



HHS Public Access

Author manuscript

Emerg Med J. Author manuscript; available in PMC 2017 May 23.

Published in final edited form as:

Emerg Med J. 2016 April ; 33(4): 280–285. doi:10.1136/emermed-2015-204964.

Teammate familiarity and risk of injury in Emergency Medical Services

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Abstract

OBJECTIVE—We investigated the association between teammate familiarity and workplace injury in the Emergency Medical Services (EMS) setting.

METHODS—We abstracted a mean of 29-months of shift records and Occupational Safety Health Administration injury logs from 14 EMS organizations with 37 total bases located in four U.S. Census regions. Total teammate familiarity was calculated for each dyad as the total number of times a clinician dyad worked together over the study period. We used negative binomial regression to examine differences in injury incidence rate ratios (IRR) by familiarity.

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Competing Interests: The authors report no competing interests or conflicts of interests.

RESULTS—We analyzed 715,826 shift records, representing 4,197 EMS clinicians and 60,701 unique dyads. We determined the mean shifts per dyad was (5.9, SD 19.7), and quartiles of familiarity were 1 shift worked together over the study period, 2–3 shifts, 4–9 shifts, and 10 shifts worked together. More than half of all dyads worked one shift together (53.9%, n=32,739), 24.8% of dyads 2–3 shifts, 11.8% worked 4–9 shifts, and 9.6% worked 10 shifts. The overall incidence rate of injury across all organizations was 17.5 per 100 FTE, range 4.7 to 85.6 per 100 FTE. The raw injury rate was 33.5 per 100 FTEs for dyads with one shift of total familiarity, 14.2 for 2–3 shifts, 8.3 for 4–9 shifts, and 0.3 for 10 shifts. Negative binomial regression confirmed that dyads with 10 shifts had the lowest incidence of injury (IRR=0.03; 95%CI 0.02–0.04).

CONCLUSIONS—Familiarity between teammates varies in the EMS setting, and less familiarity is associated with greater incidence of workplace injury.

Keywords

Team; safety; injury; teamwork; familiarity

INTRODUCTION

Teamwork is essential in the safe delivery of healthcare.¹ Teamwork is ...”*behaviors of team members that engender a sharing of information and a coordination of activities.*”² Previous research in aviation, surgery, and other high-risk occupations shows a link between the amount of shared work experiences among teammates (familiarity) and outcomes.^{3–6} The relationship between Emergency Medical Services (EMS) clinician teammate familiarity and safety outcomes, such as occupational injuries, adverse events, and medical errors, has not been comprehensively studied.

The need to consider familiarity between EMS teammates as a contributor to crew safety and performance is compelling. First, the delivery of EMS healthcare in the U.S. and in most other nations occurs with coordination between two EMS clinician co-workers. These clinicians perform tasks outside the hospital setting where resources and information are often limited, stress levels are elevated, and time to perform critical interventions is restricted.⁷ Poor teamwork may contribute to poor performance during time-sensitive episodes of care and lead to a negative patient outcome and/or increased risk for EMS injury. Workplace injuries and fatalities occur more often in the EMS setting than in the general U.S. workforce.^{8–11} Musculoskeletal sprains and strains are the most commonly reported non-fatal injuries, of which most can be linked to bodily exertion/movement.⁸ Injuries that lead to lost time from work or medical evaluation are more common among EMS clinicians than firefighters and police, according to one U.S.-based study.¹² Exposure to violent patients and bystanders, bodily fluids, and stressful situations are common for EMS clinicians.^{13–15}

