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Post—September 11, 2001, Incidence of Systemic Autoimmune Diseases in World Trade Center—Exposed Firefighters and Emergency Medical Service Workers

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Abstract

Objective—To estimate the incidence of selected systemic autoimmune diseases (SAIDs) in approximately 14,000 male rescue/recovery workers enrolled in the Fire Department of the City of New York (FDNY) World Trade Center (WTC) Health Program and to compare FDNY incidence to rates from demographically similar men in the Rochester Epidemiology Project (REP), a population-based database in Olmsted County, Minnesota.

Patients and Methods—We calculated incidence for specific SAIDs (rheumatoid arthritis, psoriatic arthritis, systemic lupus erythematosus, and others) and combined SAIDs diagnosed from September 12, 2001, through September 11, 2014, and generated expected sex- and age-specific rates based on REP rates. Rates were stratified by level of WTC exposure (higher vs lower). Standardized incidence ratios (SIRs), which are the ratios of the observed number of cases in the FDNY group to the expected number of cases based on REP rates, and 95% CIs were calculated.

Results—We identified 97 SAID cases. Overall, FDNY rates were not significantly different from expected rates (SIR, 0.97; 95% CI, 0.77–1.21). However, the lower WTC exposure group had 9.9 fewer cases than expected, whereas the higher WTC exposure group had 7.7 excess cases.

Conclusion—Most studies indicate that the healthy worker effect reduces the association between exposure and outcome by about 20%, which we observed in the lower WTC exposure

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group. Overall rates masked differences in incidence by level of WTC exposure, especially because the higher WTC exposure group was relatively small. Continued surveillance for early detection of SAIDs in high WTC exposure populations is required to identify and treat exposure-related adverse effects.

Systemic autoimmune diseases (SAIDs) are relatively rare in North American and European populations and predominantly affect women (>75% of cases). Published incidence and prevalence estimates vary considerably, due, in part, to differences in characteristics of the underlying population that are associated with disease prevalence. Further, diagnoses may be based on clinical judgment rather than diagnostic criteria. The few studies of SAID incidence in occupational cohorts are subject to similar limitations, relying on self-reported diagnoses from survey responses[1,2] or on diagnoses from death certificates.[3] The lack of SAID incidence studies in specific occupational groups impedes efforts to identify nongenetic risk factors that might contribute to differences in disease distribution by occupation and over time.

The terrorist attacks on the World Trade Center (WTC) on September 11, 2001 (9/11), with subsequent building collapses and fires, exposed thousands of rescue/recovery workers and residents to aerosolized WTC dust— an amalgam of pulverized cement, glass fibers, silica, asbestos, lead, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and polychlorinated furans and dioxins.[4] Environmental sampling of the area around New York City identified 287 chemicals and chemical groups[5]; some had previously been linked to SAIDs in non— WTC-exposed workers.

The Fire Department of the City of New York (FDNY) WTC Health Program monitors a cohort of approximately 16,000 firefighters and emergency medical service (EMS) workers who participated in rescue/recovery efforts at the WTC site. Clinical observations of SAIDs in this mostly healthy, white male cohort triggered an interest in estimating the incidence of SAIDs in this population. The current study includes the following diagnoses: rheumatoid arthritis (RA), spondyloarthritis (psoriatic arthritis, seronegative arthritis, and ankylosing spondylitis), systemic lupus erythematosus (SLE), inflammatory myositis (polymyositis and dermatomyositis), antiphospholipid syndrome, Sjögren syndrome, systemic sclerosis (scleroderma), granulomatosis with polyangiitis (formerly, Wegener granulomatosis), and eosinophilic granulomatosis with polyangiitis (Churg-Strauss syndrome). We excluded sarcoidosis because we[6] and others[7,8] have previously reported on sarcoidosis after WTC exposure.

The primary study aims were to (1) estimate the incidence of SAIDs from September 12, 2001, through September 11, 2014, in male WTC-exposed FDNY rescue/recovery workers and (2) compare SAID incidence in our WTC-exposed cohort to rates from demographically similar men from Olmsted County, Minnesota, and to other published rates.

