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RESEARCH ARTICLE

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A pilot study to identify factors associated with frailty within the World Trade Center general responder cohort

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Abstract

Background: Given the significant exposures experienced by the World Trade Center (WTC) general responders, there is increasing interest in understanding the effect of these exposures on aging in this population. We aim to identify factors that may be associated with frailty, a clinical syndrome characterized by a decrease in one's reserve that has been linked to poor health outcomes.

Methods: WTC general responders enrolled in the WTC Health Program aged 50 and older provided informed consent. Validated frailty assessments, the Frailty Phenotype (with the Johns Hopkins Frailty Assessment Calculator) along with the FRAIL scale, categorized nonfrail from prefrail/frail. Fall risk, functional status, and cognition were also assessed. WTC variables, including an identified WTC-certified condition, were utilized. The risk of frailty was estimated using log binomial regression analysis. A 95% confidence interval (CI) was used to estimate the prevalence ratio (PR).

Results: One hundred and six participants were included; 38 (35.8%) were classified as pre-frail or frail. More of the pre-frail/frail group were obese (57.9% vs. 25%; $p = 0.004$) and had a WTC-certified condition (78.9% vs. 58.8%; $p = 0.036$). Obesity (PR = 2.43, 95% CI = 1.31, 4.53), a WTC-certified condition (PR = 1.77, 95% CI = 1.09, 2.89), and risk of falling (PR = 1.97, 95% CI = 1.01, 3.84) were independently associated with frailty.

Conclusions: Obesity and having a WTC-certified condition were found to be risk factors for frailty in our pilot study. Future work may focus on further identifying risk factors for frailty in the larger WTC general responder population.

KEYWORDS

frailty, frailty phenotype, obesity, world trade center

1 | INTRODUCTION

The World Trade Center (WTC) attacks on September 11, 2001 were a devastating event and over the last decades, research has revealed the harmful physical and psychological effects of this disaster on general responders who were involved in the rescue and recovery efforts. The smoke and dust from the towers that fell contained a mixture of volatile compounds and particulate matter including cement, glass, asbestos, and persistent organic pollutants.[1] Not only were there high levels of toxicants, but the general responders were also exposed to significant psychological trauma.[1-4] Since then, the WTC Health Program (WTCHP) has followed this occupational cohort of general responders via yearly monitoring visits and via treatment visits if the general responder has a health condition that is designated as a WTC-certified condition.[5,6] A WTC-certified condition is defined as a physical or mental health condition that likely developed, at least in part, or was aggravated by a participant's WTC exposures.[7,8] About 40% of the general responders have a WTC-certified condition with the most common including upper respiratory disorders, gastroesophageal reflux disease, and obstructive airway disease.[7,9] Additionally, mental health conditions, including post-traumatic stress disorder (PTSD), are commonly certified as well as cancers.[7] Occupational and environmental exposures along with imperfect occupational ergonomic conditions and psychosocial factors can have lasting negative effects and hasten aging.[10-13]

Frailty is a common syndrome in aging adults with wide-ranging implications on health. Frailty is characterized by an increased difficulty in returning to a steady state after a stressful event that can lead to poor health outcomes.[14] This clinical syndrome is marked by decreased strength, endurance, and physiological reserve, and there has been increasing efforts to screen patients for frailty to implement early interventions.[14,15] While there is no single gold standard assessment for frailty, a frequently utilized method for evaluation is the Frailty Phenotype. This assesses clinical signs and symptoms through measures of unintentional weight loss, physical activity, weakness, exhaustion, and walking speed.[16,17] More recently, the shorter FRAIL scale was developed that evaluates frailty via questions related to fatigue, resistance, ambulation, chronic conditions, and weight loss.[18,19] Another approach to measuring frailty is via an index, or a deficit accumulation model of frailty that evaluates participants' aggregated clinicaldeficits and can include signs, symptoms, disabilities, and even laboratory values.[20] Frailty as determined by all these measures has been associated with mortality.[21-24] Of note, the Frailty Phenotype may be limited by the need for specialized equipment and in the presence of disability; whereas the Frailty Index requires a full clinical evaluation to ascertain all the criteria that comprise the specific index.[25]