There are no prescribed or evidence-based guidelines for formation of EMS work teams based on familiarity amongst clinician teammates. Most teams are deployed in shifts and include two clinicians. A U.S.-based licensed EMS clinician may be credentialed as a first responder, Emergency Medical Technician Basic (EMT-B), an EMT-Intermediate or advanced level EMT, paramedic, prehospital nurse, respiratory therapist, or prehospital

physician. It is unclear if familiarity between clinicians is a factor when configuring EMS teams the shiftwork schedule. Three common approaches to EMS shift scheduling include: 1) pairing clinicians based on availability, 2) giving senior clinicians preference on shift selection, and 3) allowing clinicians to “bid” on open shifts or schedules. Despite seniority, some EMS clinicians may maintain a particular schedule with a consistent/familiar partner due to preferences in scheduling and work-life balance, rather than preferences germane to a particular teammate. These practices may contribute to EMS teams with low or high levels of teammate familiarity. Previous research in other occupations confirms a link between co-worker familiarity, performance, and safety in high-risk environments.³⁻⁶ One study of three EMS organizations determined the average EMS clinician works with 19.3 (± 12.4) different teammates annually, and spends approximately two-thirds of scheduled shifts with a co-worker with whom he/she has not worked with previously.¹⁶ Lack of evidence-based approaches to EMS clinician configuration and deployment imply an opportunity for improvement in EMS team deployment and workplace safety.

We sought to assess variation in familiarity between EMS teammates across U.S.-based EMS organizations and examine the association between familiarity and work-related injury. We hypothesized that EMS clinician teams with greater familiarity were less likely to experience a work-related injury compared to co-worker teams with less familiarity.

METHODS

Study design and sample

We used a retrospective cohort design and convenience sample of 14 EMS organizations comprising 37-individual agencies/base sites and 4,446 total EMS employees. This sample included agencies with all-paid employees spread across all major U.S. Census regions with variation in EMS workers per agency from 96 to 348 EMS workers. We collected minimum of one and maximum of three years of administrative shift scheduling records and occupational injury/illness records. We used these data to operationalize the outcome of interest (occupational injury), independent variable of interest (EMS teammate familiarity), and relationship between the two. The University of Pittsburgh Institutional Review Board approved our study.

Study protocol

First, we collected between one and three years of injury records from participating EMS organizations. Most EMS organizations maintained injury records based on the requirements of the Occupational Safety and Health Association (OSHA) 300 log requirements for injury documentation. Some EMS organizations maintained injury records using a format similar to the requirements of OSHA. For purposes of this study, we standardized all injury records in accordance with the OSHA 300 log format. Prior to receipt of injury records, we required that each EMS organization replace identifiable employee information with a unique identification number and that this number and its linkage to individual EMS clinicians be maintained at the agency by an agency-designated administrator assigned to work with the study team. Injury records with incomplete documentation were excluded.

Next, we collected and collated administrative shift records from study site coordinators to calculate EMS teammate familiarity. Prior to receipt of shift record data, site coordinators removed all identifiable information (e.g., names) and replaced these fields with a study assigned unique identification number. We received de-identified shift records in electronic format and reformatted data files with each row representing a dyadic shift record. Each file contained the following information: 1) a study assigned code number for EMS organization, 2) a code number for the first clinician crewmember; 3) a code number for the second clinician crewmember; 4) date and time of shift start, and 5) the date and time of shift end. We excluded shift records if: 1) the record represented a shift of a non-clinical worker (e.g., a mechanic); 2) an employee code number was missing; or 3) the shift represented a non-dyadic shift record (e.g., a single clinician worker or 3 clinicians on the same unit/shift). We used the study assigned unique identification numbers for EMS agencies and individual clinicians along with dates to match injury records to shift records.

