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## **NIOSH HEALTH HAZARD EVALUATION REPORT**

**HETA #2002-0095-2955  
Metropolitan Transit Authority of New York City  
New York City, New York**

**March 2005**

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**DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health**

The NIOSH logo, consisting of the word "NIOSH" in a bold, italicized, sans-serif font. The "N" is significantly larger and more prominent than the other letters.

## PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

## ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Loren Tapp of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Richard Driscoll, Jenise Brassell, Lynette Hartle, Larry Mazzuckelli, and Debby Gibson. Desktop publishing was performed by Elaine Moore. Editorial assistance provided by Ellen Galloway.

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## Highlights of the NIOSH Health Hazard Evaluation

### Evaluation of WTC-related exposures and health outcomes of MTA-NYCT employees working in various locations in NYC, including the WTC area, on the morning of September 11, 2001

In April and May, 2002, NIOSH investigators conducted a health hazard evaluation of the Metropolitan Transit Authority, New York City Transit (MTA-NYCT) to assess the impact of the WTC disaster on MTA-NYCT employee mental and physical health.

#### What NIOSH Did

- We created a questionnaire to assess the mental and physical health symptoms of NYC transit employees.
- We used qualitative checklists to evaluate underground subway stations, bus depots, trains, and train yards representing typical worksites of MTA-NYCT workers to determine whether environment factors were similar between the exposed and comparison workers groups.
- We administered questionnaires to 269 MTA-NYCT employees.
- We analyzed questionnaire data to determine the prevalence of mental and physical health symptoms in MTA-NYCT worker and to evaluate the relationships between these symptoms and exposures related to the WTC event.

#### What NIOSH Found

- Workers in the dust cloud at the time of the WTC collapse had significantly higher risk of persistent lower respiratory and mucous membrane symptoms and depressive and Post Traumatic Stress Disorder (PTSD) symptoms 7 1/2 months later compared to those not exposed to the dust cloud.

- Most symptomatic workers exposed to the dust cloud reported that their physical symptoms had improved, but 10% to 25% said they continued to experience persistent mucous membrane and/or respiratory symptoms 7 1/2 months later.

#### What Metropolitan Transit Authority of New York City, New York Managers Can Do

- Provide clinical follow up for physical and psychological health conditions for public transportation workers subsequent to a catastrophic event.
- Strengthen the existing Health and Safety Committee.
- Prepare a readiness plan for future disasters.

#### What the Metropolitan Transit Authority of New York City, New York Employees Can Do

- Continue participating in the existing government-funded medical screening, surveillance, and follow-up programs offered to WTC workers.
- Report potential work-related physical and psychological conditions to appropriate union and management personnel.



**What To Do For More Information:**  
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #HETA #2002-0095-2955



**Health Hazard Evaluation Report 2002-0095-2955  
Metropolitan Transit Authority of New York City  
New York City, New York  
March 2005**

**Loren Tapp  
Ken Wallingford  
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## **SUMMARY**

In January 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) of the Metropolitan Transit Authority, New York City Transit (MTA-NYCT) from representatives of the Transport Workers Union (TWU), Local 100. The Amalgamated Transit Union (ATU), Local 726, later asked to be included in this HHE. The HHE request cited concerns about respiratory and mental health symptoms among MTA employees subsequent to the September 11 World Trade Center (WTC) attack. Employees believed exposure to the World Trade Center (WTC) attacks caused these symptoms.

In response, NIOSH investigators conducted meetings between MTA-NYCT management and union representatives to prepare for a study to evaluate worker concerns. The initial site visit included an opening conference, a walk-through evaluation of three subway train stations near the WTC, and a closing conference. During the week of April 30, 2002, NIOSH investigators administered questionnaires to 269 MTA employees. This self-administered questionnaire contained questions about demographics, past medical history, smoking history, work duties and location, WTC-related activities performed, and symptoms occurring on and after September 11.

Questionnaire data analysis showed that workers in the dust cloud at the time of the WTC collapse had significantly higher risk of persistent lower respiratory symptoms (OR=9.85; 95% CI: 2.24, 58.93), persistent mucous membrane symptoms (OR=4.91; 95% CI: 1.53, 16.22), depressive symptoms (OR=2.48; 95% CI: 1.12, 5.51), and Post Traumatic Stress Disorder (PTSD) symptoms (OR=2.91; 95% CI: 1.003, 8.16) compared to those not exposed to the dust cloud. Based on these data, we conclude that clinical follow up for physical and psychological health conditions should be provided for affected public transportation workers subsequent to a catastrophic event.

NIOSH sent an interim letter including preliminary results to MTA and union officials on December 17, 2002. This report describes our final results, analyses, conclusions, and recommendations.

NIOSH investigators determined that NYC transit workers exposed to the dust cloud at the time of the September 11, 2001, WTC collapse had significantly higher risk of persistent lower respiratory and mucous membrane symptoms, and depressive and PTSD symptoms 7½ months later compared to those not exposed to the dust cloud. Clinical follow up of affected transit workers for physical and psychological conditions should be continued through existing federal programs. Worker participation in these programs should be encouraged by MTA management.