There has been some limited work in this population focused on age-related conditions. There is evidence that WTC trauma and environmental exposure may affect cognition with a 2019 study finding a higher incidence of mild cognitive impairment in general responders than anticipated.[26] Another study evaluated a sample of general responders using the Montreal Cognitive Assessment (MoCA) and found almost 13% to have cognitive impairment.[27] Interestingly, Kuan et al. showed an increase in transcriptional aging, a measure of biological aging, in WTC general responders with PTSD.[28] With the burden of disease as well as the advancing age of this population (the median age in the general cohort was 59 in 2020), there is an increased need to examine aging and frailty in this population.[8] Two indices of frailty have been developed and validated using routinely collected measures in the WTC General Responder (WTCGR) cohort. First, a physiological frailty index (FI) was created using 20 parameters from physical exam findings as well as laboratory tests and pulmonary function tests.[29] Additionally, a clinical FI was developed and validated showing a strong association with all-cause mortality.[30]

The goal of this current study was to evaluate frailty in a pilot subset of the WTCGR cohort using commonly studied frailty measures. We evaluated other geriatric assessments to identify additional factors associated with frailty.

2 | METHODS

2.1 | Patient selection and data collection

Participants were selected from the WTCGR cohort who are followed in the WTCHP at the Mount Sinai Clinical Center of Excellence (CCE). A general responder is defined as a person involved in the rescue, recovery, and cleanup of the WTC disaster site after the events on September 11, 2001.[7,8] Eligibility for the cohort and receipt of medical services through the WTCHP has been previously published.[7] Through support from the Centers for Disease Control's National Institute for Occupational Safety and Health, participants are followed with yearly routine monitoring and care for conditions that are certified to be associated with exposure to the attacks.[8,31] This health monitoring includes questionnaires related to physical health, mental health, and WTC-related exposures along with a physical examination and medical testing (chest radiography, laboratory work, and pulmonary function tests).[7]

Participants seen at the Mount Sinai CCE under this program were considered eligible for the present study if they were 50 years of age or older, were enrolled in the WTCHP, and had previously consented to be contacted for research purposes. Participants unable to provide written consent or speak/understand English were excluded. For this study, participants were recruited from the clinic and consented via the study personnel. Due to COVID-imposed restrictions for clinic-based monitoring evaluations, it was not possible to assess all the enrolled participants in-person and certain measures were performed remotely.

When possible, patients received an in-person assessment using the Frailty Phenotype (with the John Hopkins Frailty Assessment Calculator).[32] This assessment collects data on unintentional weight loss, weakness, exhaustion, walking speed, and physical activity.[16] Participants who were not in-person completed the telephone-based FRAIL scale, a 5-question assessment that evaluated the participant's tiredness, difficulty walking up steps (10 steps) and long distances

(several hundred yards), illnesses (e.g., hypertension, diabetes, cancer), and weight change in the last year.[15,18,33,34] A person was considered frail for this current study if they met criteria for frail or prefrail on either scale based on the following scoring: a score of 1 or more (both with a maximum score of 5).[16,35] We will refer to these participants as the frail group in the subsequent sections. Not frail was defined as a score of 0 on both assessments.

2.2 | Other geriatric assessments

The participants were also asked to complete several other geriatric assessments as outlined below. A functional assessment was performed by asking each participant about their ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs) independently or not independently.[36,37] Questions included use of the telephone, getting places using public transportation or driving a car, grocery shopping, preparing meals, doing light household work, taking medications, handling money, caring for themselves (washing, dressing, eating), and walking around their home. Participants indicated whether they performed each task "on their own or without help" (2 points), "with some help" (1 point), or "unable" (0 points). A score of 24 was considered fully independent.

Based on previous work, we also evaluated fall risk.[38] Three questions were utilized: if the participant had fallen and injured themselves in the last year, if they have fallen 2 or more times in the last year, and if they are afraid of falling because of balance or walking problems.[39] A "yes" on any of the questions indicated a participant was at risk for falls.