Outcome of interest

Our principal outcome of interest was EMS clinician injury or illness as measured by the U.S. Department of Labor Occupational Safety Health Administration (OSHA) 300 log. In the U.S., OSHA requires an employer to report work related injuries and illnesses using the standardized OSHA 300 log or a similar system if exempt from the OSHA format. Each agency provided complete injury documentation for the study period, which included date of injury, where the event occurred, a description of the injury or illness, classification of the case as (a death, days away from work, job transfer or restriction, or other recordable case), days away from work, job restriction, and type of injury as either 1) an injury, 2) skin disorder, 3) respiratory condition, 4) poisoning, 5) hearing loss, or 6) all other illness. Two co-authors reviewed all reported injuries and illnesses and excluded minor reports that did not meet the minimum definition of injury or illness by OSHA. We used these definitions to minimize bias from agencies or individuals with low thresholds for reporting injuries and illnesses. The process was performed sequentially by two co-authors and confirmed by consensus. Our case definition of a work-related injury was: *“any wound or damage to the worker’s body that resulted from an event in the work environment requiring medical care beyond basic first aid or resulted in loss of consciousness or inability to perform normal work-related duties.”* We defined work-related illness as: *“any illness or exposure to an infectious illness that resulted from a work-related event and was not preventable with use of personal protective equipment.”*

Independent variable of interest

Our independent variable of interest was EMS worker teammate familiarity. There are no standards or prescribed measurements for quantifying familiarity between EMS teammates. Prior research reports the following measures of EMS familiarity using one-year of administrative shift records: 1) annual mean number of unique partners/teammates, and 2) the proportion of shifts worked with the most common partner.¹⁶ For measure 1, we determined the total number of different partners for each EMS clinician in the database. We divided this number by the total years of participation for comparison purposes. For measure 2, we calculated the total number of shifts worked with each unique partner. We isolated the

partnership with the maximum number of shifts for each employee. We then divided that number by the total number of shifts worked with all partners during the time period.

We calculated measures similar to those reported in previous research.¹⁶ We calculated ‘total familiarity,’ defined as the total number of times a worker dyad worked together during the study period. We explored stratifying familiarity into quartiles or tertiles to aid in the interpretation and application of results. We estimated incidence rates of worker injury across categories of total familiarity and examined the association between categories of total familiarity and rate of injury.

Statistical analysis

We describe the outcome and independent variables of interest for the study sample at the EMS organization level with descriptive statistics such as means, standard deviations (SD), median, minimum, maximum, frequencies, and percentages. We tested for differences in shift duration for all clinician dyads and number of unique teammates per year across agencies using ANOVA. We calculated the rate of workplace injury/illness as the number of injury reports per 100 full-time equivalent (FTE) workers. An FTE was defined as scheduled shift work of 2000 hours per year.

We stratified total familiarity into four approximately equal categories (quartiles): 1 shift worked together, 2–3 shifts, 4–9 shifts, and 10 shifts worked together. We examined differences in injury incidence rate ratios (IRR) across quartiles of total familiarity at the dyadic level using negative binomial regression.¹⁷ The p-values from the likelihood ratio test and associated confidence intervals of the IRR estimates were used to evaluate the differences across quartiles of total familiarity. We included the total hours of work as an exposure or offset factor in the negative binomial model and included EMS organization as a control variable. We assessed model fit using observed versus predicted plots and compared to alternate models using Akaike information criterion (AIC), Bayesian information criterion (BIC), the likelihood ratio test, and the Vuong test.

Statistical analysis was conducted using STATA Version 12.1, MP (College Station, TX).

RESULTS

We collected 989,444 administrative shift records and 972 OSHA 300 log injury records (Figure 1). We retained 715,826 administrative shift records and 803 injury records following exclusions for 1) non-clinical shifts; 2) records missing employee code numbers; 3) shifts that were non-dyadic (e.g., three-person teams); and 4) failure to meet criteria for injury reporting. We summarize the descriptive characteristics of our study sample in Table 1.

Dyads and co-worker familiarity

The total number of dyadic level shift records was 357,913 and ranged from 6,930 over 13 months at EMS organization #2 to 53,864 over 30 months at EMS organization #1 (Table 1). The mean shift duration for all EMS clinician dyads was 12.8-hours (± 4.4 -hours) and varied by EMS organization ($p < 0.001$). The overall mean number of unique EMS teammates per

year at 18.6 (SD 10.2) was similar to that reported in previous research,¹⁶ and varied by EMS organization [min=14.3, max=32.2; $p<0.001$]. The proportion of shifts that EMS clinicians worked annually with their most common co-worker was 40.9% (SD 25.4%) overall, and varied by and within EMS organizations ($p<0.001$). The distribution of total familiarity stratified into quartiles was: 53.9% of dyads with 1 shift worked together, 24.7% with 2–3 shifts worked together, 11.8% with 4–9 shifts worked together, and 9.6% with 10 shifts worked together.

