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RESEARCH ARTICLE

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Effects of 9/11-related injury on retirement patterns among World Trade Center Health Registry enrollees

Kacie Seil MPH | Shengchao Yu PhD, MA | Robert Brackbill PhD, MPH | Howard Alper PhD, MS | Junaid Maqsood MPH

New York City Department of Health and Mental Hygiene, World Trade Center Health Registry, Long Island City, New York, USA

Correspondence

Kacie Seil, New York City Department of Health and Mental Hygiene, World Trade Center Health Registry, 30-30 47th Ave, Suite 414, Long Island City, NY 11101, USA.
Email: kseil@health.nyc.gov

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Abstract

Background: Many survivors of the 9/11/2001 terrorist attacks in New York City sustained injuries. The aim of this study was to understand how 9/11-related injuries affected retirement patterns of World Trade Center Health Registry enrollees.

Methods: The study included enrollees who participated in the 2017 Health & Quality of Life Survey, focused on 9/11-related injuries and quality of life, and the 2017–2018 Health & Employment Survey, focused on retirement and employment ($N = 3535$). Using Cox proportional hazards and logistic regression modeling, we calculated the risk of retiring at earlier ages and the odds of retirees working again, controlling for relevant covariates.

Results: Results showed that 9/11-related injuries did affect retirement patterns. Injured enrollees were at greater risk of retiring at younger age compared to non-injured enrollees. Compared to more severely injured retirees, non-injured and less severely injured retirees were significantly more likely to work again postretirement. Our results suggested that being injured on 9/11 was associated with retirement, meaning that if the injury had not occurred, the individual may have continued working longer.

Conclusions: The need to retire earlier than planned could be addressed with employer and societal changes. Employers should consider making accommodations for those impacted by 9/11 a priority, as it is imperative for those who were injured on 9/11 to have the ability to work to support their physical, mental, and financial well-being.

KEYWORDS

aging, disaster response, injury, retirement

1 | INTRODUCTION

Many individuals directly exposed to the 9/11/2001 terrorist attacks in New York City (NYC) experienced fatal or nonfatal injuries.[1–3] Two leading causes of injury among 9/11 survivors were descending downstairs and tripping and falling.[1] Research on survivors enrolled in the World Trade Center Health Registry (WTCHR) suggests that injured individuals had significantly lower perceived physical functioning when surveyed 15 years after the disaster.[2] Those who sustained an injury on 9/11 were also found to be more likely to develop heart disease.[3] A qualitative study consisting of interviews with 33 people who were injured on 9/11 highlighted other challenges that contributed to the difficulties of recovering, such as exposure to traumatic events, difficulty in receiving needed healthcare, and social isolation.[4] The degree to which those injured on 9/11 are still affected by their

experiences—for instance, their ability to continue working—is only partly understood.

As the WTCHR enrollee population ages, retirement will be a more frequently occurring event. Although approaches to retirement planning vary widely, many researchers agree that health is the most important factor when it comes to decision-making about retirement,[5–7] as opposed to family or financial factors.[8,9] Our understanding of the factors that affect retirement decisions is similar to that of Sundstrup et al.[10] who stipulated that early labor force exits are due to interactions of health and work characteristics when work requirements exceed an individual's resources. The framework presented by Dwyer et al.[7] also aligns with our understanding; it proposes that workers choose a retirement age that maximizes utility during their life course. Health issues may lead to earlier retirement as poor health may reduce productivity and earnings or may make postretirement leisure shorter than anticipated.

Existing research on the WTCHR enrollee population has shown that those with 9/11-related health conditions are more likely to retire before age 60, particularly those with multiple conditions and/or probable posttraumatic stress disorder (PTSD).[11,12] Studies on other populations have found that having sustained a serious injury,[13] having musculoskeletal problems[14–17] or physical disabilities,[18] or dealing with chronic pain,[19] are all risk factors for early retirement or disability retirement in working populations; comorbid psychological problems further increase the risk of early retirement.[14,15]

Poor health may lead to earlier retirement, but early retirement can also have adverse effects on one's physical and emotional health.[20] Some researchers have found an association between early retirement and decrements in cognitive functioning.[20] Involuntary (or unplanned) retirement is one type of early retirement that may occur unexpectedly and lead to stress and worsened psychological well-being[20]; it is also associated with unhealthy behaviors like increased smoking, increased alcohol use, and decreased physical activity.[20] In the United States, leaving the labor force at age 62 (a Social Security eligibility threshold) has been linked to increased mortality risk among men, possibly due to significant increases in causes of death related to job loss (i.e., traffic-related deaths and deaths due to lung cancer and chronic obstructive pulmonary disease) and an increase in unhealthy behaviors following retirement.[21]

