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Review Article

Implications of the World Trade Center Health Program (WTCHP) for the Public Health Response to the Great East Japan Earthquake

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Abstract: The attacks on the World Trade Center (WTC) on September 11, 2001 resulted in a serious burden of physical and mental illness for the 50,000 rescue workers that responded to 9/11 as well as the 400,000 residents and workers in the surrounding areas of New York City. The Zadroga Act of 2010 established the WTC Health Program (WTCHP) to provide monitoring and treatment of WTC exposure-related conditions and health surveillance for the responder and survivor populations. Several reports have highlighted the applicability of insights gained from the WTCHP to the public health response to the Great East Japan Earthquake. Optimal exposure monitoring processes and attention to the welfare of vulnerable exposed sub-groups are critical aspects of the response to both incidents. The ongoing mental health care concerns of 9/11 patients accentuate the need for accessible and appropriately skilled mental health care in Fukushima. Active efforts to demonstrate transparency and to promote community involvement in the public health response will be highly important in establishing successful long-term monitoring and treatment programs for the exposed populations in Fukushima.

Key words: Fukushima, World Trade Center, Mental health, Occupational medicine, Disaster response

Introduction

The 9/11 attacks on the World Trade Center (WTC) caused the worst environmental catastrophe that has ever befallen New York City. Over 2,900 individuals died. A cloud of toxic particles generated by the burning and collapse of the towers spread over lower Manhattan and parts of neighboring counties[1)]. Rescue workers and community members exposed to these materials developed significant, chronic physical illnesses[2–4)] Psychological trauma consequent to the horror of the events continues to impact thousands of lives[5, 6)].

Early in the course of the disaster, occupational physicians at Mount Sinai's Selikoff Center and other medical centers provided care for injured workers. Vigorous advocacy by these clinicians, labor representatives, community leaders and local elected officials resulted in federal support of medical monitoring and treatment for the affected populations[7, 8)]. The Zadroga Act of 2010 extended the availability of this health care by establishing the WTC Health Program (WTCHP)[9)]. Major elements of the WTCHP include Clinical Centers, which monitor and treat patients with WTC-related physical and mental illnesses, three separate WTC Data Centers that analyze

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Program information and provide health surveillance, and an epidemiologic center, the WTC Registry.

While the 9/11 disaster is unique in many ways, recent studies of WTC-related health effects and certain aspects of the public health response to 9/11 under the Zadroga Act highlight important elements of environmental disaster response. These elements have significant implications for the ongoing response to the Great East Japan Earthquake. Several recent reports from Fukushima also bring their applicability to "3/11" into sharp focus.

Assessment of Both Acute and Chronic Exposures

Exposure data from the collapse of the WTC towers is incomplete. There is no real-time personal monitoring data for any WTC responder that records the actual particulate and gaseous composition of the dust cloud. Assumptions about the contents of the dust cloud are based in large part on the analysis of settled dust[1]. Despite this lack of contemporaneous monitoring data, variables such as "total time spent working at the WTC site" and "caught in the dust cloud" proved to have a dose-response relationship to symptoms, illnesses and functional decrements experienced by WTC responders[2, 10, 11]. The dust's alkaline pH and the presence of glass fibers contributed to its acute irritant quality[12]. A recently completed laboratory study of the settled dust provides evidence of its carcinogenicity[13] and further informs ongoing discussion about the treatment of WTC exposure-related cancer.

In the follow up of the Great East Japan Earthquake, Akiba *et al.* (2013) have summarized the efforts to carefully document short-term radiation exposure due to the nuclear accidents. For nuclear workers the maximum and average cumulative doses up to 11/30/2011 were 680 mSv and 12 mSv[14]. While these doses are much lower than those reported for the workers involved in the Chernobyl recovery operation[15], appropriate long term medical follow up is indicated for these workers.

For the community near the WTC, the impact of long-term chronic dust exposure on residents who returned to or remained in areas contaminated by WTC dust has been an ongoing concern. Recently, Maslow *et al.* (2011) carefully examined the health impact of acute 9/11 exposure and dimensions of chronic dust exposure in the homes and workplaces of community members. Consistent with a prior report by Lin *et al.* (2007)[16], he demonstrated dose-dependent relationships of variables such as the extent of surface dust coverage and the depth of thickest dust layer in workplaces and households to lower respiratory symptoms[17].

