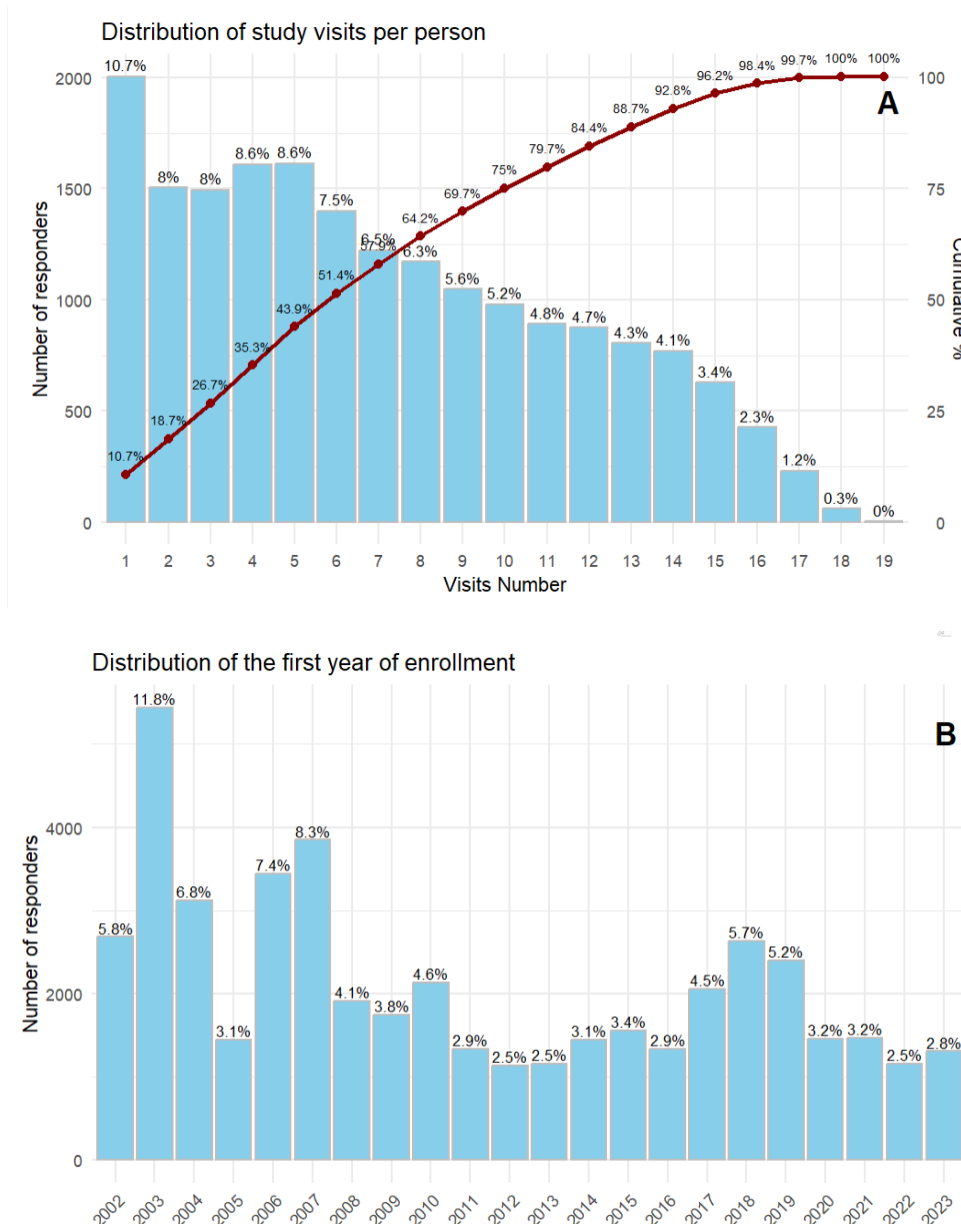


SUPPLEMENTARY INFORMATION

Urban Exposures, Frailty, and Mental Illness in World Trade Center

Health Program Responders

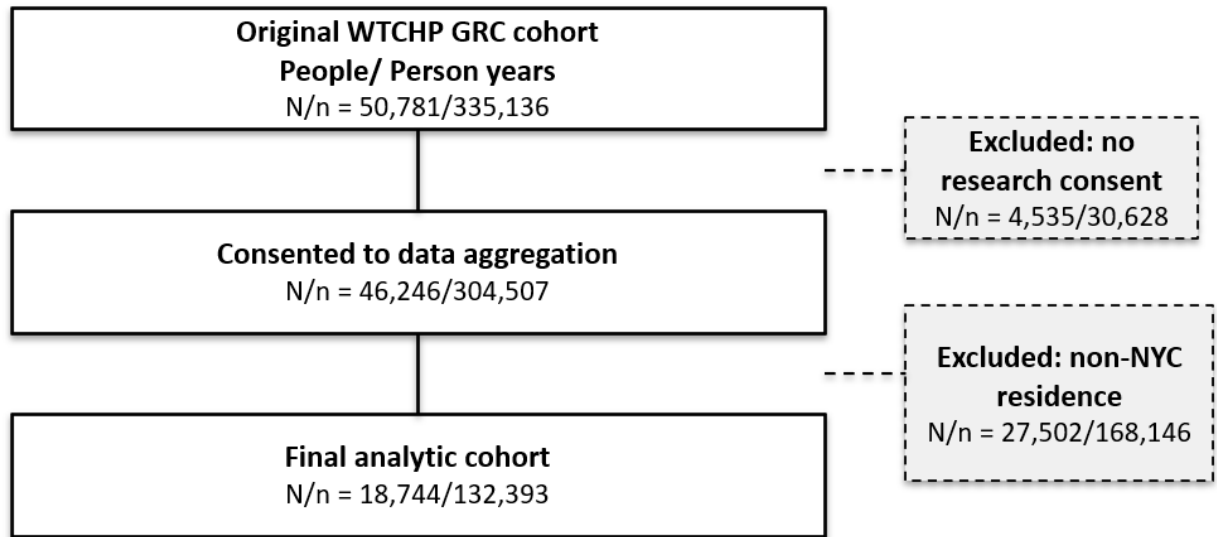
Figure S1. Distribution of the responders monitoring visits



We included general responders from the WTCHP cohort, an open cohort that continuously enrolls responders. Eligible individuals include responders who took part in rescue, recovery, and clean-up tasks following the 9/11/2001 attack on the WTC. The cohort includes over 50,000 responders who were enrolled between 2001 and 2023. General responders enrolled in the WTCHP are offered annual clinical visits, termed monitoring