between the metal barrier and the scanner, and between the conveyor guard and the scanner. Only the lateral surface of the guard which bridges the gap between the scanner and the right chute is needed in this checkstand design. The reduction in horizontal reach requirement, if coupled with the elimination of the scale as recommended in item 1a above, and the addition of baggers as recommended in item 1b above, could provide an acceptable reduction in postural stresses associated with this checkstand design (see Figure 9a).

3. Full left chute (Clark and Middletown)

Provide a horizontally-mounted scanner with either a flush-mounted scale (or no scale as discussed above) and keyboard mounted above the scanner, as in the recommended design (see Figure 9b). The design of a full left chute is such that the two segments of the conveyor are located in a straight line on either side of the scanner. The cashier scans items while standing perpendicular to the scanner, which tends to require wrist flexion if the left hand is predominantly used, or wrist extension if the right hand is predominantly

used. The interim recommendation for this checkstand design contains all elements of the recommended design, except for the bag stand and the cash drawer location.

4. Full left chute (Sayreville)

Eliminate the vertical metal barrier located between the initial conveyor belt and the secondary conveyor belt (non-scanner checkstand). The barrier appeared to serve no vital purpose and required the cashiers to lift each item rather than slide items smoothly from the first conveyor to the second.

5. Express lane - all stores

Eliminate one of the metal bag frames so that the cashier can stand at the end of the conveyor and reach only over the scanner for items. Excessive reaching was judged to be the main postural stressor at the express lanes, particularly when plastic bags were used. Care must be taken that access to the keyboard is not complicated by rearrangement of the bag frames. No action regarding bag location need be taken at the stores where only paper bags are used. As noted above for all checkstands, the scale should be mounted flush with the scanner or eliminated (see Figure 9c).

## X. REFERENCES


1. Armstrong, T, Foulke J, Joseph, B, and Goldstein, S. Investigation of cumulative trauma disorders in a poultry processing plant. Am. Ind. Hyg. Assoc. J. 43: 103-116, 1982.

2. Badger, DW, et al. Chef Francisco, Inc., HETA Report 83-053-1554, NIOSH, HETAB, 1985.

3. Onishi N, et al. Fatigue and strength of upper limb muscles of flight reservation system operators. J Human Ergology 2: 133-142, 1973.

4. Armstrong TJ. Ergonomics and cumulative trauma disorders. Hand Clinics 2: 553-565, 1986.

5. Luopajarvi, T, Kuorinka, I, Virolainen, M, and Holmberg, M. Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. Scand. J. Work Environ. & Health 5: suppl. 3, 48-55, 1979.

6. Streib EW, Sallie FS. Distal ulnar neuropathy in meatpackers, JOM 26:842-843, 1984.

7. Viikare-Juntura E. Neck and upper limb disorders among slaughterhouse workers. Scand J Work Environ Health 9: 283-290, 1983.

8. Maeda K, et al. History of the studies of occupational cervicobrachial disorder in Japan and remaining problems. J Human Ergology 11: 17-29, 1982.

9. Falck B, Aarnio P. Left-sided carpal tunnel syndrome in butchers. Scand J Work Environ Health 9: 291-297, 1983.

10. Finkel ML. The effects of repeated mechanical trauma in the meat industry. Am J Ind Med 8: 375-379, 1985.

11. Armstrong, TJ, and Chaffin, DB. Carpal tunnel syndrome and selected personal attributes. JOM (21) 7: 481-486, 1979.

12. Tanzer, R. The carpal tunnel syndrome. J. Bone Joint Surg 41A: 626-634, 1959.

13. Hymovich, L and Lindholm, M. Hand, wrist, and forearm injuries, the result of repetitive motions. JOM 8: 573-577, 1966.

14. Birkbeck, M and Beer, TC. Occupation in relation to the carpal tunnel syndrome. Rheumatol Rehabil 14: 218-221, 1975.

15. Hales, T, Habes, D, Fine, L, Hornung, R, Boiano, J. NIOSH HETA Report 88-180-1958, John Morrell & Co., 1989.

16. Pfeffer, GB, Gelberman, TH, Boyes, JH, Rydevik, B. The history of carpal tunnel syndrome. Journal of Hand Surgery, 13B: 28-34. 1988.

17. Robbins H. Anatomical study of the median nerve in the carpal tunnel and etiologies of the carpal tunnel syndrome. J Bone Joint Surg 45A: 953-966, 1963.

18. Armstrong TJ, Chaffin DB. Some biomechanical aspects of the carpal tunnel. J. Biomechanics 12: 567-570, 1979.

19. Hozman R, Skosey JL. Differentiating upper-extremity entrapment syndromes. Diagnosis 30-48, 1987.

20. Phalen GS. The carpal tunnel syndrome. Clinical Orthopaedics 83:29-40, 1972.

21. Phillips, R. Carpal tunnel syndrome as a manifestation of systemic disease. Ann. Rheum. Dis. 26: 59-63, 1967.

22. Silverstein BA, Fine LJ, Armstrong TJ. Hand-wrist cumulative trauma in industry. Br J Ind Med, 43:779-784, 1986.

23. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome, Am J Ind Med, 11:343-358, 1987.

24. Armstrong, T, Fine, L, and Silverstein, B. Occupational risk factors: cumulative trauma disorders of the hand and wrist. Final Report of Contract CDC 200-82-2507, 1985.

25. Tichauer, ER. Some aspects of stress on forearm and hand in industry. JOM 8: 63-71, 1966.

26. Kurppa, K, Waris, P, and Rokkanen, P. Peritendinitis and tenosynovitis. Scand. J. Work Environ. & Health 5: Suppl. 3, 19-24, 1979.

27. Maeda, K, Hunting, W, and Grandjean, E. Localized fatigue in accounting machine operators. JOM (22)12: 810-817, 1980.

28. Hammer, A. Tenosynovitis. Medical Record, 140: 353, 1934.

29. Boiano, J, Watanabe, A, and Habes, D. NIOSH HETA Report 81-143, Armco Composites, 1982.

30. Muckart, R. Stenosing tendovaginitis of abductor pollicis longus and extensor pollicis brevis at the radial styloid. Clin. Orthop., 33: 201- 208, 1964.

31. Discher D, et al. Pilot study for development of an occupational surveillance method. HEW(NIOSH) Pub. No. 75-162, 1975.

32. Fine LJ, et al. An alternative way of detecting cumulative trauma disorders of the upper extremities in the workplace. Proceedings of 1984 International Conference on Occup Ergonomics, 425-429, 1984.

33. Nishiyama, K, Nakasako, M, Hosokawa, M. Labor in supermarkets and its effect on health (Report No. 1). Cash register operators work and its hygienic problems in a supermarket. Sangyo Igaku 15(3):229-243, 1973.

34. Ohara, H, Aoyama, H, Itani, T. Health hazard among cash register operators and the effect of improved working conditions. J. Human Ergol., 5:31-40, 1976.

35. Bitsch, HU. Study on optimizing the design of cashier worksites from the standpoint of occupational medicine. Research Report: Federal Institute for Occupational Protection and Accident Research, Dortmund, 1979.

36. Elias, R, et al. Ergonomic job study of self-service cashiers. Cahiers de Notes Documentaires 103:211-220, 1981.

37. Stoffman, LD. An occupational health survey of clerks and cashiers in the B.C. retail food industry. Retail Clerks Union, Local 1518, United Food and Commercial Workers Union. (Unpublished Report), 1983. Available through the United Food and Commercial Workers Union, Washington, D.C.