These careful studies are models for future investigations that must be undertaken when the evacuated populations in Fukushima return to the disaster areas currently undergoing cleanup. The Maslow study's methodology, which encouraged community members to collaborate on the design of study interview, is particularly praiseworthy. Such community participation can increase both public awareness of risks and public confidence in results. This clear demonstration of the health effects of ongoing, low level chronic exposure is yet another reason for continued monitoring and treatment of the WTC populations and argues for similar careful observation in Fukushima's contaminated regions.

Regarding the community radiation exposure from the Fukushima accident, the Basic Survey of the Fukushima Health Management Survey was designed to estimate radiation doses received by residents from external exposure in the interval from 03/2011 to 07/2011[18]. The maximum cumulative dose among residents (excluding radiation workers) was 3.9 mSv. Whole-body count survey of 54,126 residents conducted between 06/2011 and 06/2012 to estimate internal exposure demonstrated a maximum of less than 4 mSv[14].

These measurements reduced concerns about acute radiation impacts and indicated that the risks of certain outcomes, such as cancer, might be less likely than initially feared for the exposed population. Nonetheless, just as in the WTC population, legitimate concerns remain about chronic exposure in contaminated areas[19, 20]. A January 2013 *New York Times* report on the cleanup of contaminated areas is critical of the current decontamination techniques, some of which risk the escape of contaminated material into the air or the runoff[21]. These concerns should be addressed in an open, transparent manner, and any exposure evaluation should enlist and welcome community participation in both design and implementation. Failure to openly address these issues will create mistrust among the populace. After 9/11 local government failed to regulate residential and workplace cleanup in communities near the WTC disaster site. The community's bitterness and cynicism about this failure was captured by contemporary journalists[22] and is still palpable today.

It is important to note that radiation was not the only hazardous exposure for Fukushima nuclear workers. These workers were also at risk for the more common acute workplace exposures and injuries. Recognizing these risks, the University of Occupational and Environmental

Health (UOEH), Japan, dispatched physicians to the damaged plant to provide first-aid services in mid-May, 2011. The physicians adopted a strategic approach to protecting workers from the existing health risks. Ultimately UOEH also presented recommendations on occupational health systems and preventive measures against heat stress to the Government and TEPCO[23]. This intervention demonstrates, just as the Occupational Medicine response to the WTC disaster demonstrated, that the appropriate care of workers in environmental disasters depends on the availability of trained and experienced Occupational Medicine staff[8].

Attention to Vulnerable Subgroups in the Exposed Population

No population of disaster responders and no disaster-exposed community is homogeneous in its vulnerability to a toxic exposure. Intrinsic characteristics of group members as well as their preparation and training have an enormous impact on an individual member's risk of exposure-related illness. There is no complete roster of the rescue and recovery personnel who responded to the WTC disaster. Estimates of the number of responders range from 60,000 to 90,000[24]. Similarly, the estimate of the community population at risk, approximately 400,000, was drawn from census and local employment data[25]. The lack of certainty as to which workers and community members were exposed during the WTC disaster hinders the identification of sub groups that might be more highly vulnerable to the impact of this exposure. The absence of a roster is also unfortunate for workers: medical benefits for WTC workers under the Zadroga Act are contingent upon their possession of "proof of presence" at the WTC site[26], and workers who have no proof or who cannot find it may be denied legislated benefits.

Ongoing research has demonstrated the toll of the WTC disaster on identified vulnerable subgroups. Debchoudhury *et al.* (2011) have shown that WTC volunteer responders without formal affiliation with a rescue organization had a higher rate of WTC-related accidents, physical illness and mental illness than affiliated responders[27]. As more than half of the volunteers in the study started working during the chaos of the first two days, they likely had little training in safe work practices. That lack of training had consequences for the respiratory health of these volunteers and other responders. Antao *et al.* (2011) have demonstrated an association of the reported use of respiratory protection by WTC responders with decreased reported symptoms. Training in respiratory protection was associated in turn with use of the equipment[28].

