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Evaluation of Medical Surveillance and Incidence of Post-September 11, 2001, Thyroid Cancer in World Trade Center–Exposed Firefighters and Emergency Medical Service Workers

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IMPORTANCE Elevated incidence rates of thyroid cancer among World Trade Center (WTC)–exposed individuals may be associated with the identification of asymptomatic cancers during medical surveillance.

OBJECTIVE To examine the association between WTC exposure and thyroid cancer among Fire Department of the City of New York (hereafter, Fire Department) rescue/recovery workers as well as the association with medical surveillance.

DESIGN, SETTING, AND PARTICIPANTS This closed-cohort study classified the method of detection (asymptomatic and symptomatic) of thyroid cancers in 14 987 men monitored through the Fire Department–WTC Health Program diagnosed from September 12, 2001, to December 31, 2018. Age-, sex-, and histologic-specific Fire Department incidence rates were calculated and compared with demographically similar men in Olmsted County, Minnesota, from the Rochester Epidemiology Project using age-standardized rates, relative rates (RRs), and 95% CIs. The secondary analysis was restricted to papillary carcinomas.

EXPOSURES World Trade Center exposure was defined as rescue/recovery work at the WTC site from September 11, 2001, to July 25, 2002.

MAIN OUTCOMES AND MEASURES The outcomes evaluated comprised (1) number of incident thyroid cancers and their detection method categorizations in the Fire Department and Rochester Epidemiology Project cohorts; (2) Fire Department, Rochester Epidemiology Project, and Surveillance, Epidemiology, and End Results-21 age-standardized incidence rates of thyroid cancer; and (3) RRs comparing Fire Department and Rochester Epidemiology Project overall and by detection method categorization.

RESULTS Seventy-two post-9/11 Fire Department cases of thyroid cancer were identified. Among the 65 cases (90.3%) with a categorized detection method, 53 cases (81.5%) were asymptomatic and 12 cases (18.5%) were symptomatic. Median (interquartile range) age at diagnosis was 50.2 (44.0-58.6) vs 46.6 (43.9-52.9) years for asymptomatic vs symptomatic cases. Associated primarily with asymptomatic cancers, the overall age-standardized incidence of Fire Department thyroid cancers (24.7; 95% CI, 17.4-52.3) was significantly higher than the Rochester Epidemiology Project (10.4; 95% CI, 8.5-12.7) and Surveillance, Epidemiology, and End Results-21 (9.1; 95% CI, 9.0-9.1) per 100 000 person-years. Furthermore, the RR of thyroid cancer among symptomatic men in Fire Department cases was not significantly different from that of men in the Rochester Epidemiology Project (0.8; 95% CI, 0.4-1.5); however, the rate of asymptomatic cancers was more than 3-fold that of the Rochester Epidemiology Project rate (RR, 3.1; 95% CI, 2.1-4.7).

CONCLUSIONS AND RELEVANCE Excess asymptomatic thyroid cancer in Fire Department WTC–exposed rescue/recovery workers is apparently attributable to the identification of occult lesions during medical surveillance. Among WTC-exposed cohorts and the general population, these findings appear to have important implications for how thyroid cancer incidence rates are interpreted and how diagnoses should be managed.

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Supplemental content

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Over the past 4 decades, thyroid cancer incidence rates have increased nearly 3-fold,[1,2] resulting in its current status as one of the most commonly diagnosed cancers in the US. During the 1990s, thyroid cancer incidence rates began to increase from an annual age-standardized rate of 4.9 to 14.2 per 100 000 person-years in 2010-2014.[1] Rates among US men (8.0 per 100 000 person-years) are about one-third that of women (23.3 per 100 000 person-years), although mortality rates are similar, at 0.52 vs 0.49 per 100 000 person-years.[1] The increased incidence is primarily limited to the least aggressive histologic type: papillary thyroid cancer.[2-6]

Many studies have concluded that thyroid cancer's increasing incidence is largely owing to the incidental detection of small, asymptomatic lesions associated with improvements in diagnostic imaging,[4,5,7-11] although other studies challenge this theory.[2,12-15] Studies proposing an increase in incidence often attribute the increase to environmental exposures, such as atmospheric or medical radiation therapy,[14,16] or to excess body mass.[17-19]

