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Prevalence of and factors associated with mammography and prostate-specific antigen screening among World Trade Center Health Registry enrollees, 2015–2016

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ABSTRACT

To compare the prevalence of mammography and prostate-specific antigen (PSA) testing in 9/11-exposed persons with the prevalence among the US population, and examine the association between 9/11 exposures and these screening tests using data from the World Trade Center Health Registry (WTCHR) cohort. We studied 8190 female and 13,440 male enrollees aged ≥40 years at survey completion (2015–2016), who had a medical visit during the preceding year, had no self-reported breast or prostate cancer, and did not have screening for non-routine purposes. We computed age-specific prevalence of mammography (among women) and PSA testing (among men), and compared to the general population using 2015 National Health Interview Survey data (NHIS). We also computed the adjusted prevalence ratio (PR) and 95% confidence interval (95% CI) to examine the relationship between 9/11 exposures and screening uptakes using modified Poisson regression. Our enrollees had higher prevalences of mammogram and PSA testing than the US general population. 9/11 exposure was not associated with mammography uptake. Proximity to the WTC at the time of the attacks was associated with PSA testing in the age 60–74 group (PR = 1.06; 95% CI = 1.00–1.12). Among rescue/recovery workers and volunteers (RRW), being a firefighter was associated with higher PSA testing than other RRW across all age groups (40–49: PR = 1.45, 95% CI 1.16–1.81; 50–59: PR = 1.33, 95% CI 1.22–1.44; 60–74: PR = 1.14, 95% CI 1.06–1.23). Screening activities should be considered when studying cancer incidence and mortality in 9/11 exposed populations.

1. Introduction

Several studies of cancer among persons who were directly exposed to the World Trade Center terrorist attacks on September 11, 2001 (9/11) in New York City (NYC) have found a slight excess in the incidence of cancer overall (Li et al., 2012, 2016; Solan et al., 2013; Zeig-Owens et al., 2011). Excess breast cancer rate among civilians exposed to WTC disaster has been reported (Li et al., 2016), and excess cases of thyroid and prostate cancer have been found in several different cohorts (Boffetta et al., 2016), and associated with higher levels of 9/11-related exposures (Moir et al., 2016; Solan et al., 2013).

One common characteristic of these types of cancer is that they are detectable by screening. The US Preventive Services Task Force (USPSTF) recommends biennial screening mammography for women aged 50 to 74 years (Siu, 2016), but has discouraged PSA screening for prostate cancer since May 2012 (Moyer et al., 2012). Because federally-funded health care for 9/11-exposed persons is available through the World Trade Center Health Program (WTCHP), it is likely that persons who survived the 9/11 attacks have better access to medical care, and thus are offered cancer screening more often than the general population. For instance, health assessments including complete blood counts and prostate-specific antigen (PSA) test are offered every 12–18 months in the Fire Department of NYC (FDNY) (Boffetta et al., 2016; Zeig-Owens et al., 2011) to all participating male firefighters aged 45 years or older since 9/11 (Moir et al., 2016). Full medical exams including breast cancer screening are offered to non-FDNY exposed rescue/recovery workers who were enrolled in the World Trade Center Health Consortium (WTCHC) (Boffetta et al., 2016). It is unknown whether the observed excess in cancer incidence among 9/11-exposed persons is attributable to more rigorous screening of this population than of the general population.

We wished to examine whether 9/11-exposed persons underwent screening for cancer more frequently than the general population. We focused on screening for breast and prostate cancer because an

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increased incidence of each has been reported in previous WTC studies, and well-established national screening guidelines exist for both. We assessed the prevalence of screening for these two cancers among the World Trade Center Health Registry ("WTCHR") enrollees to provide information on cancer screening in this population, and examined associations of 9/11-related exposures with mammography and PSA screening.

2. Methods

2.1. Study population

The WTCHR has been described in detail elsewhere (Brackbill et al., 2009; Farfel et al., 2008). Briefly, between September 12, 2003 and November 24, 2004, 71,431 people completed a computer-assisted (95%) or in-person (5%) enrollment interview on demographics, exposures incurred during and after the WTC disaster, and health information. WTCHR enrollees include rescue/recovery workers and volunteers (RRW) and community members not involved in rescue/recovery (Farfel et al., 2008). Since the enrollment survey (Wave 1), the Registry has conducted three follow-up surveys (Waves 2–4) via mail, website, or telephone interview to collect updated health information. The adult response rate for Wave 2, Wave 3, and Wave 4 was 65.2%, 60.4%, and 51.6%, respectively.