38. Stoffman, LD, Wallersteiner, U, Gordon, R. Integreting ergonomics into the design of lasar/scanner checkout systems. Retail Clerks Union, Local 1518, United Food and Commercial Workers Union. (Unpublished Report) 1986. Available through the United Food and Commercial Workers Union, Washington, D.C.

39. Rosenstock, L, et al. Carpal tunnel syndrome in Seattle grocery checkers, NIOSH HETA Report 85-012, August 1985.

40. Barnhart S, Rosenstock L. CTS in grocery checkers: cluster of work-related illness. West J Med 147:37-40, 1987.

41. Margolis W, Kraus, JF. Prevalence of carpal tunnel syndrome in female supermarket checkers. JOM 29:953-956, 1987.

42. Osorio, AM, Ames, R, Jones, J. Carpal tunnel syndrome among grocery store workers. California Department of Health Services, OHSEP Final Report FI-86-005, August 1988. Available through COHP, California Department of Health Services, Berkeley,

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## XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Shoprite Supermarkets
2. United Food and Commercial Workers Union
3. OSHA, Region II

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

**FULL-CHUTE CHECKSTAND DESIGN CHARACTERISTICS**

SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344

| Store | Takeaway Chute | Bagger | Scanner |
|---|---|---|---|
| BRICKTOWN | Right | No | Yes |
| CLARK | Left | No | Yes |
| MIDDLETOWN | Left | Yes | Yes |
| SAYREVILLE | Left | No | No |

Table 2

PHYSICAL EXAMINATION CASE DEFINITIONS

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

For all maneuvers where the response required a grading of pain, a positive response was considered greater than 1 on a scale of 0-5.

Neck
- Pain on one of the following maneuvers:
  - Resisted flexion
  - Resisted extension
  - Resisted rotation
  - Trapezius palpation

Shoulder
- Rotator Cuff:
  - Pain on one of the following:
    - Resisted abduction
    - Deltoid palpation
- Bicipital tendinitis:
  - Pain on Yergason's maneuver

Elbow
- Pain on any one of the following in the hand or proximal 2/3 of forearm:
  - Medial or lateral epicondyle palpation
  - Resisted wrist flexion
  - Resisted wrist extension
  - Resisted finger flexion
  - Resisted finger extension
  - Resisted 3rd finger extension
  - Resisted 5th finger extension

Hand/Wrist
- Tendon related:
  - Pain on any one of the following in the hand or distal 1/3 of forearm:
    - Resisted wrist flexion
    - Resisted wrist extension
    - Resisted finger flexion
    - Resisted finger extension
    - Resisted 3rd finger extension
    - Resisted 5th finger extension
    - Presence of a ganglion
- Tendon or arthritis related:
  - Decreased ROM of wrist (30 degrees flex/ext, 10 degrees ulnar/radial)

Table 2 (cont)

Nerve related:
- Positive for any one of the following:
  - Carpal Tinel
  - Guyon Tinel
  - Phalen's

Carpal Tunnel Syndrone:
- Positive for either:
  - Carpal Tinel
  - Phalen's

De Quervain's:
- Positive Finkelstein's

Joint related:
- MCP:
  - ROM less than 90 degrees
- PIP:
  - ROM less than 100 degrees

Table 3

LIST OF ANALYZED JOBS

SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344

| TASK | # ANALYZED |
|---|---|
| Cashier | |
| Clark, NJ | |
| FULL | 5 |
| EXPRESS | 3 |
| Bricktown, NJ | |
| FULL | 4 |
| EXPRESS | 5 |
| Sayreville, NJ | |
| FULL | 3 |
| Middletown, NY | |
| FULL | 6 |
| EXPRESS | 1 |
| Non-Cashier | |
| Dairy | 5 |
| Produce | 11 |
| Produce Package Preparation | 3 |
| General | |
| Cosmetics | 4 |
| Soda | 2 |
| Juice | 1 |
| Warehouse | 1 |
| Salad Bar Preparation | 4 |
| Courtesy Counter | 1 |
| Bakery | 6 |
| Seafood Package Preparation | 3 |
| Pharmacy | 1 |
| Horticulture | 4 |

Table 4

OVERALL RISK DETERMINATION MATRIX

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

| | | REPETITION | | |
|---|---|---|---|---|
| | | **LOW** | **MEDIUM** | **HIGH** |
| **FORCE** | | | | |
| | **LOW** | Low | Medium | High |
| | **MEDIUM** | Medium | Medium | High |
| | **HIGH** | High | High | High |

Table 5

JOB TITLES OF PARTICIPANTS INCLUDED IN THE FIELD STUDY*

| | Female | Male | Total |
|---|---|---|---|
| Checkers | 119 | 5 | 124 |
| Non-Checkers | 56 | 101 | 157 |
| Grocery | 5 | 41 | 46 |
| Baggers/carts | 10 | 12 | 22 |
| Bakery | 13 | 8 | 21 |
| Produce | 3 | 17 | 20 |
| Courtesy | 10 | 4 | 14 |
| Maintenance | 0 | 9 | 9 |
| Dairy | 0 | 8 | 8 |
| Office | 7 | 0 | 7 |
| Salad Bar | 3 | 0 | 3 |
| Horticulture | 2 | 1 | 3 |
| Pharmacy | 2 | 0 | 2 |
| Snack Bar | 1 | 1 | 2 |

*Excluding those under 18, deli/meat/fish workers, & pregnant workers

Table 6

DEMOGRAPHICS OF FIELD PARTICIPANTS

SHOPRITE SUPERMARKETS
NEW YORK- NEW JERSEY
HETA 88-344

| | Checkers | | Non-Checkers | |
|---|---|---|---|---|
| | Female | Male | Female | Male |
| Number | 119 | 5 | 56 | 101 |
| (%) | 96% | 4% | 36% | 64% |
| Average Age | 34 | 25 | 34 | 34 |
| Range | 18-69 | 18-37 | 18-65 | 18-72 |
| Average Years in Industry | 8 | 5 | 8 | 12 |
| Range | <1-34 | <1-12 | <1-23 | <1-37 |
| Average Hours Work/Week | 28 | 31 | 33 | 36 |
| Range | 12-47 | 20-40 | 18-46 | 12-50 |

Table 7

PREVALENCE OF CUMULATIVE TRAUMA DISORDERS

| | | Others | |
|---|---|---|---|
| | Checkers (124) | Male (101) | Female (56) |
| By Questionnaire and Exam | | | |
| Neck | 16% | 3% | 10% |
| Shoulder | 15% | 1% | 4% |
| Elbow | 8% | 2% | 4% |
| Hand | 29% | 6% | 19% |
| Carpal Tunnel Syndrome | 11% | 1% | 4% |
| Any CTD | 51% | 11% | 31% |
| By Questionnaire only | | | |
| Back | 45% | 21% | 24% |