The large quantity and variety of toxicants released into the environment following the World Trade Center (WTC) terrorist attacks on September 11, 2001 (9/11),[20] may represent an environmental exposure contributing to the 2- to 3-fold greater risk of thyroid cancer among WTC-exposed populations compared with the general population.[21-24] Two recent studies describe WTC-related thyroid cancers and suggest a true excess risk among WTC responders compared with matched controls.[25,26] While radiation exposure was not reported to be elevated at the WTC site, other known carcinogens, such as polybrominated diphenyl ethers, were present at high levels[20,27,28] and may disrupt mechanisms of thyroid hormone production.[29-31] To our knowledge, no chemical substance has been consistently associated with thyroid cancer in humans. Alternatively, since 9/11, WTC-exposed rescue/recovery workers are provided with annual medical monitoring and treatment visits, which often include chest computed tomographic scans.[21,23] The elevated thyroid cancer rate may therefore be an artifact of such frequent and detailed medical surveillance. The WTC Health Program does not include thyroid screening by ultrasonographic scans unless a nodule is suspected on examination or imaging paid for by the WTC Health Program.

In this study, we assessed whether the association between WTC exposure and thyroid cancer diagnosed between September 12, 2001, and December 31, 2018, in male, WTC-exposed Fire Department of the City of New York (hereafter, Fire Department) firefighters and emergency medical service workers was also associated with medical surveillance. To do so, we determined the rate of thyroid cancer incidence in demographically similar individuals from the Rochester Epidemiology Project, which included all residents of Olmsted County, Minnesota, during a similar period (January 1, 2000, to December 31, 2018). The primary aim of this study was to compare the relative rate of thyroid cancer, overall and by detection method, among Fire Department rescue/recovery workers and Olmsted County residents from the Rochester Epidemiology Project.

Key Points

Question Are rates of thyroid cancer among World Trade Center–exposed populations associated with medical surveillance?

Findings In this cohort study of 14 987 male Fire Department of the City of New York rescue/recovery workers, the overall age-adjusted incidence rate of thyroid cancer among the Fire Department of the City of New York World Trade Center–exposed cohort was significantly greater than the rate among demographically similar, non–World Trade Center–exposed men. This difference may be explained by the high rate of asymptomatic cancers detected among individuals from the Fire Department of the City of New York; in addition, the Fire Department of the City of New York found no thyroid cancer–specific deaths or metastatic disease.

Meaning These findings suggest that increased rates of thyroid cancer in World Trade Center–exposed cohorts may be associated with heightened surveillance rather than an increase in disease.