Early retirement can also create financial stress.[9,22] In a study of workers who sustained a work injury and planned to retire early as a result, high levels of financial difficulties were reported.[6] Among the WTCHR enrollee population, retiring before age 60 was associated with greater postretirement income loss—an effect that was especially pronounced for those with probable PTSD.[11,12] Involuntary (or unplanned) retirement in particular often leads to financial strain,[23] as individuals who do not have a pension or sufficient retirement savings may experience financial difficulties following an earlier-than-anticipated labor force exit.

Research has shown that 9/11-related injury is associated with physical health issues,[2,3] and that health issues related to 9/11 exposure increase the likelihood of retiring before age 60.[12] This study is the first we are aware of that examines the direct association between 9/11-related injury and retirement. We hypothesized that individuals who sustained a 9/11-related injury, especially those more severely injured, are more likely to retire at earlier ages than those who did not report an injury. We also hypothesized that retirees with a 9/11-related injury would be less likely to work again postretirement compared to those without an injury.

2 | METHODS

2.1 | Surveys and study sample

The WTCHR is a longitudinal cohort of survivors of the 9/11/2001 terrorist attacks that enrolled over 71,000 eligible individuals in 2003–2004 with the completion of the Wave 1 baseline survey. Enrollees who were not deceased and did not withdraw from the Registry were invited to participate in three follow-up major health surveys: Wave 2 in 2006–2007, Wave 3 in 2011–2012, and Wave 4 in 2015–2016. Smaller samples of the cohort were also invited to participate in topic-specific in-depth surveys, such as the 2017 Health & Quality of Life Survey (HQoLS), focused on 9/11-related injuries and quality of life, and the 2017–2018 Health & Employment Survey (HES), focused on retirement and employment. This study included enrollees who participated in both the HQoLS and the HES. The HQoLS sample included enrollees who reported a 9/11-related injury in Wave 1 and a similar number of non-injured enrollees chosen via a simple random sample.[1] The HES sample included enrollees who had previously reported retiring or being unemployed due to disability/health reasons, as well as a similar number of age-matched enrollees who had not retired.[12] More detailed information on the sampling methodology for these two surveys can be found in previous publications.[1,12] The institutional review boards of the Centers for Disease Control and Prevention and the New York City Department of Health and Mental Hygiene approved the Registry protocols, including the use of the data.

2.2 | Variables

Our study examined potential associations between 9/11-related injuries and retirement patterns among WTCHR enrollees with age at retirement and working again postretirement as the two main outcomes. Enrollees were classified into one of three retirement groups based on their response to the "Are you currently retired?" question on the HES. Those who responded "Yes, retired and not employed since" were assigned to the "Retired and not employed since" group, and those who responded "Yes, retired and am currently employed again" or "Yes, retired, employed again at some point, but not currently employed" were assigned to the "Retired and employed again" group. Enrollees who responded "No, not retired" to the HES question were assigned to the "Not retired" group. Age at retirement was then estimated for those who were ever retired using self-reported month and year of retirement.