Table 8

FEMALE CHECKER CTD CASES
GETTING MEDICAL CARE OR MISSING WORK DAYS

SHOPRITE SUPERMARKETS
NEW YORK-NEW JERSEY
HETA 88-344

| | Number of Cases | Got Medical Care at least once # | Got Medical Care at least once % | Missed at least one workday # | Missed at least one workday % |
|---|---|---|---|---|---|
| Neck | 17 | 2 | 12 | 3 | 18 |
| Shoulder | 17 | 1 | 6 | 3 | 18 |
| Elbow | 10 | 2 | 20 | 2 | 20 |
| Hand | 33 | 10 | 30 | 4 | 12 |
| Carpal Tunnel Syndrome | 13 | 5 | 38 | 3 | 23 |
| Back (by questionnaire) | 43 | 11 | 26 | 6 | 14 |

Table 9

SIDE AFFECTED BY CTD
FEMALE CHECKERS

| | Number Cases | % Right Side Only | % Left Side Only | % Both Sides |
|---|---|---|---|---|
| Shoulder | 17 | 39% | 33% | 28% |
| Elbow | 10 | 30% | 30% | 40% |
| Hand | 33 | 27% | 18% | 55% |
| Carpal Tunnel Syndrome | 13 | 38% | 38% | 23% |

Table 10

VARIABLES TESTED IN LOGISTIC MODELS

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

Work-Related

Job (Checkers versus Others)
Months Working in Supermarkets
Hours Working per Week

Confounders

Age
Hobbies
Second Jobs
Systemic Disease [1]
Obesity [2]

[1] Includes diabetes, lupus erythematosus, gout, thyroid disease, and rheumatoid arthritis.
[2] Defined as at least 30% above the ideal body weight for sex and height

Table 11

MULTIPLE LOGISTIC REGRESSION MODELS
CTDS IN FEMALES
CHECKERS VERSUS NON-CHECKERS

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

| DISORDER | ODDS RATIO CHECKERS VS NON-CHECKERS | 95% CONFIDENCE INTERVAL |
|---|---|---|
| Neck<br>Adjusted for[1]:<br>Duration of Work | 2.0 | 0.6 - 6.7 |
| Shoulder<br>Adjusted for:<br>Duration of Work | 3.9* | 1.4 - 11.0 |
| Elbow<br>Adjusted for:<br>Age | 2.3 | 0.5 - 11.3 |
| Carpal Tunnel Syndrome<br>Adjusted for:<br>Duration of Work<br>Hobby | 3.7 | 0.7 - 16.7 |
| Lower Back[2]<br>Adjusted for:<br>Duration of Work | 2.5* | 1.1 - 5.6 |
| Any Cumulative Trauma<br>Adjusted for:<br>Duration of Work | 2.6* | 1.2 - 5.8 |

*Statistically Significant
[1] Adjusted by these factors which significantly affect disease
[2] By questionnaire only

Table 12

PREVALENCES OF CTDS FOR EACH STORE

SHOPRITE SUPERMARKETS
NEW YORK-NEW JERSEY
HETA 88-344

| | BRICKTOWN | CLARK | MIDDLETWON | SAYERVILLE |
|---|---|---|---|---|
| # of Checkers | 47 | 33 | 24 | 15 |
| Disorder | | | | |
| Neck | 12% | 27% | 13% | 15% |
| Shoulder | 9% | 26% | 24% | 0 |
| Elbow | 9% | 9% | 9% | 7% |
| Hand | 26% | 38% | 33% | 21% |
| Carpal Tunnel Syndrome | 9% | 24% | 4% | 0% |
| Back* | 53% | 34% | 44% | 38% |

* Diagnosed by questionnaire only

Table 13

PREVALENCES OF CTDS
CHECKERS USING SCANNERS VS NOT USING SCANNERS

| | LASER SCANNER USE | | | |
|---|---|---|---|---|
| | YES | | NO | |
| | # | % | # | % |
| # of Checkers | 104 | | 15 | |
| Prevalence of Disorders | | | | |
| Neck | 15 | 17%[1] | 2 | 15% |
| Shoulder | 17 | 17% | 0 | 0 |
| Elbow | 9 | 10% | 1 | 7% |
| Hand/Wrist | 30 | 32% | 3 | 21% |
| Carpal Tunnel Syndrome | 13 | 13% | 0 | 0 |
| Back[2] | 38 | 45% | 5 | 38% |

[1] These percentages may not be based on 104 and 15 checkers because of exclusions

[2] By questionnaire only

Table 14

**PREVALENCES OF CTDS AND ODDS RATIOS[1]**
**CHECKERS USING SCANNERS VS NOT USING SCANNERS**
**CASES BY QUESTIONNAIRE ONLY**

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

| | # Cases | Scanner (104) | No Scanner (15) | ODDS RATIO | 95% CI |
|---|---|---|---|---|---|
| Neck | 8 | 38% | 31% | 1.6 | (0.4 - 5.7) |
| Shoulder | 34 | 34% | 7% | 8.6* | (1.0 - 72.2) |
| Elbow | 19 | 17% | 13% | 1.7 | (0.3 - 8.8) |
| Hand | 45 | 46% | 36% | 1.6 | (0.4 - 6.7) |
| Carpal Tunnel Syndrome | 19 | 18% | 7% | 2.9 | (0.3 - 25.4) |
| Back | 43 | 45% | 38% | 1.3 | (0.4 - 4.3) |

* Statistically Significant
[1] Adjusted for all significant variables

Table 15

PREVALENCES OF CTDS AND ODDS RATIOS[1]
CHECKERS USING LEFT VS RIGHT TAKEOFF BELTS

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

| | # Cases | Left (58) | Right (46) | ODDS RATIO | 95% CI |
|---|---|---|---|---|---|
| Neck | 17 | 22% | 12% | 2.2 | (0.6 - 7.7) |
| Shoulder | 17 | 25% | 9% | 3.3 | (0.9 - 12.1) |
| Elbow | 10 | 9% | 9% | 0.7 | (0.1 - 3.9) |
| Hand/Wrist | 33 | 36% | 26% | 2.0 | (0.7 - 5.5) |
| Carpal Tunnel Syndrome | 13 | 16% | 9% | 2.9 | (0.7 - 12.7) |
| Back[2] | 43 | 38% | 53% | 0.5 | (0.2 - 1.2) |

[1] Adjusted for all significant variables
[2] By questionnaire only

Table 16

PREVALENCES OF CTDS AND ODDS RATIOS[1]
SHORT CHECKERS[2] VS OTHERS

| | # Cases | Short (33) | Others (86) | ODDS RATIO | 95% CI |
|---|---|---|---|---|---|
| Neck | 17 | 10% | 19% | 0.4 | (0.1 - 1.7) |
| Shoulder | 17 | 21% | 13% | 2.1 | (0.7 - 6.9) |
| Elbow | 10 | 9% | 8% | 1.4 | (0.3 - 6.2) |
| Hand/Wrist | 33 | 41% | 26% | 1.8 | (0.7 - 4.8) |
| Carpal Tunnel Syndrome | 13 | 19% | 8% | 2.7 | (0.7 - 10.6) |
| Back | 43 | 26% | 51% | 0.3 | (0.1 - 0.8)* |

[1] Adjusted for all significant variables
[2] Short - 5'2" or less
* Statistically significant