Fear of falling was assessed using the Falls Efficacy Scale-International (FES-I). This tool evaluates a patient's fear of falling through a series of questions related to their activities.[40-42] The FESI scoring goes up to 64 with a higher score indicating a higher concern for fall. Particularly, a low concern was defined as a score of 16–19, moderate was 20–27, and high was 28–64.[40,43,44] This is important for our study because the fear of falling can indicate a risk of future falls, functional decline, and even mortality.[45,46] Furthermore, a 2022 systematic review found a link between this fear and frailty for older adults living in the community.[47]

To assess cognition, we used two methods: the in-person Montreal Cognitive Assessment (MoCA) or the phone Callahan assessment. The MoCA tool has been used previously by the WTCGR population.[26,27] MoCA is a quick screening tool developed to assess several areas of cognition including executive function, memory, and visuospatial ability. A score of 26 and above is suggestive of normal cognition, and it has been shown to be effective in identifying mild cognitive impairment.[48-51] A cognitive impairment screener by Callahan et al. was also employed for participants who required telephone screening again due to COVID-imposed restrictions.[52] This tool is helpful in evaluating cognitive impairment and is similar to the Mini Mental Status Exam with the questions relating to remembering and repeating three words as well as knowing the day of the week, the month, and the year.[52] Participants were categorized as impaired if they had a score of 0-3 on the Callahan or a score of 25 or lower on the MoCA.[48,52]

2.3 | Other WTC variables

Data on the participants' particular exposures during their involvement in the WTC rescue and recovery activities had previously been collected by the WTCGR Data Center and was provided for this study.[7] The variables included sex, age at most recent visit, race/ethnicity, body mass index (measured at yearly monitoring visits and presented in this study as a mean), smoking status, educational level, occupation before 9/11, involvement in law enforcement, first day at the WTC site, any WTC-certified condition, and overall exposure severity. A WTC-certified condition is defined as a physical or mental health condition that was deemed by the WTCHP as being related to or aggravated by a participant's work at the WTC site.[7,8] For this study, we classified the certifications based on their general category: mental health, cancer, or physical (any other medical condition). WTC-related exposure was characterized by the participant's total time involved at the WTC site, their exposure to the dust/debris cloud when the WTC towers collapsed, and their participation with cleaning the debris. These factors were evaluated as a composite variable with exposure severity grouped into levels: low, intermediate, high, and very high.[53,54]

The Institutional Review Board of the Icahn School of Medicine at Mount Sinai approved this study.

2.4 | Statistical analysis

We categorized participants into two groups: a frail group–defined as those participants who scored in the pre-frail or frail range on either or both assessments (FRAIL scale and Frailty Phenotype)–and a non-frail group–defined as those who were not considered pre-frail or frail. Due to a limited sample size, we did not assess pre-frail and frail separately. We used the Cohen's kappa statistic to assess interrater reliability between frailty assessments for participants who completed both assessments.[55] To evaluate differences in participant characteristics, WTC exposure characteristics, and other assessments between the two groups, Chi-squared testing and Monte-Carlo estimations were performed. A stepwise backward logistic regression analysis was completed to identify factors associated with frailty (Supplemental Materials). We selected a 5% statistical significance level. Age (continuous, in years), sex, and smoking status was also added into the logistic regression model to adjust for other significant factors. Log binomial analysis was then utilized with this final post-selection model to estimate the prevalence ratio (PR) with a 95% confidence interval (CI). Evaluation of variables associated with frailty in our study population identified BMI (normal as a reference group), if a participant had a WTC-certified condition (no WTC-certified condition as a reference group), and if they were at risk for a fall (no risk as a reference group). Statistical analysis was performed using SAS® 9.4 (SAS Institute).

3 | RESULTS

One hundred and twenty-three participants were consented to participate in the study from February 2021 until November 2021, 106 of whom had at least one evaluable frailty assessment. Characteristics for the Mount Sinai CCE compared with our study sample are provided as a Supplemental Materials. Our study sample had slightly more females (22.6% compared with 15.1%), was older, and had more college educated participants (45.3% compared with 27.7%). The other sociodemographic variables (race/ethnicity, BMI, and smoking status) were similar to the larger cohort. Regarding the participants' WTC exposures, our study sample contained more participants with high or very high exposure severities (30.2% and 17.9%) versus the Mount Sinai CCE cohort (15.9% and 4.2%). Additionally, 66% of our study sample had a WTC-certified condition, whereas 49.8% had a WTC-certified condition in the larger cohort.