visits, during which a healthcare professional performs physical and mental examinations along with a survey of demographic and health-related questions. The figure above represent the cumulative and absolute frequency of visits (A) as well as the frequencies of study visits (B).

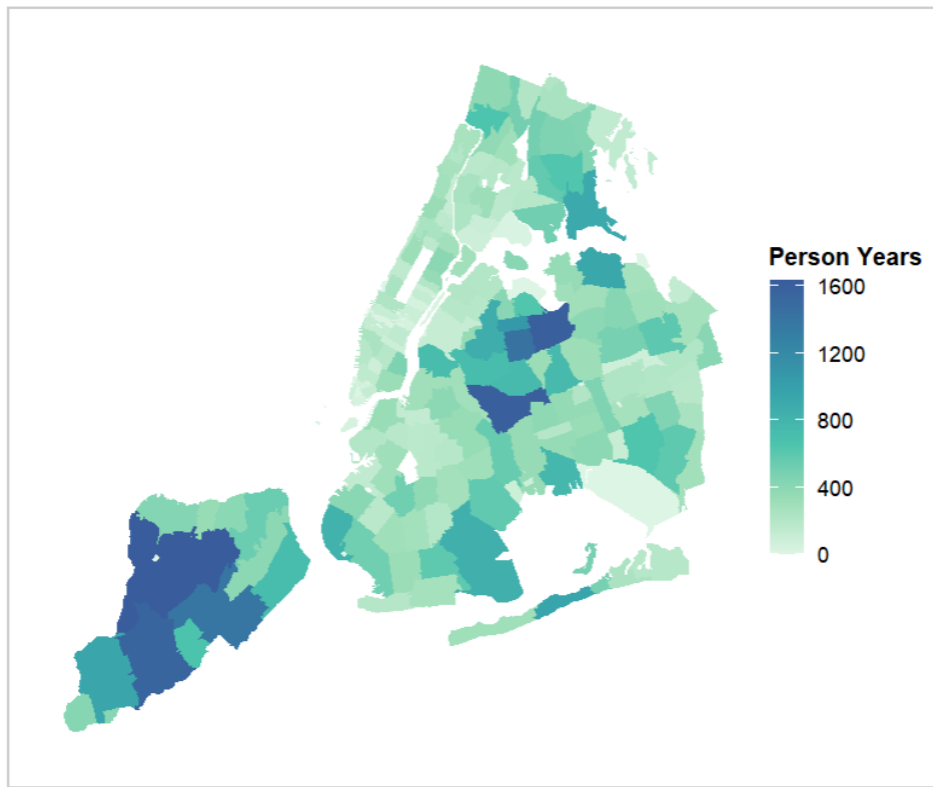
Source data are provided as a source data file

Figure S2. Flowchart of the study population



The figure presents a flowchart diagram with numbers of individuals and person years based on certain criteria. WTCHP = World Trade Center Health Program; GRC = General Responders Cohort; NYC = New York City; N = Number of observations; n= Number of observations in person years

