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Effect of resiliency and age on musculoskeletal injuries and lost workdays in emergency medical service personnel

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ABSTRACT

Emergency medical service (EMS) personnel are highly skilled health care professionals who often provide lifesaving clinical care to patients. Paradoxically, they may be repeatedly exposed to a unique set of occupational hazards that could endanger their own health. This cross-sectional study sought to examine the relation between resiliency and musculoskeletal injuries (MSIs) and between resiliency and lost workdays due to MSIs, and explore whether age modifies these associations. Multivariable Poisson main effects regression models showed that resiliency had a protective effect against MSIs, but not lost workdays. In the unadjusted regression model to evaluate the relation between resiliency and age, results suggested that no differences in distributions existed between younger and older EMS personnel and resiliency. However, given the same unit increase in resiliency, findings from multivariable Poisson interaction regression models indicated that older workers had a higher prevalence of MSIs and lost workdays than younger workers. Results from main effects models may reflect diverging routes on a pathophysiological pathway, in which resiliency acts as a prognostic factor for MSIs but not lost workdays. Findings might also indicate the association between resiliency, and MSIs and lost workdays varies by age.

Relevance to industry: The largest growth of labor in the US is expected to occur in the oldest segments of the population. While older workers may offer more experience and show similar resiliency to younger workers, they might be more vulnerable to individual risk factors and occupational exposures. If management wants to retain older workers as assets, they should design the work environment to match the capabilities of all workers.

1. Background

1.1. Emergency medical technicians (EMTs)

Emergency medical technicians (EMTs) and paramedics are core elements of emergency medical service (EMS) departments and an important part of the United States (US) disaster response system (Maguire et al., 2005). There were over 800,000 EMS personnel who responded to more than thirty-six million calls in 2009 in the US (McCallion, 2011). While EMS personnel are highly knowledgeable and skilled professionals who often provide advanced lifesaving clinical care to patients, they are also repeatedly exposed to a unique set of occupational hazards that may endanger their health. Their work is associated with mechanical exposures, such as patient handling in isolated, uncontrolled work environments (Broniecki et al., 2010), transportation-related incidents (Maguire, 2011), violence (Bigham et al., 2014), and physical exposures, including whole body vibration. Other reported hazards include blood-borne pathogens (Klein et al., 2004) and psychosocial exposures, such as shift work (Broniecki et al., 2010) and time pressure (Van Der Ploeg and Kleber, 2003). EMS personnel might also be exposed to traumatic events, such as critical incidents (Alexander and Klein, 2001), on a daily basis.

As a result of these working conditions, EMS personnel experience more work-related health problems and lost workdays than other health

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care professionals and first responders (Maguire et al., 2005). One review found that EMS personnel have a wide range of health issues, including hypertension, fatal accidents, infectious disease, and musculoskeletal disorders (MSDs) (Sterud and ØHem, 2006). In this same review, musculoskeletal injuries (MSIs) were one of the most common health conditions associated with early retirement (Sterud and ØHem, 2006). Psychological disorders have also been linked with early retirement in EMS personnel (Sterud and ØHem, 2006).

A constellation of common psychological conditions among EMS personnel are affective or mood disorders (Wieclaw et al., 2006). Determinants associated with these disorders among EMS professionals are inadequate treatment time for complex patients (Boykin et al., 2003) and making patient-related, life-changing decisions, often with incomplete information (Egan, 1993) (McAllister and McKinnon, 2009). The physical and mental stress related to EMS work may lead to job burnout (Gayton and Lovell, 2012) (high employee turnover, low job tenure), increased operating costs (Broniecki et al., 2010), and a reduction in the quality of EMS care provided to local communities (Maguire et al., 2005). Because of the high levels of potential job strain related to this occupation and to better understand why certain EMS personnel are more resilient than others (i.e., the ability to positively adapt to risk and adversity (Luthar et al., 2000) (Luthar and Cushing, 2002)), authors have examined the impact of critical EMS incidents on emotional well-being (Alexander and Klein, 2001), whether greater resiliency protects against adverse mental health effects among first responders (Pietrantoni and Prati, 2008), whether time on the EMS job and work experience are related to improved well-being and resiliency (Gayton and Lovell, 2012), and whether having a "hardy EMS personality" leads to improved health (McAllister and McKinnon, 2009).

1.2. Risk and adversity

Based on the resiliency literature, resiliency was conceptualized as an individual characteristic or risk factor. The operational definition of "risk" was any group of individuals who are more likely than others to develop an MSI. It referred to the relative contribution of a determinant on an outcome, such as an MSI. It also referred to any situation that increases the onset or persistence of an MSI (Fraser et al., 1999) (Coie et al., 1993). The operational definition of "adversity" was any group of individuals with the inability to brace oneself against problems and who lack physical, psychosocial, and functional robustness (Hildon et al., 2009) (Bowling and Dieppe, 2005).

In the resiliency literature, EMS personnel who have low risk and highly robust characteristics (i.e., high resiliency) exhibit certain personality traits, including lower stress and burnout levels (Alexander and Klein, 2001) (Gayton and Lovell, 2012) (Shakespeare-Finch and Scully, 2005), faster psychological and emotional recovery from stressful situations (Alexander and Klein, 2001) (Gayton and Lovell, 2012), and stout personalities (Alexander and Klein, 2001) (Gayton and Lovell, 2012). Other personality traits include believing their work is meaningful, having a strong sense of commitment to work, actively engaging in their surroundings, being internally motivated, recognizing the benefits of occupational hardship (i.e., hardship comes with the job) (Gayton and Lovell, 2012) (Bartone et al., 2008), and adapting constructively to occupational trauma (Gayton and Lovell, 2012) (Luthar et al., 2000).

The definition of resiliency used in this study had similarities and differences with past literature. Our study considered those who can positively adapt to trauma (Luthar et al., 2000), show commitment to work (Gayton and Lovell, 2012), and display faster psychological and emotional recovery times after exposure to occupational hazards. Conversely, our study did not address hardy personalities, meaningful work, or the benefits of occupational hardship (Gayton and Lovell, 2012).