PATIENTS AND METHODS

Fire Department of the City of New York

We obtained information from FDNY employee databases, self-administered health questionnaires, FDNY physician records, and rheumatologist-reviewed patient medical records and self-reported information.

The FDNY WTC Health Program schedules monitoring evaluations of the WTC-exposed workforce every 12 to 18 months. This visit includes a physical examination and completion of a self-administered health questionnaire. In 2005, we added a question about doctor-diagnosed SAIDs, and in 2009, we created an autoimmune registry to capture potential cases in 2 ways. Most commonly, potential cases were reported on the physical health questionnaires. Specifically, the question asks: “Since your last FDNY WTC annual medical, has a doctor or health professional told you that you have arthritis or any autoimmune disease listed below?” Answer choices include “rheumatoid arthritis,” “lupus,” “polymyositis/ dermatomyositis,” and “other, for example, psoriatic arthritis or scleroderma.” Additionally, the registry included potential cases reported to an FDNY physician during a medical monitoring examination or a treatment visit. This information was recorded as part of the patient medical history.

The FDNY WTC disease registry clinician (N.J.) called all 739 patients in the autoimmune registry who potentially had SAID; 522 (70.6%) reported no diagnosis of autoimmune disease by a physician and were determined to be “reporting errors.” Of the remaining 217 possible cases, 63 were confirmed by documentation from treating physicians/ rheumatologists that included the specific SAID diagnosis, treatment plan (medications), and approximate diagnosis date (month and year). We also identified 34 “probable” cases. Probable cases were patients who did not submit adequate documentation from their treating physician by the close of the study but reported an SAID diagnosis, met criteria of the initial screening phone call, and provided at least one piece of evidence supporting an SAID diagnosis, most commonly a medication used almost exclusively for SAIDs, as determined by 2 board-certified rheumatologists (J.B., B.Q.). Excluded possible cases (N=120) included 61 patients that the rheumatologists concluded lacked sufficient evidence for probable SAID and 59 patients we were unable to contact by either phone or mail. The final case population consisted of 63 confirmed and 34 probable SAID cases (N =97). Confirmed diagnoses met American College of Rheumatology criteria for SAID.[9–15] The study was approved by the institutional review board at Montefiore Medical Center.

WTC Exposure Ascertainment

We used 2 measures of WTC exposure. Time of initial arrival at the WTC site was taken from the first post-9/11 questionnaire, which was administered starting October 2, 2001. “Arrival time” was categorized as arriving on the morning of 9/11 vs arriving any time thereafter until July 25, 2002,[16] when the site was closed to FDNY workers. Questions about duration of work at the WTC site were added to the monitoring questionnaires on October 15, 2002. These questions asked members to indicate the months in which they worked at least 1 day at the WTC site between 9/11 and July 25, 2002.[17] Duration (range, 1–10

months) was categorized as 7 or more vs 6 or fewer months. This split was chosen to designate 15.5% (n=2156) of the population as the high-duration group to match the 15.6% (n=2171) in the earliest arrival group to create a composite “higher WTC exposure measure” of WTC arrival during the morning of 9/11 and/or prolonged work at the WTC site for 7 or more months, classifying 28.2% (n=3912) of the population as “higher exposure.”

Study Population

The population at risk consisted of 14,966 WTC-exposed male firefighters and EMS workers. Inclusion criteria for this study required (1) having completed a monitoring questionnaire during or after 2005 to ensure the potential to self-report SAIDs, (2) not having a pre-9/11 SAID diagnosis, (3) having known exposure to the WTC site (known time and date of first arrival and number of months worked at the WTC site), (4) having a working telephone number, and (5) having provided written consent for research. The final study population totaled 13,892 patients (92.8% of the population at risk).