**KEYWORDS:** 4111 Local and Suburban Transit workers, bus, subway, terrorist attacks, catastrophe, dust, depression, PTSD, respiratory, mucous membrane

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## INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) of the Metropolitan Transit Authority, New York City Transit (MTA-NYCT) in January 2002 from representatives of the Transport Workers Union (TWU), Local 100. The Amalgamated Transit Union (ATU), Local 726, later requested to be included in this HHE. The HHE request reported concerns of respiratory symptoms and mental health symptoms among MTA employees felt to be due to exposure to the World Trade Center (WTC) attacks on September 11, 2001.

In response, NIOSH investigators conducted meetings with MTA-NYCT management and union representatives to prepare for a study to evaluate worker concerns. The initial site visit included an opening conference, a walk-through evaluation of three subway stations in the area of the WTC, and a closing conference. During the week of April 30, 2002, NIOSH investigators administered questionnaires to MTA employees. An interim letter including preliminary results of NIOSH findings was sent to MTA and union officials on December 17, 2002. This report describes our final results, analyses, conclusions, and recommendations.

## BACKGROUND

On September 11, 2001, approximately 600 to 800 MTA-NYCT bus and subway workers were working in areas adjacent to the WTC towers. When the WTC towers collapsed, five subway stations and adjoining train tunnels were immediately closed due to structural damage and resulting instability. Buses near the WTC were evacuated and then, in some cases, crushed by falling debris. Transportation services provided by approximately 4,500 buses along 200 bus routes and 700 trains through 470 subway stations stopped for several hours, then resumed to undamaged areas later that day. There were no transit employee fatalities, but approximately 115 injuries were attributable to the collapse, including 49 workers with injuries from contact

with chemicals and 40 with smoke inhalation. During the following days, an estimated 2,300 MTA-NYCT workers participated in rescue and recovery activities at Ground Zero and provided transportation services to and from the area.

After the WTC disaster, unions representing the MTA-NYCT employees received reports from members concerned about health effects from exposure to airborne substances originating from the collapse of the WTC buildings. Adding to employee concerns were scattered reports of MTA-NYCT employees who had developed symptoms they attributed to the WTC collapse. Several employees reported breathing problems and throat irritation when returning to work after the WTC disaster, and some also experienced symptoms suggestive of depression and anxiety. In January 2002, the unions contacted the Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (CDC/NIOSH) to request a health hazard evaluation (HHE) to address these health concerns.

In response to this HHE request, NIOSH investigators conducted a study of the MTA-NYCT workers employed in the stations, trains, and buses of NYC to document the extent of physical and mental health symptoms among these workers. This study focused on employees who provided routine transportation services on the morning of the disaster and then were exposed to the physical and psychological trauma of the WTC attacks. In this report, we describe the prevalence of mental and physical health symptoms reported by MTA-NYCT workers 7½ months after the WTC disaster and evaluate the relationships between these symptoms and various exposures related to the WTC event. This study was done in parallel with similar NIOSH HHE studies requested by other groups of employees working near the WTC.<sup>1</sup>

## METHODS

### *Study Design*

This cross-sectional study included MTA-NYCT employees working in various locations in NYC,

including the WTC area, on the morning of September 11. WTC-related exposures and health outcomes were determined by questionnaire responses. This study took place the week of April 30, 2002.

## **Study Population**

The study population included two groups. The first group, defined a priori as exposed, was randomly selected from the roughly 800 full-time MTA-NYCT employees who were working the subway stations, trains, or bus routes between 8:30 A.M. and 11:00 A.M. on September 11, 2001, **and** who were either working in the area of Manhattan south of Canal Street or had a job requiring them to pass through the area. The second group, defined a priori as unexposed, consisted of MTA-NYCT employees who worked outside of the Lower Manhattan area (north of Canal Street or outside of the borough of Manhattan) in similar work environments (e.g., all station workers who worked in underground stations) on September 11 during those same hours. Only workers present at the study sites on the days of the surveys were invited to participate. Due to the logistical challenges of visiting over 100 worksites, those worksites with the greatest number of potential participants were chosen. A joint union/management letter encouraging participation was sent to each eligible worker prior to the survey.

## **Questionnaire**

A self-administered questionnaire was used to obtain information on demographics, past medical history, smoking history, work duties and location, WTC-related activities performed, and symptoms occurring on and after September 11. Participants were asked to complete the survey before or after their shift; those unable to do so received a stamped, pre-addressed envelope to return the questionnaires directly to CDC/NIOSH. MTA-NYCT management compensated each eligible study participant who returned a survey, whether completed or not, for 30 minutes of pay (participation in the study was not required for compensation).