Of the 106 participants in our study sample, 38 (35.8%) were found to be frail compared to 68 (64.2%) not frail. Of the 38 frail patients, 29 were pre-frail on either or both assessment(s) and 9 were frail on either or both assessment(s). Cohen's kappa for interrater reliability between the two frailty assessments utilized was 0.50 ($p < 0.0001$), which is considered moderate agreement.[55] There was no difference in age between the two groups. Most participants in both groups were between 55 and 64 (Table 1). Additionally, 65.8% of the frail and 69.1% of the non-frail participants self-identified as white while 25% of both groups were female. Smoking status and education level did not differ between groups. The frail group had more obese participants compared with the non-frail group (57.9% compared with 25%; $p = 0.004$).

Before 9/11, more of the frail group reported doing construction or transportation/material moving occupations, which trended toward significance ($p = 0.057$). No differences were seen between the groups for other WTC environmental exposure measures including the date of first arrival to the WTC site and exposure severity. However, almost 79% of frail participants had a WTC-certified condition compared to 58.8% of the non-frail participants ($p = 0.036$). Of the specific WTC-certified conditions, mental health certifications were more common amongst those who were frail (30% compared with 12.5%; $p = 0.017$).

Comparison of disability, falls, and other characteristics by frailty status are included in Table 2. Frail participants were statistically more likely to be not fully independent in ADL/IADLs compared with the non-frail (28.9% vs. 11.8%; $p = 0.027$). There were no differences between the groups based on cognitive status with most participants in both groups having normal cognition (76.3% in the frail group and 82.4% in the not frail group). Both fall assessments showed statistically significant differences between the non-frail and frail groups ($p = 0.02$ for the fall risk assessment and $p < 0.0001$ for the FES-I). Specifically, the fall risk assessment was higher at 34.2% in the frail group versus 14.7% in the non-frail group. Additionally, there was high concern for falls in almost 29% of the frail participants for the FES-I compared with 0% in the non-frail group.

TABLE 1 WTC general responder participant characteristics ($N = 106$).

	Not frail ($N = 68$) *N* (%)	Frail ($N = 38$) *N* (%)	*p* value*
Demographics			
Female sex	17 (25)	7 (25)	0.882
Age at most recent visit			0.620
50–54	13 (19.1)	5 (13.2)	
55–64	36 (52.9)	21 (55.3)	
65+	19 (28.0)	12 (31.6)	
Race/ethnicity			0.905
Black or African American	6 (8.8)	4 (10.5)	
White	47 (69.1)	25 (65.8)	
Other	8 (11.8)	6 (15.8)	
Not reported	7 (10.3)	3 (7.9)	
BMI**			**0.004**
Underweight/ normal (<25)	15 (22.1)	6 (15.8)	
Overweight (25–29.9)	35 (51.5)	10 (26.3)	
Obese (≥30)	17 (25)	22 (57.9)	
Not reported	1 (1.5)	0	
Smoking status			0.540
Current smoker	3 (4.4)	4 (10.5)	
Former smoker	20 (29.4)	12 (31.6)	
Never smoker	44 (51.5)	22 (57.9)	
Not reported	1 (1.5)	0	
Education level			0.085
Less than high school	0	2 (5.3)	
High school	5 (7.4)	7 (18.4)	
Some college	26 (38.2)	14 (36.8)	
College	35 (51.5)	13 (34.2)	
Not reported	2 (2.9)	2 (5.3)	
WTC characteristics			
Occupation before 9/11			0.057
Construction	2 (2.9)	4 (10.5)	
Electrical, telecom, installation	4 (5.9)	1 (2.6)	
Protective services, military	42 (61.8)	17 (44.7)	
Transportation, material moving	0	3 (7.9)	
Unemployed/retired	3 (4.4)	0	
Other	12 (17.6)	10 (26.3)	
Not reported	5 (7.4)	3 (7.9)	

(Continues)

TABLE 1 (Continued)