Rochester Epidemiology Project

The Rochester Epidemiology Project (REP) was established in 1966 and has medical records from over 700,000 former or current Olmsted County, Minnesota, residents. In 2010, the Olmsted County population included 70,485 males (82.8% white, n=58,328) compared with 13,892 males (88.5% white, n=12,294) in the FDNY cohort.[18] The REP records include all conditions that come to medical attention in Olmsted County at Mayo Clinic and Olmsted Medical Center and their outpatient facilities, emergency rooms, and inpatient hospitalizations and from private practitioners, urgent care facilities, and nursing homes.

The REP provided age- and sex-specific incidence rates during a similar time period as the FDNY case accrual for the following 5 SAIDs: RA, psoriatic arthritis, ankylosing spondylitis, SLE, and scleroderma. Given their geographic distance from New York City (~1300 miles), it is likely that the REP participants are entirely non—WTC exposed. Occupational history was not available. For all REP cases, individual medical records were reviewed to validate the diagnosis using established diagnostic/ classification criteria.[19,20]

Statistical Analyses

We calculated incidence including both confirmed and rheumatologist-determined probable cases (N=97) for each specific SAID and for all SAIDs combined. The SAID incidence was calculated as the number of cases per 100,000 person-years. Person-time (denominator) accrual began on September 12, 2001, or the FDNY hire date, whichever was later. Follow-up ended on the earliest of the following events: death of the participant, end of the study (September 11, 2014), or, for retired members, the last FDNY treatment or medical monitoring visit. Approximate 95% CIs were calculated for standardized incidence ratios (SIRs) using the Poisson distribution[21] and for direct standardized incidence rates using the modified gamma approximation method,[22] which assumes a Poisson distribution. Because for probable cases we only had self-identified year of diagnosis, age and date of diagnosis were estimated using age on July 1 of the diagnosis year. For external comparison with non-FDNY cohorts, incidence rates were age adjusted to the US 2000 male population aged 18 years and older (Table 1).

To compare FDNY rates with REP rates in men, we generated age-specific expected numbers of cases for the FDNY cohort assuming that the REP rates applied to the FDNY cohort (Table 2). We compared rates by individual diagnoses and overall and also stratified by level of WTC exposure, higher vs lower. Standardized incidence ratios, which are the ratios of the observed number of cases in the FDNY cohort to the expected number of cases based on the REP rates, were calculated assuming that the expected rates are fixed and that the observed number of cases follows a Poisson distribution. An SIR of greater than 1 indicates that the observed number of cases is higher than expected, and an SIR of less than 1 indicates that the observed number of cases is lower than expected. All analyses were performed using SAS statistical software, version 9.4 (SAS Institute Inc).

RESULTS

We identified 63 confirmed and 34 probable cases of post-9/11 SAIDs diagnosed between September 12, 2001, and September 11, 2014 (Table 3). The mean age of the patients at diagnosis was 49.5 years (range, 28.4–69.4 years).

Ascertainment of exposure usually occurred well before diagnosis. The median time between ascertainment of arrival time at the WTC site from the monitoring questionnaire and diagnosis of SAID was 5.5 years; the median time between ascertainment of duration of exposure and diagnosis of SAID was 3.0 years because duration questions were a later addition to our monitoring program.

Table 4 presents selected characteristics of the study population by SAID status. Those with SAIDs were more likely to have had higher WTC exposure (36 of 3912 vs 61 of 9980; P=.05). Standardized SAID incidence rates for men in the FDNY cohort (Table 1) ranged from 19.0 per 100,000 person-years (95% CI, 12.1–28.9 per 100,000 person-years) for RA to 0.3 per 100,000 person-years (95% CI, 0.0–4.8 per 100,000 person-years) for granulomatosis with polyangiitis. Table 5 presents incidence rates of selected SAIDs from published studies. We included only studies that provided sex-specific rates for men and were published after 2000. The FDNY rates for RA are generally lower than published rates but appear to be higher for both SLE and inflammatory myositis. The underlying racial/ethnic composition of the population is sometimes not reported, which makes meaningful comparisons difficult.