## **Statistical Analysis**

When we began the data analysis, we learned that our a priori selection of the exposed and unexposed study groups did not accurately classify study participants with regard to their actual, direct exposure to WTC events. To reduce misclassification, we opted to disregard the original group designations and to focus analyses on questionnaire responses to specific exposures. The correlation between being “in the dust cloud” and “in the tower zone” (i.e., Manhattan south of 14<sup>th</sup> street) was moderate (correlation coefficient = 0.58); 83% of those in the dust cloud were also in the tower zone; however, the tower zone encompassed areas with little chance of being in the dust cloud. We chose “in the dust cloud” as our major exposure variable for the day of the disaster. We analyzed physical symptoms in relation to two exposure variables (“in the dust cloud” and “participating in Ground Zero activities”) and mental health symptoms in relation to four exposure variables (“knowing a victim” and “witnessing events on September 11”, in addition to the two previously mentioned). Reference groups for each exposure variable included workers without that specific exposure. Potential confounding factors, such as age, gender, race, Hispanic ethnicity, prior history of physical or mental health diagnoses, and social contact, were taken into consideration where appropriate. Because prior studies have found that persons diagnosed with depression are more likely to report physical symptoms and seek medical care for reasons other than depression,<sup>2,3</sup> we also analyzed the physical symptom outcomes considering depressive symptoms as a confounding factor.

To examine the relationships between our outcomes and exposures, we first constructed 2×2 tables and calculated odds ratios (OR) along with their corresponding 95% confidence intervals (95% CI). Where the data were sufficient (i.e., the expected counts of the 2×2 table cells equaled five or greater), we reported OR and 95% CI based on asymptotic results. Exact results were reported where the data may not have been sufficient. Stratified analyses controlled for extraneous dichotomous risk factors and logistic regression adjusted for



extraneous continuous risk factors. Due to the small number of cases for each of our outcomes, we were limited to controlling for one factor at a time. Results were considered statistically significant when the 95% CI excluded 1. Statistical software used for the analyses included SAS version 8.02, SAS Institute, Cary, NC, and StatXact-5, Cytel Software Corporation, Cambridge, MA.

## **Work Environment Assessment**

MTA-NYCT work environments, including subway stations, bus depots, trains, and train yards, were evaluated by NIOSH investigators using qualitative checklists to determine whether environmental factors were similar between the original exposed and comparison worker groups. The checklists included factors such as type of ventilation and occupational exposures to chemical or physical hazards.

## **EVALUATION CRITERIA**

### **Health Outcomes**

The Center for Epidemiologic Study-Depression scale (CES-D)<sup>4</sup> was used to assess symptoms associated with depression, and the Veterans Administration Post Traumatic Stress Disorder (PTSD) checklist<sup>5</sup> was used to assess the prevalence of post traumatic stress symptoms among participants. The nature of the WTC disaster and the likelihood that respondents might report a high number of acute symptoms of depression found on the depression scale led us to raise the score needed to define major depression to 22 or higher out of a possible 60 points on the CES-D, rather than the score (16 or higher) generally used as the standard for major depression.<sup>4, 6, 7</sup>

Information was also obtained on physical symptoms (i.e., upper and lower respiratory irritation, mucous membrane irritation, and gastrointestinal symptoms). Individual symptoms were assessed by a positive or negative response to the question, “Have you had any of the following symptoms after the WTC disaster on September 11?” Symptom

clusters were also assessed. Mucous membrane symptoms were defined as having both eye irritation **and** nose or throat irritation. Lower respiratory symptoms were defined as having either wheezing or cough without phlegm **and** either shortness of breath or chest tightness. We defined persistent symptoms as either: (1) symptoms that existed before September 11 but worsened since September 11 or (2) new onset symptoms since September 11 that had not improved. “Persistent mucous membrane irritation” was defined as having both persistent eye irritation **and** persistent nose or throat irritation. “Persistent lower respiratory irritation” was defined as having either persistent wheezing or persistent cough without phlegm **and** persistent shortness of breath or persistent chest tightness.

### **Exposure Variables**

Several indicators of WTC exposure were included in the questionnaire. Workers were classified as “in the dust cloud” if they answered yes to either “I was in a dust cloud so thick I could not see in front of me” or “I was in a dust cloud, but it did not prevent me from seeing where I was going.” Workers “in the tower zone” included those who indicated that they were in the area of Manhattan south of 14<sup>th</sup> Street when the WTC towers collapsed. Workers “participating in Ground Zero activities” indicated that they provided paid or volunteer services at Ground Zero during the 7 days following September 11. These services included search and rescue, food, transportation, and others. Workers “knowing a victim” answered yes to “Did you know anyone personally who was seriously injured or killed during the WTC disaster?” Workers “witnessing any events from September 11, 2001” indicated that they had personally witnessed (1) the plane(s) crashing into the WTC, (2) the collapse of the WTC tower(s), (3) individuals falling or jumping from WTC windows, (4) bodies or parts of bodies, or (5) pieces of the plane (s).

### **Other Variables**

Two variables were created to take into account an individual’s social support networks.

“Perceived support” expressed the participant’s view of supportiveness from family, co-workers, and supervisors (“high” vs. “low”). The amount of “social contact”, a continuous variable, was defined by responses to questions concerning the time spent with family members, friends, religious or non-sectarian groups, clubs, and organizations.