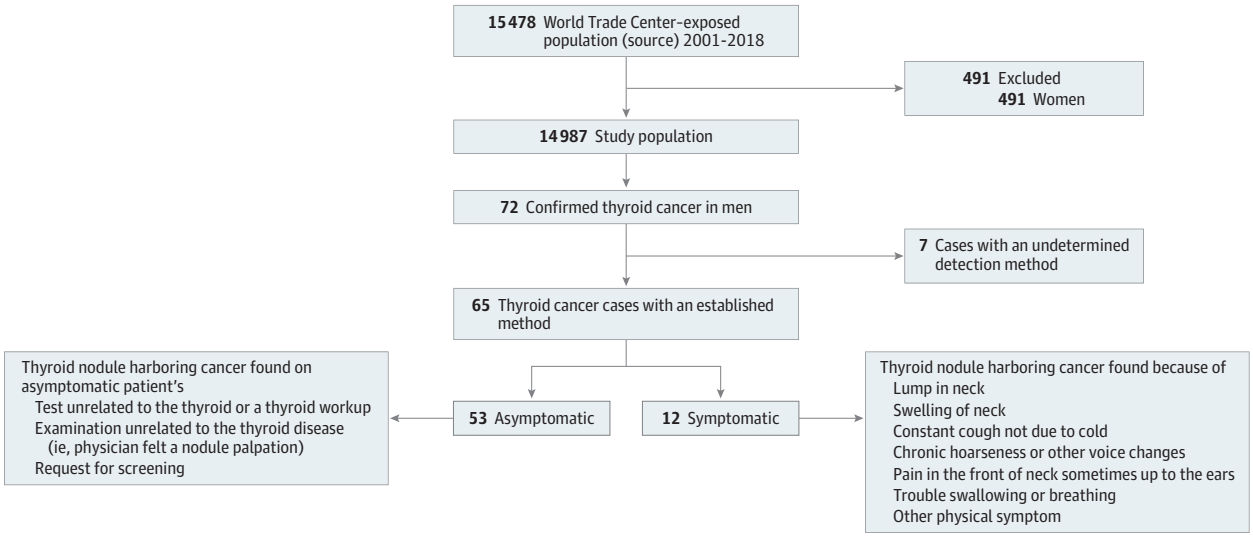
Methods

The source population consisted of 15 478 WTC-exposed firefighters and emergency medical service personnel who arrived at the disaster site between the morning of 9/11 and July 25, 2002. Women were excluded (n = 491) owing to the small sample size. The final study population consisted of 14 987 participants (**Figure 1**). The Montefiore Medical Center/Albert Einstein College of Medicine Institutional Review Board approved this study and waived the need for informed consent because the review of medical records research involves no more than minimal risk to the patients.

Methods used to obtain information on cancer diagnoses from state registries are described elsewhere.[21] Briefly, thyroid cancer diagnoses were ascertained via 2 methods: by linkage to state cancer registries[32] and medical record confirmation of cases reported to the Fire Department Bureau of Health Services. Specifically, confirmation was completed by a trained clinician (N.J.) who contacted participants reporting a cancer not already identified through state cancer registry matches and requested documentation. We required a report of pathologic findings or detailed treating physician notes/evaluations to confirm these cases.[21] Only confirmed thyroid cancers, either by medical records or as obtained from any state cancer registry match, diagnosed between September 12, 2001, and December 31, 2018, were included in this study.

The Fire Department WTC Health Program performs health evaluations on all active and retired WTC-exposed firefighters and emergency medical service workers every 12 to 18 months. Demographic data (race/ethnicity, sex, birth date, and body mass index) and medical testing history before the diagnosis date (chest and sinus computed tomographic scans, magnetic resonance imaging of the head and neck, stress tests, positron emission tomographic scans, cervical imaging, echocardiograms, stress tests, gastrointestinal tract tests, sleep studies, or surgeries) were collected from WTC Health Program records. No demographic data were missing. Level of WTC

Figure 1. Detection Method Categorization for Fire Department of the City of New York–Confirmed Thyroid Cancer Cases



Study population and detection method categorization criteria for Fire Department of the City of New York thyroid cancer cases.

exposure was defined from the earliest post-9/11 health questionnaire as arriving the morning of 9/11; arriving the afternoon of 9/11; arriving on September 12, 2001; arriving between September 13 and September 24, 2001; and, arriving between September 25, 2001, and July 25, 2002.[33] Duration of work at the WTC site ranged from 1 to 10 months.[34]

Method of thyroid cancer detection was abstracted from medical records and confirmed by one of us (N.J.) during follow-up telephone calls; cases confirmed only by state cancer registry linkages were not included. Abstracted records were then categorized as either an asymptomatic or symptomatic case (Figure 1). Detection method was missing from 7 cases (9.7%). Method of detection was defined according to the criteria used by previous Rochester Epidemiology Project investigations of thyroid cancer incidence (Figure 1).[7] Reliability of categorizations between the Fire Department and Rochester Epidemiology Project[7] investigators was estimated by independent assessment (N.J. from the Fire Department and N.G. from the Rochester Epidemiology Project) of a random subset of 34 Fire Department cases; 100% agreement was found.

The Rochester Epidemiology Project reference cohort, a previous comparison population for WTC-exposed firefighters[35,36] described in detail by Brito et al,[7] has medical records from Olmsted County, Minnesota, residents. Given their geographic distance from New York City (approximately 1300 miles), it is unlikely that Rochester Epidemiology Project participants were WTC exposed. In 2017, Olmsted County had approximately 111 000 adults aged 20 years or older, and 85% of the county was white.[37] In addition, over 90% of Olmsted County residents are evaluated by medical health care professionals in any 3-year period.[38] Occupational history was unavailable.