Table 2 provides the observed number of incident SAIDs in the FDNY male cohort and the expected age- and sex-specific number of incident cases based on REP rates. The overall number of observed cases was similar to the number of expected cases (SIR, 0.97; 95% CI, 0.77–1.21); the impact of the healthy worker effect is clear in the lower exposure group, in which we identified 9.93 fewer cases than expected (an incidence rate 17.1% below expectation based on REP data; SIR, 0.83; 95% CI, 0.61–1.10). The effect of higher WTC exposure is also evident—we identified 7.7 excess cases (34.4% above expectation based on the REP data; SIR, 1.34; 95% CI, 0.91–1.92).

Because REP rates were not available for all diagnoses, we compared rates within the FDNY cohort by level of WTC exposure in the polymyositis/dermatomyositis group. In the higher WTC exposure group, rates were about double the rates in the lower exposure group: 8.3

(95% CI, 3.1–22.2) vs 4.1 (95% CI, 1.7–9.9), a rate ratio of 2.0. Other individual diagnoses have too few cases for this comparison.

DISCUSSION

We found an excess of SAID cases in the higher WTC exposure group of FDNY rescue/recovery workers. Projecting the deficit in cases observed in the lower exposure group, in which FDNY cases reached 83% of expectation, we would have anticipated 18.5 SAID cases among the higher exposure group, which is 11.5 cases *fewer* than were observed. This result of excess cases in the higher exposure group is supported by our recent case-control study[35] which, using different methodology, found similar results. In that study, prolonged work exposure conferred a 13% increased risk for each month at the WTC site compared with risk in those who worked only 1 month, and early arrival at the WTC site during the morning of 9/11 conferred an additional independent risk (conditional odds ratio, 1.85; 95% CI, 0.86–3.89). In the current study, we required either early WTC arrival or long duration of work at the WTC site for inclusion in the higher WTC exposure category, in which individuals generally reached or exceeded expected SAID rates, whereas in the lower WTC exposure group, FDNY rates were mostly similar to or lower than expected rates. The REP reference rates were not available for all included diagnoses. Therefore, we investigated risk for some SAIDs using an internal comparison between FDNY rescue/recovery workers with higher and lower WTC exposure and found that rates were doubled in the higher exposure group.

For SLE, higher than expected rates were not limited to the higher exposure group; we observed excess cases in all WTC-exposed workers. In 2012, a National Institute of Environmental Health Sciences expert panel reported consensus findings, stating “confidence” in an association between SAIDs and crystalline silica.[36] Crystalline silica has been well studied in occupational settings, and these previous studies have revealed associations with RA, SLE, and scleroderma.[37,38] One explanation for the role of environmental factors like crystalline silica is that they induce the breakdown of tolerance in genetically susceptible individuals.[39] Experimental data from animal models[40] suggest that inhaled silica dust becomes trapped in the lungs and other tissues, and the resulting cycle of apoptosis, together with increased exposure to self-antigens and inflammation, leads to the development or acceleration of autoimmunity.[41] Other silicates like asbestos may act similarly. This relationship may be partially obscured because some exposures are thought to lead to immune activation and/or antibodies but not necessarily to a specific SAID outcome.[36] There may also be an extended latency period between exposure and disease that has not been well characterized. For example, in a military cohort, antinuclear antibodies at a 1:120 dilution were seen up to 9 years before diagnosis in a majority of patients.[42]

It is likely that WTC workers inhaled silica and numerous other elements because of the inadequate availability of effective respiratory protective equipment in the early post-9/11 days and inadequate use of respirators thereafter. Evidence of the effects of the intensive exposure were obvious because more than 70% of FDNY workers reported one or more acute aerodigestive symptoms in the first post-9/11 year, which, for some, became FDNY-diagnosed chronic conditions.[43] Other evidence of lung injury comes from our longitudinal

analyses of forced expiratory volume in 1 second,[44] which revealed a large decrease in pulmonary function—the equivalent of 10 to 13 years of normal age-related decline—in the first year after 9/11; the magnitude of the decrease was related to initial time of arrival at the WTC site.