TABLE 1 Description of the study sample, HQoLS and HES, *N* = 3297

	Total sample *N* = 3297		Retired and not employed since *N* = 1482		Retired and employed again *N* = 658		Not retired *N* = 1157	
	N	%	*N*	%	*N*	%	*N*	%
Injury severity								
No injury	2639	80.0	1114	75.2	555	84.3	970	83.8
Less severe injury	363	11.0	193	13.0	66	10.0	104	9.0
More severe injury	295	8.9	175	11.8	37	5.6	83	7.2
Sex								
Male	2210	67.0	1034	69.8	504	76.6	672	58.1
Female	1060	32.2	439	29.6	152	23.1	469	40.5
Missing	*27*	*0.8*	*9*	*0.6*	*2*	*0.3*	*16*	*1.4*
Age at HES								
30–49 years	234	7.1	39	2.6%	20	3.0	175	15.1
50–59 years	682	20.7	243	16.4%	172	26.1	267	23.1
60–64 years	922	28.0	333	22.5%	167	25.4	422	36.5
65+ years	1459	44.3	867	58.5%	299	45.4	293	25.3
Race/ethnicity								
Non-Hispanic White	2582	78.3	1164	78.5	548	83.3	870	75.2
Non-Hispanic Black	236	7.2	112	7.6	37	5.6	87	7.5
Hispanic	283	8.6	138	9.3	42	6.4	103	8.9
Asian	103	3.1	31	2.1	17	2.6	55	4.8
Multiple/other	93	2.8	37	2.5	14	2.1	42	3.6
Eligibility group								
Rescue/recovery worker	1761	53.4	840	56.7	450	68.4	471	40.7
All other groups	1536	46.6	642	43.3	208	31.6	686	59.3
Marital status								
Married or living with partner	2346	71.2	1082	73.0	516	78.4	748	64.6
Divorced or separated	424	12.9	179	12.1	71	10.8	174	15.0
Widowed	119	3.6	72	4.9	14	2.1	33	2.9
Never married	379	11.5	135	9.1	51	7.8	193	16.7
Missing	*29*	*0.9*	*14*	*0.9*	*6*	*0.9*	*9*	*0.8*
Household income								
Less than $50,000	546	16.6	269	18.2	95	14.4	182	15.7
$50,000–$74,999	507	15.4	258	17.4	96	14.6	153	13.2
$75,000–$149,999	1279	38.8	577	38.9	292	44.4	410	35.4
$150,000 or more	756	22.9	259	17.5	146	22.2	351	30.3
Missing	*209*	*6.3*	*119*	*8.0*	*29*	*4.4*	*61*	*5.3*
Educational attainment								
High school graduate or less	459	13.9	274	18.5	84	12.8	101	8.7
Some college	1082	32.8	547	36.9	244	37.1	291	25.2
Bachelor's degree	912	27.7	364	24.6	168	25.5	380	32.8

(Continues)

TABLE 1 (Continued)

	Total sample N = 3297		Retired and not employed since N = 1482		Retired and employed again N = 658		Not retired N = 1157	
	N	%	N	%	N	%	N	%
Postgraduate degree	822	24.9	286	19.3	158	24.0	378	32.7
Missing	*22*	*0.7*	*11*	*0.7*	*4*	*0.6*	*7*	*0.6*
Ever probable PTSD								
Yes	1144	34.7	583	39.3	194	29.5	367	31.7
No	2118	64.2	886	59.8	455	69.1	777	67.2
Missing	*35*	*1.1*	*13*	*0.9*	*9*	*1.4*	*13*	*1.1*

Abbreviations: HES, Health & Employment Survey; HQoLS, Health & Quality of Life Survey; PTSD, posttraumatic stress disorder.

Enrollees were classified as injured if they reported a 9/11-related injury in the Wave 1 survey and provided an affirmative response to the question "Were you injured on 9/11?" in the HQoLS. Injuries reported in Wave 1 included a cut/abrasion/puncture wound, sprain/strain, burn, broken bone/dislocation, concussion/head injury, eye injury/irritation, or another type of injury sustained as a result of the 9/11 attacks. Injury severity was then classified into one of three levels using responses to HQoLS questions: no injury, less severe injury, and more severe injury. Enrollees who reported requiring a cane/crutch or wheelchair during the week following the injury, treatment at an emergency department/hospital visit, or surgery were classified as having severe injuries, and all other injuries were classified as less severe. Enrollees who responded "No" to all Wave 1 injury questions and responded "No" to the HQoLS "Were you injured on 9/11?" question were classified as having no injury. Those with discordant injury responses in Wave 1 and HQoLS were also classified as having no injury.

Sociodemographic variables of interest included sex, age group (at time of HES), race/ethnicity, and Registry eligibility group (rescue/recovery workers [RRW's] vs. area workers, residents, students/school staff, and passers-by). Other covariates included marital status, household income, and educational attainment reported in Wave 4. PTSD was classified in two ways; the first classification was an indicator for probable PTSD at any wave, as measured by a score of 44 or greater on the PTSD Checklist-Specific (PCL-S) scale,[24,25] and the second classification was probable PTSD status at the wave before retirement or probable PTSD status at Wave 4 if the enrollee had not retired.

2.3 | Analyses

The initial analytic sample included those who participated in both the HQoLS and HES ($N = 3535$). After excluding 97 retirees with missing or invalid responses to the injury items from Wave 1, the HQoLS questions that asked whether the individual sustained an injury on 9/11, or the HES question that asked if the individual was retired, an additional 141 enrollees with retirements before September 2001 or a missing or invalid retirement month and/or year were also excluded. The final analytic sample was 3297 enrollees.