Outcome of interest

Total injuries by EMS organization ranged from 11 over 22-months to 205 over 24-months (Table 1). The overall incidence rate of injuries per 100 Full-Time Equivalent (FTE) EMS workers was 17.5. Nearly one-third (28.6%) of injuries resulted in work restriction and one-fifth (17.1%) with time away from work. The rate of injuries with duty restriction or time away from work was similar across EMS agency ($p=0.67$). The raw injury rate was 33.5 per 100 FTEs for dyads with one shift of total familiarity, 14.2 for 2–3 shifts, 8.3 for 4–9 shifts, and 0.3 for 10 shifts of total familiarity.

Association between total familiarity and injury

The incidence rate of injury was highest for EMS teammate dyads with only one shift worked together over the study period (Figure 2). Compared to these dyads, teammate dyads with 2–3 total shifts of total familiarity were nearly 60% less likely to report an injury (IRR 0.43, 95% CI 0.31–0.60) after controlling for agency. Dyads with 4–9 shifts were 75% less likely than the 1-shift dyads to experience an injury (IRR 0.25; 95% CI 0.19–0.35), and dyads with 10 shifts of familiarity had the lowest risk of injury relative to dyads with 1-shift (IRR 0.03; 95% CI 0.02–0.04; Figure 2). A model examining total familiarity as a continuous exposure estimated a 2% reduction in injury rate for every additional shift of familiarity (IRR 0.977; 95% CI 0.976–0.979) after controlling for agency. We confirmed that a negative binomial strategy was the preferred modeling approach for our data versus a Poisson model by examining overdispersion and model fit statistics. A negative binomial model was favored over a zero inflated negative binomial model when evaluating model fit statistics and the Vuong test.

DISCUSSION

Previous research has been limited to small samples of EMS organizations or injury surveillance data that is often associated with the most severe of workplace injuries, rather than all injuries and illnesses.^{9,10,12} We show that in a diverse sample of EMS organizations and with multiple years of scheduling data, most EMS clinicians have limited familiarity with their teammates. The EMS industry may use our descriptive findings as base-rate data for purposes of comparing teammate familiarity between EMS organizations. Finally, we show that the risk of injury is lower for EMS clinician dyads with greater shared work experiences (shifts together) over time than in teams with less shared experiences at work.

Our prior smaller-sample research noted that EMS clinicians spend approximately one-third of their shifts with their most common co-worker.¹⁶ Prior research was limited to one year

of shift scheduling data and three EMS organizations. The current data come from a larger sample of 14 diverse EMS organizations that provided an average of 29.3 months of shift scheduling data. These data provide additional years of scheduling patterns and are more inclusive of events that may disrupt team familiarity in the workplace over the long term (e.g., employee turnover, absences, and other factors). Our findings imply that pairing EMS clinicians with limited familiarity increases risk of worker injury. One potential explanation for this finding is that a team with limited time or limited shared experiences working together may lack team cohesion. Team cohesion refers to a team's "*shared commitment to the group task and a shared attraction and mutual liking for one another.*"¹⁸ Cohesion is considered a critical variable of teams because of its linkage to positive team outcomes in diverse settings.^{19–23} Future research should explore the evolution and role of team cohesion amongst EMS teammates.