The causes of SAIDs are unknown and likely multifactorial. Genetic susceptibility may be the critical first factor, followed by an antigenic event such as an environmental exposure and triggering of immunologic-inflammatory-oxidative pathways leading to an autoimmune response resulting in disease.[36] Although the evidence of post-9/11 pulmonary compromise is compelling, there is also direct evidence of intrusion by foreign matter into the respiratory system of WTC-exposed workers prompting an inflammatory response.

Ten months after the WTC collapse, induced sputum samples from 39 FDNY firefighters were compared with samples from firefighters in Tel Aviv, Israel. In FDNY firefighters, the percentage of particles larger than 2 μm was greater, and the particles were more irregularly shaped and contained more identified elements and were associated with an inflammatory response.[45] Recently, a study evaluated particles found in the lung tissue of 7 WTC-exposed individuals (nonfire-fighters) in whom interstitial lung inflammation and disease developed.[46] This report identified aluminum and magnesium silicates, chrysotile asbestos, calcium phosphate and calcium sulfate, small shards of glass, and carbon nanotubes of various sizes and lengths in the lung biopsy specimens from some of these workers. Finally, markers of systemic inflammation that predict accelerated lung function decline have been found in the serum of FDNY WTC-exposed workers.[47–49] These studies documenting intrusion of foreign matter leading to an inflammatory response lend biological plausibility to an association between WTC exposure and SAIDs.

Because we were unable to identify studies of SAID incidence in occupational cohorts, we summarized studies published since 2000 that provide population-based incidence rates for men to provide context for FDNY rates. However, these rates are not directly comparable for numerous reasons, especially because the healthy worker effect is striking in occupational cohorts like FDNY employees who have met stringent, prehire physical requirements. Most studies estimate that the healthy worker effect reduces the association between exposure and outcome by about 20%, depending on the outcome.[50] Second, most of the rates from published articles are neither age adjusted to a standard population nor adjusted for race/ethnicity. Therefore, reported rates reflect differences in the underlying population, which is important because SAID diagnoses are known to peak in specific age and racial/ethnic groups. Third, although none of the studies in Table 5 relied on self-reported diagnoses, the criteria for becoming a case varied considerably. Fourth, the time period during which cases were accrued and the technological tools available for diagnosis varied over time, which is why we only included recent studies. Finally, because most SAIDs are relatively rare, published rates, including our own, should be validated.

Our study has several strengths. First, our REP coinvestigators provided age- and sex-specific rates from a similar time period for the generation of expected FDNY rates, providing excellent population-based comparison rates for WTC-exposed males. Second, our cohort existed before 9/11, eliminating recruitment bias. Third, all persons in the cohort

had the opportunity to report SAID diagnoses on their monitoring questionnaires or to their FDNY physicians. Reports were screened, reviewed, and validated by our rheumatology case consultative review panel. Fourth, it is unlikely that members of our cohort had unrecognized pre-9/11 SAID because the physical demands of firefighting and EMS work would have made concealment difficult. Finally, information about WTC exposures was collected from questionnaires completed by all cohort members regardless of symptoms and, in most cases, were obtained years before the date of diagnosis, arguing against recall bias.

Study limitations include our lack of direct access to physician records outside the FDNY, which may have led to an underestimation of SAID incidence. For this reason, potential cases were reviewed by our team of rheumatologists. Second, we lacked an FDNY non—WTC-exposed comparison group, potentially minimizing the effect of higher WTC exposure on SAID outcomes. Third, our results may not be generalizable to other occupational cohorts because our population was relatively small (~13,000), exclusively male, and mostly white and had above-average physical health before WTC exposure. Lastly, we lack information about family history of SAIDs and about non—WTC-related exposures, both work-related and recreational.