	Not frail (*N* = 68) *N* (%)	Frail (*N* = 38) *N* (%)	*p* value*
Date of first day on WTC site			0.787
September 11, 2001	36 (52.9)	22 (57.9)	
September 12, 2001–September 13, 2001	14 (20.6)	9 (23.7)	
September 14, 2001–September 30, 2001	6 (8.8)	3 (7.9)	
October 1, 2001 and after	0	0	
Not reported	12 (17.6)	4 (10.5)	
Exposure severity			0.292
Low	0	0	
Intermediate	21 (30.9)	15 (39.5)	
High	22 (32.4)	10 (26.3)	
Very high	15 (22.1)	4 (10.5)	
Not reported	10 (14.7)	9 (23.7)	
WTC-certified condition			0.036
Any certification	40 (58.8)	30 (78.9)	
No certification	28 (41.2)	8 (21.1)	
Specific WTC-certified condition			
Cancer			0.139
Yes	19 (47.5)	9 (30)	
No	21 (52.5)	21 (70)	
Mental health			0.017
Yes	5 (12.5)	11 (30)	
No	35 (87.5)	19 (70)	
Physical health			0.344
Yes	28 (70)	24 (80)	
No	12 (30)	6 (20)	

Abbreviations: BMI, Body Mass Index; WTC, World Trade Center; NYPD, New York Police Department.

*Significance evaluated with Chi-Squared Test and Monte-Carlo estimation were assessed at 0.05.

**Data presented as mean of monitoring visits.

On log binomial regression, participants with any WTC-certified condition had 1.8 times higher risk of being frail compared to those without (95% CI: 1.09, 2.89; Table 3). Additionally, participants who were at a higher risk of falling had increased risk of frailty (PR = 1.97, 95% CI: 1.01, 3.84). Having a BMI categorized as obese compared with normal was also an independent predictor of frailty (PR = 2.43, 95% CI: 1.31, 4.53).

TABLE 2 WTC general responder participant geriatric assessments.

	Not frail (*n* = 68) *N* (%)	Frail (*n* = 38) *N* (%)	*p* value*
Functional status			0.027
Independent	60 (88.2)	27 (71.1)	
Not fully independent	8 (11.8)	11 (28.9)	
Fall risk			0.020
At risk	10 (14.7)	13 (34.2)	
Not at risk	58 (85.3)	25 (65.8)	
Falls efficacy			<0.0001
Low concern	60 (88.2)	22 (57.9)	
Moderate concern	8 (11.8)	5 (13.2)	
High concern	0	11 (28.9)	
Cognitive status			0.216
Normal/not impaired	56 (82.4)	29 (76.3)	
Impaired	7 (10.3)	8 (21.1)	
Not reported	5 (7.4)	1 (2.6)	

*Significance evaluated with Pearsons' Chi-Squared Test.

TABLE 3 Log binomial regression analysis to evaluate the association with frailty.*

	Prevalence ratio	Confidence limits lower	upper
BMI			
Underweight/normal	Ref	Ref	Ref
Overweight	1.766	1.007	3.097
Obese	2.431	1.306	4.526
WTC-Certified condition			
No	Ref	Ref	Ref
Yes	1.774	1.090	2.886
Risk of fall			
No	Ref	Ref	Ref
Yes	1.970	1.012	3.835

Abbreviations: BM, Body Mass Index; WTC, World Trade Center.

*Model adjusted for age (continuous years), sex, and smoking status.

4 | DISCUSSION

We evaluated a cohort of WTC general responders using validated and commonly utilized frailty measures and found obesity, having any WTC-certified condition, including mental health certifications, and being at risk

of falls were significantly associated with frailty. This study highlights the growing need in the WTC population to screen for frailty, as it is vital to respond to the changing health needs of this population as it ages.