1.3. Resiliency and pain

Pain threshold is that level of a stimulus at which an individual initially recognizes pain (Woodrow et al., 1972); it represents the onset of pain, in which an increase in stimuli increases in intensity until there is a risk of tissue damage, but damage has not yet occurred (Gibson and Farrell, 2004). Pain tolerance is that greater level of stimulus at which an individual wants to stop the stimulus (Woodrow et al., 1972); it can be considered a behavioral index of motivation due to increased pain intensity and an unpleasant sensation, although other factors, including cognitive and mood responses, also influence an individual's withdrawal from painful stimuli (Gibson and Farrell, 2004).

High resiliency has been associated with higher levels of pain acceptance (Ramírez-Maestre et al., 2012) and lower levels of pain intensity (Ong et al., 2010) and disability (Karoly and Ruehlman, 2006). Results from a meta-analysis reported that determinants such as self-efficacy and effectively coping with challenges have been shown to be related to resiliency (Connor and Davidson, 2003) and improved physical well-being (Lyubomirsky et al., 2005). In a cross-sectional study of EMS personnel, authors (Gayton and Lovell, 2012) found that increased resiliency was associated with better physical and mental health.

1.4. Resiliency and age

Based on management and organizational science literature, older workers are defined in this study as individuals who are older than 45 years of age (Manuti and Depergola, 2013). Gayton and Lovell found a positive correlation exists between age and experience, with both variables initially being associated with high resiliency. They also found that working up to five years on the job as an EMS professional was associated with increased resiliency and suggested that experiencing trauma on the job may have a positive effect on resiliency (Gayton and Lovell, 2012). Similarly, Cydulka and colleagues (Cydulka et al., 1994) found that somatic distress was greater among EMS personnel with less than one year of work experience than those with eight years of experience. Alexander and Klein observed that EMS experience may initially help to manage emotional trauma (Alexander and Klein, 2001). Based on a broad interpretation of learning theory, Breznitz and Eshel noted that past experience, albeit perhaps painful, is required for better coping strategies and improved quality of life (Breznitz and Eshel, 1983) (Elder and Clipp, 1989). However, the Gayton and Lovell (2012) data also indicated that resiliency may decrease after five years of EMS work. Likewise, Alexander and Klein results suggested that experience did not reduce the impact of critical incidents on mental health problems over time, with prolonged job experience making it more difficult to cope (Alexander and Klein, 2001). Other authors have found a positive association between older EMS personnel and job burnout, and have noted the relation between job burnout and emotional exhaustion (Grigsby and Knew, 1988).

At least three interconnecting reasons may exist for the association among older age, resiliency, and health. First, after five years EMS personnel may have reached a saturation point, with additional years on the job offering no further improvement in resiliency. Second, ceiling effects might have occurred, in which resiliency has leveled off at year five, and EMS personnel are no longer able to positively adapt to occupational exposures. Lastly, despite their resiliency, older EMS personnel are no longer able to buffer hazards, in which additional exposures lead to an accumulation of fatigue (Gayton and Lovell, 2012). These findings indicate that older EMS personnel with more experience than their younger colleagues may be at increased risk of adverse health effects, even while exhibiting similar levels of resiliency to their younger counterparts. Thus, while older adults have the potential to be highly skilled and productive employees, they might also be among the most vulnerable to psychological distress (Silverstein, 2008).

Studies also suggest that older adults may be more vulnerable to greater physical distress than their younger colleagues. Normal aging results in altered anatomy within the central nervous system (CNS), and reductions in bone density, oxygen uptake, and physical capacity (Raz, 2005) (Buckwalter et al., 1993) (Krumpe et al., 1985). Older adults experience more severe injuries and longer recovery times following the onset of work-related MSIs. Recent Bureau of Labor Statistics (BLS) data indicate that older workers accounted for more lost workdays than those 45 years of age or younger (Bureau of Labor Statistics, 2015) (defined as younger workers in this study). In a large study (Coggon et al., 2013) that examined numerous occupational groups, disability-related MSIs were 55% more prevalent in older than younger workers. Research also indicated that manual work increases the risk of disability in older age groups. For example, Polvinen et al. found that a high risk of disability retirement due to MSIs was associated with manual work, with authors observing a relation among physically demanding work, older workers, and disability retirement (Polvinen et al., 2013).

1.5. Resiliency and effort-reward imbalance

Based on a literature review, Connor and Davidson (2003) reported that resiliency is comprised of specific attributes within individuals. These include giving your best effort no matter what; when things look hopeless you never give up; you engage the support of others; you know where to turn for help; you are not easily discouraged by failure; when under pressure you can focus and think clearly; you encourage challenges; you tolerate negative outcomes; you recognize the limits of your lack of control; and your commitment to work. The effort-reward imbalance (ERI) model is centered on the hypothesis that benefits at work are based on the reciprocity between work-related efforts and rewards (Van Vegchel et al., 2005). Efforts include job demands, while rewards include money, esteem, job security, and opportunity. Over-commitment will exacerbate high job demands and low rewards (Van Vegchel et al., 2005). To date, no research has examined resiliency in terms of ERI and over-commitment in EMS personnel, although Feldt and colleagues (Feldt et al., 2013) have evaluated the ERI model to study occupational wellbeing and work engagement, while Bakker et al. (2008) noted that personal resources, characterized by the ability to successfully control and impact an environment during demanding circumstances, are related to work engagement and resiliency (Hobfoll et al., 2003). Based on the characteristics of resilient individuals as defined by Connor and Davidson (2003) and the work by Bakker (Bakker et al., 2008) and Feldt (Feldt et al., 2013), the components of the ERI model appear to target similar constructs used to define resiliency.