Rochester Epidemiology Project investigators provided age-, sex-, detection-, and histologic-specific thyroid cancer incidence rates during a similar period (January 1, 2000, to December 31, 2018) as the Fire Department case accrual. Only rates of thyroid cancer in men from this cohort were included in our analysis. The Rochester Epidemiology Project medical record linkage system, validation, and data retrieval processes have been described elsewhere.[7] From each record, demographic characteristics, the date of diagnosis, and histologic codes were abstracted by an experienced retrieval specialist from the Rochester Epidemiology Project. Clinicians (N.G., J.P.B., O.M.E.K.) designated the cases as having asymptomatic or symptomatic detection as defined by Brito et al[7] and detailed above. The Surveillance, Epidemiology, and End Results–21 (SEER-21) program was used to calculate the US male thyroid cancer rate and 95% CIs from January 2000 to December 2016.[39]

Statistical Analysis

Demographic and other characteristics of the study population and detection method subgroups were assessed as proportions, medians, interquartile ranges, and means (SDs), as appropriate. Age-standardized incidence was calculated as the number of confirmed cases per 100 000 person-years. Person-time accrual began on September 12, 2001, or on the Fire Department hire date, whichever occurred later. Follow-up ended on the earliest of the following dates: death, diagnosis of incident thyroid cancer, end of the study (December 31, 2018), or, for retired members, the last Fire Department treatment date or post-9/11 Fire Department medical monitoring visit. Relative rates (RRs) were estimated using Poisson regression models for grouped data, controlling for age group (in 5-year strata). Approximate 95% CIs were calculated for RRs using the Poisson distribution[40] and for direct standardized incidence rates, using the modified γ approximation method,[41] which assumes a Poisson distribution.

Fire Department, Rochester Epidemiology Project, and SEER-21 annual incidence rates were directly standardized to

the US 2000 male population aged 20 years and older. The RRs for the Fire Department and Rochester Epidemiology Project were compared in the following analyses: overall, by restricting to asymptomatic cases and then to symptomatic cases, across an early period (September 12, 2001, to December 31, 2009) and a late period (January 1, 2010, to December 31, 2018), and by 3 definitions of WTC exposure based on arrival the morning of 9/11 or later and duration of work at the WTC site.[36] Secondary analyses calculated the same estimates comparing only papillary thyroid cancer cases. We performed 2 sensitivity analyses. First, we conducted the same RR comparisons as the primary analysis but restricted to ages 30 to 79 years since US men's thyroid cancer rates are greatest between ages 30 and 80 years[42,43] and the Fire Department did not identify cases among those aged 20 to 29 or older than 80 years. Second, we recalculated the symptomatic RR comparison of the primary analysis, assuming that all Fire Department cases without a categorized detection method were symptomatic.

Findings were considered significant at 2-sided $P = .05$. All analyses were performed using SAS, version 9.4 (SAS Institute Inc).

Results

From September 12, 2001, to December 31, 2018, we identified 72 men with confirmed cases of post-9/11 thyroid cancer. The median age at diagnosis was 50.0 (interquartile range, 44.2-58.2) years and the median time to diagnosis was 11.5 (interquartile range, 6.8-14.5) years post-9/11. None of the men with thyroid cancer who were monitored in the Fire Department program experienced thyroid cancer–specific mortality and none developed metastatic disease. About half of the men (38 [52.8%]) are known to have had unrelated medical testing before their thyroid cancer diagnosis. Demographic characteristics (ie, age and body mass index) of those with and without thyroid cancer were largely similar (eTable 1 in the Supplement), although men without thyroid cancer had a slightly higher proportion of ever-smokers (5514 [37.0%] vs 19 [26.4%]). Furthermore, the characteristics of the Fire Department and Olmsted County 2000 general population were equivalent regarding their median ages (40.0 vs 35.0 years) and race/ethnicity (88.0% vs 90.3% white).[44]