We first described the distribution of 9/11-related injury severity, sociodemographic factors, and covariates in our study sample by retirement status (i.e., retired and not employed since, retired and employed again, and not retired). Cox proportional hazards modeling was then used to examine the association between 9/11-related injury severity and age at retirement, controlling for sociodemographic factors and probable PTSD status before retirement or censoring. A time scale of age at retirement was used in the model. To avoid potential bias due to using age at retirement instead of time on study, the model was stratified by the continuous age on 9/11 variable, wherein separate models were run for each age, and the results were combined over age to generate the final model results.[26] Therefore, follow-up of each enrollee began at 9/11 and ended at the time of retirement or at the time that HES was completed. A logistic regression analysis was then used to calculate the odds of retirees working again postretirement based on 9/11-related injury severity, sociodemographic factors, and probable PTSD status. Two-sided $p$values < 0.05 were considered significant. All analyses were completed with SAS version 9.4 (SAS Institute Inc.).

3 | RESULTS

Among our study sample, 20% reported being injured on 9/11/2001 consistently between the Wave 1 survey and the HQoLS (Table 1). The majority of the sample was male (67%), non-Hispanic White (78%), and married or living with a partner at the time of the Wave 4 survey (71%). Approximately 44% were 65 years or older at the time of the HES survey, and more than half (53%) had a bachelor's or postgraduate degree. About 53% of the sample were RRW's, and 35% of the sample had probable PTSD during at least one of the wave surveys.

Nearly two-thirds (65%) of the sample retired sometime after 9/11, though 20% of the 3297 enrollees in our sample went on to work again postretirement. Whereas 25% of those who permanently retired reported a 9/11-related injury, only 16% of retirees who

worked again and 16% of non-retirees reported a 9/11-related injury (Table 1). Over two-thirds of those who retired and worked again were RRW's compared to only 41% of non-retirees; 57% of those who permanently retired were RRW's. Among the non-retired group, 65% reported being married or living with a partner compared to 73% who were permanently retired and 78% of those who retired and were employed again. About 19% of those who were retired permanently had a high school degree or less compared to 9% of those who were not retired; 13% of retirees who worked again had a high school degree or less. Thirty-nine percent of those who permanently retired had probable PTSD at some point post-9/11 compared to 30% of retirees who worked again and 32% of non-retirees.

Results of the Cox proportional hazards model showed that being injured on 9/11 was associated with a higher risk of retiring at younger ages (Table 2). The adjusted hazards ratio (AHR) of age at retirement was 1.26 (95% confidence interval [CI]: 1.09, 1.45) for those with a less severe injury, compared to those with no injury. The AHR for those with a more severe injury was 1.34 (95% CI: 1.15, 1.58). Sex was associated with decreased risk of retirement at younger ages, with females showing a significantly lower AHR than males (AHR: 0.79, 95% CI: 0.71, 0.89). Eligibility group was also associated with the outcome: non-RRW's had a significantly lower risk of earlier age at retirement than RRW's (AHR: 0.65, 95% CI: 0.59, 0.72). Compared to enrollees who were married or living with a partner, divorced/separated and never married enrollees had a significantly lower risk of retirement at younger ages. Enrollees with the greatest household income ($150,000 or more) also had a lower probability of earlier age at retirement compared to those with lower levels of income; educational attainment showed a similar pattern. Probable PTSD status was also associated with a higher risk of earlier age at retirement; those with probable PTSD at the wave before retirement had an AHR of 1.36 (95% CI: 1.20, 1.53) compared to those who did not have probable PTSD.

The logistic regression model calculated the likelihood of retirees working again postretirement (Table 3). Compared to retirees who sustained more severe 9/11-related injuries, those with less severe injuries were 1.7 times as likely to work again after retiring (95% CI: 1.05, 2.72); the likelihood of working again postretirement was greater for those with no injury (odds ratio [OR]: 2.24, 95% CI: 1.50, 3.35). Compared to those aged 65 years and older, younger age groups of 50–59 years and 60–64 years were more likely to return to work after retirement (50–59 years: OR: 2.16, 95% CI: 1.64, 2.86; 60–64 years: OR: 1.46, 95% CI: 1.14, 1.88). RRW's were 45% more likely to work again postretirement compared to non-RRW's (OR: 1.45, 95% CI: 1.13, 1.85). Retirees with probable PTSD post-9/11 were about 30% less likely to work again than those without probable PTSD (OR: 0.71, 95% CI: 0.57, 0.90). Higher levels of educational attainment were also associated with returning to work postretirement. Those with a bachelor's degree were 1.5 times as likely to return to work compared to those with a high school diploma or less (95% CI: 1.08, 2.13); those with a postgraduate degree were