## RESULTS

### **Questionnaire**

We conducted surveys at approximately 30 subway stations, the Maintenance of Way (MOW) headquarters, 17 train line break rooms, and 5 bus depots. There were 381 MTA-NYCT employees at work at the selected worksites during the scheduled survey times; 27 employees were out due to illness and were not included. Of these 381 employees, 269 (71%) completed the questionnaire and 112 (29%) refused or did not respond to the survey notification.

### **Demographics**

The average age of participants was 45 years (range 25 to 65); 15% were female. Race among participants included 42% Black, 41% White, 3% Asian or Pacific Island descent, 7% other; 7% chose not to answer. Seventeen percent indicated Hispanic origin. The average number of years worked for MTA-NYCT was 14; the average number of years worked at the current job was 12. Of the 269 participants, 138 (51%) were train operators or conductors, 79 (29%) were bus operators, and 52 (19%) were station workers (26 station agents, 5 station cleaners, 15 MOW workers, and 6 structural or station maintenance workers). The percentage of study participants in each job type was similar to the percentages in the overall MTA-NYCT worker population. Among participants, 62 (24%) reported being in the dust cloud and 88 (33%) participated in Ground Zero activities. Additional demographic information relating to dust cloud exposure is given in Table 1.

### **Prevalence of physical symptoms since September 11**

Table 2 lists the prevalence of individual symptoms and defined clusters of symptoms after September 11 and prevalence of persistent symptoms by exposure to the dust cloud. The most prevalent symptoms after September 11 among workers in the dust cloud (in descending order) were eye irritation (67%), cough of any kind (62%), nose/throat irritation (59%), headache (50%), and congestion (45%). The most prevalent persistent symptoms since September 11 among those in the dust cloud (in descending order) were eye irritation (25%), congestion (22%), nose/throat irritation (20%), cough of any kind (20%), headache (18%), and shortness of breath (17%). Of dust cloud-exposed workers having at least one physical symptom, 16 (26%) reported taking time off work due to the symptom(s).

### **Persistent Lower Respiratory Symptoms by Exposure**

Workers in the dust cloud had significantly higher risk of persistent lower respiratory symptoms (OR=9.85; 95% CI: 2.24, 58.93) compared to those not exposed to the dust cloud (Table 3). Involvement in Ground Zero activities was not significantly related to increased risk of lower respiratory symptoms (OR=2.63; 95% CI: 0.64, 11.19). Controlling individually for potential confounders (age, gender, current smoking status, diagnosis of allergies prior to September 11, and diagnosis of lung disease [asthma, chronic bronchitis, emphysema, or chronic obstructive pulmonary disease] prior to September 11) did not meaningfully change the relationships between these exposure variables and persistent lower respiratory symptoms. Taking into account depressive symptoms, the associations between persistent lower respiratory symptoms and the exposure variables were also essentially unchanged.

### **Persistent Mucous Membrane Symptoms by Exposure**

Workers in the dust cloud and those involved in

Ground Zero activities had significantly higher risk of persistent mucous membrane symptoms (OR=4.91; 95% CI: 1.53, 16.22; and OR=2.88; 95% CI: 1.03, 8.02, respectively). Controlling individually for potential confounders (age, gender, current smoking status, and diagnosis of allergies prior to September 11) did not meaningfully change the relationships between these exposure variables and persistent lower respiratory symptoms. The adjusted odds ratios for the associations between persistent mucous membrane symptoms and the exposure variables, taking into account depressive symptoms, were similar to those obtained in the unadjusted analyses.

### ***Prevalence of symptoms consistent with depression and PTSD***

We documented the number of MTA-NYCT workers who reported witnessing events related to the disaster or knowing a WTC victim. Of the survey participants, 45 (17%) reported witnessing one or both planes crashing into the towers, 28 (10%) witnessed people jumping from the towers, 57 (21%) reported witnessing the collapse of one or both WTC towers, 23 (9%) witnessed plane parts amid the debris, 12 (4%) witnessed lifeless bodies or body parts, and 110 (41%) reported knowing a WTC victim. Thirty-one (12%) of transit workers reported symptoms consistent with major depression and 21 (8%) reported symptoms consistent with PTSD. Table 4 illustrates the prevalence of depressive symptoms and PTSD symptoms by our four exposure variables. Forty (16%) of 256 participants reported that they thought supportive counseling would be helpful, however, when looking at only those workers with symptoms of depression and/or PTSD, 12 of 35 (34%) felt counseling would be helpful. We were unable to evaluate the effect of pre-September 11 physician-diagnosed mental disorders on these relationships because of the low number of subjects (13) meeting the case definitions.