Few have investigated the relationship between clinician teammate familiarity and safety outcomes. The preponderance of research on this topic has been restricted to non-healthcare settings. For example, greater familiarity amongst co-workers in the air-traffic control environment has been linked to positive teamwork behaviors, such as assisting teammates when backup was needed or requested.²⁴ Less familiarity between pilot / co-pilot teammates has been linked to crashes and errors.³⁴⁶ In some healthcare settings, increased familiarity between the attending surgeon and assisting surgeon is associated with improved performance.²⁵

We followed the approach used in prior research and examined the teammate familiarity-outcome relationship treating familiarity as a cumulative / total exposure over time.^{624–26} We determined that limited familiarity over time was associated with greater risk of EMS clinician injury. Odds of injury decreased with relatively small increases in the total number of shifts worked together. A likely explanation is that EMS teams experience rapid development of team behaviors and quickly enter a stage of team development known as "norming." Norming is a stage of team progression outlined by Tuckman in a popular model of team development.²⁷ It refers to the act of teammates leveraging the knowledge and skills of prior experiences and bringing those forward to influence team behavior and impact performance.²⁷ A rapid progression into norming behaviors may be unique to dyadic work teams like those deployed in the EMS occupation. Our data suggest opportunities for reducing the risk of injury associated with limited co-worker familiarity in teams with 0 or only 1 prior shift together. One opportunity may involve a pre-deployment intervention that requires first time EMS teammates to assemble immediately prior to a scheduled shift and simulate their respective roles across possible scenarios that may arise during their shiftwork. An intervention of this type may promote more frequent communication about work-related tasks. This type of intervention seems relevant given prior research that shows communication amongst first-time teammates is often related to social issues rather than matters related to work.⁴ Another opportunity that is common in many healthcare settings may involve a training program for new hires that emphasizes the importance of teamwork to avoid injury or medical error due to poor team interaction with new teammates.

Worker safety and patient safety are high priorities for the federal government and EMS professional oversight organizations in the U.S. The recent white paper, *Strategy for a*

National EMS Culture of Safety, highlights significant gaps in policies, procedures, training, and operations that impact safety of patients and EMS clinicians.²⁸ EMS clinicians experience work-related injuries and death at a rate higher than the general working population and higher than other public safety occupations with similar risk factors.⁸⁻¹⁰¹² We have shown that less teammate familiarity contributes to negative safety outcomes for EMS clinicians, and may contribute similarly to outcomes for patients. The U.S.-based EMS system of prehospital emergency care is an important resource for public health and safety, with more than 19,000 U.S.-based EMS organizations and 800,000 - one million EMS workers.²⁹ Our findings warrant a minimum of two lines of future research. Research is needed to determine the evolution of a cohesive team in the EMS setting. How long does a newly formed EMS team need to be together before they develop routines, good communication, and reduce their risk of negative safety outcomes such as injury and medical error? Research is needed to test novel and cost-effective team configuration and deployment strategies as well as use of pre-deployment interventions as a mechanism to improve workplace safety.

LIMITATIONS

Our findings are limited to the EMS organizations that participated in our study, which may differ from other EMS organizations. While sample bias is possible, we think our inclusion of 14 diverse EMS organizations with multiple base sites (n=37) from across four major Census regions of the U.S. and more than 350,000 dyadic shifts over multiple years mitigates that concern. Our observations are congruent with others, further lessening any distortion concern.

We limited our sample to dyadic shifts, which led to the exclusion of 250,256 non-dyadic shift records, including single-clinician or 3+ clinician shift deployments. Some EMS systems (e.g., fire-based systems) utilize or promote utilization of 3+ teams on ambulances or fire apparatus. While these do represent an interesting team dynamic, they were not the focus of this study. Other factors that may confound the association between familiarity and injury, yet not controlled for in this study include EMS clinician age, length of employment at the EMS organization, race/ethnicity, and sex.

While there is no prescribed approach to measurement of familiarity in the EMS setting or in other settings, we used previous research as a guide.⁶¹⁶²⁴²⁶ One area for future research is measurement of familiarity in teams, especially dyadic teams.