TABLE 2 Multivariable Cox regression analysis of age at retirement based on 9/11-related injury, $N = 3297$[a]

	AHR	95% CI	*p* value
Injury severity			
No injury	Ref	–	–
Less severe injury	1.26	1.09, 1.45	0.002
More severe injury	1.34	1.15, 1.58	<0.001
Sex			
Male	Ref	–	–
Female	0.79	0.71, 0.89	<0.001
Race/ethnicity			
Non-Hispanic White	Ref	–	–
Non-Hispanic Black	0.98	0.82, 1.18	0.866
Hispanic	0.91	0.78, 1.08	0.285
Asian	0.63	0.46, 0.86	0.003
Multiple/other	0.75	0.55, 1.01	0.061
Eligibility group			
Rescue/recovery worker	Ref	–	–
All other groups	0.65	0.59, 0.72	<0.0001
Marital status			
Married or living with partner	Ref	–	–
Divorced or separated	0.78	0.68, 0.91	0.001
Widowed	0.93	0.74, 1.18	0.555
Never married	0.74	0.63, 0.88	<0.001
Household income			
Less than $50,000	1.28	1.08, 1.50	0.003
$50,000–$74,999	1.29	1.11, 1.51	0.001
$75,000–$149,999	1.30	1.15, 1.48	<0.001
$150,000 or more	Ref	–	–
Educational attainment			
High school graduate or less	Ref	–	–
Some college	0.93	0.81, 1.06	0.289
Bachelor's degree	0.74	0.64, 0.85	<0.0001
Postgraduate degree	0.60	0.51, 0.70	<0.0001
Probable PTSD before retirement or censoring			
Yes	1.36	1.20, 1.53	<0.0001
No	Ref	–	–

Abbreviations: AHR, adjusted hazard ratio; CI, confidence interval; PTSD, posttraumatic stress disorder.

[a]Regression model was stratified by age on 9/11/2001.

TABLE 3 Among retired individuals, the likelihood of working again based on injury severity, $N = 2140$

	OR	95% CI	*p* value
Injury severity			
No injury	2.24	1.50, 3.35	<0.0001
Less severe injury	1.69	1.05, 2.72	0.031
More severe injury	Ref	–	–
Sex			
Male	Ref	–	–
Female	0.96	0.74, 1.25	0.784
Age at HES			
30-49 years	1.42	0.78, 2.58	0.248
50-59 years	2.16	1.64, 2.86	<0.0001
60-64 years	1.46	1.14, 1.88	0.003
65+ years	Ref	–	–
Race/ethnicity			
Non-Hispanic White	Ref	–	–
Non-Hispanic Black	0.99	0.65, 1.52	0.980
Hispanic	0.70	0.47, 1.04	0.080
Asian	1.77	0.92, 3.39	0.087
Multiple/other	1.04	0.53, 2.03	0.911
Eligibility group			
Rescue/recovery worker	1.45	1.13, 1.85	0.003
All other groups	Ref	–	–
Marital status			
Married or living with partner	Ref	–	–
Divorced or separated	0.92	0.66, 1.27	0.596
Widowed	0.54	0.29, 0.99	0.047
Never married	0.84	0.58, 1.24	0.382
Household income			
Less than $50,000	1.16	0.80, 1.67	0.433
$50,000 - $74,999	0.90	0.64, 1.26	0.528
$75,000 - $149,999	1.02	0.79, 1.33	0.873
$150,000 or more	Ref	–	–
Educational attainment			
High school graduate or less	Ref	–	–
Some college	1.32	0.97, 1.81	0.080
Bachelor's degree	1.52	1.08, 2.13	0.016
Postgraduate degree	2.01	1.41, 2.88	<0.001
Ever probable PTSD			
Yes	0.71	0.57, 0.90	0.004
No	Ref	–	–

Abbreviations: CI , confidence interval; HES, Health & Employment Survey; OR, odds ratio; PTSD, posttraumatic stress disorder.

2.0 times as likely to work again (95% CI: 1.41, 2.88). Widowed retirees were 46% less likely to work again after retiring compared to those who were married or living with a partner (OR: 0.54, 95% CI: 0.29, 0.99). Sex, race/ethnicity, and household income were not significantly associated with working again postretirement.