Table 17

**SUMMARY OF STANDARD CART DATA FOR FULL-CHUTE AND EXPRESS LANES**

SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344

| | CLARK | | BRICKTOWN | | SAYREVILLE | MIDDLETOWN | |
|---|---|---|---|---|---|---|---|
| | FULL | EXPRESS | FULL | EXPRESS | FULL | FULL | EXPRESS |
| Cycle Time (secs) | 283 | 205 | 280.7 | 163 | 295 | 155.4 | 207 |
| # Items | 33 | 33 | 34 | 33 | 32 | 35 | 35 |
| # Scans | 37 | 40 | 36 | 42 | 0 | 41 | 38 |
| # Keyins | 10 | 7 | 6 | 3 | 33 | 10 | 9 |
| Total Mvmts/Cycle | | | | | | | |
| Right | 133 | 105 | 128 | 93 | 125 | 41 | 75 |
| Left | 99 | 57 | 102 | 72 | 98 | 42 | 73 |
| Total Mvmts/hour | | | | | | | |
| Right | 1689 | 1848 | 1638 | 2055 | 1525 | 951 | 1305 |
| Left | 1257 | 1003 | 1306 | 1591 | 1196 | 974 | 1270 |

Table 18

AWKWARD POSTURES OBSERVED DURING VARIOUS ACTIVITIES AT EXPRESS CHECKSTANDS (STANDARD CART ORDERS)

SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344

| ACTIVITY | Reaching for Items | | | | Scanning | | | | Keying | | | | Reaching to Scale | | | | Placing Items | | | | Opening Bags | | | | Bagging | | | | Handling Bags | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STORES | B | C | M | S | B | C | M | S | B | C | M | S | B | C | M | S | B | C | M | S | B | C | M | S | B | C | M | S | B | C | M | S |
| POSTURES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **WRIST** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ULNAR | | L | | L | R | | 2 | | | | | | | | | | | L | | | | | | | | | | | | | | |
| RADIAL | | R | | | | | 2 | | | | | | | | | | | | | | L | R | | | | R | | L | 2 | 2 | | L |
| FLEXION | | | | L | | 2 | L | | L* | | | | | | | | | | R | | | | | | | | | | R | | | |
| EXTENSION | L | L | | | 2 | L | 2 | | | | | | | | L | | R | R | R | | | L | | | 2 | L | | R | | | | L |
| | | | | | | | | | | | | | | | | | | | | | 2 | R | | | 2 | R | | L | | 2 | | L |
| **FOREARM** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SUPINATION | R | R | R | L | | | | | | | | | | | | | | L | | | | | | | | | | | | | | |
| PRONATION | R | | | | R | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **SHOULDER** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ABDUCTION | | | | L | | | | | | | | | | | | L | | L | | L | | | | | | | | 2 | | | | 2 |
| FLEXION | 2 | | | L | | | | | | | | | R | 2 | 2 | L | R | L | | | | | | | | | | L | | 2 | | 2 |
| EXTENSION | | | | | | | | | | | | | | | | | | | L | L | | | | | | | | | | | | |
| **TRUNK** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FLEXION | X | X | X | | | | | | | | | | | | | | | X | | | | | | | X | X | | | | | | X |
| ROTATION | X | X | | | | | | | | | | | | | X | | X | X | X | X | | | | | | | | X | | X | | |

STORES: B - BRICKTOWN C - CLARK M - MIDDLETOWN
LATERALITY: R - RIGHT SIDE L - LEFT SIDE 2 - BOTH SIDES
X - POSTURE OBSERVED
* Ulnar deviation while holding item (Right hand is keying)

Table 19

**AWKWARD POSTURES OBSERVED DURING VARIOUS ACTIVITIES AT EXPRESS CHECKSTANDS (STANDARD CART ORDERS)**

SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344

| ACTIVITY | Reaching | | | Scanning for Items | | | Keying | | | Reaching to Scale | | | Opening Bags | | | Bagging | | | Lifting/Handling Bags | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STORES | B | C | M | B | C | M | B | C | M | B | C | M | B | C | M | B | C | M | B | C | M |
| POSTURES | | | | | | | | | | | | | | | | | | | | | |
| **WRIST** | | | | | | | | | | | | | | | | | | | | | |
| ULNAR | | | | R | L | 2 | | | L* | | | | 2 | L | 2 | R | L | | 2 | | |
| RADIAL | | | | | R | 2 | | | | | | | | | | | L | | | | |
| FLEXION | | 2 | 2 | R | 2 | | | | | | | | | R | 2 | R | 2 | | | | |
| EXTENSION | 2 | 2 | R | | R | 2 | R | | | | | | 2 | 2 | 2 | | 2 | L | 2 | | R |
| **FOREARM** | | | | | | | | | | | | | | | | | | | | | |
| SUPINATION | | R | | | R | | | R | | | R | | | | | | | | | | |
| PRONATION | | R | | R | | R | | | | | | | | | | | | | | | |
| **SHOULDER** | | | | | | | | | | | | | | | | | | | | | |
| ABDUCTION | | | 2 | | | R | | | | | R | L | | | | | R | R | 2 | | 2 |
| FLEXION | 2 | R | 2 | | | | | | | | | | | 2 | | | | | | | |
| EXTENSION | | | | | | | | | | | | | | | | | | | | | |
| **TRUNK** | | | | | | | | | | | | | | | | | | | | | |
| FLEXION | X | X | | X | | | | | | | | X | X | | | | | | | | |
| ROTATION | X | | X | | | | | X | | | X | | | | | | | | | | |

STORES: B - BRICKTOWN C - CLARK M - MIDDLETOWN
LATERALITY: R - RIGHT SIDE L - LEFT SIDE 2 - BOTH SIDES
X - POSTURE OBSERVED
* Ulnar deviation while holding item (Right hand is keying)

Table 20

**FULL-CHUTE LANE COMPARISONS BETWEEN STANDARD CART (STND) AND CUSTOMER ORDERS (CUST)**

**SHOPRITE SUPERMARKETS**
**NEW JERSEY-NEW YORK**
**HETA 88-344**

| | BRICKTOWN | | CLARK | | MIDDLETOWN | | SAYREVILLE | |
|---|---|---|---|---|---|---|---|---|
| | Stnd | Cust | Stnd | Cust | Stnd | Cust | Stnd | Cust |
| # of Checkers | 1 | 4 | 1 | 5 | 1 | 6 | 1 | 3 |
| Cycle Time (s) | 281 | 236 | 283 | 83 | 155 | 240 | 295 | 91 |
| # Items | 34 | 41 | 33 | 11 | 35 | 65 | 32 | 12 |
| # Scans | 36 | 43 | 37 | 10 | 41 | 63 | 0 | 0 |
| # Key-Ins | 6 | 7 | 10 | 3 | 10 | 15 | 33 | 13 |
| # Cycles/hour | 12.8 | 15.3 | 12.7 | 43.4 | 23.2 | 15.0 | 12.2 | 39.6 |
| Total #Mvmts/Cycle | | | | | | | | |
| Right | 128 | 110 | 133 | 33 | 41 | 103 | 125 | 45 |
| Left | 102 | 73 | 99 | 25 | 42 | 84 | 98 | 21 |
| Total #Mvmts/hour | | | | | | | | |
| Right | 1638 | 1683 | 1689 | 1432 | 951 | 1545 | 1525 | 1782 |
| Left | 1306 | 1117 | 1257 | 1085 | 974 | 1260 | 1196 | 832 |
| Est. Average Force | LOW | LOW | LOW | LOW | LOW | LOW | LOW | LOW |
| Est. Peak Force | MED | MED | MED | MED | MED | MED | MED | MED |
| Overall Risk | | | | | | | | |
| Right | MED | MED | MED | MED | LOW | MED | MED | MED |
| Left | MED | LOW | MED | LOW | LOW | MED | LOW | LOW |
| # Mvmts/Item | | | | | | | | |
| Right | 3.8 | 3.7 | 4.0 | 4.0 | 1.2 | 1.5 | 3.9 | 3.8 |
| Left | 3.0 | 2.5 | 3.0 | 3.0 | 1.2 | 1.3 | 3.1 | 1.8 |