Frailty is a syndrome that describes the overall decline from the collective physiological systems and is typically associated with aging.[56] In an early study, Fried et al. reported a prevalence of almost 7% in a population of adults 65 and older living in the community using the frailty phenotype.[16] Other studies using various measures have reported varying prevalences.[57-61] In this study, our mean age was about 61 years for both groups with 36% of the study participants identified as frail or pre-frail. In a systematic review of community dwelling adults aged 65 and above, the overall weighted average prevalence of pre-frailty was 41.6% and frailty was 10.7%.[61] In a review of younger adults aged 18-65 years of age, the cited prevalence was between 4% and 63%.[58] It also should be noted that our previous work with the WTC population estimated a frailty of around one-third using a clinical frailty index.[30] While our current study is a pilot, these differences in rates of frailty may reflect unique characteristics of the study populations, such as age, or differences in the definition of frailty.[16,30] Further work is needed to fully characterize how the complexities of the WTCGR cohort, including their WTC exposure and chronic conditions, affect frailty. Interestingly, one meta-analysis reported a much higher prevalence of 40.4% in participants with depression.[62]

We found a higher risk of frailty in those with WTC-certified conditions, including having a mental health certification. While a WTC-certified condition is not synonymous with having co-morbidities, it highlights how a participants' added health conditions could increase the risk of a person being frail. A 2018 study reported over a five-fold increase in the odds of multi-morbidity in frail individuals compared to non-frail.[21] Additionally, a 2019 systematic review found frailty and multimorbidity associated with a likely bidirectional relationship.[63] Previous research has highlighted the increased risk for frailty in participants with depression.[62,64] Work in the WTC population on health mental health conditions, especially PTSD, has shown associations with cognitive impairment and aging. In those with PTSD, mild cognitive impairment was more common along with transcriptional aging.[26-28] Other studies found measures of aging, handgrip strength and the Short Physical Performance Battery, to be associated with PTSD suggesting PTSD may play a role in aging.[65,66] Our pilot study strengthens the understanding of the impact of mental health in the WTC population and aging. Future research is warranted to evaluate cognitive impairment and aging.

Another important finding is the increased frailty rates amongst participants who are obese. This association continued to be present even after adjusting for WTC-certified conditions and risk of falls. While weight loss is a component of the frailty measures, previous studies have shown an association with BMI and frailty; however, it is to variable degrees.[16,18] One 2022 study showed greater odds of frailty in participants who had a BMI of 35 or greater, with lower odds in those with a BMI between 25 and 34.[67] Others showed this association with a BMI of 30 or greater or just in women (and not men).[68-71] Additionally, the Women's Health Initiative Observational Study in 2005 found participants who were underweight had a higher hazard ratio of being frail.[70] A U-shaped relationship between frailty and BMI has been noted in the literature including in a recent meta-analysis.[72,73] Among individuals who are underweight, frailty may be related to decreased muscle mass and lack of nutrition.[67,73,74] Whereas, in the obese group, the frailty association is thought to be related to co-morbidities, such as diabetes and cardiovascular disease, which are frequently found with obesity.[67] Another factor adding to this complex relationship between BMI and frailty may be related to increased inflammation leading to decreased muscle mass and sarcopenic obesity.[73] Sarcopenic obesity is a term used to describe the disproportionate muscle mass and strength compared to body size in obese individuals that has been related to disability.[75,76] Finally, it is postulated that obesity and its association with depression and cognitive impairment may contribute to an increased risk of frailty.[73] This is pertinent in our population, in which a large portion of participants has WTC-certified conditions including depression.[7] Unfortunately, too few participants were underweight to investigate this category separately. These studies also focused exclusively on populations older than the WTCGR Cohort making extrapolation difficult to a younger population.[67-72]

Finally, we observed that the risk of frailty was higher in those who were at an increased risk of falling, consistent with previous literature.[77,78] A 2015 meta-analysis found that frailty was associated with the future risk of falling in community-dwelling individuals.[78] These findings further highlight the importance of evaluating frailty within this population. This result was also consistent regardless of obesity status. Interestingly, this was not observed in a 2013 study where researchers found obese participants to have less falls and no interaction between obesity, falls, and frailty.[79] Another study of women showed frailty was not associated with falls among obese participants.[80] It should be noted that some previous studies evaluating obesity and falls have shown obese patients to have a higher rate of falls.[81,82] There is likely a complex interplay between falls, obesity, and frailty that warrants further investigation.