4 | DISCUSSION

Our aim was to understand how 9/11-related injuries affected retirement patterns of WTCHR enrollees, both in regard to age at retirement, as well as the likelihood of working again postretirement. As hypothesized, results showed that 9/11-related injury did affect retirement patterns, even when controlling for relevant sociodemographic factors, PTSD status, and eligibility group. Injured enrollees were more likely to retire at earlier ages than those who were not injured. Compared to more severely injured retirees, noninjured and less severely injured retirees were significantly more likely to work again postretirement.

The risk of retiring at a younger age was greatest for those who were more severely injured, but the risk for those less severely injured was only a bit lower. The data showed a greater effect of injury severity when measuring the likelihood of working again. The reason for this may be that many other factors go into the retirement decision: other health issues not related to 9/11, financial considerations, personal or family preferences, etc.

The association between injury and retirement remained even when controlling for RRW's who retired at significantly younger ages and were more likely to work again postretirement than non-RRW's (e.g., residents and area workers). Many RRW's were uniformed workers from NYC agencies that, depending on the agency's rule, offered pensions based on 50% of the final salary after 20–25 years of service (e.g., NYC Fire Department [FDNY], NYC Police Department [NYPD], NYC Department of Sanitation).[11] Many uniformed workers were also eligible for disability retirement pensions based on 75% of the final salary.[11] These retirement offerings affect the retirement patterns among this group, especially in comparison with private-sector workers, who are typically reliant on retirement savings.[27]

Our results suggest that being injured on 9/11 was associated with retirement, meaning that if the injury had not occurred, the individual may have continued working longer. Retirement trends have shifted dramatically over time, with more Americans now working at older ages than before. There are many reasons for this, including gains in life expectancy and population health, as well as decreases in physically demanding jobs.[28,29] Policy changes have also played a substantial role in the shifting trends, with changes to Social Security benefits over the past few decades (e.g., increase in age at which full benefits can be collected, discontinuation of policies that disincentivized working at older ages) resulting in workers staying in the labor force at older ages.[30–32] Secular trends in how employers handle retirement have changed a great deal as well. Fewer employers now offer health benefits after retirement (66% in 1998 vs. 24% in 2016),[32] leading workers to stay in the labor force longer. Compared to previous generations, workers are now less likely to

have pensions—instead being reliant on self-management of their retirement finances—and more likely to experience labor force exit gradually.[30–32]

Gradual retirement in its many forms (e.g., phased retirement [reduced hours], partial retirement [different employer with possibly reduced hours], and labor force reentry[28]) is thought to be an indicator of flexibility related to working later in life, which is an incentive for workers.[27] Working longer (i.e., to an older age) can benefit the individual, as it can lead to higher income and better health (e.g., lower risk of mortality, depression, and diabetes[33]). Research has shown that even when controlling for preretirement health status, those who continued working in a bridge job (i.e., a transitional job between career employment and labor force exit[34]) were healthier than those who did not.[30] Flexibility in employment opportunities for older workers may be improving, but our results show that those injured on 9/11 retire years earlier than those classified as non-injured, indicating that more support is needed for this group to continue working. Workplace interventions may be a key approach to retaining older workers; unfortunately, data-driven evidence for effective interventions is somewhat lacking.[35] That said, supporting individuals with chronic health conditions—physical and mental—in the workplace is possible by ensuring access to healthcare and rehabilitation, as well as a healthy work environment[36]; this may include optimizing work tasks[15] or allowing for flexible work arrangements,[23] fewer job demands, resolution of workplace conflicts and ambiguities, and better supervisor support.[37] Social norms should also move towards greater acceptance of older workers from younger colleagues, managers, and those in charge of hiring.[23]

4.1 | Strengths and limitations

A strength of this study is that the sample was large and represents a diverse group of 9/11 survivors, as opposed to solely RRW's, who are often the population of focus in research studies. An additional strength is that injury classifications in this study are appropriate and accurate because they were reported in both Wave 1 and the HQoLS. The longitudinal data in this study also allowed us to be certain that the injury preceded the retirement event, thus establishing temporality. Furthermore, our results fall in line with previous findings on 9/11-related health conditions being associated with retirement before age 60.[11,12] Although we did not examine postretirement income loss in this study, we would expect this to be more prevalent among injured enrollees versus non-injured enrollees based on previous research on this cohort.[12]

One limitation of this study is that the data did not allow us to describe the type of employment that followed the retirement for those individuals who worked again (e.g., bridge job, phased retirement, etc.), nor were we able to fully assess whether or not one's retirement was voluntary. Another limitation is that we may be undercounting 9/11-related injuries among our population; results from Jacobson et al.[1] showed that nearly half of those who reported an injury during Wave 1 did not report the injury in the HQoLS. Many of these were likely minor injuries. Finally, while RRW status was a significant predictor in retirement outcomes, the group is heterogeneous in the sense that it contains uniformed and non-uniformed workers; it also contains volunteer workers, though only 16.9% of RRW's in our study sample were volunteers.