Of the total 72 thyroid cancer cases, 65 cases (90.3%) had an established method of detection (asymptomatic or symptomatic). Compared with symptomatic cases, asymptomatic cases comprised more white individuals (47 [88.7%] vs 10 [83.3%]), firefighters (50 [94.3%] vs 10 [88.3%]), and ever-smokers (15 [28.3%] vs 2 [16.7%]) (**Table**). Among the 7 cases without a detection method, most (4 [57.1%]) were identified exclusively by state registry matching. Of the 65 patients with categorized cancer, 53 men (81.5%) were asymptomatic and 12 men (18.5%) were symptomatic (Figure 1). The eFigure in the Supplement shows the number of post-9/11 Fire Department cases by year of diagnosis, stratified by detection method. Among the categorized cases, age at diagnosis spanned 30 to 79 years. Fewer than half of the 65 cases were diagnosed in the early period (23 [35.4%]) (September 12, 2001, to December 31, 2009). Papillary thyroid cancer accounted for 52 of 53 (98.1%) of Fire Department cancers with a detection method; only 1 of these was a follicular carcinoma. Overall, 37 cases (57.0%) identified with a detection method had unrelated medical testing before the thyroid cancer diagnosis. The proportion of patients with asymptomatic cases known to have had unrelated medical testing (62.3%) was almost twice that of those with symptomatic cases (33.3%).

There were 99 Rochester Epidemiology Project thyroid cancer cases, with 54 asymptomatic (54.5%) and 45 symptomatic (45.5%) at detection. The age range at diagnosis was

Table. Demographic and Other Characteristics of the Fire Department of the City of New York Population by Thyroid Cancer Detection Method[a]

Characteristic	No. (%)	
	Asymptomatic cases (n = 53)	Symptomatic cases (n = 12)
WTC arrival group		
Morning of 9/11	9 (17.0)	2 (16.7)
Afternoon of 9/11	25 (47.2)	5 (41.7)
9/12/2001	9 (17.0)	3 (25.0)
9/13/2001-9/24/2001	9 (17.0)	2 (16.7)
After 9/24/2001	1 (1.9)	0
WTC work duration, median (IQR), mo	3 (1.0-6.0)	2.5 (1.5-4.5)
Age on 9/11, median (IQR)	38.8 (32.5-46.8)	36.2 (31.1-41.7)
Race/ethnicity		
White	47 (88.7)	10 (83.3)
Nonwhite	6 (11.3)	2 (16.7)
Current smoking status		
Never smoker	38 (71.7)	10 (83.3)
Ever smoker	15 (28.3)	2 (16.7)
Unknown	0	0
BMI at end of follow-up, mean (SD)[b]	30.9 (3.9)	30.8 (3.2)
Work assignment		
Firefighter	50 (94.3)	10 (83.3)
Emergency medical service	3 (5.7)	2 (16.7)
Died	1 (1.9)	0
Age at diagnosis, median (IQR)	50.2 (44.0-58.6)	46.6 (43.9-52.9)
Range	30.3-76.3	38.2-59.6
Years to diagnosis post-9/11, median (IQR)	12.2 (6.7-14.4)	11.5 (7.8-16.0)
Prediagnostic testing[c]	33 (62.3)	4 (33.3)
Thyroid cancer histologic findings		
Papillary	52 (98.1)	12 (100.0)
Follicular	1 (1.9)	0

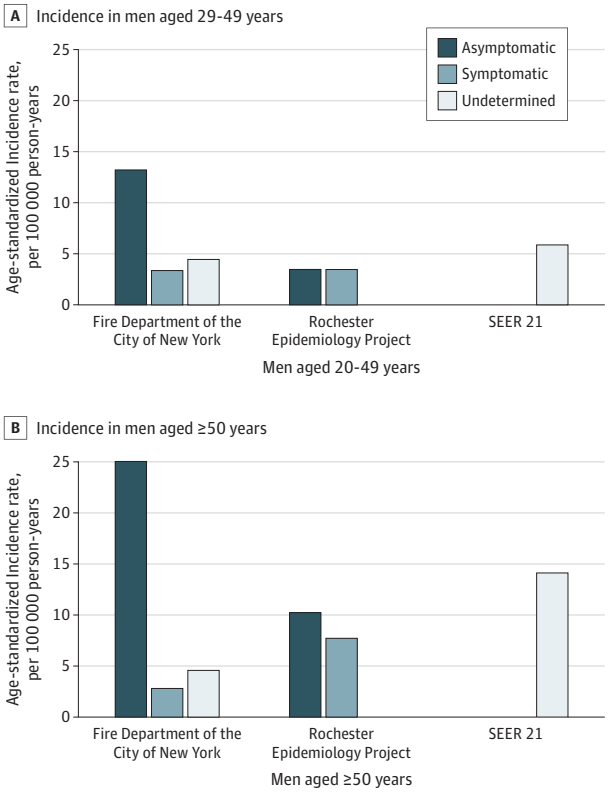
Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); IQR, interquartile range; WTC, World Trade Center.