The Wave 4 adult survey, administered March 2015 through January 2016, was the first Registry survey to inquire about cancer screening. Therefore, Wave 4 participants (n = 36,864) were eligible for this study. We excluded participants who were younger than 40 years old at the time of the survey (n = 3005), had not have a medical visit for routine check-up within the past 12 months (n = 7426), and missing age or answers for each screening question (n = 1926). On Wave 4, we asked "When did you last visit a doctor for a routine check-up that was not for a specific injury, illness, or condition?" The answers include "Within the last 12 months", "Over a year ago but less than 2 years ago", "2 or more years ago but less than 5 years ago", "5 or more years ago", and "Never in my life". Those who answered "Within the last 12 months" were considered as having a medical visit for routine check-up within the past 12 months, and therefore included in the study sample. For the screening questions, we asked "In the last 12 months, did you have a mammogram (for women) or a PSA test (for men)?" If participants answered "Yes" to the question, we further asked the purpose of their most recent screening test (i.e., as "part of routine examination", "because of a problem", "other reason", or "don't know"). The screening questions were adapted from the Cancer Control Supplement of the 2010 National Health Interview Survey (NHIS) (US Department of Health and Human Services, 2010). We excluded those who had screening for reasons other than routine examination to avoid the over-estimation of screening activity (n = 1323, including 374 women and 949 men). We also excluded women with self-reported breast cancer (n = 688) and men with self-reported prostate cancer (n = 866). The inclusion and exclusion criteria were adapted from a study that examined the PSA screening test in NHIS sample (Drazer et al., 2015). Our final sample for analysis included 21,630 participants, with 8190 women and 13,440 men.

The study was approved by the Institutional Review Board (IRB) at the New York City Department of Health and Mental Hygiene. The Centers for Disease Control and Prevention and New York City DOHMH IRBs approved the overall Registry protocols. Verbal consent was obtained from the participants at enrollment.

2.2. Study variables

The outcome variables of interest were self-reports of having a mammogram (for women) or PSA testing (for men) as "part of a routine examination" in the past 12 months.

The 9/11-related exposure variables were collected at Wave 1. These included Registry eligibility group, a dichotomous variable referring to either RRW or community members; proximity to the WTC site on 9/11 morning, defined as being south of Chambers Street in lower Manhattan on the morning of 9/11; and dust cloud/debris exposure on 9/11, defined as being outdoors in the dust and debris cloud resulting from the collapse of the WTC towers on 9/11.

Covariates included socio-demographic variables at Wave 4 (age, race/ethnicity, marital status, education level, household income, smoking status, and body mass index (BMI)), history of any clinician-diagnosed mental health disorders (PTSD, anxiety or depression), as previous literature reported under-utilization of screening for persons with mental health issues (Carney and Jones, 2006; Park et al., 2010), ever received services from WTCHP clinics, and family history of breast or prostate cancer. Family history of cancer was self-reported. We solicited this information using a skip pattern question structure. We asked "Has your biological father ever had cancers?" If yes, a follow-up question on type(s) of cancer is asked. The same method was used for asking cancer history of biological mother, biological brothers/sisters (include half-brothers/sisters but not step-brother/sister), and any other blood relatives. We categorized biological parents or siblings as first degree relatives, all other blood relatives as second degree or further, and all others who reported none as no family history.

2.3. Statistical analyses

All analyses were performed using SAS software (SAS Institute, Cary, NC, v9.4). Statistical significance was set at a 2-sided alpha = 0.05 level. We computed the prevalence of mammography and PSA testing in the last 12 months by socio-demographic variables, family history of cancer, and various types of WTC exposures. We described and compared the age-specific prevalence of cancer screening by level of family history using Pearson's chi-squared test.

We also compared the age-specific prevalence of each screening in the last 12 months to the general population using 2015 NHIS data (CDC, 2015). NHIS is a nationally representative cross-sectional survey sample of the civilian non-institutionalized population. The NHIS sampling design involves stratification, clustering and over sampling of specific sub-groups. We extracted age, sex, type of cancer diagnosed, and times of most recent routine medical visit from the "sample adult" dataset, time of most recent PSA testing and reason for testing from the "sample cancer" dataset (CDC, 2015) to compute prevalence of mammography and PSA testing in the NHIS sample with comparable inclusion criteria. We incorporated sampling weights to adjust for the complex survey design (CDC, 2016).