Our study had several limitations. First, our study was a cross-sectional pilot study intended to explore the various factors associated with frailty in the WTCGR Cohort. We recruited a small subset of this population, which limited our power and contributed to slightly wider confidence intervals. However, it should be highlighted that our study sample had largely comparable characteristics to the wider Mount Sinai CCE cohort. Our study sample notably differed in the portion of participants that were older, had a WTC-certified condition, and had a high/very high WTC exposure severity. Thus, our current study sample is fairly robust, and our results likely to be applicable to the wider cohort. Second, we chose to use stepwise backward logistic regression for model building and log binomial analysis to evaluate the potential associations with frailty given the pilot nature of our current cross-sectional study. Further work is indicated to evaluate our current pilot study's generalizability to the wider WTCGR cohort as well as additional modelling to assess risk of the associations identified in this current study.[83-85] Third, frailty was defined using both pre-frail and frail scores. Additional research is

needed to understand how pre-frailty and frailty individually affect the WTCGR Cohort. Particular focus on the pre-frail group may provide specific insight into unique risk factors within that subgroup that may be targeted for intervention. Furthermore, our frailty measurements were taken at a single time point. This may limit our understanding of how frailty changes over time. It should be noted that the reported BMI in this study was a mean of monitoring visits for each participant, which strengthens our understanding of BMI and helps to adjust for changes in weight over time. Fourth, the WTC-certified conditions are not all inclusive, and they importantly do not include diabetes, hypertension, and heart disease. While the WTCGR Cohort does have a high burden of disease, it is currently unknown how other co-morbidities are associated with frailty in this population. Fifth, cognitive impairment was investigated using two different assessments, which may have limited our ability to evaluate the association between cognitive impairment and frailty. Lastly, the WTCGRC is an occupational cohort, and thus healthy work effect may limit our findings generalizability to a larger general population.[86] However, given the pilot nature of the current study and our purpose of creating interventions focused on the WTCGRC, we present important, preliminary findings towards this goal.

Despite these limitations, our study reveals important preliminary findings. The WTCGR Cohort is relatively young; however, we saw a high burden of frailty within our subset, which will likely increase as this population ages. We additionally reported factors, including obesity and WTC-certified condition status, which could be utilized for future research to identify a subset of WTCGRs who are more at risk.

5 | CONCLUSION

We assessed risk factors for frailty to better understand the aging process in a pilot study of a subset of WTC general responders. Obesity, physical and mental health co-morbidities (WTC-certified conditions) and being at risk for falls were found to be associated with frailty. It is vital to respond to the changing health needs of this population as it ages. These findings show that certain individuals may be more at risk for frailty within the WTCGR Cohort and provide a starting point to identifying those most at risk who may benefit from targeted interventions. Further work is needed to understand the association between cognitive impairment and frailty in this population.

AUTHOR CONTRIBUTIONS

Conceptualization: Drs. Ko, Hung, Lucchini, and Ornstein; Methodology: Drs. Ko, Hung, Lucchini, Teitelbaum, and Ornstein; Formal Analysis: Mr. Sabra and Drs. Bello and Colicino; Investigation: Drs. Thompson, Thanik, and Ornstein; Resources: Drs. Ko, Hung, Lucchini, and Ornstein; Data Curation: Mr. Sabra and Drs. Thompson and Thanik; Writing—Original Draft Preparation: Dr. Thompson; Writing—Review and Editing: all authors; Visualization: all authors; Supervision: all authors; Project Administration: Drs. Ko, Hung, and Ornstein; Funding Acquisition: Drs. Lucchini and Ornstein.

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CONFLICT OF INTEREST STATEMENT

Hannah Thompson, Roberto Lucchini, Michael Crane, Ghalib Bello, Ahmad Sabra, Erin Thanik, Susan Teitelbaum, William Hung, Elena Colicino, and Fred Ko have no conflicts of interest to disclose.

DISCLOSURE BY AJIM EDITOR OF RECORD

Leena Nylander-French declares that she has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The study was performed at the Icahn School of Medicine at Mount Sinai and conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Icahn School of Medicine at Mount Sinai, protocol code STUDY-20-00792 and HS 11-02030/GCO 16-2633. Dates were: initial approval, September 10, 2020, initial effective, June 5, 2020, and approval end, June 4, 2023. Informed consent was obtained from all subjects involved in the study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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