[a] Does not include the 7 cases in which no method of detection could be determined.

[b] Body mass index data only available for 52 asymptomatic cases.

[c] Included chest and sinus computed tomographic scans, sleep studies, gastrointestinal tract tests, echocardiograms, magnetic resonance imaging of the head and neck, stress tests, positron emission tomographic scans, cervical imaging, or surgery.

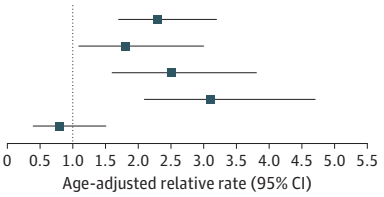
Figure 2. Age-Standardized Thyroid Cancer Incidence Rates by Cohort and Detection Method



Bar graphs of the total age-standardized thyroid cancer incidence rate (per 100 000 person-years) among men are stratified by those aged 20 to 49 years at diagnosis (A) and those aged 50 years and over (B) from the Fire Department of the City of New York, Rochester Epidemiology Project, Rochester, Minnesota, and the US National Cancer Institute Surveillance Epidemiology and End Results–21 (SEER-21) registries. Data were age-adjusted to the 2000 US standard population.

Figure 3. Age-Adjusted Relative Rates (RRs) of Thyroid Cancer Overall, by Early and Late Period, and by Detection Method Comparing Fire Department of the City of New York With the Rochester Epidemiology Project

Variable	Age-adjusted RR (95% CI)
Overall	2.3 (1.7-3.2)
Early period	1.8 (1.1-3.0)
Late period	2.5 (1.6-3.8)
Asymptomatic	3.1 (2.1-4.7)
Symptomatic	0.8 (0.4-1.5)



Relative rates, controlling for age group (in 5-year strata), comparing Fire Department of the City of New York and Rochester Epidemiology Project incident thyroid cancer rates, overall, by an early (September 12, 2001, to December 31, 2009) and late (January 1, 2010, to December 31, 2018) period and by detection method (asymptomatic and symptomatic). An RR greater than 1 indicates that the incidence rate of thyroid cancer is greater in the Fire Department compared with the Rochester Epidemiology Project, Rochester, Minnesota, and an RR less than 1 indicates that the incidence rate of thyroid cancer is greater in the Rochester Epidemiology Project.

20 to older than 85 years; the median age was 50.0 (interquartile range, 41.8-61.3) years. Most (92 [92.9%]) of the Rochester Epidemiology Project cases were papillary cancers.

The overall age-standardized incidence of thyroid cancer among men aged 20 years or older was greater in the Fire Department cohort: 24.7 (95% CI, 17.4-52.3) vs 10.4 (95% CI, 8.5-12.7) in the Rochester Epidemiology Project and 9.1 (95% CI, 9.0-9.1) in SEER-21 per 100 000 person-years; asymptomatic cancers accounted for this difference. We observed an apparent interaction between thyroid cancer incidence and age (<50 vs ≥50 years), particularly among symptomatic cases. However, for both age groups, Fire Department asymptomatic age-standardized rates (13.2 per 100 000 for age 20-49 years and 25.1 per 100 000 for ≥50 years) were greater than the total rates for the Rochester Epidemiology Project (6.9 per 100 000 for age 20-49 years and 18.0 per 100 000 for ≥50 years) and SEER-21 (5.9 per 100 000 for age 20-49 years and 14.1 per 100 000 for ≥50 years) (**Figure 2**A and B). Furthermore, the age groups' crude absolute rates for the detection methods within each cohort were consistent with their respective age-adjusted rates; the one exception was among Fire Department men aged 20 to 49 years, in which undetermined age-adjusted rates were higher than the crude rates (4.4 vs 1.6) and asymptomatic and symptomatic adjusted rates were lower (age-adjusted vs crude: 13.2 vs 18.8 asymptomatic and 3.4 vs 6.3 symptomatic).