1.6. Objectives

While a few papers (Alexander and Klein, 2001) (McAllister and McKinnon, 2009) (Gayton and Lovell, 2012) (Pietrantoni and Prati, 2008) have examined resiliency among EMS personnel, none have sought to determine whether resiliency characteristics in EMS personnel are associated with MSIs requiring medical attention or lost workdays due to MSIs, and none have sought to identify whether age modifies these associations. The objectives of this study were to examine the relation between MSIs and resiliency, examine the relation between lost workdays and resiliency, and determine whether the association between MSIs and resiliency, and between lost workdays and resiliency, varies by age. We hypothesize that if resiliency is high, pain threshold will be high and EMS personnel will have a stronger buffering capacity against MSIs and lost workdays. Likewise, we hypothesize that an increase in resiliency will, overall, be related to a lower prevalence of MSIs and lost workdays. Lastly, we hypothesize that age will modify these effects; the positive effect of resiliency on reduced MSIs and lost workdays will be greater in younger than older workers. Hypothesized pathways and mechanisms explaining the potential interaction phenomenon are discussed and work design guidelines to assist EMS personnel are listed.

2. Materials and methods

2.1. Study design

This was a cross-sectional study that examined MSIs, resiliency, and age in EMS personnel in one of the largest EMS and health care systems in the US. The study was approved by the Feinstein Institute for Medical Research Institutional Review Board at Northwell Health, located in New York State.

2.2. Study sample

The EMS Operations Unit (EMSOU) handles almost 850 daily calls. It provides ambulance services in 1700 square miles to a large metropolitan city and its surrounding counties. The EMSOU employs over twenty-five supervisors and over 500 EMTs and paramedics who operate over 110 available response units and respond to more than 120,000 requests for service a year. EMSOU staff were included as study participants only if they were EMTs, paramedics, dispatchers, or supervisors. There were 550 eligible EMS personnel, of which 263 agreed to participate, resulting in a participation rate of 47.8%. Among these participants, 170 reported having at least one MSI over their EMS working life that required medical care.

2.3. Distributions among EMS survey participants (N = 263) versus all EMSOU personnel (N = 550)

No differences in distributions were observed between EMS survey participants and all EMSOU personnel for younger workers (73.4% v 77.9%), non-Latino/non-Hispanic ethnicity (83.3% v 79.4%), and male gender/sex (73.8% v 72.6%). Group differences in distributions were, however, seen by race, income, and patient care status. Compared with all EMSOU personnel, more survey participants reported their race was "white" (67.3% v 56.1%) and had an income level of greater than $60,000.00 (68.1% v 46.31%), while fewer survey participants reported they worked in direct patient care job categories (86.3% v 91.7%).

2.4. Survey participants: percent of completed surveys by employment status and job category (N = 263)

No differences in distributions were observed for those who fully completed the surveys by employment status. The percent of completed surveys among full-time workers compared with per-diem workers was 95.9% and 95.7%, respectively.

Job categories for participants were dichotomized into exposed and unexposed groups based on job descriptions, as described by the human resources department within the health care system. Exposed personnel consisted of direct patient care workers (EMTs, paramedics), while unexposed personnel consisted of non-direct patient care workers (dispatchers, supervisors). No differences in distributions were seen between exposed and unexposed groups for those who completed the surveys. The percent of completed surveys among direct patient care personnel versus non-direct patient care personnel was 95.6% and 97.2%, respectively.

2.5. Survey

Using a health insurance portability and accountability act compliant research electronic data capture system (Harris et al., 2009), a twenty-minute anonymous electronic survey was sent to all eligible participants in the EMSOU one-time per month over a six month period. EMSOU management reported that no substantial organizational or structural changes were made during this time period in the department. All personnel were told that they could complete the survey during working or non-working hours, but it had to be completed without interruption. The survey was developed by the EMS operation's director within the health system (PP), and the principal (JD) and senior (HK) investigators. It was adapted from six previously constructed instruments: the Longitudinal EMT Attributes and Demographics Study, University of California San Francisco key EMS informant questions, University of Washington rural and volunteer key EMS informant questions, EMS workforce blog questions, national registry of EMT 2004 re-registration survey, and the effort-reward imbalance generic measure (Chapman et al., 2008) (Siegrist et al., 2009).

These surveys have been used to collect cross-sectional and longitudinal data to characterize demographics and individual characteristics (e.g., age, resiliency), psychosocial exposures (e.g., job satisfaction, skill sets required), mechanical exposures (e.g., number of calls per day, length of work shift), compensation and finance, utilization of EMS professionals, occupational safety and health issues, challenges and barriers in the EMS profession, EMS recruitment and retention, occupational medical history (e.g., incident on-the-job injuries), and comorbid conditions of EMS personnel throughout the US. Based on these surveys, the current survey collected information on seven domains: demographics, individual characteristics, psychosocial and mechanical exposures, utilization of EMS services, retention, and worker safety.

2.6. Specific domains

Demographics: These consisted of age group (≤45, > 45 years old), gender, ethnicity, race, education, body mass index, financial support to children or parents, and total EMS income over the past year, for a total of eight items.

Individual characteristics: These consisted of four health conditions or problems that may have developed over the EMS working life (sleeping, cardiovascular, psychological, weight gain), overall physical fitness, amount of physical activity per week, employment status, and whether s/he had experienced one or more work-related motor vehicle or workplace violence incidents or work-related MSIs that resulted in a physician's visit, for a total of ten items. Among those who answered “yes” to having a work-related MSI that required medical treatment, we asked about the severity (intensity) of musculoskeletal pain due to the MSI. Severity of musculoskeletal pain was obtained using a ten point Likert scale to characterize the most severe injury in six anatomical regions (neck, upper back/shoulders, elbow, lower back, knees, and ankles). Pain severity was dichotomized as mild to moderate (1–4) and moderate to severe (5–10) for analysis. Participants were asked about whether the MSI was a repeat injury, the number of lost workdays due to the MSI, the chronicity of the MSI, and the likelihood the MSI could reoccur.