Table 21

**EXPRESS LANE COMPARISONS BETWEEN STANDARD CART (STND) AND CUSTOMER ORDERS (CUST)**

**SHOPRITE SUPERMARKETS**
**NEW YORK-NEW JERSEY**
**HETA 88-344**

| | | BRICKTOWN | | CLARK | | MIDDLETOWN | |
|---|---|---|---|---|---|---|---|
| | | Stnd | Cust | Stnd | Cust | Stnd | Cust |
| # of Checkers | | 1 | 5 | 1 | 3 | 1 | 1 |
| Cycle Time (s) | | 163 | 42 | 205 | 56 | 207 | 67 |
| # Items | | 33 | 6 | 3 | 6 | 35 | 7 |
| # Scans | | 42 | 6 | 40 | 3 | 38 | 7 |
| # Key-Ins | | 3 | 3 | 7 | 5 | 9 | 1 |
| # Cycles/hour | | 22.1 | 85.7 | 17.6 | 64.3 | 17.4 | 53.7 |
| Total #Mvmts/Cycle | | | | | | | |
| | Right | 93 | 31 | 105 | 21 | 75 | 18 |
| | Left | 72 | 13 | 57 | 10 | 73 | 25 |
| Total #Mvmts/hour | | | | | | | |
| | Right | 2055 | 2657 | 1848 | 1350 | 1305 | 967 |
| | Left | 1591 | 1114 | 1003 | 643 | 1270 | 1343 |
| Est. Average Force | | LOW | LOW | LOW | LOW | LOW | MED |
| Est. Peak Force | | MED | LOW | MED | MED | MED | MED |
| Overall Risk | | | | | | | |
| | Right | MED | HIGH | MED | MED | MED | MED |
| | Left | MED | LOW | LOW | LOW | MED | MED |
| #Mvmts/Item | | | | | | | |
| | Right | 2.8 | 5.7 | 3.2 | 3.8 | 2.1 | 2.6 |
| | Left | 2.2 | 2.3 | 1.7 | 1.8 | 2.1 | 3.6 |

Table 22

RISK LEVELS OF NON-CASHIER JOBS
BASED ON THE PORTIONS OF THE JOBS ANALYZED

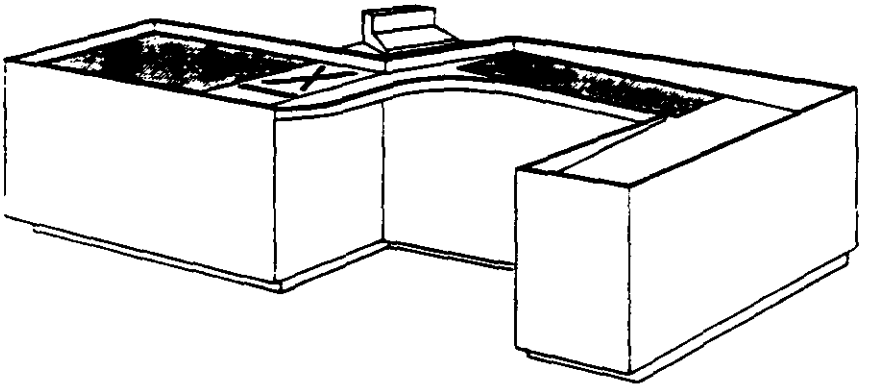
SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344

| JOB | REPETITION | FORCE | OVERALL |
|---|---|---|---|
| Stocking | Medium | Medium | Medium |
| Pkg Prep | Medium | Medium | Medium |
| Bagging | Medium | Medium | Medium |
| Bakery | Medium | Medium | Medium |
| Service | Medium/Low* | Low | Medium/Low |
| Produce | Medium | Low | Medium |
| Horticulture | Medium/Low* | Medium | Medium |

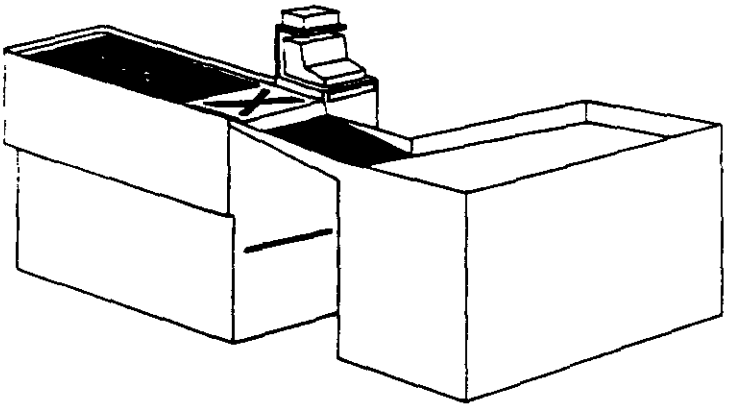
* Risk level differed between Right/Left hands

Figure 1
FULL-CHUTE CHECKSTAND DESIGNS

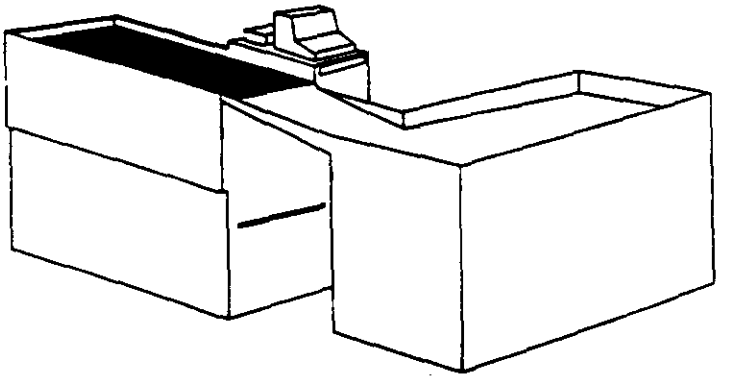
SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344