CONCLUSION

We found excess incident SAIDS in rescue/ recovery workers with higher WTC exposure. Because overall rates were within normal limits, higher incidence in specific subgroups might have been missed. Continued surveillance of WTC-exposed workers, particularly persons most highly exposed, is necessary to minimize the known effects of SAIDs and to understand the full spectrum of health consequences resulting from WTC exposure.

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Abbreviations and Acronyms

EMS	emergency medical service
FDNY	Fire Department of the City of New York
RA	rheumatoid arthritis
REP	Rochester Epidemiology Project
SAID	systemic autoimmune disease
SIR	standardized incidence ratio
SLE	systemic lupus erythematosus

WTC	World Trade Center
9/11	September 11, 2001

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TABLE 1

Incidence of Systemic Autoimmune Diseases Directly Standardized to the 2000 US Male Population Aged 18 Years or Older[a]

Systemic autoimmune disease	FDNY cases	Rate[b] (standardized)	95% CI
Rheumatoid arthritis	40	19.0	12.1–28.9
Spondyloarthritis	27	10.8	6.5–17.8
Psoriatic arthritis	21	8.8	4.8–15.6
Seronegative arthritis	3	1.0	0.2–5.5
Ankylosing spondylitis	3	1.0	0.2–5.5
Systemic lupus erythematosus	11	5.1	2.0–11.6
Inflammatory myositis	9	6.6	2.0–15.6
Polymyositis	7	6.0	1.5–15.0
Dermatomyositis	2	0.7	0.1–5.2
Antiphospholipid syndrome	4	1.3	0.3–5.8
Sjögren syndrome	3	1.2	0.2–5.7
Systemic sclerosis (scleroderma)	2	0.8	0.1–5.3
GPA	1	0.3	0.0–4.8
Total	97	45.1	33.9–59.0

[a] FDNY = Fire Department of the City of New York; GPA = granulomatosis with polyangiitis (formerly, Wegener granulomatosus).

[b] Per 100,000 person-years. Combined rates may not equal sum of component rates due to rounding.

TABLE 2

Observed and Expected Cases of SAIDs in the FDNY Cohort Based on Rates From the Rochester Epidemiology Project

Variable	Observed	Expected	SIR (95% CI)
Entire FDNY cohort			
Rheumatoid arthritis	40.0	44.06	0.91 (0.65–1.24)
Psoriatic arthritis	21.0	24.64	0.85 (0.53–1.30)
Ankylosing spondylitis	3.0	8.48	0.35 (0.07–1.03)
Systemic lupus erythematosus	11.0	1.50	7.33 (3.66–13.12)
Sjögren syndrome	3.0	1.58	1.90 (0.39–5.55)
Total	78.0	80.26	0.97 (0.77–1.21)
FDNY cohort by WTC exposure			
Higher WTC exposure			
Rheumatoid arthritis	10.0	11.71	0.85 (0.41–1.57)
Psoriatic arthritis	11.0	7.30	1.51 (0.75–2.70)
Ankylosing spondylitis	2.0	2.51	0.80 (0.10–2.88)
Systemic lupus erythematosus	5.0	0.38	13.16 (4.27–30.71)
Sjögren syndrome	2.0	0.42	4.76 (0.58–17.20)
Total	30.0	22.32	1.34 (0.91–1.92)
Lower WTC exposure			
Rheumatoid arthritis	30.0	32.35	0.93 (0.63–1.32)
Psoriatic arthritis	10.0	17.34	0.58 (0.28–1.06)
Ankylosing spondylitis	1.0	5.96	0.17 (0.0–0.93)
Systemic lupus erythematosus	6.0	1.12	5.36 (1.97–11.66)
Sjögren syndrome	1.0	1.16	0.86 (0.02–4.80)
Total	48.0	57.93	0.83 (0.61–1.10)

FDNY = Fire Department of the City of New York; SAID = systemic autoimmune disease; SIR = standardized incidence ratio; WTC = World Trade Center.