We used modified *Poisson* regression with a robust error variance (Zou, 2004) to examine the associations of WTC disaster-related exposure variables with having a mammogram among women or PSA testing among men, adjusting for covariates. We stratified the analyses by age 40–49 and 50–74 years for mammography, and by age 40–49, 50–59, and 60–74 years for PSA testing.

Since high WTC exposure level has been reported to be associated with increased incidence of prostate cancer among RRW (Boffetta et al., 2016), we performed a sub-analysis of PSA testing among male RRW to explore whether rescue/recovery-specific exposures were associated with screening. Rescue/recovery-specific exposures included total number of days worked at the WTC site, date of first arrival with or without working on pile, and worker categories. Workers were categorized into the FDNY and other firefighters, NYC Police responders, sanitation workers, and all other workers, since routine health monitoring may vary between worker categories (Yip et al., 2016).

3. Results

Compared to female Wave 4 participants who were excluded, a higher proportion of female participants in the current study were non-Hispanic Black (17.7% vs 12.9%); widowed, divorced, or separated

Table 1
Characteristics of the sample and prevalence of routine mammography in women and prostate-specific antigen (PSA) testing in men by socio-demographics and 9/11 exposure, WTCHR enrollees, 2015–2016 (N = 21,630).

	Women	Men
	N of enrollees (% mammography screened)	N of enrollees (% PSA screened)
Total	8190 (74.2)	13,440 (57.2)
Characteristics at Wave 4		
Age, year		
40–49	1802 (69.3)	2776 (27.2)
50–59	2581 (78.0)	5116 (59.4)
60–74	3326 (76.0)	4908 (71.0)
≥75	481 (58.6)	640 (62.5)
Race/ethnicity		
Non-Hispanic White	4824(73.8)	10,330 (59.6)
Non-Hispanic Black	1448 (79.6)	760 (57.1)
Hispanic	1070 (74.3)	1317 (49.1)
Asian	523 (66.9)	637 (37.1)
All other or unknown[a]	325 (66.8)	396 (52.3)
Marital status		
Married or living with a partner	4215 (75.8)	10,691 (58.5)
Widowed, divorced or separated	2338 (72.5)	1583 (53.8)
Single	1501 (72.6)	1042 (47.8)
Unknown or missing	136 (71.3)	124 (62.1)
Highest education achieved		
High School or less	1290 (73.2)	2334 (51.2)
Some College or above	6819 (74.4)	11,001 (58.5)
Unknown or missing	81 (74.1)	105 (53.3)
Household income, $		
$150,000 or more	1575 (79.6)	3839 (58.8)
$50,000–$149,999	3763 (75.2)	6950 (57.9)
Less than $50,000	2294 (68.6)	1838 (49.5)
Unknown or missing	558 (74.7)	813 (60.9)
Smoking status		
Never	4634 (75.3)	7147 (56.4)
Former	2481 (74.6)	4414 (60.5)
Current	592 (65.2)	1027 (49.3)
Unknown or missing	483 (72.1)	852 (55.9)
BMI		
Obese (BMI ≥ 30)	2487 (73.9)	4901 (56.6)
Overweight (25 to < 30)	2398 (75.1)	5846 (58.9)
Under or normal weight (< 25)	3012 (73.4)	2450 (55.3)
Unknown or missing	293 (76.1)	243 (46.5)
Ever received services from WTC health clinics		
Yes	1113 (73.3)	3655 (58.0)
No	6826 (74.5)	9355 (57.0)
Unknown or missing	251 (69.3)	430 (54.9)
Any reported history of clinician diagnosed PTSD, anxiety or depression		
Yes	2987 (70.2)	3623 (55.1)
No or missing	5203 (76.4)	9817 (57.9_
Family history of corresponding breast or prostate cancer		
1st degree (close)	1214 (79.9)	1398 (70.7)
2nd degree (distant)	1786 (77.5)	708 (55.9)
None	5086 (71.7)	11,054 (55.6)
Unknown or missing	104 (72.1)	280 (54.3)
9/11 exposure		
WTCHR eligibility group		
Rescue/recovery workers & volunteers	2091 (72.9)	8272 (57.0)
Community members	6099 (74.6)	5168 (57.4)
Proximity to the WTC site on 9/11 morning[b]		
Yes	5974 (75.0)	7105 (57.5)
No	2188 (72.1)	6307 (56.9)
Unknown or missing	28 (60.7)	28 (42.9)
Dust cloud/debris exposure on 9/11		
Yes	4620 (74.2)	6709 (56.7)
No	3534 (74.0)	6680 (57.6)
Unknown or missing	36 (80.6)	51 (51.0)

PSA, prostate-specific antigen test.
[a] Includes multiracial, American Indian/Alaskan Native, or unknowns.
[b] Being in Manhattan South of Chambers Street between time of first plane impact and noon on 9/11.