Reports from Fukushima also demonstrate how vulnerable populations suffer disproportionately. Elderly and disabled patients demonstrated tragic vulnerability after their evacuation out of the path of the plume. Nomura *et al.* (2013) have reported that the relative mortality risk for nursing home residents doubled after they were evacuated from Fukushima, a stark reminder of the risk of this very basic response to catastrophe[29].

An interesting report from Fukushima illustrates how improper monitoring of workers' exposure can also increase the vulnerability of a worker population. Yokogawa *et al.* (2011) surveyed municipal offices in the designated radiation zones and evaluated the measures undertaken to monitor employees' occupational radiation exposure. These municipalities had approximately 34,000 employees, who performed evacuation and temporary return of residents, body recovery and debris clean-up. The study found that the municipalities had suboptimal administrative measures for radiation protection compared to the other public institutions, including those measures for monitoring internal and external radiation exposure[30]. Inadequate monitoring would place these workers at risk for exposure to dangerous levels of radiation. Optimal monitoring must be extended to all at risk employees to protect them from excessive exposure.

Responsiveness to the Ongoing Mental Health Consequences of the Disaster

A number of researchers documented the mental health impact of the WTC attacks[31–33]. Among WTC responders in the screening program, Stellman *et al.* (2008) reported that 11.1% met criteria for probable PTSD, 8.8% met criteria for probable depression, 5% for probable panic disorder and 62% for substantial stress reaction. PTSD was significantly associated with loss of family members and friends; disruption of family, work and social life and higher rates of behavioral symptoms in children of workers[5].

A recent study shows that these rates of illness do not remain stagnant but may increase over time. Reporting from the Registry questionnaires, Bowler *et al.* (2012) found an increased prevalence of PTSD among police officers at 5–6 yr following 9/11, compared to 1–2 yr post-event. Increased PCL symptom scores were associated with witnessing more traumatic events on 9/11, with less social integration, having lost their job after 9/11 and be-

ing disabled[34]. Individuals with lower scores on the PCL may be very troubled as well. Pietrzak's study of police officers, who were monitored by the Mount Sinai WTC Consortium, found that subsyndromal PTSD has a highly significant impact on mental health status. Rates of comorbid conditions (depression, panic disorder, alcohol use problems, somatic symptoms and functional difficulties) were highest among police with full PTSD, but were also elevated among police with subsyndromal PTSD. Police with full and subsyndromal PTSD were both significantly more likely than controls to report needing mental health care[35].

While the need for care is substantial and possibly increasing in the WTC- exposed population, information on the current overall mental health status of this population is sparse and decidedly mixed. Brackbill *et al.* (2013) evaluated the subjective unmet health care needs (UMHCN) reported by the Registry population in 2006–2007, defined as a participant's report of not receiving needed mental health care or counseling in the preceding 12 months. UMHCN were reported by 4.2% of those surveyed and were significantly associated with poor mental health quality of life (greater than 14 poor mental health days in the last 30 d), low social support and high 9/11 exposure. Individuals with symptoms of PTSD or serious psychological distress were significantly more likely to report UMHCN and poor mental health quality of life, and to be among those highly exposed at 9/11. Approximately 10% of the population reported both mental health symptoms and a mental health diagnosis: 63% of these individuals reported poor mental health quality of life. 8% of the overall population reported symptoms but had not been diagnosed. 40% of this group reported poor mental health quality of life. This latter group had a rate of mental health service utilization closer to that of asymptomatic persons[36], possibly because of barriers to accessing care.

Prior studies have confirmed that patients in the U.S. delay seeking care for mental illness[37]. Reasons cited for this delay in the National Comorbidity survey included low perceived need for treatment, structural barriers to care such as inconvenience and lack of financial means to pay, and attitudinal barriers such as the mental health stigma and the desire to "handle it on my own"[38].

When Stuber *et al.* (2006) surveyed NYC metro-area residents six to eight months after 9/11, 60% of respondents with probable PTSD or depression interviewed had not sought help from a mental health professional after the attacks despite the fact that most of these respondents reported diminished functioning[31]. Stuber's respondents cited similar barriers to those noted in the National Comorbidity survey.