Resiliency factors were adapted from the ERI generic measure (Chapman et al., 2008) (Siegrist et al., 2009) and a resiliency scale was created by summing six of the ERI items to reflect the ability to positively adapt to risk and adversity. Three items were reverse scored to indicate greater resiliency as values increased, with an overall higher score suggesting increased resiliency. Table 1 presents the resiliency scale items, response anchors, and ranges. Cronbach's alpha was then used to examine the degree of internal consistency. A Cronbach's alpha approximating 0.70 was considered acceptable (Zou, 2004). The resiliency scale ranged from 6 to 24 and had acceptable reliability (Cronbach's alpha = 0.71).

Psychosocial exposures: Eighteen stressors were initially examined in this domain. These consisted of organizational adequacy of resources to meet the work demand, employee input over the work environment, ability to take time off, exercise facilities available, availability of employee assistance counseling, understanding the injury management process, easy access to rehabilitation once injured, satisfied with the EMS profession, satisfied with the physical condition of the ambulance, availability of proper equipment, required to work overtime, adequate social support from EMS management, experienced workplace violence or workplace injury in the past six months, adequate communication between partners and situational awareness, lack of choice when choosing a partner, rushing and moving too quickly, and multitasking on the job.

Table 1
Resiliency items on whether EMS professionals can positively adapt to risk and adversity.

Six items[a]
Respect and prestige within the organization
Job has become more demanding over the past few years[b]
Can relax at home and switch off work
Sacrifice too much for work[b]
Work rarely lets me go[b]
Support from colleagues within health system (other than the EMSOU)

Six item scale Cronbach's alpha = 0.71.
[a] Items were adapted from the effort-reward imbalance generic measure. Response anchors range from “Strongly disagree” to “Strongly agree,” with corresponding values ranging from 1 to 4.
[b] Items were reverse scored to indicate greater resiliency as values increased.

Mechanical exposures: Twelve items, consisting of job title, years worked as an EMS professional, a second EMS job outside of the health system, hours per week worked in EMS, patient handling (comprised of four items: weight of the patient, carrying a patient on stairs, lateral transfers, disoriented or aggressive patients), tours longer than twelve hours, long sitting time between calls, weight and amount of equipment handled, and physical fitness of their partner, were used to assess this domain.

Utilization of EMS services: One variable, number of patient encounters per week, was examined in this domain.

Retention: One item about the likelihood of remaining in the EMS profession in five years was used to assess this domain.

Worker safety: Five items were used to assess this domain. These consisted of annual ergonomics training, pre-employment screening and agility testing, testing injured workers prior to returning to work, post-offer physical agility screening test, and agility screening as a proper assessment of the job.

2.7. Outcome variables

Having a work-related MSI throughout the EMS career that required medical treatment (no/yes within the year, yes over a year ago) was evaluated using the total study sample (N = 263). Among those who had an MSI (N = 170), lost workdays due to a MSI (no/yes one to seven days, yes more than seven days) were also analyzed. Based on the distributions of MSIs and lost workdays, dependent variables were dichotomized into “no work-related MSI(s) throughout EMS career” and “yes, work-related MSI(s) throughout EMS career” for the first outcome variable, and “no lost workdays due to an MSI” and “yes, lost workdays due to an MSI” was used for the second outcome variable.

2.8. Data analysis

Data were first imported from REDCap into SAS (statistical analysis software, 9.4v, North Carolina, USA). Descriptive statistics of demographics and individual characteristics were calculated for the total study sample (N = 263) and sample of participants who indicated having an MSI (N = 170).

To determine the association between resiliency and having an MSI, a multivariable Poisson regression model with robust error variances (Zou, 2004) was used, while controlling for factors associated with MSIs (adjusted main effects models). Among participants who had an MSI (N = 170), a second multivariable Poisson regression model was used to evaluate whether there was an association between resiliency and having a lost work day due to an MSI. All determinants from the seven domains (demographics, individual characteristics, psychosocial and mechanical exposures, utilization of EMS services, retention, and worker safety) were assessed as possible control variables using unadjusted Poisson regression models. A determinant was entered into the adjusted main effects model if its effect on the outcome in the unadjusted analyses was at least 30% (Vandergrift et al., 2012) and its 95% confidence interval (CI) did not include the null value (1.0) (Hoogendoorn et al., 2002). Pain severity (mild to moderate vs. > moderate severity) was assessed only for the model evaluating lost work days, as it was only applicable for those who reported an MSI.

To determine if the effect of resiliency varied by age group, multivariable Poisson regression models for both outcomes (MSI, lost work days) were performed using the same adjustments, and also included an interaction between resiliency and age group (interaction models). Unadjusted and adjusted prevalence ratios (PR) and 95% CIs were reported for all models. PRs for resiliency were reported in units of three. For models that included an interaction term, Bonferroni adjusted CIs were reported to correct for testing the effect of resiliency within each age group.

3. Results

3.1.1 Table 2 presents demographics and individual characteristics of the total sample (N = 263) and MSI cases (N = 170). The majority of EMS personnel in both groups were 45 years or age or younger, male, white, and non-Hispanic/non-Latino, reported average or better physical fitness, and performed physical activity at least two times per week. Nearly 25% of the total sample and about 28% of MSI cases reported co-morbid conditions, such as sleeping or weight gain problems. About 26% of the total sample experienced injuries due to workplace motor vehicle incidents, while about 21% in this group experienced workplace violence. A somewhat higher percentage of motor vehicle incidents (about 34%) and workplace violence (about 24%) was reported among MSI cases. Almost 65% of the total sample experienced at least one MSI that required medical care over their working life. Among the MSI cases, just over 80% reported greater than moderate pain severity, almost 80% reported lost workdays, just over one-half stated the injury had become chronic, nearly one-third stated there was a 60% or more likelihood that an MSI could occur again, and almost 30% noted the MSI was a repeat injury. The resiliency scale ranged from 6 to 24. In the total sample, mean resiliency scores for younger and older workers were 15.0 (SD = 3.5) and 14.7 (SD = 3.6), respectively. Among MSI cases, mean resiliency scores for these same groups were 14.2 (SD = 3.3) and 14.8 (SD = 3.7).