### ***Symptoms of Depression by Exposure***

Our analyses found that persons in the dust cloud had significantly higher risk of symptoms of depression (OR=2.48; 95% CI: 1.12, 5.51) compared to those not in the dust cloud (Table 3). We considered the effects of the following variables on the associations between exposure and symptoms of depression: gender, race, Hispanic ethnicity, having been a witness to or victim of a prior traumatic event, amount of social contact, job satisfaction, and perceived support from family, supervisors, and coworkers. Adjustment for these factors resulted in no meaningful differences in the relationship between depressive symptoms and two of the four exposure variables (being in the dust cloud and participating in Ground Zero activities). Differences emerged, however, for the exposure variables of witnessing the disaster and knowing a victim. When we controlled for reported perceived support, we found a statistically significant association between witnessing the disaster and depressive symptoms (OR=2.31; 95% CI: 1.04, 5.15). For those subjects who reported being a victim of or a witness to a prior traumatic event, the relationships between depressive symptoms and knowing a WTC victim (OR=3.75 ; CI: 1.18, 11.94) and between depressive symptoms and witnessing the disaster (OR=3.94; CI: 1.27, 12.17) were statistically significant.

### ***Symptoms of Depression by Exposure***

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in no meaningful differences in the relationship between depressive symptoms and two of the four exposure variables (being in the dust cloud and participating in Ground Zero activities). Differences emerged, however, for the exposure variables of witnessing the disaster and knowing a victim. When we controlled for reported perceived support, we found a statistically significant association between witnessing the disaster and depressive symptoms (OR=2.31; 95% CI: 1.04, 5.15). For those subjects who reported being a victim of or a witness to a prior traumatic event, the relationships between depressive symptoms and knowing a WTC victim (OR=3.75 ; CI: 1.18, 11.94) and between depressive symptoms and witnessing the disaster (OR=3.94; CI: 1.27, 12.17) were statistically significant.

### ***Symptoms of Post Traumatic Stress Disorder by Exposure***

The risk of PTSD symptoms was significantly greater among those who reported knowing a victim (OR=3.07; 95% CI: 1.20, 7.90) or being in the dust cloud (OR=2.91; 95% CI: 1.003, 8.16) (Table 3).

We evaluated the effects of the following variables on the associations between the exposure variables and symptoms of PTSD: gender, race, Hispanic ethnicity, having been a victim of or witness to a prior traumatic event, amount of social contact, and perceived support from family, supervisors, and coworkers. Adjustment for these factors resulted in no meaningful differences in the analyses involving being in the dust cloud, participating in Ground Zero activities, and witnessing the disaster. For those subjects who perceived low support from family, coworkers, and supervisors, the association between PTSD symptoms and knowing a victim was statistically significant (OR=16.41; CI: 2.14, 722.96). Among those subjects who did not perceive low support there was no association between PTSD symptoms and knowing a victim (OR=0.74; CI: 0.12, 3.66). We found that males had increased risk of PTSD symptoms when they were in the dust cloud (OR=4.07; CI: 1.02, 15.97), but females had no

such increase in risk (OR=0.98; CI: 0.13, 6.29); however, these odds ratios did not significantly differ for males and females. Table 3 shows the odds ratios for each exposure and outcome, controlling for confounders if appropriate.

### ***Prevalence of health conditions newly diagnosed by a physician***

When comparing MTA-NYCT workers exposed to the dust cloud with those not exposed, six (10%) reported being diagnosed with PTSD after September 11 compared to one (<1%) of those not in the dust cloud, four (7%) were diagnosed with depression or mood disorder compared to two (1%) of unexposed, two (5%) were diagnosed with allergies compared to three (2%) of unexposed, and one (2%) were diagnosed with asthma compared to four (2%) of unexposed. The medical conditions were reportedly diagnosed by a physician and those reporting the conditions as pre-existing (prior to September 11) were not included

### ***Work Environment Assessment***

Twenty underground subway stations representing typical worksites of MTA-NYCT workers were evaluated. Two subway train yards, one each in Manhattan and Brooklyn, and a bus depot in Staten Island were also visited. After completing the environmental assessment for these sites, it was determined that there were no fundamental differences in the work environments between workers within the same job types, regardless of the original exposure category.

## **DISCUSSION AND CONCLUSIONS**

This is the first study to document the extent of physical and mental health symptoms among NYC transportation workers following the WTC disaster. Nearly 3,000 of the 45,000 MTA-NYCT workers had direct exposures to WTC dust, smoke, and fumes, and personally experienced the events of the disaster. Hundreds

of MTA-NYCT employees worked in the subway stations and drove the buses and trains that transported people to and from the WTC towers on the morning of September 11, and over 2,300 participated in search and rescue activities or transported Ground Zero workers to and from the site after the disaster occurred.

In addition to the economic burden of search and recovery efforts, rubble removal, the loss of numerous businesses and jobs, and costly clean-up of residential and commercial property, the public health impact of the WTC attacks has been great. Studies of residents and working populations in the WTC area post-September 11 have shown an elevated risk of physical and psychological symptoms resulting from exposures to the WTC collapse.<sup>1, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18</sup> Occupational studies have found significant physical and psychological symptoms in office workers and school staff working in the vicinity of the WTC towers.<sup>1, 18</sup> Medical screening and follow-up of volunteers and workers involved in search and rescue efforts and clean-up at Ground Zero have found physical and psychological conditions related to WTC activities that have persisted up to the current time, some severe enough to prevent return to work.<sup>9, 12</sup> Our findings are consistent with these prior studies; although the number of persons identified in our survey with physician-diagnosed illness was relatively small, the impact of the WTC attacks was evident.