a) Bricktown



b) Clark/Middletown

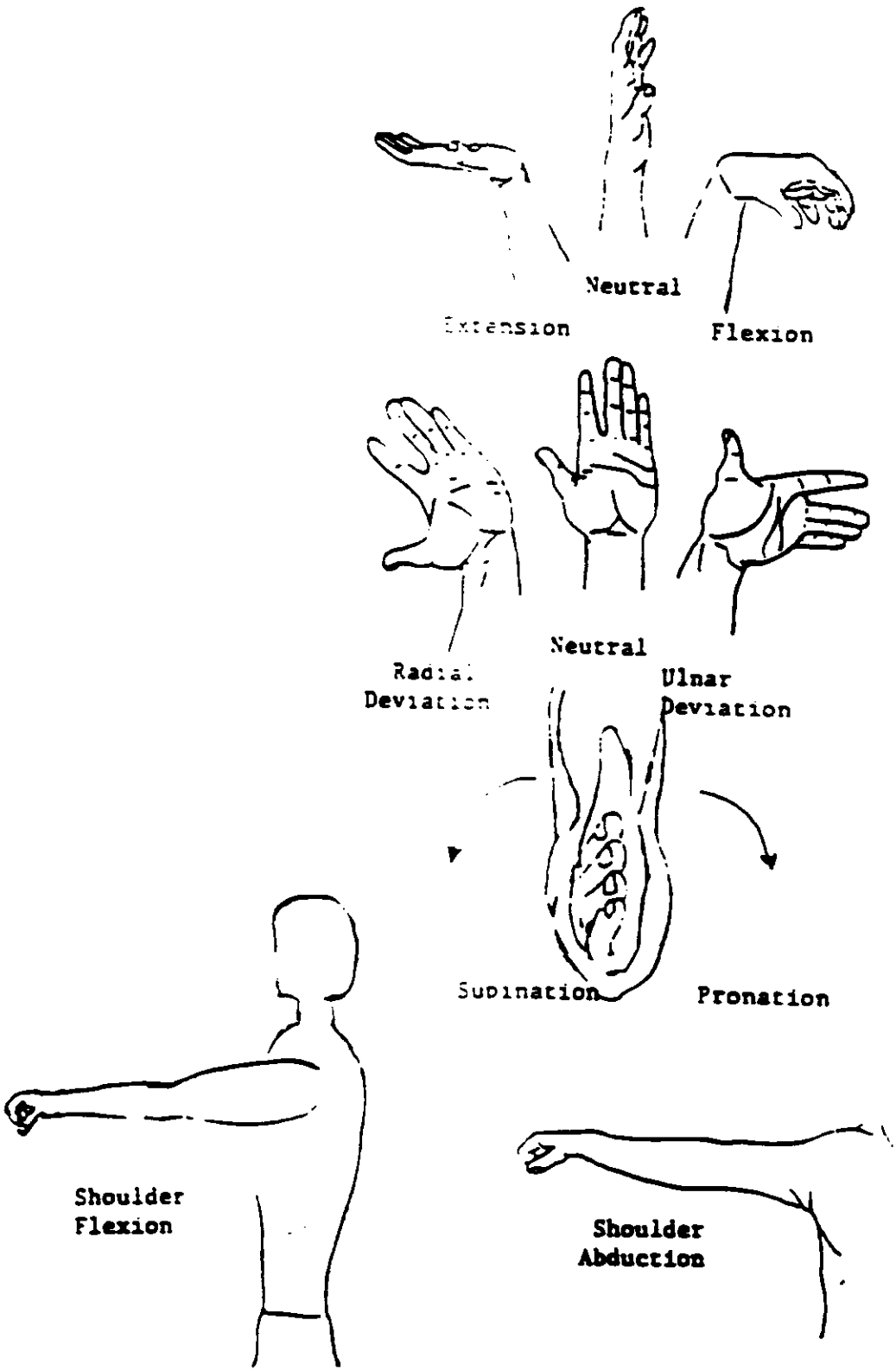


c) Sayerville

Figure 2

AWKWARD POSTURES OF THE WRIST, FOREARM AND SHOULDER

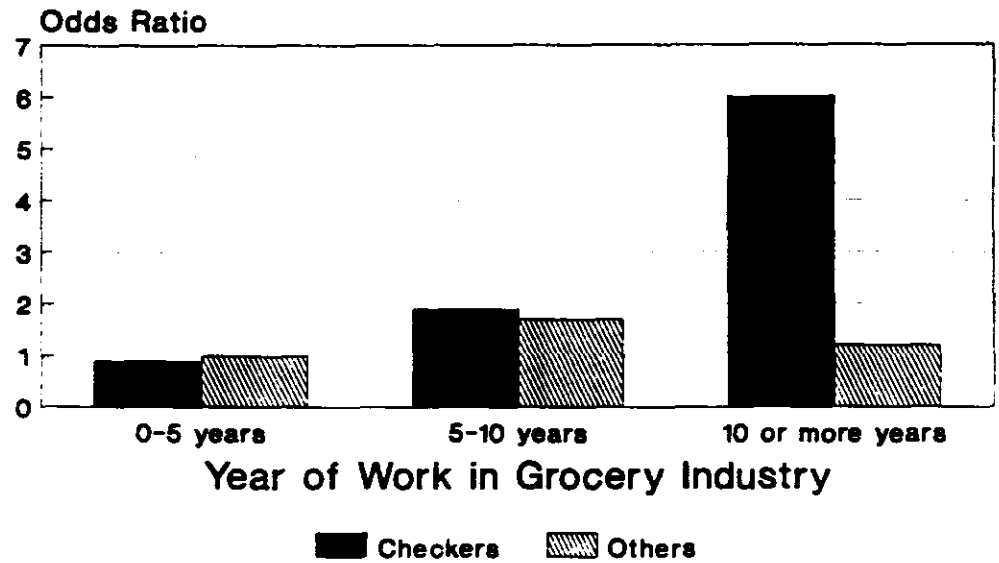
SHOPRITE SUPERMARKETS
NEW JERSEY-NEW YORK
HETA 88-344



SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

Figure 3

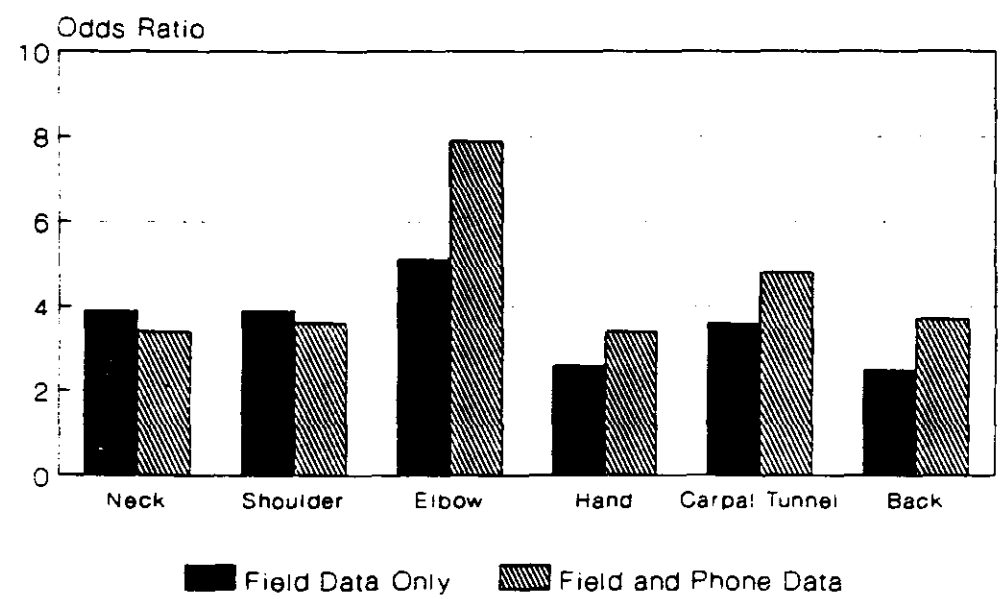
# Odds Ratio* Checkers vs Others
## Hand and Wrist Disorders




