

MULTIDISCIPLINARY RESEARCH TO PREVENT SLIP, TRIP, AND FALL (STF) INCIDENTS AMONG HOSPITAL WORKERS

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Hospitals are diverse work environments with slip, trip, and fall (STF) incidence rates that are 67% higher than other U.S. private industry. **Objective:** To conduct lab and field research to identify risk factors for STF incidents and evaluate a 'best practices' STF prevention program in three hospitals. **Methods and Results:** 1) A descriptive analysis of six-years of workers' compensation data identified 316 STF claims, 2) A case follow-back field study identified contaminants and surface transitions as transient risk factors, 3) lab evaluations of flooring and footwear identified promising slip-resistant shoes and flooring, 4) assessments identified STF hazards, and 5) a field study found a 58% reduction in STF incidents after a 'best practices' program was implemented. **Conclusions:** Food service workers, housekeepers, nurses, EMS/Transport, and office staff are at highest risk of STF injury. This study applied multiple research methods to design a STF prevention program and demonstrate it's effectiveness in three hospitals.

Background

Falls are the second leading global cause of accidental death, after motor vehicle collisions. In the United States (US), STFs on the same level are a leading cause of occupational injury resulting in an average of 52 deaths and 220,000 non-fatal injuries annually and account for the largest proportion of lost time injuries to health care workers (21%) (Courtney *et al*, 2001). The health services sector is the largest employer in US private industry with an estimated 13 million workers. The large population of health care workers and the high frequency of STF incidents create a substantial risk for health care workers.

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

Study design and methods

Descriptive analyses

Six-years of STF workers' compensation injury data were analyzed to identify the circumstances and locations of STF incidents to target prevention efforts.

Case-crossover/case follow-back studies

Case-crossover (case follow-back) methodologies examined transient risk factors and described STF circumstances that could be targeted for prevention. Health care workers were interviewed by telephone with a structured questionnaire (Courtney *et al.*, 2006).

Laboratory testing of shoe-floor slip resistance

Laboratory studies evaluated the slipperiness of shoes (most commonly worn and slip-resistant), and hospital flooring (existing and slip-resistant) tested with 'soapy' and 'oily' contaminants. The test apparatus was a slip simulator instrument which can closely reproduce the biomechanical parameters during heel strike in normal gait. In this study, the test parameters were: normal force 500 N, sliding velocity 0.4 m/s, and heel contact angle 5 degrees. The dynamic friction coefficient was computed during the time interval 100–150 ms from heel strike, which in level walking represents a critical moment for a slip and fall.

Seven shoe types were first pre-tested on a stainless steel surface (roughness, Rz 1.6 μm) as new (intact heel and sole) and after abrasion according to draft standard (European Standard EN 13287: 2004). Glycerol 85% wt was used to simulate the 'oily' condition.

Ten different floorings were tested using two significantly different performing shoe types (no. 2 and no. 3) with abraded heels and soles with glycerol 85% wt ('oily' condition) and natrium lauryl sulphate 0.5% wt in water ('soapy' condition) used as contaminants. Paired t-tests compared the differences between initial (intact) and abraded shoe heels and soles, and between the different floorings and contaminants. The following slip-resistance classification for dynamic coefficient of friction was used:

| Dynamic friction coefficient (DCOF) | Slip resistance class |
|-------------------------------------|---------------------------|
| >0.30 | Slip-resistant |
| ≥ 0.20 –0.30 | Moderately slip-resistant |
| <0.20 | Slippery |

Hospital hazard assessments

On-site STF hazard assessments examined the condition of walkway surfaces, projecting objects or cords, lighting, handrails, and drains. Areas examined inside included entrances, stairs, ramps, operating rooms, the emergency room, scrub sink areas, nursing stations, pharmacy, histology lab, hallways, kitchen, dishwashing areas, cafeteria, patient rooms, bathrooms, surgical instrument decontamination, engineering and carpenter shops and the morgue. Outside areas examined included the parking garage, street, handicap ramps, and sidewalks. Photos of STF hazards and preventive recommendations were described in a written report that was provided to hospital management, safety staff, the housekeeping manager and the groundskeeper manager.