In this study, persistent physical and psychological symptoms reported by MTA-NYCT workers were significantly associated with WTC-related exposures. MTA-NYCT workers who were directly exposed to the dust cloud had a significant risk of persistent mucous membrane and lower respiratory symptoms and symptoms of PTSD. The majority of symptomatic workers exposed to the dust cloud had improvement of most of their physical symptoms, but 10% to 25% reported that they continued to experience persistent mucous membrane and/or respiratory symptoms 7½ months post-WTC disaster.

The persistent physical symptoms associated with exposure to the dust cloud are likely due to exposure to multiple environmental contaminants (e.g., smoke, respirable airborne particulates, and fire combustion products) from the collapse of the towers and ensuing fires. Environmental air sampling performed days after the collapse of the WTC<sup>19, 20</sup> did not find exposures above established criteria. However, because of the lack of exposure data in the first hours and days after the collapse, airborne contaminant concentrations, characteristics, and their relationship to resulting health effects remain unclear. Environmental monitoring of undisturbed, settled dust at Ground Zero documented high levels of particulate matter composed of construction material, soot, and glass fiber that was highly alkaline in character (pH > 11).<sup>21</sup> Exposure to these types of particulates would likely account for the symptoms of mucous membrane and respiratory tract irritation. Little is known about the health effects from complex exposures such as occurred as a result of the WTC collapse and subsequent fires. Studies such as the WTC Worker and Volunteer Medical Screening Program coordinated by Mt. Sinai Center for Occupational and Environmental Medicine<sup>22</sup> involving in-depth evaluations and long-term follow-up of first responders, rescue and recovery workers, clean-up workers, and others who worked at Ground Zero should provide useful information for the affected individuals and for those involved with emergency response and preparedness.

We found that 20% of transit workers in the dust cloud had symptoms consistent with major depression and those witnessing the disaster had a greater risk for symptoms of depression. The rate of major depressive disorder (using the American Psychiatric Association Diagnostic and Statistical Manual [DSM-III] criteria) in the general US population is 3% to 5%, with transportation worker depression rates falling within this range.<sup>23</sup> Although we used a different diagnostic tool, comparing our findings with these national rates suggests that the prevalence of major depression in MTA-NYCT workers exposed to the dust cloud was four to five times

greater than the rate one would expect to see in a worker population. The CES-D scale we used to identify those with symptoms of major depression may have exaggerated the number of workers with these symptoms since it is used clinically as a 20-question screening tool. In clinical practice a subsequent psychiatric interview (or the highly structured Diagnostic Interview Schedule used in the occupational depression study previously referenced) would eliminate those individuals who do not fulfill the DSM-III (now DSM-IV) criteria for major depressive disorder which was not done in this study. In addition, comparing our depressive symptom rates with that study's rates may not be appropriate since those populations had not recently experienced a major disaster. We attempted to balance these discrepancies by using a more stringent CES-D score criterion.

Of NYC transit workers with exposure to the dust cloud, 15% had symptoms consistent with PTSD, and those knowing a victim of September 11 had a higher risk for symptoms of PTSD. The prevalence of PTSD symptoms among these transit workers was nearly three times greater than that found 6 months post-September 11 in a national population outside New York City (5.8%); this latter population was categorized by a similar PTSD scale (the Impact of Events Scale-Revised). A study that evaluated survivors 6 months after the bombing of the Federal Building in Oklahoma City found that 34% met the diagnostic criteria for PTSD;<sup>24</sup> these individuals had a greater severity of psychological trauma exposure than the transit workers. Various studies of New York City residents conducted since September 11 have identified elevated prevalence of symptoms of depression and PTSD using a variety of assessment methods.<sup>13, 15, 16</sup>

Factors other than WTC-related exposures are also important to the mental health of transit workers. Social support influenced how the workers in this study were affected by the psychological trauma of the WTC disaster. Prior studies evaluating psychological symptoms and sick days in subway drivers who experienced a person jumping or falling in front of their train

show conflicting results. One study found that significantly more sick days were reported (associated with a high depression score) from 3 months to 1 year following the event than among those who did not experience such an event;<sup>25</sup> the other found that those with psychological symptoms one month post-event had a marked reduction of these symptoms 5 months later.<sup>26</sup> One might expect that these types of traumatic experiences would heighten the psychological impact of a disaster such as the attack and collapse of the WTC; on the other hand, these experiences may serve to blunt some individuals' psychological reaction to other distressing events.

It is difficult to predict the long-term effect from this disaster on mental health. Responses to extraordinary traumatic events may provoke a range of reactions, and symptoms alone are not adequate to fully diagnose medical conditions. Many of the symptoms the transit workers experienced may be normal and reversible reactions to a traumatic event. Researchers evaluating the Oklahoma City bombing found that most individuals directly involved did not develop diagnosable psychiatric illness, but the majority reported experiences such as sleep disturbance, feeling emotionally upset afterwards, and loss of concentration. One additional aspect to consider is that metropolitan transportation workers comprise a working population that may be more likely to experience a terrorist act (e.g., suicide bombings of Israeli buses, the release of nerve agent [Sarin] in the Tokyo subway) since they are easily accessible, transport the general public, and do not have rigorous security measures, as seen in airports. This could lead to added work-related anxiety.