From 2002–2004 WTC responders and community members had the benefit of Project Liberty[7], a government-funded program designed to overcome barriers such as the cost and inconvenience of accessing mental health care and the stigma of mental illness. It may have had some success in reducing these barriers. Project Liberty funds paid for short-term interventions for individuals and groups experiencing psychological sequelae of the WTC disaster from 2002–2004. It included a media campaign to raise public awareness of disaster distress and to destigmatize the available free counseling services ("Even Heroes Need to Talk" was one campaign slogan). Messaging alerted the public to counseling and referral services through 1–800-LIFENET, a preexisting toll-free, 24-h, multilingual mental health hotline. The campaign conveyed that post-disaster stress symptoms appear not only immediately after a disaster but many months later. By the one-year anniversary of the attacks, over 50% of New Yorkers surveyed reported knowing about Project Liberty, and 33% reported that they had called or were considering calling LIFENET. There was broad awareness of the program among responders and community members[39].

Yet despite this intervention, extrapolation of Brackbill's (2013) findings to the WTC-exposed community population of 400,000 suggests that tens of thousands of those individuals may be experiencing poor mental health quality of life, many with undiagnosed symptoms caused by the WTC disaster. Even with vigorous public health efforts in treatment and education, the challenges of addressing the mental health impact of the 9/11 disaster in the WTC-exposed population remain formidable.

Recognizing these difficulties, Welch *et al.* (2012) assembled focus groups at the WTC Registry to examine barriers to accessing free WTC Health Program services. The groups focused on specific issues such as stigmatization, WTC Program inaccessibility, patients' unfamiliarity with 9/11-related health problems and services, and lack of referrals to WTC Health Program services from their primary health care providers[40].

In response to this information, staff members at WTC Registry have been trained to educate potential participants about the connection between the WTC disaster and their symptoms; to reduce stigmatization by normalizing enrollees' feelings about their post-9/11 mental health symptoms and health care; and to customize outreach activities describing Program services directly to population subgroups. The WTC Registry has also developed

methods to directly engage primary care providers in the WTC Health Program referral process.

While addressing barriers to health services, this study demonstrates another critical function of disaster health programs: to elicit direct feedback from client groups and to promptly and visibly respond to it. Such steps may reduce barriers to care, but the mental health system must still be robust enough and the home communities resilient enough to respond to the needs of disaster patients. A significant but remediable limitation of mental health systems may be the inadequate training of mental health practitioners in the care of trauma patients[39].

Studies of the Chernobyl disaster by Bromet (2011) and others have clearly documented the long-term mental health problems that have afflicted radiation-exposed populations, including depression, PTSD and poor self-rated health[41]. After the Fukushima nuclear accident, mental health professionals moved quickly to assess workers' health status. Shigemura *et al.* (2012) examined the psychological status of 1,495 Fukushima nuclear power workers 2 to 3 months after the earthquake. The study included workers from the severely damaged Daiichi plant and the nearby Daini plant, which had also sustained damage but remained intact. 47% of Daiichi workers showed high levels of general psychological distress, and 30% had significant PTSD symptoms, versus 37% and 19% respectively at Daini. Slurs and discrimination directed at workers because of their employment at the plant were significantly associated with symptoms. Psychological distress was also significantly associated with tsunami evacuation and major property loss and PTSD symptoms with preexisting illness and major property loss[42]. Other researchers have documented the mental health effects of the Fukushima nuclear plant accident on non-nuclear workers. For example, Matsuoka *et al.* (2012) found a strong association of psychological distress with concern about radiation exposure among a population of disaster medical personnel[43]. These striking findings argue for close mental health follow up and treatment of exposed workers[41].

The Mental Health and Lifestyle component of the Fukushima Health Management Survey targets 200,000 evacuees. It measures general psychological distress in adults through the K6 and PTSD symptoms though the PCL. Results of the first 88, 000 questionnaires showed that approximately 5% of adults, and a similar percentage of children, needed immediate support based on questionnaire scoring[18]. The support offered by this survey was telephone counseling by mental health professionals with referral to physicians if indicated.