3.1. Main effect and interaction models for MSIs requiring medical treatment

Poisson multivariable regression models were used to assess PRs of MSIs by resiliency among the total sample (N = 259) (Table 3). The adjusted main effects model showed that an increase in resiliency was associated with a 7% reduction in the prevalence of MSIs (PR = 0.93, 95%CI = 0.86–0.99). A difference in the prevalence of MSIs was also seen by age group, with older workers having a 9% greater likelihood of MSIs than younger workers (PR = 1.09, 95%CI = 0.92–1.29), although the 95% CI included the null value. Working less than five years as an EMS professional was associated with a 37% protective effect against MSIs (PR = 0.63, 95%CI = 0.45–0.87), while workplace vehicle crashes and the perception that "physical fit testing of injured EMS personnel before returning to work was unimportant" were associated with an increased prevalence of MSIs by 27% (PR = 1.27, 95%CI = 1.09–1.47) and 41% (PR = 1.41, 95%CI = 1.22–1.63), respectively.

In the overall adjusted model with the interaction between resiliency and age group, a borderline statistically significant finding was observed for the association between resiliency*age group and prevalence of MSIs (p-value = 0.08). As resiliency increased, there was an associated 11% reduction in prevalent MSIs in younger workers (PR = 0.89, 95%CI = 0.81–0.98). Conversely, a 1% increase in the prevalence of MSIs was observed in older workers (PR = 1.01, 95%CI = 0.88–1.15), although the 95%CI included the null value. Effect sizes and their corresponding 95%CIs among covariates in the interaction model were similar to that of the main effects model.

Table 2
Demographics & individual characteristics.

	Category	Total Sample	MSI cases
		N = 263 [a]	N = 170 [b]
		n (%)	n (%)
Age	18–45 years	193 (73.4)	119 (70.0)
	> 45 years	69 (26.2)	51 (30.0)
Gender/sex	Male	194 (73.8)	117 (68.8)
Ethnicity	Not Hispanic or Latino	219 (83.3)	147 (86.5)
Race [c]	White	211 (80.2)	147 (86.5)
Education	Less than BA/BS	163 (62.0)	115 (67.7)
BMI (mean, standard deviation)		30.9 (6.4)	31.7 (6.2)
Primary financial support provider	Yes	170 (64.6)	115 (67.7)
Annual money earned	≥$60,000	179 (68.1)	124 (72.9)
Co-morbid conditions [d]	> 2	63 (24.0)	48 (28.2)
Overall physical fitness	Average or better	226 (85.9)	146 (85.9)
Physical activity > 2×/week	Yes	143 (54.4)	87 (51.2)
Employment status	Full-time	194 (73.8)	138 (81.2)
	Per-diem	69 (26.2)	32 (18.8)
EMS motor vehicle accident	Yes	67 (25.5)	57 (33.5)
Experience workplace violence	Yes	55 (20.9)	41 (24.1)
Experience musculoskeletal injury (MSI) working as an EMS, requiring medical treatment [b]	No	92 (35.0)	
	Yes, in the past 12 months	46 (17.5)	46 (27.1)
	Yes, > 1 year	124 (47.2)	124 (72.9)
MSI pain (> moderate severity) [e]	Yes		140 (82.4)
Repeat injury	Yes		49 (28.8)
Lost workdays due to a MSI	Yes		135 (79.4)
MSI has become chronic	Yes		86 (50.6)
Likelihood that MSI could happen again (yes)	Tertile 1: ≤40%		42 (24.7)
	Tertile 2: 40%–60%		67 (39.4)
	Tertile 3: > 60%		55 (32.4)
Resiliency scale score (mean, standard deviation) [f]		14.9 (3.6)	14.4 (3.4)
Age group 18–45 years		15.0 (3.5)	14.2 (3.3)
Age group > 45 years		14.7 (3.6)	14.8 (3.7)

Percents may not add to 100% due to missing values.
BA/BS = bachelor of art or science. BMI = body mass index.
[a] Questions are based on the total number of participants who completed surveys, but may or may not have had an MSI (N = 263).
[b] Questions are based on the number of participants who experienced an MSI (N = 170).
[c] Race (other) = Black, African American, Asian, American Indian, Native American, Pacific Islander, Native Hawaiian.
[d] Co-morbid conditions = sleeping, cardiovascular, and weight gain problems, mental health issues.
[e] Pain severity scale range = 1 to 10.
[f] Resiliency scale based on six items, ranging from 6 to 24.

3.2. Main effect and interaction models for lost workdays due to MSIs

Table 4 presents Poisson regression models that were used to evaluate whether the prevalence of lost workdays due to an MSI was associated with resiliency within MSI cases (N = 169). The adjusted main effects model showed that increased resiliency was associated with a 4% increase in the prevalence of lost workdays (PR = 1.04,

Table 3
Poisson regression models used to evaluate the prevalence ratio (PR) of musculoskeletal injuries (MSIs) by resiliency [a](N = 259).

Category		MSI		
		Unadjusted model: PR (95% CI)	Adjusted main effects model: PR (95% CI)	[b] Adjusted model, with resiliency*age interaction term: PR (95% CI)
Resilience	3 units	0.88 (0.82–0.95)	0.93 (0.86–0.99)	
Age group 18–45 years				0.89 (0.81–0.98)
Age group > 45 years				1.01 (0.88–1.15)
Race (ref = other) [c]	White	1.54 (1.13–2.12)	1.30 (0.96–1.76)	1.29 (0.96–1.74)
Employment status(ref = part-time)	Full-time	1.54 (1.18–2.02)	1.33 (1.04–1.71)	1.33 (1.04–1.71)
Years worked as an EMS professional over lifetime (ref= > 5 years)	≤5 years	0.54 (0.38–0.77)	0.63 (0.45–0.87)	0.64 (0.46–0.89)
Physical fit testing injured workers prior to returning to work (ref = very important)	Not important	1.45 (1.24–1.70)	1.41 (1.22–1.63)	1.38 (1.20–1.60)
Vehicle crash with injury to one or more individuals (ref = no)	Yes	1.46 (1.26–1.72)	1.27 (1.09–1.47)	1.26 (1.09–1.46)
Age (ref = ≤45 years)	> 45 years	1.20 (1.00–1.43)	1.09 (0.92–1.29)	–

[a] Analytic model sample size = 259 due to missing data from N = 263. Prevalence ratios (PR) and 95% confidence intervals (95% CI) are presented.
[b] Model includes age group as an effect modifier. Interaction p-value = 0.08. Main effects for age and resilience are not interpretable in adjusted interaction model.
[c] Race (other) = Black, African American, Asian, American Indian, Native American, Pacific Islander, Native Hawaiian.