Strengths of our study include the well-established measurement tools used to define the psychological outcome variables, the reasonably good participation rate, and the method of defining exposure groups based on reported dust exposure instead of proximity to the WTC area. The major limitation of the study was the potential for recall bias; self-reported data was collected 7½ months after the WTC disaster occurred and remembering circumstances and

symptoms close to the time of the event may have been difficult for some. Reporting bias may have been a factor; those in the dust cloud may have been more likely to report symptoms because of early news accounts about the WTC disaster's health effects. Additionally, there is potential for selection bias with regard to the role of social support when selecting the train operator and conductor worksites because we chose worksites with the greatest number of employees. There may be an inherent difference in social support networks between worksites with few employees compared to many employees.

## RECOMMENDATIONS

1. Encourage MTA-NYCT workers directly exposed to the WTC disaster to continue participating in government-funded medical screening, surveillance, and follow-up programs for WTC workers.
2. Strengthen the existing Health and Safety Committee, ensuring open communication between management and employees. The Committee should meet regularly and consist of representatives from all affected departments. To be most effective, the Committee must operate with the full and active support of MTA management to determine lessons learned from the September 11 disaster, take advantage of opportunities to improve worker health and safety as issues arise, and make decisions on appropriate interventions for employees affected by future disasters.
3. Work in conjunction with employee unions and institutions involved with urban disaster planning to prepare a readiness plan for future disasters. The plan should identify appropriate health services for NYC transit employees directly exposed to the disaster and institute a surveillance program for these workers to follow them for chronic health effects due to mental and physical illnesses occurring as a result of a disaster.

4. Actively encourage transit employees who are directly exposed to any future disaster to seek appropriate health services.

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**Table 1**  
**Dust Cloud Exposure and Demographics**  
**Metropolitan Transit Authority New York City Transit Workers**  
**April 2002**

Demographic Information	Exposed to Dust Cloud N <sup>1</sup> =62	Not Exposed to Dust Cloud N <sup>2</sup> =198
<b>Average Age</b>	<b>46 years</b>	<b>45 years</b>
<b>Female gender</b>	<b>14 (23%)</b>	<b>23 (12%)</b>
<b>Non-white</b>	<b>29 (52%)</b>	<b>100 (57%)</b>
<b>Hispanic ethnicity</b>	<b>6 (10%)</b>	<b>37 (19%)</b>
<b>Current smokers</b>	<b>47 (22%)</b>	<b>161 (18%)</b>
<b>Completed college</b>	<b>8 (13%)</b>	<b>24 (12%)</b>
<b>Previous diagnosis of depression</b>	<b>4 (7%)</b>	<b>0</b>
<b>Previous diagnosis of PTSD</b>	<b>0</b>	<b>5 (3%)</b>

N<sup>1</sup> = total number of participants directly exposed to the dust cloud. For some items, the number was less due to missing data.

N<sup>2</sup> = total number of participants not directly exposed to the dust cloud. For some items, the number was less due to missing data.

**Table 2**

**Number of Workers with Physical Symptoms after 9/11/01 and Persistent Physical Symptoms<sup>1</sup> since 9/11/01 by Exposure to Dust Cloud  
Metropolitan Transit Authority New York City Transit Workers  
April 2002**

	Symptoms since the WTC disaster		Persistent Symptoms since the WTC disaster	
	IN dust cloud	NOT IN dust cloud	IN dust cloud	NOT IN dust cloud
Nose/throat irritation	35 (59%)* <sup>2</sup>	68 (35%)	12 (20%)*	13 (7%)
Eye irritation	40 (67%)*	66 (34%)	15 (25%)*	19 (10%)
Skin irritation	20 (33%)*	16 (8%)	5 (8%)	10 (5%)
Congestion	27 (45%)	72 (37%)	13 (22%)*	16 (8%)
Cough, any kind	38 (62%)*	74 (38%)	12 (20%)*	17 (9%)
Cough, with phlegm	17 (29%)	45 (23%)	6 (10%)	8 (4%)
Chest tightness	19 (31%)*	23 (12%)	7 (11%)*	6 (3%)
Shortness of breath	22 (37%)*	30 (15%)	10 (17%)*	11 (6%)
Wheeze	14 (24%)*	16 (8%)	7 (12%)*	3 (2%)
Headache	30 (50%)*	58 (30%)	11 (18%)*	15 (8%)
Indigestion	17 (28%)	41 (21%)	3 (5%)	16 (8%)
Nausea	5 (8%)	16 (8%)	0	2 (1%)
Diarrhea	16 (26%)*	29 (15%)	1 (2%)	3 (2%)
Mucous Membrane	30 (52%)* <sup>3</sup>	41 (21%)	9 (16%)* <sup>4</sup>	7 (4%)
Lower Respiratory	18 (31%)* <sup>5</sup>	17 (9%)	8 (13%)* <sup>6</sup>	3 (2%)

<sup>1</sup> Persistent symptoms were defined as either of the following: 1) those with symptoms that existed before September 11 that worsened since September 11, or 2) those with new onset symptoms since September 11 that had not improved.