Figure 3 shows the post-9/11 incidence of thyroid cancer by age-adjusted relative rates overall, by early and late periods, and by detection method. Overall, the Fire Department thyroid cancer incidence rate was twice that of the rate for the Rochester Epidemiology Project (RR, 2.3; 95% CI, 1.7-3.2). The early time-period RR was moderately different between the Fire Department and Rochester Epidemiology Project (RR, 1.8; 95% CI, 1.1-3.0); however, the Fire Department incidence rate was higher during the late period (RR, 2.5; 95% CI, 1.6-3.8). By detection method, the thyroid cancer rate for the whole period among symptomatic Fire Department cases was not significantly different from that of Rochester Epidemiology Project cases (RR, 0.8; 95% CI, 0.4-1.5); however, there was a larger rate of asymptomatic cancers in the Fire Department cohort (RR, 3.1; 95% CI, 2.1-4.7). The crude RRs for all of the comparisons were slightly larger than their age-adjusted counterparts. Relative rates across all levels of WTC exposure were similar, with no exposure gradient (eTable 2 in the Supplement).

Effect sizes in the secondary analysis restricted to papillary thyroid cancers were similar (eTable 2 in the Supplement). Results from the first sensitivity analysis restricting to men aged 30 to 79 years were analogous to those from the primary and secondary analyses (eTable 2 in the Supplement). In the second sensitivity analysis, the thyroid cancer rate among symptomatic Fire Department cases, including the uncategorized 7 as symptomatic cases, was not significantly different from that of the Rochester Epidemiology Project (RR, 1.3; 95% CI, 0.7-2.3).

Discussion

Previously reported excess thyroid cancer rates among Fire Department WTC-exposed firefighters[21] are likely associated with overdiagnosis owing to medical surveillance. We found that the Fire Department age-standardized incidence rate of asymptomatic cases exceeded the rate of both our non-WTC-exposed comparison from the Rochester Epidemiology Project and the US general population. Furthermore, we found a significant age-adjusted RR among asymptomatic cancers, in which the Fire Department RR was approximately 3 times greater than that of the Rochester Epidemiology Project. There was no statistically significant difference between Fire Department and Rochester Epidemiology Project rates among symptomatic cases, even assuming that cases without a categorized detection method were symptomatic. In addition, there was no metastatic disease or thyroid cancer-specific deaths among Fire Department cases. Our study provides evidence that the increase in thyroid cancer rates is not owing to clinically apparent disease; rather, we suggest that the predominant factor in the higher WTC incidence rate is asymptomatic thyroid cancers detected incidentally via non-thyroid-related medical surveillance.

There was no significant difference in the Fire Department thyroid cancer incidence compared with the Rochester Epidemiology Project incidence during the early post-9/11 period; however, during the late period (2010-2018), when access to medical care increased with the passage of the James L. Zadroga 9/11 Health and Compensation Act, the Fire Department incidence increased to 2 and a half times that of the Rochester Epidemiology Project. Given that detection of subclinical pools of thyroid cancer lesions can be directly related to health care access,[45] we believe that the totality of our results suggests that incidental detection has played a role in the elevated incidence of WTC-exposed thyroid cancers reported by previous studies.[21-24]

Several other explanations for the higher overall incidence rate of thyroid cancer among the Fire Department compared with the Rochester Epidemiology Project may be suggested. One such explanation is that the incidence of Fire Department cancer cases may be a product of medical radiation exposure.[16] Yet, previous research investigating the risk of thyroid cancer among WTC-exposed firefighters due to radiation exposure from diagnostic procedures was not conclusive, even when comparing the highest level of radiation exposure with the lowest.[46] Another argument is that overweight and obesity may predispose individuals to thyroid cancer. Some cross-sectional studies of patients with papillary thyroid cancer suggest that overweight and obesity are associated with aggressive clinical and pathologic tumor characteristics.[17-19] Most Fire Department tumors cannot be characterized as aggressive because we did not observe thyroid cancer-specific mortality or metastatic disease; furthermore, there was no statistically significant difference in the average body mass index between cases and noncases in the Fire Department cohort. In addition, while it was suggested that some physicians may be more likely to diagnose a WTC-exposed patient with thyroid cancer than a non-WTC-exposed patient, at least one study found this not to be the case.[26]