95%CI = 0.98–1.11). A 9% increase in prevalence was also seen by age group, with older workers having a greater likelihood of lost workdays than younger workers (PR = 1.09, 95%CI = 0.93–1.28). However, the 95% CI of both estimates included the null value. EMS personnel with greater than moderate pain severity had a 50% higher prevalence of lost workdays than those with mild to moderate pain severity (PR = 1.50, 95%CI = 1.10–2.06).

In the overall adjusted model with the interaction between resiliency and age group, the association between resiliency and prevalence of lost work days was modified by age group (resiliency*age group, p-value = 0.03). In younger workers, a 1% protective effect in lost workdays was seen (PR = 0.99, 95% CI = 0.91–1.07), although the 95%CI of the interaction estimate included the null value. Conversely, in older workers, an increase in resiliency was associated with a 15% increase in prevalence of lost workdays (PR = 1.15, 95%CI = 1.01–1.31). The effect of pain severity on prevalence of lost workdays was similar to that of the main effects model.

4. Discussion

4.1. Main effects models

We hypothesized that if resiliency was high, pain threshold would be high and the capacity to buffer against MSIs and lost workdays would be enhanced in EMS personnel. We further hypothesized that increased resiliency would, in general, be related to a lower prevalence of MSIs and lost workdays. While increased resiliency had a protective effect on the prevalence of MSIs, it had an adverse effect on the prevalence of lost workdays. This may reflect diverging routes on a pathophysiological pathway, in which resiliency acts as a prognostic factor (a protective determinant in workers with pain (Juul-Kristensen and Jensen, 2005)) on route to one of two endpoints (MSIs and lost workdays). Specifically, resiliency might act as prognostic factor against pain threshold, but not pain tolerance. Findings may also indicate that pain tolerance signals a withdrawal from daily occupational exposures and attendant lost workdays in EMS personnel, regardless of increased resiliency.

Main effects models might also suggest that resiliency and pain tolerance may be linked to one or more dimensions of pain. One “key” measure of injury severity in BLS data is days away from work (Bureau of Labor Statistics, 2016). Among those with MSI cases, we adjusted for pain severity in multivariable models with lost workday outcomes. However, two other dimensions of pain exist: duration and frequency. Lost workdays may better reflect more than one dimension of pain, and study findings may partially be explained by differences in unmeasured characteristics of pain tolerances.

4.2. Interaction models

In an unadjusted linear regression model used to examine the relation between resiliency and age, no differences in the distribution between younger and older workers by resiliency were found, although younger workers had a 0.3 point increase in resiliency compared with older workers (B = 0.3, SE 0.5, 95% CI = −0.7–1.3). Effect modification is a biological phenomenon in which a moderator (e.g., age) states under which conditions the exposure or prognostic factor (e.g.,

Table 4
Poisson multivariable regression models used to evaluate the prevalence ratio (PR) of lost workdays due to musculoskeletal injuries (MSIs) by resiliency [a](N = 169).

Category		MSI		
		Unadjusted model: PR (95% CI)	Adjusted main effects model: PR (95% CI)	[b] Adjusted model, with resiliency*age interaction term: PR (95% CI)
Resilience	3 units	1.04 (0.98–1.10)	1.04 (0.98–1.11)	
Age group 18–45 years				0.99 (0.91–1.07)
Age group > 45 years				1.15 (1.01–1.31)
Pain severity(ref = mild to moderate pain severity)	> moderate pain severity	1.49 (1.08–2.05)	1.50 (1.10–2.06)	1.49 (1.09–2.04)
Age (ref = ≤45 years)	> 45 years	1.09 (0.94–1.27)	1.09 (0.93–1.28)	–

[a] Analytic model sample size = 169 due to missing data from N = 170. Prevalence ratios (PR) and 95% confidence intervals (95% CI) are presented.
[b] Model includes age group as an effect modifier. Interaction p-value = 0.03. Main effects for age and resilience are not interpretable in adjusted interaction model.

resiliency) will function to produce an outcome; it is assumed to affect the relation between exposure and outcome (Boston University, 2013) (Kraemer et al., 2001). In our interaction models, we hypothesized that age would modify the association between MSIs, lost workdays, and resiliency; a positive effect of resiliency on reduced MSIs and lost workdays would be greater in younger than older workers.

Overall, interaction models corresponded with main effects models, suggesting that resiliency acted as a prognostic factor on route to one of two endpoints (MSIs and lost workdays) on a pathophysiological pathway. Results from our first interaction model showed there was a lower prevalence of MSIs in younger EMS personnel as resiliency increased. An increase in resiliency in older workers was associated with a slight, likely clinically irrelevant increase in the prevalence of MSIs (Table 3). In the second interaction model (Table 4), an increase in resiliency had a small, likely clinically irrelevant protective effect on the prevalence of lost workdays in younger workers. Conversely, there was an increase in the prevalence of lost workdays in older workers as resiliency increased. Specifically, findings indicated that an increase in resiliency was ineffective as a buffer against the prevalence of lost workdays in older workers, perhaps due to differences in pain tolerance.