Figure S3. Distribution of the responders' (person years) locations



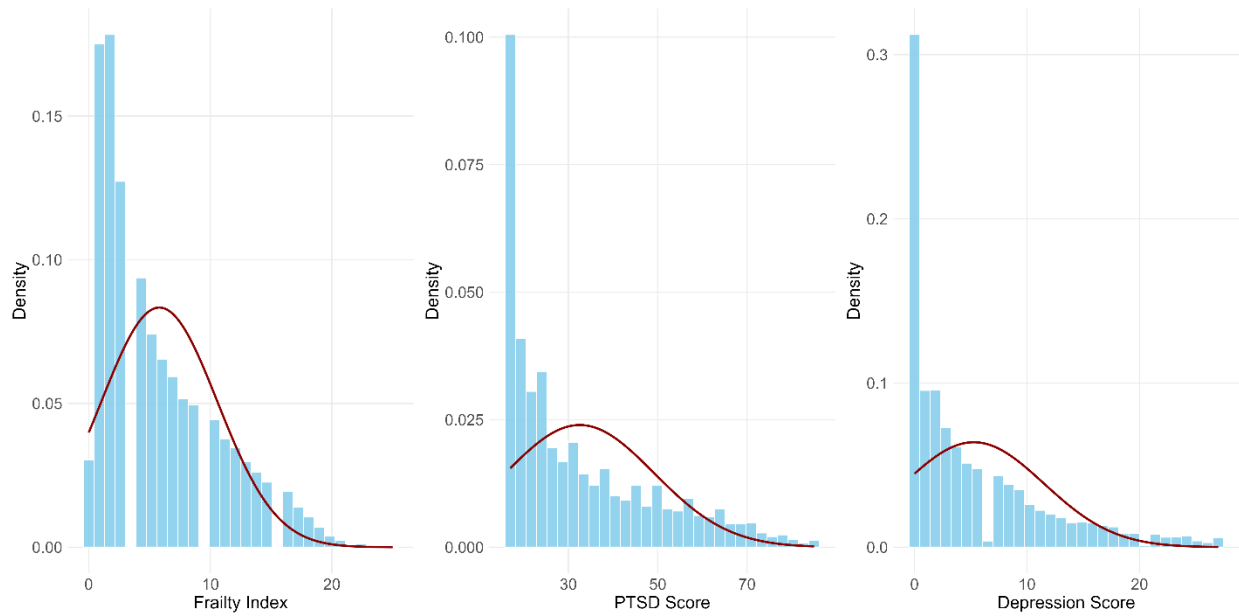
We restricted the population to responders living in New York City (N=18,734) to capture associations in a dense metropolitan environment using high-resolution measure of street-level greenery. The figure represents the distribution of the responders' (person years) locations.

Map was created using Rstudio version 4.3.1 if census track boundary data is sourced from the U.S. Census Bureau. (2024). TIGER/Line Shapefiles: Census Tracts [Shapefile]. U.S. Department of Commerce.

<https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html>

Source data are provided as a source data file

Figure S4. Distributions of the studied outcomes



We used a quasi-Poisson link function in our multivariable generalized additive mixed-effect models to account for the over-dispersion and based on the test score distributions.

PTSD = Post Traumatic Stress Disorder

Source data are provided as a source data file

Table S1. Number of deficits (person years) between 2003-2023 (N = 134,229)

Item	Number of deficits (person years)
Ever had pneumonia	2
Ever had diabetes	108
Persistent fatigue	30,896
Unexplained weight loss	4,107
Difficulty urinating	20,159
Inability to taste	8,227
Difficulty swallowing	13,547
Change in bowel habits	15,138
Coughing after you lie down or eat	16,352
Difficulty hearing	22,461
Concurrent medications (polypharmacy)	55,919
Self-rated health	36,916
Difficulty performing moderate activities (e.g., moving a table, pushing a vacuum cleaner, bowling, or playing golf)	16,453
Difficulty climbing several flights of stairs	23,058
In past month, accomplished less than you would like	44,477
In past month, were limited in the kind of work or other activities you could perform	44,477
In past month, accomplished less due to emotional problems	34,087
In past month, did work less carefully than usual due to emotional problems	25,967
How much does pain interfere with normal work	23,319
In past month, how often felt calm/peaceful	14,394
In past month, how often felt lots of energy	22,410
In past month, how often felt downhearted	8,620
In the past month, how often have physical health/emotional problems interfered with social activities	15,635
Frequency of short-term memory problems (e.g., forgetting keys)	20,877
In past month, frequency of difficulty concentrating	16,893
Abnormal eye exam	2,023
Abnormal ear exam	5,492
Abnormal extremities exam	6,086
Abnormal heart exam	3,252
Abnormal physician-assessed general appearance	85,098

N = Number of observations.