An updated news report in Nature indicates that increased psychological distress is now being reported by 15% of survey respondents and that 20% have probable PTSD—" a rate similar to that in first responders to the attacks of 11 September 2001 in the United States"[44]. The report expresses concerns about the availability of treatment and continued funding.

Accessible and appropriately skilled mental health care is critical for this exposed population. If Brackbill's (2013) findings are at all applicable to the Fukushima population of two million persons, there may be hundreds of thousands of individuals in addition to the displaced evacuees who are experiencing poor quality of life due to this disaster.

Promotion of Accountability and Transparency in Public Health Response

The Zadroga Act created multiple WTCHP Clinical Centers of Excellence for the monitoring and medical care of responders, a treatment program for exposed members of the community (Survivors' Program), and three separate Data Centers to collect clinical information, to publish surveillance-level reports about the clinical data, and to support research. These Centers are located in independent, academic medical institutions, with the exception of the NYC Fire Department center, which has strong links to two academic medical centers[8, 9]. In addition, the government funded a WTC Registry, housed within the NYC Department of Health and Mental Hygiene, to survey a sample of the WTC Population with repeated "waves" of epidemiologic questionnaires[6]. An Executive Steering Committee, in which government, Clinical Center, Data Center, labor and community representatives participate, provides overall coordination and Program guidance. The Steering Committee and its stakeholders directly influence Program function and policy and vigorously represent the needs of their constituents. The direct feedback from the responder community at Steering Committee meetings increases the accountability and responsiveness of the Clinical Center health care providers.

As a consequence of the involvement of multiple academic medical centers, different groups of independent researchers examine the data derived from patient examinations. These groups have published independent research on health issues of concern to WTC patients such as cancer risks[45–47]. In their cancer studies, each group found somewhat different results, ranging from moder-

ately elevated to borderline to non-significant elevations of cancer rates at approximately 7 yr after 9/11. While it may seem redundant, this independent pursuit of research by multiple groups increases the confidence of patients and responders in its validity.

In 2012 a government WTC scientific advisory committee held a series of hearings to determine if certain cancers should be designated as causally related to WTC exposure. This designation would open the way to full government funding of cancer treatment for eligible WTC responders and survivors, a benefit that would spare its recipients from the potentially ruinous costs of cancer treatment. The committee reviewed evidence linking cancers to environmental and occupational exposures and found that such evidence supported a possible relationship of cancer to exposure at the WTC disaster. After accepting comments on the report, the government designated a number of the cancers that may be considered to be WTC-related and published its decisions and rationales[48].

This process did not satisfy all parties, but its openness, generosity and transparency reassured many responders that WTCHP benefits would be awarded on a fair and reasonable basis.

The authors' experience in developing the WTCHP leads us to recommend the greatest possible transparency in any public health effort related to the Fukushima nuclear accident. While the geography of the Great East Japan earthquake disaster may render the involvement of multiple academic clinical centers in patient evaluation impossible, independent data analysis by independent academic centers may increase public confidence in any results. Any considerations regarding government monitoring and treatment of the exposed workers or the Fukushima population, and any discussion of benefits or compensation for damages due to this catastrophe should be open to the public with ample opportunity for stakeholder participation.

In conclusion, this brief recounting demonstrates that the successes and failures of the public health response to 9/11 have important implications and lessons for responses to Fukushima and other disasters. Public health authorities must be prepared to address the ongoing impact of both acute and chronic exposures on the affected populations and their magnified effect on vulnerable subpopulations. The public health response must include adequate mental health resources to meet the needs of the affected population. And finally, the authors urge public health agencies to adopt responsive, transparent disaster management processes which encourage active community participation.