CONCLUSIONS

Familiarity among EMS clinician teammates is variable and often limited. Higher levels of familiarity over time are associated with lower incidence of workplace injury. The relationship between teammate familiarity and workplace safety is complex and requires additional research to account for individual, team, and organizational factors that may impact a team's familiarity.

Acknowledgments

Funding:

Work performed on this study was supported by a grant from the National Institute for Occupational Safety and Health (NIOSH), Grant #1R21OH010025-01A1 and by Dr. Patterson's career development award / KL2 training grant from the National Center Research Resources and the National Institutes of Health [NIH/NCATS Grant no: KL2 TR000146] (Dr. Reis PI). Interpretations of study findings do not represent the opinions or views of NIOSH or NIH. Authors would like to acknowledge administrative assistance from Mrs. Beth Wesoloski and Maureen Morgan. Preliminary findings were presented as a poster presentation at the National Association of EMS Physicians (NAEMSP) annual meeting in New Orleans, LA; January 22–25, 2015.

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What this paper adds

What is already known

- Previous research links limited familiarity between teammates to negative safety outcomes in high-risk settings such as aviation.
- Several studies with small samples have shown that clinicians in the in-hospital emergency department and prehospital emergency care settings have limited teammate familiarity, yet none have linked familiarity to safety outcomes.

What this study adds

- Our study shows that less familiarity amongst prehospital clinician teammates is associated with greater incidence of workplace injury.
- Our findings may impact policies and procedures that guide team formation in the prehospital emergency care setting.