TABLE 3

Distribution of Systemic Autoimmune Diseases in the Fire Department of the City of New York Cohort[a]

Systemic autoimmune disease	Confirmed (n=63)	Probable (n=34)	Total (N=97)
Rheumatoid arthritis	23 (36.5)	17 (50.0)	40 (41.2)
Spondyloarthritis	14 (22.2)	13 (38.2)	27 (27.8)
Psoriatic arthritis	11 (17.5)	10 (29.4)	21 (21.6)
Seronegative arthritis	0 (0.0)	3 (8.8)	3 (3.1)
Ankylosing spondylitis	3 (4.8)	0 (0.0)	3 (3.1)
Systemic lupus erythematosus	9 (14.3)	2 (5.9)	11 (11.3)
Inflammatory myositis	9 (14.3)	0 (0.0)	9 (9.3)
Polymyositis	7 (11.1)	0 (0.0)	7 (7.2)
Dermatomyositis	2 (3.2)	0 (0.0)	2 (2.1)
Antiphospholipid syndrome	2 (3.2)	2 (5.9)	4 (4.1)
Sjögren syndrome	3 (4.8)	0 (0.0)	3 (3.1)
Systemic sclerosis (scleroderma)	2 (3.2)	0 (0.0)	2 (2.1)
Granulomatosis with polyangiitis (formerly, Wegener granulomatosis)	1 (1.6)	0 (0.0)	1 (1.0)
Eosinophilic granulomatosis with polyangiitis (Churg-Strauss syndrome)	0 (0.0)	0 (0.0)	0 (0.0)

[a]Data are presented as No. (percentage) of patients.

TABLE 4

Selected Characteristics of the FDNY Cohort[a,b]

Variable	Total cohort (N=13,892)	Participants with SAIDs (n=97)	Participants without SAIDs (n=13,795)
Race			
White	12,294	94 (96.0)	12,200 (88.4)
Hispanic	853	3 (3.1)	850 (6.2)
Black	658	0 (0.0)	658 (4.8)
Asian	76	0 (0.0)	76 (0.6)
Other	11	0 (0.0)	11 (0.1)
Class			
Fire department	12,338	93 (95.9)	12,245 (88.8)
EMS	1548	4 (4.1)	1544 (11.2)
Civilian	6	0 (0.0)	6 (0.04)
Age (y) on 9/11/2001, median (range)	39.7 (13.9–77.6)	44.1 (24.6–63.9)	39.6 (13.9–77.6)
Smoking status			
Never	8200	50 (51.6)	8150 (59.1)
Ever	5692	47 (48.5)	5645 (40.9)
Chronic exposure			
High (≥7 mo on site)	2171	19 (19.6)	2152 (15.6)
Low (≤6 mo on site)	11,721	78 (80.4)	11,643 (84.4)
Acute exposure on 9/11/2001			
Morning arrival	2156	22 (22.7)	2134 (15.5)
Later arrival	11,736	75 (77.3)	11,661 (84.5)
Composite higher WTC exposure (9/11/2001 AM arrival and/or duration ≥7 mo)	3912	36 (37.1)	3876 (28.1)
Lower WTC exposure	9980	61 (62.9)	9919 (71.9)

[a] EMS = emergency medical service worker; FDNY = Fire Department of the City of New York; SAID = systemic autoimmune disease; WTC = World Trade Center.

[b] Data are presented as No. (percentage) of participants unless indicated otherwise.