<sup>2</sup> \*Indicates the prevalence of the symptom differs significantly (p<.05) between those in and those not in the dust cloud

<sup>3</sup> Mucous membrane irritation defined as having both eye irritation and nose/throat irritation

<sup>4</sup> Persistent mucous membrane irritation defined as having both persistent eye irritation and persistent nose/throat irritation

<sup>5</sup> Lower respiratory irritation defined as having both 1) a cough without phlegm OR wheezing, AND 2) shortness of breath OR chest tightness

<sup>6</sup> Persistent lower respiratory irritation defined as having both 1) a persistent cough without phlegm OR persistent wheezing, AND 2) persistent shortness of breath OR persistent chest tightness

**Table 3**  
**Odds Ratios of Outcomes by Exposure Variables**  
**Metropolitan Transit Authority New York City Transit Workers**  
**April 2002**

	Dust cloud <sup>7</sup>	Ground Zero activities <sup>8</sup>	Know a victim <sup>9</sup>	Witness 9/11 trauma <sup>10</sup>
	OR	OR	OR	OR
	[95% CI]	[95% CI]	[95% CI]	[95% CI]
Persistent Lower Respiratory <sup>11</sup>	<b>9.85</b> [2.24, 58.93]	2.63 [0.64, 11.19]	NA <sup>12</sup>	NA
Persistent Mucous Membrane <sup>13</sup>	<b>4.91</b> [1.53, 16.22]	<b>2.88</b> [1.03, 8.02]	NA	NA
Symptoms of Depression	<b>2.48</b> [1.12, 5.51]	1.12 [0.51, 2.46]	1.92 [0.89, 4.14]	<b>2.31<sup>14</sup></b> [1.04, 5.15]
Symptoms of PTSD	<b>2.91</b> [1.003, 8.16]	1.30 [0.52, 3.27]	<b>16.41<sup>15</sup></b> [2.14, 722.96]	1.65 [0.67, 4.08]

<sup>7</sup> Dust cloud defined by a positive response to either “in a dust cloud so thick I could not see in front of me” or “in a dust cloud, but it did not prevent me from seeing where I was going.”

<sup>8</sup> Ground Zero activities defined as providing paid or volunteer services at Ground Zero during the 7 days following 9/11/2001.

<sup>9</sup> Knowing a victim defined as a positive response to “did you know anyone personally who was seriously injured or killed during the WTC disaster?”

<sup>10</sup> Witness 9/11 trauma defined as those who personally witnessed one or more of the following: 1) the plane(s) crashing into the WTC tower(s), 2) the collapse of the WTC tower(s), 3) individuals falling or jumping from WTC windows, 4) bodies or parts of bodies, or 5) pieces of the plane(s).

<sup>11</sup> Persistent lower respiratory irritation defined as having both 1) a persistent cough without phlegm OR persistent wheezing, AND 2) persistent shortness of breath OR persistent chest tightness.

<sup>12</sup> NA = not applicable

<sup>13</sup> Persistent mucous membrane irritation defined as having both persistent eye irritation and persistent nose/throat irritation.

<sup>14</sup> Controlled for perceived low support

<sup>15</sup> Reflects those with perceived low support; those who did not perceive low support: OR=0.74, CI: 0.12, 3.66

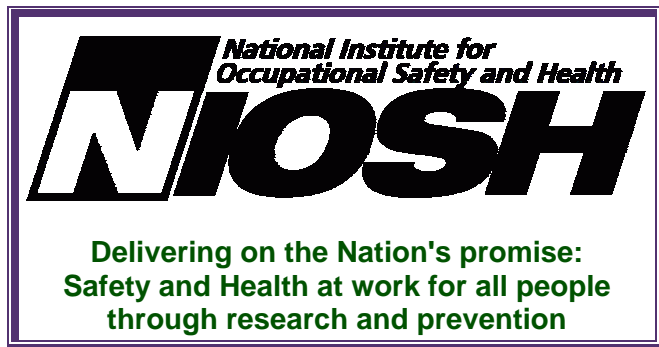
**Table 4**

**Prevalence of Mental Health Symptoms by Exposure  
Metropolitan Transit Authority New York City Transit Workers  
April 2002**

Exposure		Symptoms of Depression	Symptoms of PTSD
In the dust cloud	Yes	12 (20%)	9 (15%)
	No	18 (9%)	11 (6%)
Participated in Ground Zero activities	Yes	11 (13%)	8 (9%)
	No	20 (12%)	13 (7%)
Knew a WTC victim	Yes	17 (16%)	14 (13%)
	No	13 (9%)	7 (5%)
Witnessed WTC events	Yes	14 (17%)	9 (11%)
	No	17 (10%)	12 (7%)

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