References

1) Landrigan PJ, Lioy PJ, Thurston G, Berkowitz G, Chen LC, Chillrud SN, Gavett SH, Georgopoulos PG, Geyh AS, Levin S, Perera F, Rappaport SM, Small C (2004) Health and environmental consequences of the world trade center disaster. Environ Health Perspect **112**, 731–9.
2) Wisnivesky JP, Teitelbaum SL, Todd AC, Boffetta P, Crane M, Crowley L, de la Hoz RE, Dellenbaugh C, Harrison D, Herbert R, Kim H, Jeon Y, Kaplan J, Katz C, Levin S, Luft B, Markowitz S, Moline JM, Ozbay F, Pietrzak RH, Shapiro M, Sharma V, Skloot G, Southwick S, Stevenson LA, Udasin I, Wallenstein S, Landrigan PJ (2011) Persistence of multiple illnesses in World Trade Center rescue and recovery workers: a cohort study. Lancet **378**, 888–97.
3) Caplan-Shaw CE, Yee H, Rogers L, Abraham JL, Parsia SS, Naidich DP, Borczuk A, Moreira A, Shiau MC, Ko JP, Brusca-Augello G, Berger KI, Goldring RM, Reibman J (2011) Lung pathologic findings in a local residential and working community exposed to World Trade Center dust, gas, and fumes. J Occup Environ Med **53**, 981–91.
4) Soo J, Webber MP, Hall CB, Cohen HW, Schwartz TM, Kelly KJ, Prezant DJ (2012) Pulmonary function predicting confirmed recovery from lower-respiratory symptoms in World Trade Center-exposed firefighters, 2001 to 2010. Chest **142**, 1244–50.
5) Stellman JM, Smith RP, Katz CL, Sharma V, Charney DS, Herbert R, Moline J, Luft BJ, Markowitz S, Udasin I, Harrison D, Baron S, Landrigan PJ, Levin SM, Southwick S (2008) Enduring mental health morbidity and social function impairment in world trade center rescue, recovery, and cleanup workers: the psychological dimension of an environmental health disaster. Environ Health Perspect **116**, 1248–53.
6) Brackbill RM, Hadler JL, DiGrande L, Ekenga CC, Farfel MR, Friedman S, Perlman SE, Stellman SD, Walker DJ, Wu D, Yu S, Thorpe LE (2009) Asthma and posttraumatic stress symptoms 5 to 6 years following exposure to the World Trade Center terrorist attack. JAMA **302**, 502–16.
7) Felton CJ (2002) Project Liberty: a public health response to New Yorkers' mental health needs arising from the World Trade Center terrorist attacks. J Urban Health **79**, 429–33.
8) Herbert R, Moline J, Skloot G, Metzger K, Baron S, Luft B, Markowitz S, Udasin I, Harrison D, Stein D, Todd A, Enright P, Stellman JM, Landrigan PJ, Levin SM (2006) The World Trade Center disaster and the health of workers: five-year assessment of a unique medical screening program. Environ Health Perspect **114**, 1853–8.
9) Zadroga J (2011) 9/11 Health and Compensation Act of 2010. Pub **L**, 111–347.
10) Prezant DJ, Weiden M, Banauch GI, McGuinness G, Rom WN, Aldrich TK, Kelly KJ (2002) Cough and bronchial responsiveness in firefighters at the World Trade Center site. N Engl J Med **347**, 806–15.
11) Banauch GI, Alleyne D, Sanchez R, Olender K, Cohen