(28.6% vs 20.5%); or had health insurance (98.1% vs 91.3%). Compared to male Wave 4 participants who were excluded, male participants in this study were more likely to be married or living with a partner (79.6% vs 72.9%) or have health insurance (98.3% vs 91.3%) (Supplemental Table).

Table 1 shows the characteristics of the sample and prevalence of routine mammography and PSA testing by socio-demographic characteristics and WTC disaster-related exposures. The overall prevalence of mammography among women and PSA testing among men age 40 or older was 74.2% and 57.2%, respectively. Table 2 shows the prevalence of screening by age group and family history of each cancer. We observed an increase in age-adjusted prevalence of both screenings with closer level of family history.

3.1. Comparison with general US population

Fig. 1a shows a significantly higher prevalence of mammography among WTCHR enrollees than the US population across all age groups. Similarly, higher prevalence of PSA testing among WTCHR enrollees than the US population was observed (Fig. 1b).

3.2. Prevalence of and factors associated with mammography

The prevalence of mammography was higher in the 50–59 age group (78.0%) than in other age groups (Table 1). Women who were screened with mammography were predominantly non-Hispanic Black (79.6%), married or living with a partner (75.8%), with higher education (74.4%), higher household income (79.6%), or a first degree relative with breast cancer (79.9%). Mammography prevalence was lower in those with any history of clinician-diagnosed PTSD, anxiety or depression than those without (70.2% vs 76.4%). The prevalence of mammography was similar by WTCHR eligibility group, proximity to the WTC site and dust cloud exposure.

The WTC exposure variables were not significantly associated with mammography after adjusting for covariates in both age groups (Table 3). However, mammography uptake in those ages 50–74 was associated with being non-Hispanic Black or Hispanic, higher household income, having a family history of breast cancer in any blood related relatives, and current or former smokers.

3.3. Prevalence of and factors associated with prostate-specific antigen testing

The prevalence of PSA testing (Table 1) was higher among men ages 60–74 (71.0%), non-Hispanic whites (59.6%), those who were married or living with a partner (58.5%), had some college or higher education (58.5%), a higher income (58.8%), were former smokers (60.5%), overweight (58.9%), ever received services from WTC health clinics (58.0%), or had a first degree relative with prostate cancer (70.7%). The prevalence of PSA testing was slightly lower in those with a reported history of any clinician diagnosed PTSD, anxiety, or depression

Table 2
Prevalence of routine mammography in women and Prostate-Specific Antigen (PSA) testing in men by family history of cancer and age groups, WTCHR enrollees, 2015–2016 (N = 21,630).

	Number of enrollees (% screened)[a]			
	1st degree family	2nd degree or further	No family history	Missing family history
Mammography screening among women (N = 8190)				
Total	1214 (79.9)**	1786 (77.5)**	5086 (71.7)	104 (72.1)
40–44	93 (69.9)*	229 (66.8)*	467 (58.7)	9 (77.8)
45–49	128 (84.4)**	230 (74.8)	636 (72.8)	10 (70.0)
50–54	181 (82.3)*	272 (79.8)	750 (75.5)	16 (62.5)
≥55	812 (79.8)**	1055 (79.8)**	3233 (72.4)	69 (73.9)
PSA test screening among men (N = 13,440)				
Total	1398 (70.7)**	708 (55.9)	11,054 (55.6)	280 (54.3)
40–49	254 (49.6)**	192 (30.7)*	2278 (24.1)	52 (40.4)
50–59	585 (70.1)**	283 (60.1)	4147 (58.0)	101 (55.5)
60–74	512 (81.6)**	210 (71.9)	4089 (69.9)	97 (58.8)
≥75	47 (74.5)	23 (69.6)	540 (61.3)	30 (60.0)

* $P < 0.05$.
** $P < 0.01$.
[a] Missing family history was excluded in statistical testing. No family history was used as the referent category to compare 1st degree, and 2nd degree or further.