5 | CONCLUSIONS

Individuals who sustained injuries on 9/11 are at greater risk for retiring at earlier ages, and injured retirees are less likely to work again than retirees who were not injured. Although the injuries cannot be prevented at this point, the need to retire earlier than planned could be addressed with employer and societal changes. Employers should consider making accommodations for those impacted by 9/11 a priority, as it is imperative for those who were injured on 9/11 to have the ability to work to support their physical, mental, and financial well-being.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Steven Markowitz declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

Kacie Seil, Shengchao Yu, Robert Brackbill, and Junaid Maqsood proposed the study and planned the study design. Kacie Seil and Howard Alper analyzed the data. Kacie Seil drafted the manuscript. Shengchao Yu, Robert Brackbill, Howard Alper, and Junaid Maqsood revised the manuscript.

DATA AVAILABILITY STATEMENT

World Trade Center Health Registry data may be made available following a review of applications to the Registry from external researchers.

ETHICS APPROVAL AND INFORMED CONSENT

The institutional review boards of the Centers for Disease Control and Prevention and the New York City Department of Health and Mental Hygiene approved the Registry protocols, including use of the data.

ORCID

Kacie Seil http://orcid.org/0000-0001-9359-2794

Shengchao Yu http://orcid.org/0000-0002-4555-0220

REFERENCES

1. Jacobson MH, Brackbill RM, Frazier P, Gargano LM. Conducting a study to assess the long-term impacts of injury after 9/11: participation, recall, and description. *Inj Epidemiol*. 2019;6:8.
2. Brackbill RM, Alper HE, Frazier P, Gargano LM, Jacobson MH, Solomon A. An assessment of long-term physical and emotional quality of life of persons injured on 9/11/2001. *Int J Environ Res Public Health*. 2019;16(6):1054.
3. Alper HE, Yu S, Stellman SD, Brackbill RM. Injury, intense dust exposure, and chronic disease among survivors of the World Trade Center terrorist attacks of September 11, 2001. *Inj Epidemiol*. 2017;4(1):17.
4. Gargano LM, Gershon RR, Brackbill RM. Quality of life of persons injured on 9/11: qualitative analysis from the World Trade Center Health Registry. *PLOS Curr*. 2016:8.
5. Munnell AH, Sanzenbacher GT, Rutledge MS. *What Causes Workers to Retire Before They Plan?* Chestnut Hill, MA: Center for Retirement Research at Boston College; 2015.
6. Pransky GS, Benjamin KL, Savageau JA. Early retirement due to occupational injury: who is at risk? *Am J Ind Med*. 2005;47(4):285-295.
7. Dwyer DS, Mitchell OS. Health problems as determinants of retirement: are self-rated measures endogenous? *J Health Econ*. 1999;18(2):173-193.
8. Munnell AH, Rutledge MS, Sanzenbacher GT. Retiring earlier than planned: what matters most?:2019.19-3.
9. McGarry K. Health and retirement: do changes in health affect retirement expectations? *J Hum Resour*. 2004;39(3):624-648.
10. Sundstrup E, Hansen ÅM, Mortensen EL, et al. Retrospectively assessed physical work environment during working life and risk of sickness absence and labour market exit among older workers. *Occup Environ Med*. 2018;75(2):114-123.
11. Yu S, Brackbill RM, Locke S, Stellman SD, Gargano LM. Impact of 9/11-related chronic conditions and PTSD comorbidity on early retirement and job loss among World Trade Center disaster rescue and recovery workers. *Am J Ind Med*. 2016;59(9):731-741.
12. Yu S, Seil K, Maqsood J. Impact of health on early retirement and post-retirement income loss among survivors of the 11 September 2001 World Trade Center disaster. *Int J Environ Res Public Health*. 2019;16(1177):1-12.
13. Kuhlman MB, Lohse N, Sorensen AM, Larsen CF, Christensen KB, Steinmetz J. Impact of the severity of trauma on early retirement. *Injury*. 2014;45(3):618-623.
14. Leijten FR, de Wind A, van den Heuvel SG, et al. The influence of chronic health problems and work-related factors on loss of paid employment among older workers. *J Epidemiol Community Health*. 2015;69(11):1058-1065.