HW, Weiden M, Kelly KJ, Prezant DJ (2003) Persistent hyperreactivity and reactive airway dysfunction in firefighters at the World Trade Center. Am J Respir Crit Care Med **168**, 54–62.
12) Chen LC, Thurston G (2002) World Trade Center cough. Lancet **360** (Suppl), s37–8.
13) Soffritti M, Falcioni L, Bua L, Tibaldi E, Manservigi M, Belpoggi F (2013) Potential carcinogenic effects of world trade center dust after intratracheal instillation to Sprague-Dawley rats: first observation. Am J Ind Med **56**, 155–62.
14) Akiba S, Tokonami S, Hosoda M (2013) Summary of discussions at the symposium focusing on problems resulting from the nuclear accident at the Fukushima Daiichi nuclear power plant. J Radiol Prot **33**, E1–7.
15) United Nations Scientific Committee on the Effect of Atomic Radiation (2008) Sources and effects of ionizing radiation. Report to the General Assembly. Annex J: Exposures and Effects of the Chernobyl Accident, Volume II. United Nations, New York.
16) Lin S, Jones R, Reibman J, Bowers J, Fitzgerald EF, Hwang SA (2007) Reported respiratory symptoms and adverse home conditions after 9/11 among residents living near the World Trade Center. J Asthma **44**, 325–32.
17) Maslow CB, Friedman SM, Pillai PS, Reibman J, Berger KI, Goldring R, Stellman SD, Farfel M (2012) Chronic and acute exposures to the world trade center disaster and lower respiratory symptoms: area residents and workers. Am J Public Health **102**, 1186–94.
18) Yasumura S, Hosoya M, Yamashita S, Kamiya K, Abe M, Akashi M, Kodama K, Ozasa K & Fukushima Health Management Survey G (2012) Study protocol for the Fukushima health management survey. J Epidemiol **22**, 375–83.
19) World Health Organization (2012) Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami. http://whqlibdoc.who.int/publications/2012/9789241503662_eng.pdf. Accessed June 12, 2013.
20) World Health Organization (2013) Health risks assessment from the nuclear accident after the 2011 Great East Japan Earthquake Tsunami, based on a preliminary dose estimation. http://www.who.int/ionizing_radiation/pub_meet/fukushima_risk_assessment_2013/en/index.html. Accessed June 13, 2013.
21) Tabuchi H (2013) In Japan, a Painfully Slow Sweep. New York Times. January 7, 2013, New York.
22) Gonzalez J (2002) Fallout: The Hidden Environmental Consequences 9/11. 9/11: One Year Later. AlterNet. http://www.alternet.org.
23) Mori K, Tateishi S, Hiraoka K, Kubo T, Okazaki R, Suzuki K, Kobayashi Y, Kohno K (2013) How Occupational Health can contribute in a disaster and what we should prepare for the future–lessons learned through support activities of a medical school at the Fukushima Daiichi Nuclear Power Plant in Summer 2011. J Occup Health **55**, 6–10.
24) Savitz DA, Oxman RT, Metzger KB, Wallenstein S, Stein D, Moline JM, Herbert R (2008) Epidemiologic research on man-made disasters: strategies and implications of cohort definition for World Trade Center worker and volunteer surveillance program. Mt Sinai J Med **75**, 77–87.
25) Murphy J, Brackbill RM, Thalji L, Dolan M, Pulliam P, Walker DJ (2007) Measuring and maximizing coverage in the World Trade Center Health Registry. Stat Med **26**, 1688–701.
26) Center for Disease Control World Trade Center Program. http://www.cdc.gov/wtc/. Accessed June 11, 2013.
27) Debchoudhury I, Welch AE, Fairclough MA, Cone JE, Brackbill RM, Stellman SD, Farfel MR (2011) Comparison of health outcomes among affiliated and lay disaster volunteers enrolled in the World Trade Center Health Registry. Prev Med **53**, 359–63.
28) Antao VC, Pallos LL, Shim YK, Sapp JH 2nd, Brackbill RM, Cone JE, Stellman SD, Farfel MR (2011) Respiratory protective equipment, mask use, and respiratory outcomes among World Trade Center rescue and recovery workers. Am J Ind Med **54**, 897–905.
29) Nomura S, Gilmour S, Tsubokura M, Yoneoka D, Sugimoto A, Oikawa T, Kami M, Shibuya K (2013) Mortality risk amongst nursing home residents evacuated after the Fukushima nuclear accident: a retrospective cohort study. PLoS ONE **8**, e60192.
30) Yokogawa T, Takahashi K, Nagata T, Mori K, Horie S (2012) Suboptimal radiation protection for municipal employees operating in the Fukushima designated zone. Occup Environ Med **69**, 453–4.
31) Stuber J, Galea S, Boscarino JA, Schlesinger M (2006) Was there unmet mental health need after the September 11, 2001 terrorist attacks? Soc Psychiatry Psychiatr Epidemiol **41**, 230–40.
32) Schuster MA, Stein BD, Jaycox L, Collins RL, Marshall GN, Elliott MN, Zhou AJ, Kanouse DE, Morrison JL, Berry SH (2001) A national survey of stress reactions after the September 11, 2001, terrorist attacks. N Engl J Med **345**, 1507–12.
33) Galea S, Ahern J, Resnick H, Kilpatrick D, Bucuvalas M, Gold J, Vlahov D (2002) Psychological sequelae of the September 11 terrorist attacks in New York City. N Engl J Med **346**, 982–7.
34) Bowler RM, Harris M, Li J, Gocheva V, Stellman SD, Wilson K, Alper H, Schwarzer R, Cone JE (2012) Longitudinal mental health impact among police responders to the 9/11 terrorist attack. Am J Ind Med **55**, 297–312.
35) Pietrzak RH, Schechter CB, Bromet EJ, Katz CL, Reissman DB, Ozbay F, Sharma V, Crane M, Harrison D, Herbert R, Levin SM, Luft BJ, Moline JM, Stellman JM, Udasin IG, Landrigan PJ, Southwick SM (2012) The burden of full and subsyndromal posttraumatic stress disorder among police involved in the World Trade Center rescue and recovery effort. J Psychiatr Res **46**, 835–42.
36) Brackbill RM, Stellman SD, Perlman SE, Walker DJ, Farfel