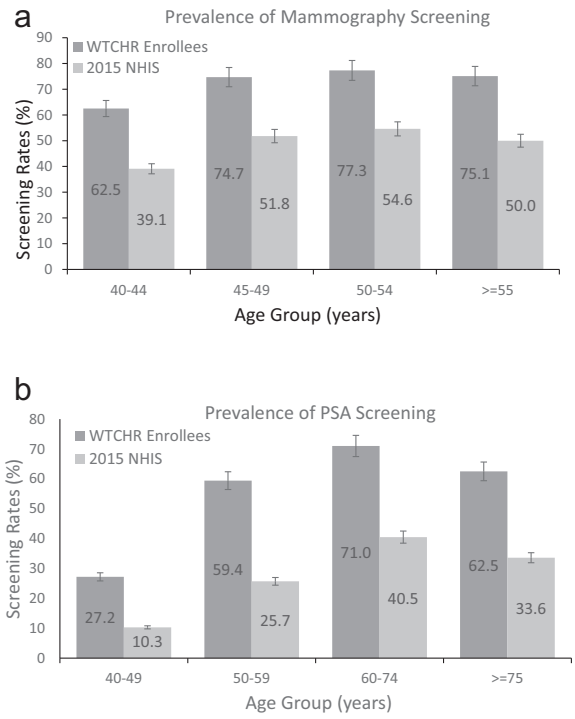

Fig. 1. Prevalence of routine mammography screening (a) and prostate-specific antigen testing (b) among WTCHR enrollees 2015–2016, compared to 2015 NHIS US population.

than in those without (55.1% vs 57.9%). The prevalence of PSA testing was similar by WTCHR eligibility group, proximity to the WTC site and dust cloud exposure.

There was a significant association between proximity to the WTC site on 9/11 morning and PSA testing, adjusting for covariates among men ages 60 to 74 (OR = 1.06, 95% CI 1.00–1.12) (Table 4). In the same age group, PSA testing was also associated with higher education, higher household income, non-smokers, and having a first degree relative with prostate cancer. Among the youngest age group, PSA testing was significantly associated with non-Hispanic Black, higher income, obese or overweight, family history of prostate cancer in first degree relatives.

3.4. Sub-analysis of PSA testing among rescue/recovery workers

In the sub-analysis limited to RRW, we found that the specific exposures at the WTC site (i.e., duration of work, time of first arrival with or without working on pile) were not significantly associated with PSA testing. However, compared to all other RRW, FDNY and other firefighters were more likely to have PSA testing across all age groups (ages 40–49: PR = 1.45, 95% CI 1.16–1.81; ages 50–59: PR = 1.33, 95% CI 1.22–1.44; ages 60–74: PR = 1.14, 95% CI 1.06–1.23) after adjusting for covariates. PSA testing among NYC police responders and Sanitation workers was not significantly different from the reference group (all other workers).

4. Discussion

4.1. Mammography

We found a higher prevalence of mammography in WTCHR enrollees than the general US population across all age groups. This increased screening uptake was not associated with various type of WTC exposures.

Several factors may have contributed to the increased prevalence of mammography. The availability of health care through the WTCHP may lead to more opportunities for providers to offer screening to WTC-exposed population (Dasaro et al., 2017), although the association between utilizing WTCHP services and mammography uptake was not significant after controlling for covariates. After the WTC attacks, there have been a general concern that the exposure may have resulted in increased numbers of cancers (Lioy et al., 2002; Pleil et al., 2004). It is likely that our enrollees have higher motivation to obtain medical screening than non-exposed population due to health concerns associated with the exposure. Another possible explanation may be due to the underlying characteristics of enrollees included in this study, such as high education and income, which have been consistently reported to be associated with increased mammography utilization (Chowdhury et al., 2016; Kim and Jang, 2008). Conflicting evidence of racial/ethnic difference in mammography utilization has been reported previously (Harris et al., 2003; Mobley et al., 2016; Rauscher et al., 2012). We observed that the mammography uptake in these groups were either not different from the white women ages 40–49, or higher than that in white women ages 50–74. Such findings may be, to some extent, due to high education and income reported in a majority of non-Hispanic Black and Hispanic women in the study.

We found that women with a report of clinician diagnosed PTSD, anxiety or depression were less likely to receive mammography,

Table 3
Multivariable analysis of routine mammography in women, WTCHR enrollees, 2015–2016 (N = 7709).