15. Kaila-Kangas L, Haukka E, Miranda H, et al. Common mental and musculoskeletal disorders as predictors of disability retirement among Finns. *J Affect Disord*. 2014;165:38-44.
16. Karpansalo M, Manninen P, Kauhanen J, Lakka TA, Salonen JT. Perceived health as a predictor of early retirement. *Scand J Work Environ Health*. 2004;30(4):287-292.
17. Siren M, Viikari-Juntura E, Arokoski J, Solovieva S. Work participation and working life expectancy after a disabling shoulder lesion. *Occup Environ Med*. 2019;76(6):363-369.
18. Park S, Cho SI, Jang SN. Health conditions sensitive to retirement and job loss among Korean middle-aged and older adults. *J Prev Med Pub Health*. 2012;45(3):188-195.
19. Lee W, Hong K, Lim SS, Yoon JH. Does pain deteriorate working life expectancy in aging workers? *J Occup Health*. 2016;58(6):582-592.
20. Fisher GG, Chaffee DS, Sonnega A. Retirement timing: a review and recommendations for future research. *Work Aging Retirement*. 2016;2(2):230-261.
21. Fitzpatrick MD, Moore TJ. *The mortality effects of retirement: evidence from Social Security eligibility at age 62*. National Bureau of Economic Research, Inc.; 2017. NBER Working Papers 24127.
22. Welch LS, Haile E, Boden LI, Hunting KL. Impact of musculoskeletal and medical conditions on disability retirement—A longitudinal study among construction roofers. *Am J Ind Med*. 2010;53(6):552-560.
23. Peterson CL, Murphy G. Transition from the labor market: older workers and retirement. *Int J Health Serv*. 2010;40(4):609-627.
24. Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD checklist (PCL). *Behav Res Ther*. 1996;34(8):669-673.
25. Brackbill RM, Hadler JL, DiGrande L, et al. Asthma and posttraumatic stress symptoms 5 to 6 years following exposure to the World Trade Center terrorist attack. *JAMA*. 2009;302(5):502-516.
26. Pencina MJ, Larson MG, D'Agostino RB. Choice of time scale and its effect on significance of predictors in longitudinal studies. *Stat Med*. 2007;26(6):1343-1359.
27. Quinn JF, Cahill KE, Giandrea MD *Transitions from career employment among public- and private-sector workers*. Cambridge, MA: National Bureau of Economic Research; 2018. Working Paper 25003.
28. Cahill KE, Giandrea MD, Quinn JF. Retirement patterns and the macroeconomy, 1992-2010: the prevalence and determinants of bridge jobs, phased retirement, and reentry among three recent cohorts of older americans. *Gerontologist*. 2015;55(3):384-403.
29. Baily MN, Harris BH. Working longer policies: framing the issues Economic Studies at Brookings; 2019.
30. Quinn JF, Cahill KE, Giandrea MD. *Early Retirement: The Dawn of a New Era?* New York: TIAA-CREF Institute; 2011.
31. Johnson RW, Butrica BA, Mommaerts C. *Work and Retirement Patterns for the G.I. Generation, Silent Generation, and Early Boomers: Thirty Years of Change*. Chestnut Hill, MA: Center for Retirement Research at Boston College; 2010.
32. Morisi T. Why more people ages 55+ are working. In. *U.S. Department of Labor Blog*. vol 2019; 2016.
33. Zulkarnain A, Rutledge MS. *How Does Delayed Retirement Affect Mortality and Health?* Chestnut Hill, MA: Center for Retirement Research at Boston College; 2018.
34. Ruhm CJ. Bridge jobs and partial retirement. *J Labor Econ*. 1990;8(4):482-501.
35. Cloostermans L, Bekkers MB, Uiters E, Proper KI. The effectiveness of interventions for ageing workers on (early) retirement, work ability and productivity: a systematic review. *Int Arch Occup Environ Health*. 2015;88(5):521-532.
36. van den Berg T, Schuring M, Avendano M, Mackenbach J, Burdorf A. The impact of ill health on exit from paid employment in Europe among older workers. *Occup Environ Med*. 2010;67(12):845-852.
37. Gharibi V, Mokarami H, Taban A, Yazdani Aval M, Samimi K, Salesi M. Effects of work-related stress on work ability index among Iranian workers. *Saf Health Work*. 2016;7(1):43-48.

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