* Adjusted for months working, hobbies

Figure 4

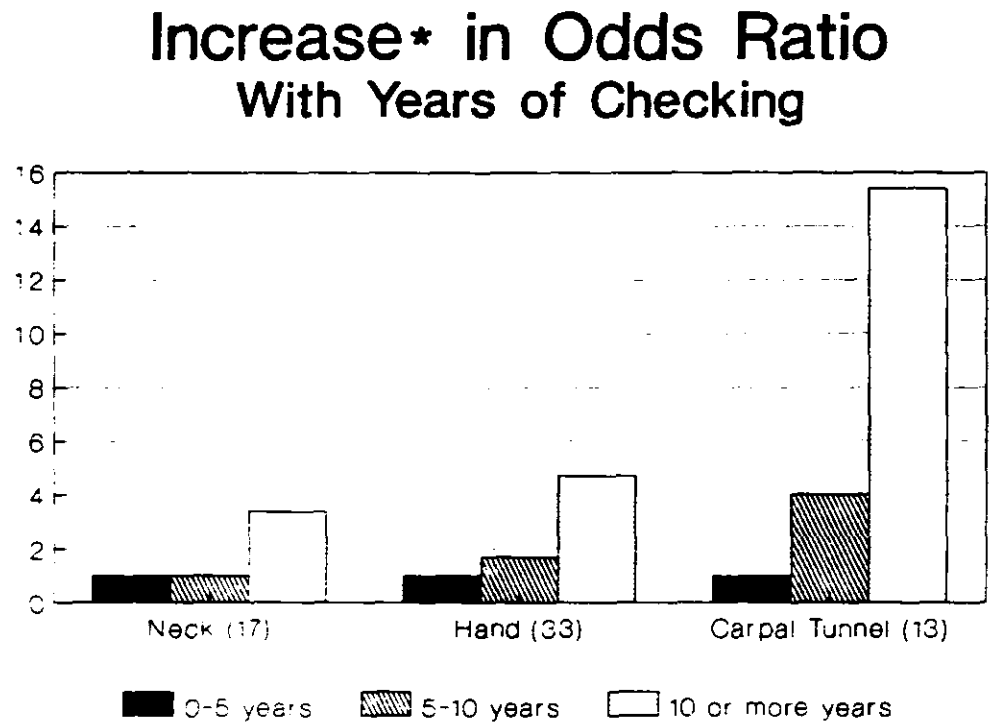
# Odds Ratios For Checkers vs Non-Checker Before and After Phone Interviews*




*All cases are by questionnaire only

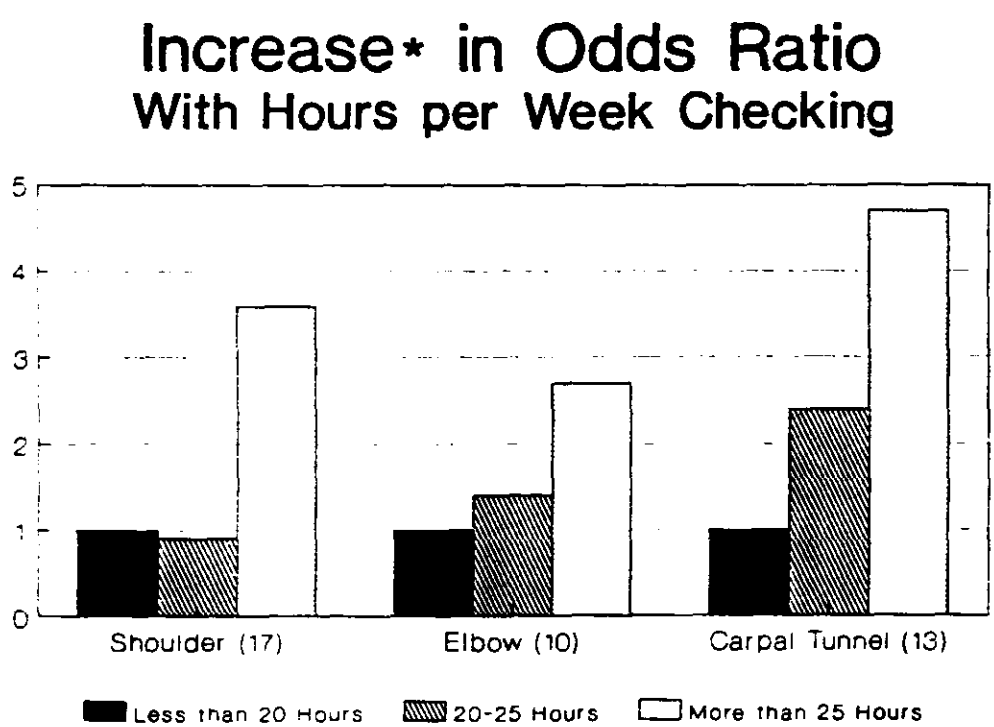
SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

Figure 5




* All are statistically significant

Figure 6

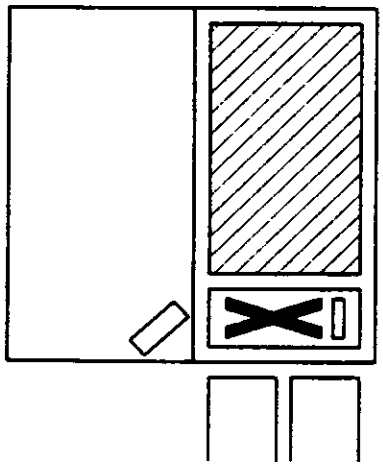



* All are significant except CTS

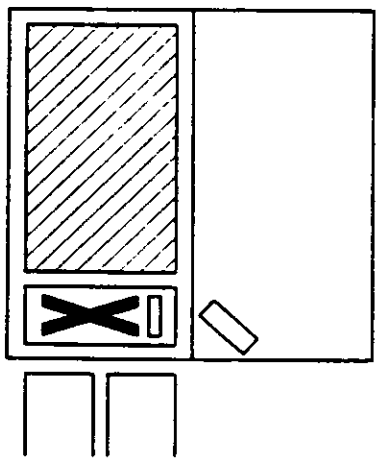
Figure 7

ESPRESS-LANE CHECKSTAND DESIGNS

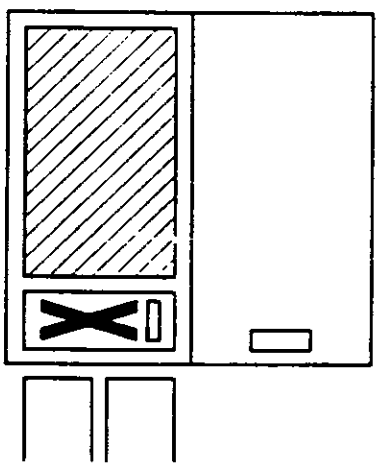
SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344