Variables	Adjusted PR (95% CI)[a]			
	Aged 40–49 years (n = 1802)		Aged 50 to 74 (n = 5907)	
Race/ethnicity				
Non-Hispanic Black	1.04	0.94–1.15	1.11	1.07–1.16
Hispanic	0.93	0.84–1.04	1.09	1.03–1.14
Asian	0.76	0.64–0.89	0.98	0.91–1.06
All other or unknown[b]	0.84	0.68–1.04	0.98	0.90–1.08
Non-Hispanic White	Ref	Ref	Ref	Ref
Marital status				
Married or living with a partner	1.01	0.92–1.11	1.02	0.97–1.06
Widowed, divorced or separated	1.06	0.94–1.19	1.01	0.97–1.06
Single	Ref	Ref	Ref	Ref
Highest education achieved				
Some college or above	0.90	0.79–1.03	0.98	0.94–1.03
High school or less	Ref	Ref	Ref	Ref
Household income, $				
$150,000 or more	1.06	0.95–1.19	1.09	1.04–1.13
$50,000–$149,000	1.20	1.06–1.35	1.15	1.09–1.21
Less than $50,000	Ref	Ref	Ref	Ref
Smoking status				
Never	1.10	0.95–1.27	1.14	1.06–1.22
Former	1.09	0.94–1.27	1.12	1.04–1.21
Current	Ref	Ref	Ref	Ref
BMI				
Obese (BMI ≥ 30)	1.06	0.98–1.16	0.94	0.91–0.98
Overweight (25 to < 30)	1.04	0.96–1.13	0.99	0.96–1.03
Under or normal weight (< 25)	Ref	Ref	Ref	Ref
Ever received services from WTC health clinics				
Yes	1.11	0.99–1.23	0.99	0.95–1.04
No	Ref	Ref	Ref	Ref
Any reported history of clinician diagnosed PTSD, anxiety or depression				
Yes	0.91	0.84–0.97	0.93	0.90–0.96
No or missing	Ref	Ref	Ref	Ref
Family history of cancer				
1st degree	1.17	1.08–1.28	1.08	1.04–1.13
2nd degree or further	1.05	0.97–1.13	1.05	1.02–1.09
No family history (none)	Ref	Ref	Ref	Ref
9/11 exposure				
WTCHR eligibility group				
Rescue/recovery workers & volunteers	0.97	0.87–1.08	0.98	0.93–1.03
Community members	Ref	Ref	Ref	Ref
Proximity to the WTC site on 9/11 morning[c]				
Yes	1.07	0.95–1.19	1.00	0.95–1.05
No	Ref	Ref	Ref	Ref
Dust cloud/debris exposure on 9/11 (DUST)				
Yes	0.97	0.90–1.04	1.01	0.97–1.04
No	Ref	Ref	Ref	Ref

Ref, referent. PR, prevalence ratio.
[a] Adjusted for variables listed in this table.
[b] Includes multiracial, American Indian/Alaskan Native, or unknowns.
[c] Being in Manhattan South of Chambers Street between time of first plane impact and noon on 9/11.

consistent with previous reports of under-utilization of mammography for women with mental health conditions (Carney and Jones, 2006; Kahn et al., 2005; Park et al., 2010). This finding suggests that the self-report of mammography may be less likely to result in over-reporting.

4.2. Prostate-specific antigen testing

Our study also found a higher prevalence of PSA testing in male WTCHR enrollees than the general US population. In 2012, the USPSTF recommended against PSA-based screening for prostate cancer in all age groups (Moyer et al., 2012). Decreasing trends of screening prevalence for men ages 50 and above have been observed nationwide since then (Drazer et al., 2015; Jemal et al., 2015; Li et al., 2015). Despite the change of recommendation, the high prevalence of PSA testing in our study suggests that screening of this population is also likely due to concerns about the potential health effects of 9/11 exposure.

Increased PSA testing has been found to be related to education and income, but not racial and ethnic factors (Drazer et al., 2015; Ogunsanya et al., 2016; Richardson et al., 2007). The findings of lower PSA testing among Hispanic and Asian men than non-Hispanic white men may be due to the small number in those groups, given that 77% of men were non-Hispanic white. Though current USPSTF guidelines discourage PSA-based screening for all men, other guidelines, such as American Cancer Society, still highlights the importance of routine screening for non-Hispanic Black at a younger age, particularly those with a family history of prostate cancer (ACS, 2016). The higher screening uptake in this group observed in our sample suggests that providers remain vigilant in their screening practice for this population. Continued follow-up on PSA screening activities among WTCHR enrollees is needed.

We found FDNY and other firefighter responders were more likely to have PSA testing than other RRW. Several studies focusing on firefighters reported increased risks of prostate or thyroid cancer, and suggested that these findings could be a result of surveillance bias (Moir et al., 2016; Zeig-Owens et al., 2011). The routine health assessment every 12–18 months for firefighters may be a potential contributing factor to their higher screening uptake than non-firefighter RRW. However, firefighters in the present study only accounted for 13% of the whole male sample, which is unlikely to fully explain the higher age-specific prevalence of PSA testing in the study.