Field study-intervention trial

An intervention trial evaluated a 'best practices' STF prevention program in three acute care hospitals. The 'best practices' program was a multi-faceted effort based on findings from the descriptive analyses, case follow-back study, on-site hazard assessments, and lab tests. The field study compared STF injuries during a 4-year pre-intervention period with a 3-year post-intervention period in a cohort of approximately 22,000 full-time equivalent workers. Workers' compensation data and personnel records were used to compute injury rates.

Results and discussion

Descriptive analysis

During the six-year period from January 1, 1996 through December 31, 2001, 12,098 individuals worked a total person-work time of 44,488,639 hours. The analysis identified 316 workers' compensation claims for STF incidents (19% of all claims). Of the 316 fall incidents, 77% were STFs on the same level, 12% were slips and trips without a fall, and 11% were falls from elevation. The most common scenarios for STFs on the same level involved workers slipping on grease, ice/snow, spilled drinks, and food. The most common circumstances for trip and fall incidents involved employees tripping over phone or medical equipment cords, surface irregularities in flooring and carpeting, and holes in the parking lot. The highest injury rates for STF incidents occurred among food service workers (4.5 STF injury claims/100 food service workers), and the most frequent injuries ($n = 99$, 31%) occurred among nursing staff and office workers ($n = 64$, 20%). The most frequent injuries were sprains, strains, dislocations, and tears (47%) involving the lower extremities (45%).

Case-crossover/case follow-back studies

Through February 2005, 123 health care workers who reported a STF to the occupational health department were recruited and interviewed using a structured

Table 1. Shoes pre-tested on the reference stainless steel surface – ‘oily’ condition.

| Shoe no. and type | Intact heel/sole DCOF (SD) | Abraded heel/sole DCOF (SD) | p-value |
|------------------------------------|-------------------------------|--------------------------------|---------|
| 1. Nursing shoe with laces | 0.159 (0.001) | 0.198 (0.022) | <0.01 |
| 2. Slip-resistant shoe w/laces – a | 0.328 (0.026) | 0.375 (0.028) | <0.001 |
| 3. Shoe with laces – b | 0.149 (0.015) | 0.173 (0.013) | <0.001 |
| 4. Clog | 0.073 (0.012) | 0.141 (0.008) | <0.001 |
| 5. Shoe with open heel | 0.084 (0.011) | 0.142 (0.012) | <0.001 |
| 6. Shoe with laces – c | 0.113 (0.009) | 0.138 (0.019) | <0.01 |
| 7. Safety shoe with laces | 0.140 (0.009) | 0.153 (0.010) | <0.05 |

* Statistically significant difference between new and abraded soles (t-test paired 2-tailed).

telephone questionnaire. Participants were predominantly female (86%) with a mean age (range) of 46 (19–67). Nurses (33%), secretaries or clerks (13%), and health technicians (9%) were the most frequently reported occupations. One hundred and eight subjects (88%) fell: 53% after slipping, 32% after tripping. Liquid contaminants (e.g., water) were involved in 36% of the events. Sixty-four percent of the STFs occurred at a transitional area: dry/wet (32%), one type of floor to another (20%), or uneven surfaces (15%). The back, knees, ankles/feet were most frequently injured. Strains and sprains (29%), contusions (27%), and non-specific pain and soreness (22%), were typical. Other injuries included abrasions, fractures, edema and lacerations. Overall, 94% of subjects were injured. Interested readers should consult Courtney *et al.*, (2006) which presents these results in detail.

Laboratory study results

The lab study identified slip-resistant shoes and flooring that performed optimally under ‘soapy’ and ‘oily’ conditions. The results for the shoes are presented in Table 1, and for the floorings in ‘oily’ and ‘soapy’ conditions in Table 2. Results confirmed previous results (Grönqvist, 1995) showing that heel and sole abrasion significantly improved slip-resistance.

Flooring testing and classification

Slip-resistance evaluations of ten hospital floorings were conducted with both good and poor performing shoes (nos. 2 and 3, Table 1). Shoe no. 2 was classified as ‘slip-resistant’ (DCOF > 0.30) and shoe no. 3 as ‘slippery’ (DCOF < 0.20) on stainless steel (‘oily’) test condition.