Even after adjusting for pain severity in our second main effects and interaction models, and despite an increase in resiliency in older EMS personnel, results indicated that older adults could be vulnerable to the impact of individual characteristics and occupational exposures. Moreover, age-related increases in pain thresholds may be more apparent when stimuli are very intense and persistent (Gibson and Farrell, 2004), suggesting that all three dimension of pain likely play a role in estimating the prevalence of lost workdays. Likewise, in work environments where pain is persistent, older adults may be particularly vulnerable to the effects of pain, as the reserve between the identification of pain and onset of injury is reduced (Gibson and Farrell, 2004).

4.3. Potential pain pathomechanisms that may overwhelm resiliency

Several age-dependent changes in the CNS could be driving changes in pain thresholds and tolerances, as an older CNS shows diffuse changes in structure, neurobiology, and function (Gibson and Farrell, 2004). An age-related increase in the pain threshold might suggest a loss of an already compromised functional reserve, with attendant impairment of an individual's early warning pain system, while a decrease in the pain threshold in older adults would likely indicate a maladaptive increase in sensitivity (Gibson and Farrell, 2004). Possible mechanisms of both scenarios are listed below.

There may be selective age-related impairment of myelinated nociceptive (pain) fiber function, resulting in weakening of early warning functions of nociceptive fibers (Gibson and Farrell, 2004). An observed activation in the spinal neuropeptide response (e.g., substance P) to nociceptive stimuli in older adults is consistent with an impaired pain inhibitory system, suggesting an age-related loss of regulatory neuronal mechanisms in older, dorsal (sensory) horns of the spinal cord (Gibson and Farrell, 2004). The interrelation among neurotransmission systems within the CNS may show different magnitudes of age-related change in selective regions of the CNS, such as the sensorimotor cortex (Gibson and Farrell, 2004) (Grachev et al., 2001); similar regional changes in neurochemical connectivity have been observed in older adults with chronic low back pain, possibly indicating there may be age-related interruptions in neurotransmission networks responsible for processing pain (Gibson and Farrell, 2004) (Grachev et al., 2000). Altered receptor mechanisms may play a part in aging effects on mechanical pain thresholds (Gibson and Farrell, 2004). Conversely, other studies have documented an overall age-related decline in neural analgesic mechanisms (Gibson and Farrell, 2004) (Hamm and Knisely, 1985) (Hamm and Knisely, 1986).

While the above age-related changes could potentially affect pain thresholds in either direction in older adults, evidence supports the finding that pain threshold is slightly increased in older adults, while the functional reserve between identification of pain and onset of injury is reduced (Gibson and Farrell, 2004). However, many of these findings are based on laboratory studies, employing adults older than 65 years of age, and using short duration thermal stimuli delivered to the distal upper extremities. The location of these stimuli may not reflect exposures associated with EMS work, particularly since the majority of MSIs among EMS personnel are often located in the trunk, neck, and shoulders (Sterud and ØHem, 2006). Likewise, EMS personnel are often exposed to prolonged and cumulative mechanical stimuli, rather than thermal stimuli of short duration. Past study limitations notwithstanding, given the susceptibility for reduced physiological reserves in older adults, injurious stimuli may be more likely to exceed tissue tolerances with advancing age (Gibson and Farrell, 2004).

Woodrow found pain tolerance to deep pain decreases with increasing age (Woodrow et al., 1972). More recent research on pain tolerance and aging also suggests the stimulus intensity required for pain tolerance is lower in older than younger adults (Gibson and Farrell, 2004). One possible explanation is there is an accelerating pain function on the stimulus-response curve in older adults that may diverge toward increased sensitivity at the upper extremes of the intensity range. A second explanation is that older adults may simply choose to withdraw from stimuli at lower levels of pain intensity and unpleasantness. A third is that unpleasantness and pain intensity might begin to demonstrate age-related differences at the point of pain tolerance (Gibson and Farrell, 2004). These explanations may also reflect why older EMS personnel, despite similar resiliency characteristics as younger EMS personnel, had a greater prevalence of lost workdays than their younger counterparts.

4.4. Changes in other biological systems in the older adult

In addition to age-related changes of CNS structure, changes in other biological systems might increase the physical vulnerability of older workers, despite an increase in resiliency. These systems include the musculoskeletal, cardiovascular, and neuromuscular systems. A decline in muscle mass begins after 30 years of age, with acceleration of loss after about 60 years of age; a decline in muscle strength is also seen with aging. The reduction in muscle strength is affected by at least three factors: a decrease in muscle mass and reduction in the number and size of muscle fibers (National Occupational Hea, 2005). The prevalence of work-limiting disabilities increases with age, from just over 3% of workers until age 28 to nearly 14% for those over 60 years of age (Wegman and McGee, 2004). Aerobic power also declines progressively over working years, with an estimated 10% loss of aerobic power per decade (Shephard, 2000). In self-paced but heavy work, the maximum efficiency of effort to maintain productivity, often described as 40% of maximal oxygen intake, may be difficult to achieve in older adults working in demanding environments, such as when exposed to intermittent peaks of intensive physical activity, which are often performed during patient-handling tasks (Shephard, 2000). Age-related decreases in reaction time have also been reported in older workers, often expressed by an employee's likelihood of adverse incidents (Shephard, 2000). While the magnitude of such problems may be reduced by modern technology and greater experience, judgment, and patience in older workers (Shephard, 2000), macro- and meso-level work factors (Cole et al., 2003), such as control over operations, excessive task difficulty, and rapidly changing technologies are likely to impact declining physical and some cognitive abilities in older workers (Shephard, 2000).

4.5. Suggestions to improve work design

Some authors have found that resiliency is related to good health and thus advocate for resiliency interventions to prepare EMS personnel for the emotional and cognitive loads associated with the job (Gayton and Lovell, 2012). However, our findings indicate that despite an increase in resiliency, older workers had a higher prevalence of lost workdays than younger workers. While behavioral-based resiliency interventions may partially provide a solution to improve health, more comprehensive controls are likely required for older workers.

If management wants to retain older workers as assets, it would behoove employers to design the work environment to match the physical and cognitive capacities of older workers, although this should conceptually be applied to all age groups (Ong et al., 2010). Management should also utilize the experience and knowledge base of older workers to improve work organization, allowing older workers to provide input on macro- (e.g., increased control over work environment) and meso-level changes (e.g, work design) (Popkin et al., 2008) (Griffiths, 1999).