TABLE 5

Published Incidence Rates of Systemic Autoimmune Disease in Men From Selected Studies[a]

Reference, year	Diagnosis	Population	Study location	Time period	Incidence (95% CI)[b]	Age[c]	Case criteria
Myasoedov,[23] 2010	Rheumatoid arthritis	Current and former residents	Olmsted County, MN	1995–2007	27.7 (23.1–32.2)	Yes	1987 American College of Rheumatology
Savolainen,[24] 2003	Psoriatic arthritis	Residents of the region (20% were <16 y)	Kuopio, Finland	2000	18.4 (6.8–40.1)	No	Peripheral arthritis with psoriasis, excluding RF-positive polyarthritis or spondylitis with psoriasis
Söderlin,[25] 2002	Psoriatic arthritis	Patients referred from primary health care centers to the rheumatology department in Växjö Central Hospital	Kronberg County, Sweden	1999–2001	5 (1–13)	No	Psoriasis in association with arthritis with negative test results for RF
Savolainen,[24] 2003	Ankylosing spondylitis	Residents of the region (20% were <16 y)	Kuopio, Finland	2000	12.3 (3.3–31.4)	No	Back pain for more than 3 mo and bilateral sacroiliitis grade 2 or more or syndesmophytes or squared vertebrae on radiographs
Wright,[26] 2014	Ankylosing spondylitis	Current and former residents (≥18 y)	Olmsted County, MN	1980–2009	4.9 (3.7–6.1)	Yes	1984 Modified New York criteria
Jarukitsopa,[27] 2014	Systemic lupus erythematosus	Current and former residents	Olmsted County, MN	1993–2005	0.8 (0.0–1.6)	Yes	1982 American College of Rheumatology
Feldman,[28] 2013	Systemic lupus erythematosus	Medicaid	United States	2000–2004	4.85 (4.23–5.55)	No	3+ Visits 3+ d apart, *ICD-9* code 710.0
Rees,[29] 2014	Systemic lupus erythematosus	Clinical Practice Research Datalink, a longitudinal database of UK general practice records since 1987	United Kingdom	1999–2012	1.44 (1.30–1.58)	No[d]	3 Definitions: **1** All read codes[d] that represented SLE or a subtype of SLE excluding cutaneous-only lupus. Codes relating to a diagnostic test, a scoring system, tuberculosis, lupus pernio, drug- induced lupus, or neonatal

Reference, year	Diagnosis	Population	Study location	Time period	Incidence (95% CI)[b]	Age[c]	Case criteria
							lupus were excluded
							2 Included cases with cutaneous subtypes
							3 Record of a positive immunological blood test result (ANA, anti-dsDNA, ENA, or anti-Ro), a prescription for a drug used in SLE, or referral to a rheumatologist for the cutaneous-only subtype
Rosa,[30] 2013	Myositis (polymyositis)	HMO	Buenos Aires, Argentina	1979–2009	0.53 (0.13–2.13)	No	Bohan and Peter,[31] 1975
Smoyer-Tomic,[32] 2012	Myositis (polymyositis, dermatomyositis, and interstitial myositis)	Marketscan (private) Medicare and Medicaid claims	United States	2004–2008	Medicare: 3.07 (2.85–3.28) Medicaid: 3.67 (2.96–4.37)	Yes	Outpatient and inpatient claims
Furst,[33] 2012	Myositis (polymyositis, dermatomyositis, and sporadic inclusion body myositis)	National managed care plan	United States	2003–2008	4.8 (4.4–5.3)	Yes	*ICD-9-CM* outpatient and inpatient (Bernatsky et al[34])
Rosa,[30] 2013	Myositis (polymyositis and dermatomyositis)	HMO	Buenos Aires, Argentina	1979–2009	0.8 (0.26–2.48)	No	Bohan and Peter, 1975[31]
Rosa,[30] 2013	Myositis (dermatomyositis)	HMO	Buenos Aires, Argentina	1979–2009	0.27 (0.04–1.89)	No	Bohan and Peter, 1975[31]

[a] ANA = antinuclear antibody; ds-DNA = double-stranded DNA; ENA = extractable nuclear antigen; HMO = health maintenance organization; *ICD-9* = *International Classification of Diseases, Version 9; ICD-9-CM* = *ICD-9, Clinical Modification*; RF = rheumatoid factor; SLE = systemic lupus erythematosus.

[b] Per 100,000 person-years.

[c] Standardized to the 2000 US population.

[d] Standardized to the 2012 UK population.