(a) Bricktown



(b) Middletown



(c) Clark

Figure 8

CHECKSTAND DESIGN RECOMMENDATIONS BASED ON ERGONOMIC ANALYSIS

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
HETA 88-344

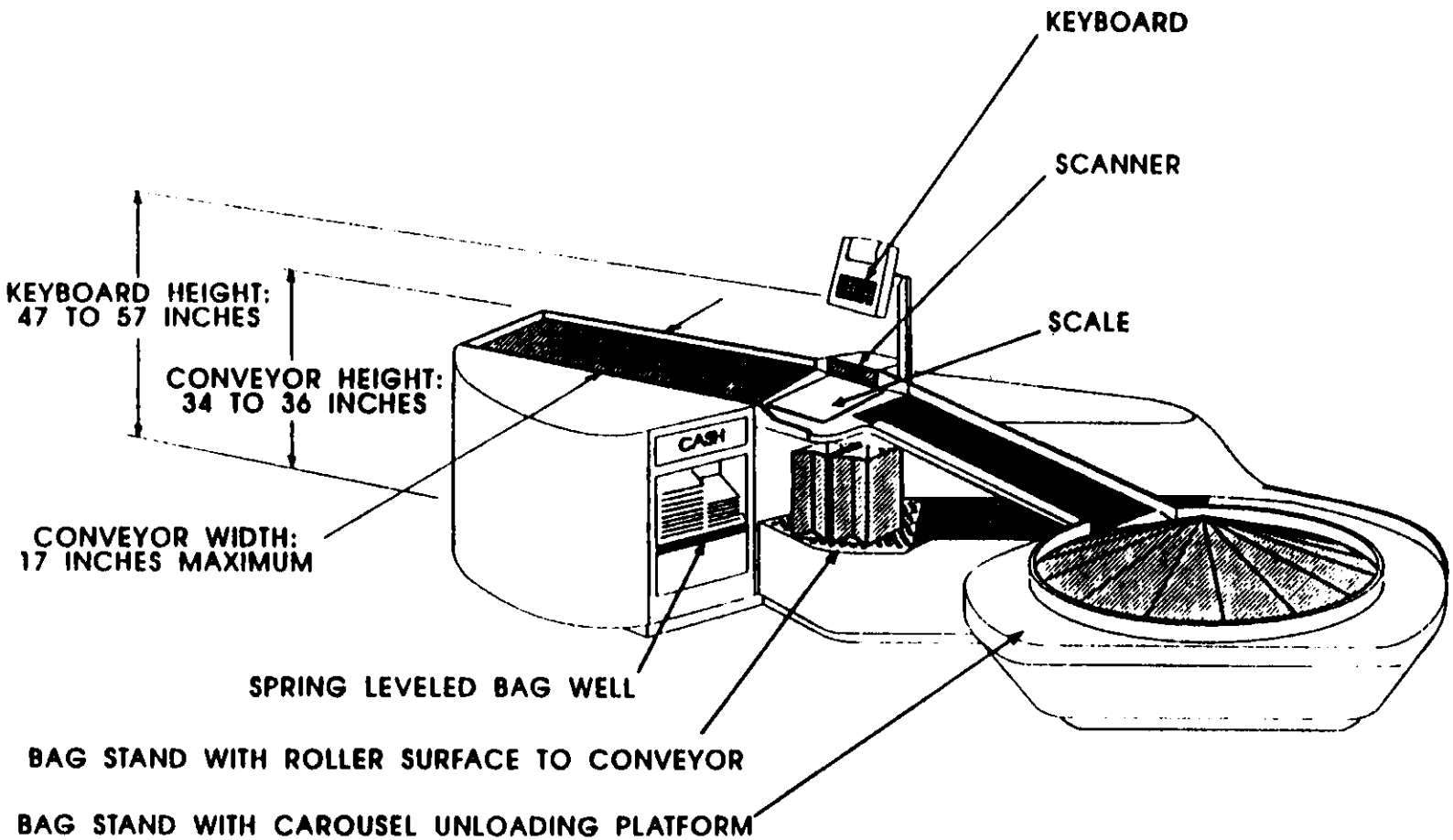
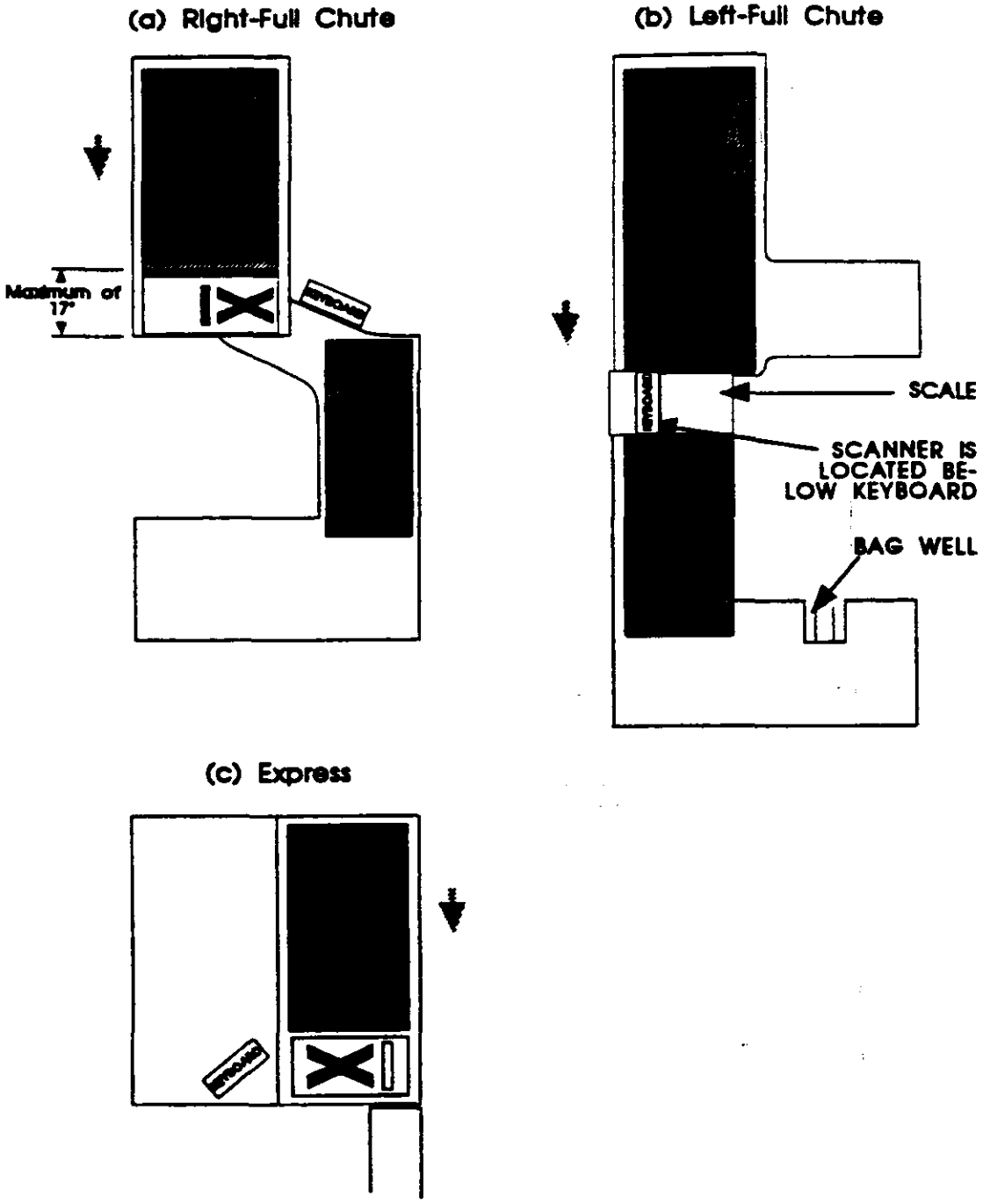


Figure 9

RECOMMENDED CHECKSTAND DESIGNS INTERIM MEASURES

SHOPRITE SUPERMARKETS
NEW JERSEY - NEW YORK
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