One model that has been used to identify the capabilities and limitations of the older worker is "work ability" (Tuomi et al., 1997). Work ability is the individual's capacity to perform job tasks. Important work ability domains are health status, physical impairment, and the physical, cognitive, and psychosocial demands of work (Tuomi et al., 1997). Tuomi and colleagues noted that determinants of increased work ability include ergonomic factors, such as increased satisfaction with supervisors; determinants associated with decreased work ability include other ergonomic factors, such as decreased recognition and esteem (Tuomi et al., 1997); determinants associated with the maintenance of work ability include ergonomic intervention strategies, such as modifying the work environment (e.g., providing self-paced work, flexible work schedules, and age-management skills for supervisors) and enhancing workers' skill sets (Silverstein, 2008) (Ilmarinen et al., 1997).

These determinants point to at least one intervention that can be implemented by management: work environment accommodations. If employers provide accommodations at the onset of a work-limiting condition, Burkhauser and coworkers (Burkhauser et al., 1995) found that workplace accommodations would lead to a 27% reduction in disability benefit applications among males within the first five years of implementation. However, employer accommodations should also consider age differences between older and younger adults for scheduling, staffing, and performance issues (Popkin et al., 2008). Older workers might have more experience and better judgment, while younger workers may have better psychomotor skills; older workers might have degradations in some aspects of cognition, while younger workers may be more impulsive. Engineering and work practice controls, assistive technology, and training would likely improve well-being and safety in both age groups (Popkin et al., 2008).

4.6. Strengths

The participation rate was acceptable. Participation rates in epidemiologic studies have been declining over the past few decades, with more profound drops seen in recent years (Galea and Tracy, 2007). For example, the Behavioral Risk Factor Surveillance Survey median survey response rate was about 71% in 1993, while it was about 46% in 2016. One major concern in nonparticipation is non-response bias. This refers to systematic errors that may be introduced into the study when reasons for study participation are associated with the exposure or endpoint of interest. However, while non-response bias is a concern, available research suggests that low participation rates do not necessarily indicate a high level of bias in a study (Galea and Tracy, 2007).

Survey participants were compared with all EMSOU personnel (non-responders) to examine the potential for selection bias. Group differences in distributions were seen by patient care status, race, and income. More survey participants were working in non-direct patient care job categories than EMSOU personnel, although differences were likely not clinically meaningful, as the difference was only 5.4% between groups. More survey participants also reported their race was "white" and had an income level of greater than $60,000.00 than EMSOU personnel. Differences in distributions for race and income between groups ranged between 11% and 22%, respectively. We were unable to determine whether selection bias among EMSOU personnel was associated with resiliency or outcomes. However, one review suggested that most studies have found little evidence of substantial bias as a result of nonparticipation (Galea and Tracy, 2007). Likewise, we believe the findings within our study sample for resiliency, MSIs, and lost workdays would not substantially differ when compared with the EMSOU population.

Industrialized countries are experiencing dramatic changes in the work environment due to population aging. Employers who do not address programs and policies required to maintain the work ability of older workers, while minimizing their vulnerabilities, will likely feel negative effects on work performance and workers' compensation (Silverstein, 2008). Likewise, employers who do not retain older workers may likely experience increased expenses associated with tighter labor markets and shortages of specific skills (Silverstein, 2008). This is one of a few studies that have examined the relation between MSIs and resiliency among EMS personnel and whether that relation varies by age. We have also analyzed over fifty potential confounding variables in unadjusted analyses, and have adjusted for confounding variables. Finally, we suggest methods to improve the work ability of older workers in order to address employee retention.

4.7. Limitations

Due to organizational constrains, we were unable to use a resiliency measure, such as the Connor-Davidson Resilience Scale (CD-RISC) (Connor and Davidson, 2003), which has been peer-reviewed, shown to be efficient and used in EMS studies, and has demonstrated high internal consistency, test-retest reliability, and convergent and divergent validity (Gayton and Lovell, 2012). While we believe the ERI scale adapted for this study, which was based on characteristics of the CD-RISC measure, reflects many of the theoretical constructs contained in the CD-RISC scale and has acceptable internal consistency, it remains uncertain the degree to which our scale provides construct validity.

This was a cross-sectional study. Cases are only counted for currently employed workers, thus exposed individuals who developed an MSI may have disproportionately left the EMSOU, introducing the healthy worker effect. Cases of long duration (e.g., chronic MSIs) are likely over-represented and over-sampled, with acute onset MSIs less likely to be captured, although it remains unknown whether long-duration cases are more or less sensitive to recent exposures. Temporality cannot be determined and causality cannot be inferred because health and exposure data are collected simultaneously (Punnett and Wegman, 2004).

4.8. Summary

Findings indicated that given the same unit increase in resiliency, older workers had a higher prevalence of MSIs and lost workdays. Findings also suggested that older adults could be more vulnerable to the impact of individual characteristics and occupational exposures than younger workers, despite increased resiliency. Results may reflect diverging routes on a pathophysiological pathway, in which resiliency acts as a prognostic factor on route to MSIs, but not lost workdays. Specifically, an increase in resiliency might buffer against MSIs in older workers, which could reflect pain threshold, but may be unable to buffer against lost workdays, as seen by pain tolerance. While pain thresholds and tolerances may be linked to pain intensity, pain intensity does not fully explain study findings. Age-related changes in pain thresholds and tolerances with respect to resiliency may be better clarified by examining all three dimensions of pain.

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Declarations of interest

None.

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Study data were partially collected and managed with REDCap (Research Electronic Data Capture) electronic data capture tools, hosted at Northwell Health. REDCap is a secure, web-based application designed to support data capture for research studies, providing an intuitive interface for validated data entry; audit trails for tracking data manipulation and export procedures; automated export procedures for seamless data downloads to common statistical packages; and procedures for importing data from external sources.

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