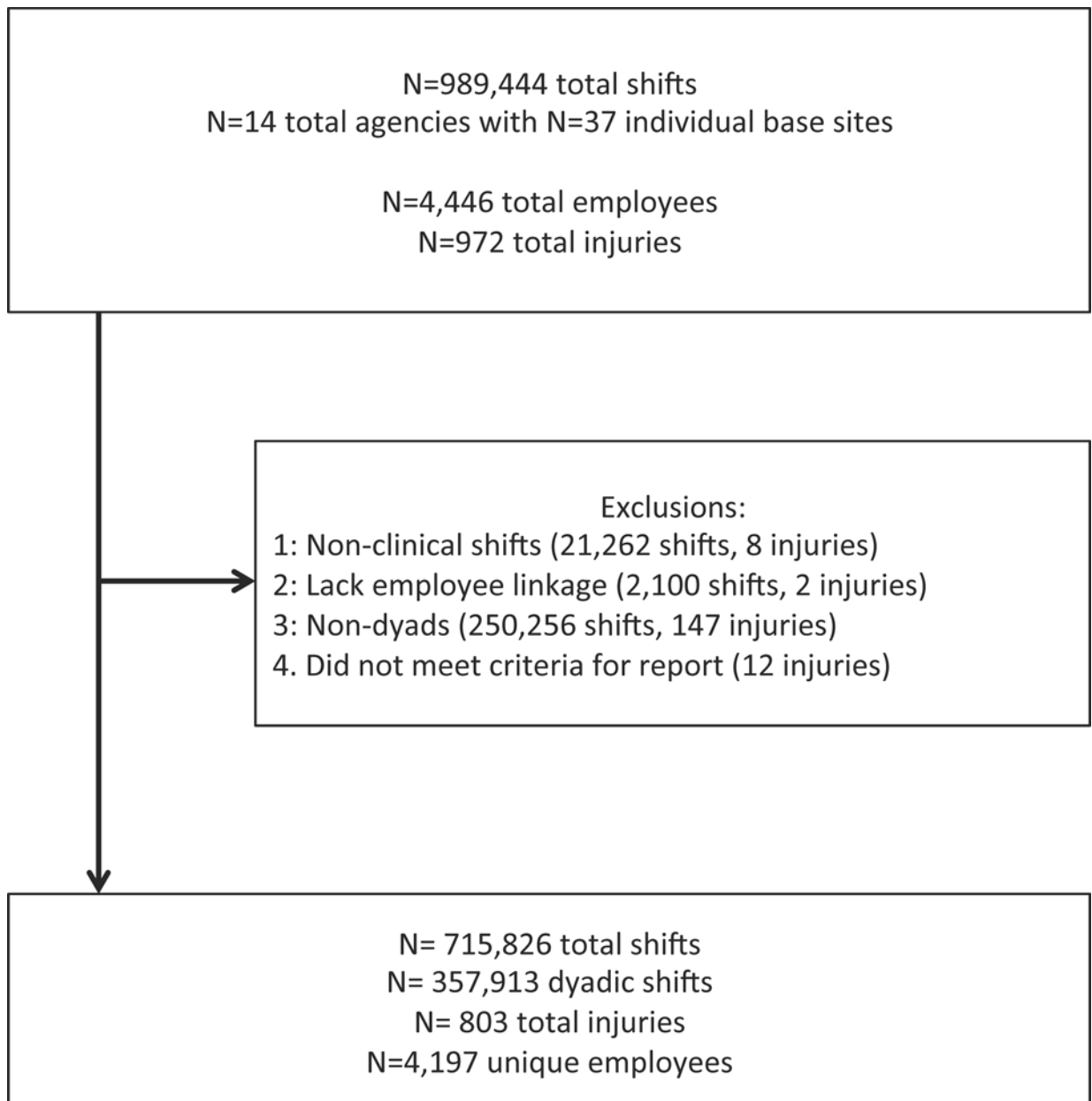


Figure 1. Consort diagram

Figure 1 is our consort diagram, which shows the original sample size for all variables of interest, inclusions and exclusions, and the final study sample for analysis purposes.

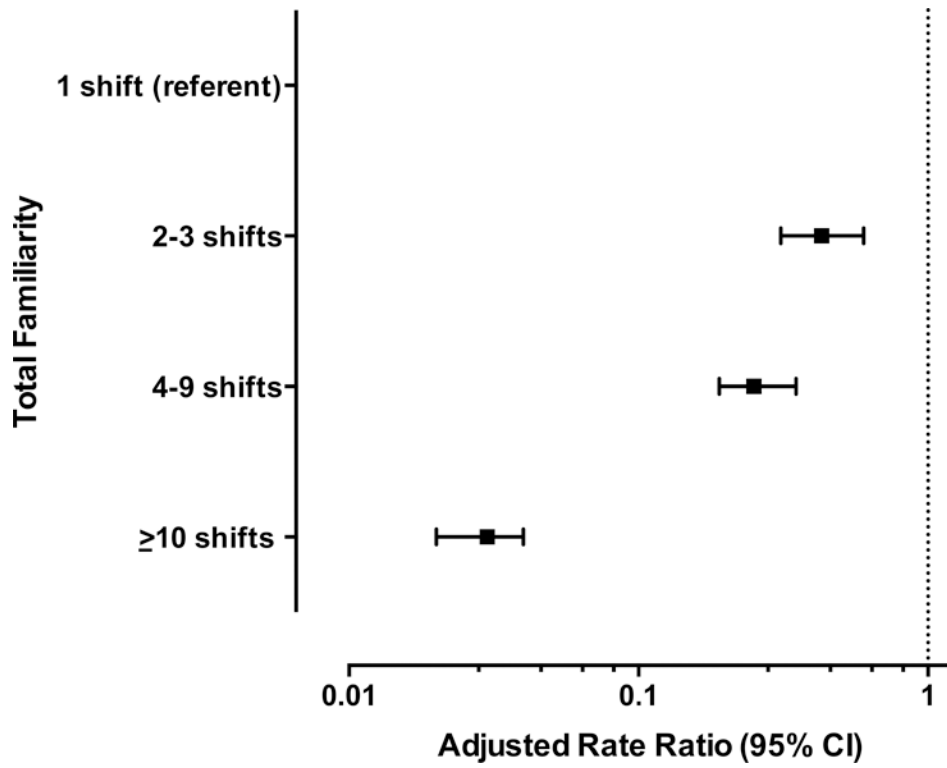


Figure 2. The association between total familiarity and occupational injury

Figure 2 shows the rate ratios for risk of injury after adjusting for clustering at the dyadic and organizational levels.