All DCOF differences between the two contaminant conditions ‘oily’ vs. ‘soapy’ were statistically significant ($p < 0.01$) for all floorings, except flooring no. 4 and no. 8 tested with shoe no. 2 (Table 2). All DCOF were significantly different (p -values < 0.01) between the two test shoes (no. 2 and no. 3) (Table 2). Quarry tile was the only tested flooring that was slip-resistant with both test shoes under all contaminant conditions (Table 2).

Table 2. Floorings tested in the 'oily' and 'soapy' conditions with two shoes.

| Flooring no. and type | Shoe no. 2* | Shoe no. 2* | Shoe no. 3** | Shoe no. 3** |
|--------------------------|----------------------------------|-----------------------------------|----------------------------------|-----------------------------------|
| | 'oily' condition DCOF (SD) | 'soapy' condition DCOF (SD) | 'oily' condition DCOF (SD) | 'soapy' condition DCOF (SD) |
| 1. Waxed vinyl tile | 0.356 (0.044) | 0.263 (0.029) | 0.133 (0.015) | 0.163 (0.008) |
| 2. Slip-resistant – a | 0.325 (0.027) | 0.452 (0.034) | 0.129 (0.012) | 0.254 (0.015) |
| 3. Slip-resistant – b | 0.369 (0.027) | 0.353 (0.021) | 0.155 (0.023) | 0.283 (0.012) |
| 4. Slip-resistant – c | 0.367 (0.034) | 0.378 (0.021) | 0.144 (0.017) | 0.290 (0.011) |
| 5. Slip-resistant – d | 0.335 (0.023) | 0.277 (0.022) | 0.131 (0.013) | 0.202 (0.007) |
| 6. Quarry tile | 0.580 (0.026) | 0.753 (0.021) | 0.288 (0.021) | 0.539 (0.018) |
| 7. Safety – a | 0.352 (0.023) | 0.405 (0.016) | 0.163 (0.008) | 0.243 (0.034) |
| 8. Safety – b | 0.311 (0.018) | 0.319 (0.012) | 0.146 (0.008) | 0.242 (0.023) |
| 9. Safety – c | 0.351 (0.022) | 0.483 (0.019) | 0.154 (0.011) | 0.248 (0.032) |
| 10. Safety – d | 0.365 (0.020) | 0.437 (0.014) | 0.168 (0.008) | 0.267 (0.025) |

* Shoe no. 2 – slip-resistant shoe w/laces. ** Shoe no. 3 – common tennis shoe w/laces.

Hazard assessments

The hazard assessments identified a range of slip, trip and fall hazards. The major hazards found were: 1) flooring and walkway surface irregularities, 2) changes in walkway level, 3) grease, water and food on floors in food cooking and serving areas, 4) loose cords under computer workstations and in operating rooms, and 5) stair visibility and handrail problems.

Field study

Analyses of workers' compensation data indicated the comprehensive 'best practices' STF prevention program resulted in a 58% reduction in workers' compensation injury incidence rates attributed to STF incidents (Bell *et al.*, manuscript under review).

STF prevention strategies emerging from this study

1. Conduct hazard assessments to proactively identify STF hazards.
2. Offer slip-resistant shoes to employees whose work in wet or greasy floors.
3. Place a sufficient number of absorbent mats at hospital entrances so that water is not tracked on the floor on rainy or snowy days. Replace mats with curled edges.
4. Implement effective procedures to degrease floors in food preparation/serving areas.
5. Provide plastic disposable umbrella bags at hospital entrances.
6. When mopping, disinfecting, stripping or waxing floor surfaces, use highly visible wet floor signs with barricades to block pedestrians from walking onto wet floors.
7. Develop a system for promptly cleaning up spills.

8. Lids should be required for drinks.
9. Use clamps/cord holders to secure medical equipment cords and cords under desks.
10. Check parking areas and covered garages, to ensure that lighting is adequate.
11. Check drains on a regular basis to ensure that there are no clogs or standing water.
12. Slip-resistant flooring and shoes may reduce the risk of slipping and falling.

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