We believe the results of this study have important implications because many thyroid cancers in the Fire Department men were asymptomatic incidentalomas that likely represent a subclinical reservoir of disease and may have been treated via lobectomy or total thyroidectomy. Although not seen in our cohort, complications of thyroidectomy have been seen to arise,[47-49] particularly in lower-volume surgical centers, and often require complex medical management.[50] The personal and financial costs of thyroid operations are approximately $35 000 per patient—a price that may increase in the next 10 years.[51] We believe these physical and financial burdens should be considered for patients diagnosed with small, asymptomatic papillary carcinomas discovered on non-thyroid-related imaging, since papillary thyroid cancers have a 5-year cancer-specific survival rate as high as 98%.[8] One strategy to attenuate a high thyroid cancer diagnosis rate was enacted by South Korea, which began to conduct fewer screenings in March 2014 and since then has experienced fewer diagnoses and surgical operations.[52] Alternatively, the American Thyroid Association has recommended adopting an active surveillance protocol for low-risk papillary microcarcinomas,[53] which could be a treatment option for qualifying WTC-exposed patients.

Limitations and Strengths

Our study had some limitations. First, we lacked a Fire Department, non-WTC-exposed comparison group; however, the male Rochester Epidemiology Project comparison group was similar in terms of demographics, access to care, and study methods.[37,38] Second, given the retrospective extraction of detection method data, both the Fire Department and Rochester Epidemiology Project could have misclassified patients. Information regarding detection method was missing from the medical records of some Fire Department cases. To address this lack of information, the detection method was determined via telephone conversations, and researchers from the Fire Department and Rochester Epidemiology Project discussed all debatable cases to achieve consensus. Differential misclassification was also possible despite efforts to follow the same protocol. However, evidence against misclassification included the full agreement between examiners in the random subset of Fire Department cases and the difference in rates among asymptomatic Fire Department and Rochester Epidemiology Project cases. Third, the Fire Department did not have information on size or staging for all thyroid cancer cases; therefore, we could not compare these characteristics with those of the Rochester Epidemiology Project or the results from other studies. Fourth, our results may not be generalizable to other occupational cohorts given that our population was exclusively male, white, and had above-average physical health prior to WTC exposure.

Despite these limitations, the study strengths are notable. First, to our knowledge, this is the only study to examine thyroid cancer detection methods among WTC-exposed responders. Second, our large, closed cohort was defined before WTC exposure, thereby minimizing enrollment bias. Third, Fire

Department and Rochester Epidemiology Project comparison populations were suitably matched; in addition, Rochester Epidemiology Project coinvestigators provided age-, sex-, and histologic-specific rates from a similar period as the collection of Fire Department rates. Fourth, our results underscore the importance of evaluating the characteristics of health care systems when considering the incidence and prevalence rates of specific diagnoses.

Conclusions

The results of this study suggest that a greater number of asymptomatic thyroid cancers have been diagnosed in Fire Department WTC-exposed rescue/recovery workers. The high incidence of thyroid cancer post-9/11 appears to be attributable to the increased diagnosis of occult lesions owing to the detailed and frequent medical testing of WTC-exposed individuals. There seems to be no incidence of disease-specific thyroid cancer mortality, and carcinoma discoveries were largely of the least-aggressive subtypes, suggesting that the observed RRs are due to a greater detection of subclinical cancers in Fire Department rescue/recovery workers than in the comparison population. This finding appears to be supported by the primary and secondary analyses of incidence rates by detection method. Our results have important implications for how thyroid cancer incidence rates are interpreted and how cases should be managed once diagnosed, not only for WTC-exposed cohorts, but for the general population as well.

ARTICLE INFORMATION

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