We found that being in proximity to the WTC site on the morning of 9/11 was associated with increased PSA testing among men ages 60–74, but neither exposure to the dust/debris cloud nor being a RRW was associated with PSA testing among men. Exposure to the WTC attack has been suggested to be associated with an increased incidence of prostate cancer and all cancers combined among RRW in previous studies (Hashim et al., 2016; Solan et al., 2013). However, previous studies on cancer incidence have not found a significant association between high level exposure and prostate cancer compared to low level of exposure in internal comparisons (Li et al., 2012, 2016). The potential impact of increased screening on the association between WTC exposure and prostate cancer incidence cannot be ruled out.

4.3. Other risk factors

Our study supported the established findings in the current literature that higher income, education, non-smoking, and a family history of cancer were associated with increased recent screening for both cancers (Gierisch et al., 2009; Kahn et al., 2005; Littlejohns et al., 2016; Ogunsanya et al., 2016). The low prevalence of both screenings among current smokers in our enrollees is consistent with other studies in which fewer mammography (Martires et al., 2014) and PSA testing (Beaulac et al., 2006) were reported in current smokers than in non- or former smokers. Smokers may be less likely to consult physicians for preventive medical service visits (Preisser et al., 1998). Risk stratification to prioritize screening may yield a potential benefit for this population.

We observed a significant association of self-reported family history of breast and prostate cancer in first degree relatives with mammography and PSA testing, respectively. Those with family members diagnosed with either cancer reported being screened more frequently than those without family history (Gierisch et al., 2009; Kahn et al., 2005; Littlejohns et al., 2016). Previous studies on validity of self-reported family history data have shown sufficient accuracy to warrant

Table 4
Multivariable analysis of routine prostate-specific antigen (PSA) testing in men, WTCHR enrollees, 2015–2016 (N = 12,800).

Variables	Adjusted PR (95% CI)[a]					
	Aged 40 to 49 (n = 2776)		Aged 50 to 59 (n = 5116)		Aged 60 to 74 (n = 4908)	
Race/ethnicity						
Non-Hispanic Black	1.30	1.01–1.69	1.09	0.99–1.20	0.90	0.81–1.00
Hispanic	0.97	0.78–1.21	0.97	0.89–1.06	0.84	0.77–0.93
Asian	0.46	0.28–0.76	0.71	0.59–0.86	0.73	0.63–0.84
All other or unknown[b]	0.88	0.59–1.31	0.87	0.71–1.05	0.89	0.78–1.02
Non-Hispanic White	Ref	Ref	Ref	Ref	Ref	Ref
Marital status						
Married or living with a partner	1.31	1.00–1.72	1.04	0.94–1.15	1.08	0.99–1.18
Widowed, divorced or separated	1.36	0.97–1.91	0.96	0.84–1.09	1.03	0.93–1.15
Single	Ref	Ref	Ref	Ref	Ref	Ref
Highest education achieved						
Some college or above	1.07	0.86–1.34	1.16	1.07–1.26	1.14	1.07–1.22
High school or less	Ref	Ref	Ref	Ref	Ref	Ref
Household income, $						
$150,000 or more	1.36	0.96–1.93	1.29	1.16–1.45	1.06	0.99–1.13
$50,000–$149,000	1.63	1.14–2.33	1.38	1.22–1.55	1.10	1.03–1.19
Less than $50,000	Ref	Ref	Ref	Ref	Ref	Ref
Smoking status						
Never	1.08	0.83–1.39	1.02	0.92–1.12	1.11	1.01–1.21
Former	0.98	0.74–1.29	1.03	0.93–1.14	1.09	1.00–1.19
Current	Ref	Ref	Ref	Ref	Ref	Ref
BMI						
Obese (BMI ≥ 30)	1.26	1.02–1.56	1.04	0.96–1.13	0.99	0.94–1.05
Overweight (25 to < 30)	1.27	1.03–1.56	1.07	0.98–1.15	1.00	0.95–1.05
Under or normal weight (< 25)	Ref	Ref	Ref	Ref	Ref	Ref
Ever received services from WTC health clinics						
Yes	1.09	0.93–1.27	1.03	0.98–1.10	1.03	0.98–1.08
No	Ref	Ref	Ref	Ref	Ref	Ref
Any reported history of clinician diagnosed PTSD, anxiety or depression						
Yes	0.98	0.84–1.15	1.01	0.95–1.06	0.96	0.92–1.00
No or missing	Ref	Ref	Ref	Ref	Ref	Ref
Family history of cancer						
1st degree	2.03	1.75–2.37	1.18	1.10–1.26	1.12	1.06–1.17
2nd degree or further	1.23	0.97–1.56	1.04	0.94–1.16	0.99	0.90–1.09
No family history (none)	Ref	Ref	Ref	Ref	Ref	Ref
9/11 exposure						
WTCHR eligibility group						
Rescue/recovery workers & volunteers	1.13	0.93–1.36	1.06	0.99–1.14	1.01	0.95–1.06
Community members	Ref	Ref	Ref	Ref	Ref	Ref
Proximity to the WTC site on 9/11 morning[c]						
Yes	1.05	0.87–1.27	1.03	0.96–1.10	1.06	1.01–1.12
No	Ref	Ref	Ref	Ref	Ref	Ref
Dust cloud/debris exposure on 9/11 (DUST)						
Yes	0.88	0.75–1.03	0.99	0.93–1.05	0.98	0.94–1.03
No	Ref	Ref	Ref	Ref	Ref	Ref