During each monitoring visit, including deficits such as diabetes, fair/poor self-rated health, difficulty climbing several flights of stairs, abnormal heart examination, and self-reported mental health conditions. Each item is coded as a binary value where a response of Fair/Poor is considered as a “deficit” (and assigned a score of 1), and a response of Excellent/Very Good/Good is assigned a score of 0 (i.e., not a deficit).

Source data are provided as a source data file

Table S2. The association between environmental exposures and PTSD, and depression scores: Sensitivity analysis using dichotomous cutoffs.

Variable	Odds Ratio (95% confidence intervals)	
	PTSD	Depression
Multivariate model		
PM _{2.5} (µg m ⁻³)	1.12 (1.08; 1.17)	1.07 (1.02; 1.12)
Mean temperature (° C)	1.02 (1.01; 1.03)	1.02 (1.01; 1.03)
Green View Index, 300m buffer	0.92 (0.90; 0.94)	0.93 (0.91; 0.95)
Exposure-mixture model		
Exposure mixture	1.01 (1.00; 1.03)	1.01 (0.99; 1.02)

PTSD = Post Traumatic Stress Disorder; PM_{2.5} = fine particulate matter

Source data are provided as a source data file

Table S3. The association between environmental exposures and Frailty, PTSD, and depression scores using Green View Index with 500m buffer

Variable	% Change (95% CI)		
	FI	PTSD	Depression
Multivariate model			
PM _{2.5} (µg m-3)	2.28% (0.68; 3.91)	2.14% (1.36; 2.92)	4.19% (2.25; 6.16)
Mean temperature (° C)	0.77% (0.42; 1.12)	0.60% (0.42; 0.78)	0.72% (0.29; 1.15)
Green View Index, 500m buffer	-1.85% (-2.61; -1.08)	-0.91% (-2.30; -1.15)	-4.40% (-5.36; -3.44)
Exposure-mixture model			
Exposure mixture	0.41% (0.00; 0.82)	0.22% (-0.00; 0.45)	0.11% (-0.44; 0.68)

FI = Frailty Index; PTSD = Post Traumatic Stress Disorder; PM_{2.5} = fine particulate matter; CI = Confidence Interval.

Source data are provided as a source data file

Table S4. The association between the exposures and Frailty: Sensitivity analysis incorporating the probability of having at least 27 items for the index calculation

Variable	Main analysis	IPW
Multivariable Model		
PM _{2.5} (µg m ⁻³)	2.27% (0.64; 3.93)	2.46% (0.84; 4.10)
Mean temperature	0.83% (0.47; 1.19)	0.77% (0.41; 1.12)
Green View Index, 300m buffer	-1.43% (-2.19; -0.67)	-1.20% (-1.96; -0.44)
Exposure-mixture Model		
Exposure-mixture	0.56% (0.14; 0.98)	0.63% (0.21; 1.05)

IPW=Inverse probability weights; PM_{2.5} = fine particulate matter.

Source data are provided as a source data file

Table S5. Sensitivity analysis of the association between environmental exposures and PTSD, restricting the data to 2012–2023.

Variable	% Change (95% CI)		
	FI	PTSD	Depression
Multivariate model			
PM _{2.5} (µg m ⁻³)	1.87% (-0.18; 3.96)	1.35% (0.21; 2.50)	3.11% (0.33; 5.96)
Mean temperature (° C)	0.90% (0.48; 1.31)	0.70% (0.47; 0.93)	0.77% (0.21; 1.33)
Green View Index, 500m buffer	-1.21% (-2.04; -0.36)	-1.62% (-2.07; -1.16)	-3.29% (-4.39; -2.17)
Exposure-mixture model			
Exposure mixture	0.64% (0.21; 1.07)	0.28% (0.04; 0.52)	0.17% (-0.40; 0.75)

FI = Frailty Index; PTSD = Post Traumatic Stress Disorder; PM_{2.5} = fine particulate matter; CI = Confidence Interval.

Source data are provided as a source data file

Table S6. The association between environmental exposures and Frailty, PTSD, and depression scores using different temperature metrics.

Variable	% Change (95% CI)		
	FI	PTSD	Depression
Multivariate model			
Summer temperature (° C)	1.49 % (0.85; 2.14)	1.29% (0.96; 1.62)	1.69% (0.90; 2.49)
Winter temperature (° C)	0.66% (0.18; 1.13)	0.59 (0.34; 0.84)	0.65% (0.05; 1.24)

FI = Frailty Index; PTSD = Post Traumatic Stress Disorder; CI =Confidence Interval.

Source data are provided as a source data file