Table 1

Descriptive characteristics by study sample

EMS Org.	Total Months of Data	Total EMS workers	Total FTE	Total Dyadic Shifts	Dyadic Shift Length in Hours (Mean, SD)	Total Injuries	Rate of Injuries (per 100 FTE)	Mean shifts per worker per year (Mean, SD)	Mean number of different co-workers per year (Mean, SD)	% of shifts worked with the same co-worker (Mean, SD)
EMS #1	30	527	667.8	53,864	12.4 (2.7)	84	12.6	81.8 (58.2)	21.3 (13.1)	46.1 (23.8)
EMS #2	13	146	81.2	6,930	11.7 (1.3)	17	20.9	87.9 (59.0)	20.8 (9.6)	44.8 (25.1)
EMS #3	30	229	346.3	28,926	12.0 (0.2)	26	7.5	101.1 (55.0)	14.5 (7.2)	51.8 (24.2)
EMS #4	33	243	306.1	17,215	17.8 (6.6)	53	17.3	51.3 (40.0)	14.3 (7.0)	45.8 (23.9)
EMS #5	32	165	286.8	14,073	20.4 (5.6)	16	5.6	63.9 (38.6)	15.9 (6.1)	33.9 (19.4)
EMS #6	35	475	498.3	40,091	12.4 (3.2)	89	17.9	57.8 (43.7)	16.1 (8.3)	38.4 (23.1)
EMS #7	35	301	433.9	36,583	11.9 (0.8)	37	8.5	83.2 (57.8)	19.9 (8.6)	38.7 (23.1)
EMS #8	30	215	180.4	16,251	11.1 (3.8)	33	18.3	60.0 (53.6)	14.1 (7.8)	56.3 (26.2)
EMS #9	24	379	366.4	28,781	12.7 (4.0)	205	56.0	75.9 (59.0)	22.5 (8.0)	23.1 (20.5)
EMS #10	35	247	270.0	21,456	12.6 (3.7)	32	11.9	59.5 (55.2)	14.7 (6.5)	41.7 (25.9)
EMS #11	34	412	405.6	31,779	12.8 (4.6)	38	9.4	54.1 (52.2)	15.8 (8.5)	45.3 (27.9)
EMS #12	35	487	333.5	28,884	11.5 (3.0)	16	4.8	40.6 (43.0)	14.8 (8.9)	46.9 (28.1)
EMS #13	22	153	170.6	21,324	8.0 (0.0)	146	85.6	152.3 (64.1)	32.2 (10.3)	27.8 (11.8)
EMS #14	22	219	236.2	11,756	20.1 (6.0)	11	4.7	58.7 (40.2)	17.3 (9.3)	25.6 (13.0)
Overall	410	4,197	4,583.1	357,913	12.8 (4.4)	803	17.5	68.9 (56.5)	18.6 (10.2)	40.9 (25.4)

Notes: The total number of EMS workers is the number of workers scheduled for at least one shift over the study period. An FTE is 2000 hours of work per annum. The number of FTE at each agency is calculated by dividing the total number of scheduled hours at each agency by 2000. The total workers and total FTEs may differ. For example, an organization with 100 employees over a three-year period employs 20 part-time workers and 80 full-time workers. The 80 full-time workers are expected to accumulate a minimum of 480,000 hours worked over three years (80 workers * 2000hours = 160,000 per year * 3 = 480,000hours). The remaining 20 part-time workers accumulate 60,000hours worked over three years (20 workers * 1000hours = 20,000 per year * 3 = 60,000hours). Total hours worked at this organization is 540,000. Total FTEs for this organization over the three year period would be 270 based on 540,000 scheduled hours worked divided by 2000. Total workers = 100. Total FTE = 270.