Ref, referent. PR, prevalence ratio.
[a] Adjusted for variables listed in this table.
[b] Includes multiracial, American Indian/Alaskan Native, or unknowns.
[c] Being in Manhattan South of Chambers Street between time of first plane impact and noon on 9/11.

the use of proband reports in research studies, with positive predictive values of over 90% on breast cancer (Fiederling et al., 2016), and 75% to 87% on prostate cancer (Ziogas and Anton-Culver, 2003).

4.4. Limitations

The main limitation in our study is loss to follow-up between surveys. Our study was based on enrollees who completed our most recent survey in 2015–2016, and it is unknown to what extent this loss to follow-up may have impacted our estimates. A previous study of WTCHR cohorts assessing non-response bias found that non-participants in the first two follow-up surveys (i.e., Waves 2 and 3) were more likely to be younger, have lower household income and education (Yu et al., 2015). In a sub-analysis of comparing Wave 4 participants who were included in the analysis to those excluded (Supplemental Table), we found included female participants were more likely to be non-Hispanic Black, widowed, divorced, or separated, or without insurance; included male participants were more likely to be married or living with a partner or without insurance. Therefore, selection bias due to attrition in this study cannot be ruled out.

Another concern is the use of NHIS sample as comparison. It is challenging to find an appropriate comparison population. Knowing that screening is dependent upon health care access, it is important to account for factors such as providers, delivery, and insurance. Though our inclusion criteria of limiting to those who had a medical routine visit in the last 12 months may lead to higher screening prevalence, we compared our prevalence to that from NHIS based on the year of survey, similar questions on screening uptake, available abstraction of data and other matching criteria, and still observed a significantly higher screening uptakes in our sample. Moreover, 98% of both analytic samples had health insurance coverage. Therefore, the impact of health care access on the screening prevalence found in this report should have been reduced.

Reliance on self-report to define routine screening may introduce

bias. The questions on screening uptakes in this study were adapted from the NHIS cancer screening questionnaire, which has been identified by *Healthy People 2020* as the means to measure screening rates (CDC, 2012). This may help to minimize potential reporting bias. Additionally, we did observe a consistent relationship between screening and other well-established factors, such as family history, clinically diagnosed mental health conditions, income, education, and smoking status, which provides some assurance of our findings. Lastly, we were unable to assess the impact of breast or prostate cancer screening on the cancer incidence among our cohort, given the data on cancer incidence for the years of 2015 and 2016 was not available.

5. Conclusion

Our study suggests that the 9/11-exposed population has a higher prevalence of mammography in women aged ≥45 years than the general population. Similarly, the prevalence of PSA testing in men aged ≥50 years was higher than the general population, despite the change in USPSTF recommendation on PSA screening. WTC exposure was not associated with screening for breast cancer. Being in proximity to the WTC site on the morning of 9/11 was associated with increased PSA testing among men ages 60–74 but no other associations with exposure were noted. The higher than general population screening activities in our sample could have resulted in the increased cancer incidence for prostate and breast cancers we reported previously (Li et al., 2012, 2016). Our findings have important implications for future studies of post-9/11 cancer incidence among exposed populations.

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Disclosure (authors)

The authors declare no conflicts of interest.

Disclaimer

None.

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