MR (2013) Mental health of those directly exposed to the World Trade Center disaster: unmet mental health care need, mental health treatment service use, and quality of life. Soc Sci Med **81**, 110–4.
37) Wang PS, Berglund P, Olfson M, Pincus HA, Wells KB, Kessler RC (2005) Failure and delay in initial treatment contact after first onset of mental disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry **62**, 603–13.
38) Mojtabai R, Olfson M, Sampson NA, Jin R, Druss B, Wang PS, Wells KB, Pincus HA, Kessler RC (2011) Barriers to mental health treatment: results from the National Comorbidity Survey Replication. Psychol Med **41**, 1751–61.
39) Sederer LI, Lanzara CB, Essock SM, Donahue SA, Stone JL, Galea S (2011) Lessons learned from the New York State mental health response to the September 11, 2001, attacks. Psychiatr Serv **62**, 1085–9.
40) Welch AE, Caramanica K, Debchoudhury I, Pulizzi A, Farfel MR, Stellman SD, Cone JE (2012) A qualitative examination of health and health care utilization after the September 11th terror attacks among World Trade Center Health Registry enrollees. BMC Public Health **12**, 721.
41) Bromet EJ, Havenaar JM, Guey LT (2011) A 25 year retrospective review of the psychological consequences of the Chernobyl accident. Clin Oncol (R Coll Radiol) **23**, 297–305.
42) Shigemura J, Tanigawa T, Saito I, Nomura S (2012) Psychological distress in workers at the Fukushima nuclear power plants. JAMA **308**, 667–9.
43) Matsuoka Y, Nishi D, Nakaya N, Sone T, Noguchi H, Hamazaki K, Hamazaki T, Koido Y (2012) Concern over radiation exposure and psychological distress among rescue workers following the Great East Japan Earthquake. BMC Public Health **12**, 249.
44) Brumfiel G (2013) Fukushima: Fallout of fear. Nature **493**, 290–3.
45) Zeig-Owens R, Webber MP, Hall CB, Schwartz T, Jaber N, Weakley J, Rohan TE, Cohen HW, Derman O, Aldrich TK, Kelly K, Prezant DJ (2011) Early assessment of cancer outcomes in New York City firefighters after the 9/11 attacks: an observational cohort study. Lancet **378**, 898–905.
46) Solan S, Wallenstein S, Shapiro M, Teitelbaum SL, Stevenson L, Kochman A, Kaplan J, Dellenbaugh C, Kahn A, Biro FN, Crane M, Crowley L, Gabrilove J, Gonsalves L, Harrison D, Herbert R, Luft B, Markowitz SB, Moline J, Niu X, Sacks H, Shukla G, Udasin I, Lucchini RG, Boffetta P, Landrigan PJ (2013) Cancer incidence in world trade center rescue and recovery workers, 2001–2008. Environ Health Perspect **121**, 699–704.
47) Li J, Cone JE, Kahn AR, Brackbill RM, Farfel MR, Greene CM, Hadler JL, Stayner LT, Stellman SD (2012) Association between World Trade Center exposure and excess cancer risk. JAMA **308**, 2479–88.
48) Health and Human Services Department, the US Government (2012) World Trade Center Health Program; addition of certain types of cancer to the list of WTC-related health conditions. Final rule. Fed Regist **77**, 56138–68.