



## Intensity of Binge Drinking a Decade After the September 11th Terror Attacks Among Exposed Individuals

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**Introduction:** The 9/11 terrorist attacks on the World Trade Center resulted in elevated post-traumatic stress disorder (PTSD) and alcohol use among exposed individuals. The relationship among traumatic exposure, PTSD, and excessive drinking is well documented; however, little is known about these relationships in the long term. This study examines factors increasing binge drinking risk among exposed individuals a decade post-9/11.

**Methods:** In 2015–2016, data were analyzed from 28,592 World Trade Center Health Registry enrollees aged  $\geq 18$  years who completed the Wave 3 (2011–2012) survey. Women comprised 38.9% of participants. Binge drinking in the last 30 days was categorized as low (men, five to seven drinks; women, four to six drinks) or high intensity (men, eight or more drinks; women, seven or more drinks). Probable 9/11-related PTSD was defined as scoring  $\geq 44$  on the PTSD Checklist. Exposures to 9/11 (e.g., witnessing horror, sustaining an injury) were categorized as none/low (zero to two) or high (three or more).

**Results:** Binge drinking was reported by 24.7% of participants, of whom 36.9% reported high-intensity binge drinking. Compared with non-binge drinkers, the odds of low- and high-intensity binge drinking were greater among enrollees who were male, aged 18–34 years, non-Hispanic white, had income  $> \$75,000$ , were rescue/recovery workers, had high 9/11 exposure, or 9/11-related PTSD.

**Conclusions:** The observed associations among traumatic exposure, PTSD, and excessive drinking underscore the need for improved therapies addressing excessive drinking and PTSD concurrently, inclusion of repeated post-event screening for excessive drinking, and evidence-based population-level interventions to reduce alcohol consumption.

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### INTRODUCTION

Excessive alcohol use, including binge drinking, is associated with multiple adverse health outcomes as well as social problems.<sup>1–3</sup> In 2010, the prevalence of binge drinking (five or more [for men] or four or more [for women] drinks on a single occasion) among adults aged  $\geq 18$  years in the U.S. was 17.1%, with an average frequency of four episodes per month and average intensity of 7.9 drinks per occasion.<sup>3</sup> In New York City (NYC), the prevalence of binge drinking (17.9%) is similar to the U.S. population<sup>4</sup> with an average intensity of 5.2 drinks among low-intensity binge

drinkers and 11.1 drinks among high-intensity binge drinkers (unpublished data). Binge drinking is strongly associated with alcohol poisoning and alcohol-related mortality<sup>5</sup> and is typically observed among men, adults aged 18–24 years, non-Hispanic whites,<sup>3,6</sup> and individuals reporting binge drinking five or more times in the last

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month.<sup>6</sup> The risks of alcohol poisoning, alcohol-related mortality, and other adverse outcomes increase as frequency and intensity of binge drinking increase.<sup>5,6</sup>

The September 11, 2001 (9/11) terrorist attacks on the World Trade Center (WTC) in NYC resulted in elevated posttraumatic stress disorder (PTSD) symptoms among exposed people immediately and for years post-disaster, with PTSD prevalence ranging from 7.5% to 18.8%.<sup>7–9</sup> Exposures related to 9/11 have been associated with dimensions of psychological stress, such as severity, unexpectedness, and threats to both physical and emotional integrity, that increase the likelihood of heavy drinking.<sup>10</sup> Studies have also reported that adverse mental health outcomes following exposure to terrorist events such as 9/11 or natural disasters have resulted in significant loss of productivity and increased economic costs.<sup>11,12</sup> The relationship between PTSD and excessive substance (alcohol or drug) use or the development of substance use disorders is well documented,<sup>13,14</sup> with approximately two thirds of individuals with PTSD developing a co-occurring substance use disorder, most frequently involving alcohol, sedative, or cannabis use.<sup>15,16</sup>

A consistent body of literature has emerged linking post-disaster increases in alcohol use with traumatic exposure across several populations, including firefighters who served as rescue/recovery workers in the aftermath of the Oklahoma City bombing<sup>17</sup>; survivors of the 2004 Southeast Asia tsunami,<sup>18</sup> Hurricane Rita,<sup>19</sup> and Hurricane Katrina<sup>19,20</sup>; and 9/11-exposed populations including Fire Department of New York members,<sup>21</sup> NYC residents,<sup>22</sup> and rescue/recovery workers and lower Manhattan community members.<sup>23</sup>

Despite research exploring the relationship among PTSD, traumatic exposure, and binge drinking, literature on the impact of such exposure on long-term drinking habits is limited. The present study is a continuation of work conducted by Welch et al. (2014)<sup>23</sup> and explores factors, such as PTSD, that increase the likelihood of low-intensity and high-intensity binge drinking. This study examines the relationship between 9/11-related PTSD and exposures and intensity of binge drinking a decade post-disaster in a large cohort of adults directly exposed to the events of 9/11.

## METHODS

The WTC Health Registry (Registry) is a cohort study of 71,431 individuals directly exposed to the 9/11 disaster in NYC. Details on Registry recruitment have been published elsewhere.<sup>24,25</sup> Briefly, Registry enrollees include adults and children who belong to one or more of five eligibility groups: rescue/recovery workers and volunteers; lower Manhattan residents; area workers; school students and staff; and passersby. There were two modes of enrollment into the Registry. List-identified enrollees (30%) were recruited from lists provided by governmental agencies,

organizations, and employers, whereas enrollees who contacted the Registry via phone or website (70%) are considered self-identified (enrollment source). The Registry has completed three surveys to date, Wave 1 (W1, 2003–2004), Wave 2 (W2, 2006–2007), and Wave 3 (W3, 2011–2012). W1 surveys were interviewer-administered, whereas W2 and W3 were interviewer- or self-administered. The Registry protocol was approved by the IRBs of the Centers for Disease Control and Prevention and the NYC Department of Health and Mental Hygiene.

The source population for this study was adult enrollees (aged  $\geq 18$  years at W3) who completed all three surveys ( $N=36,250$ ). This study was limited to enrollees who completed self-administered surveys at W3 ( $n=31,116$ ). Enrollees who had incomplete information on the frequency or intensity of binge drinking ( $n=821$ ) or a maximum number of drinks on a single occasion that was  $> 30$  ( $n=16$ ) were excluded. Also excluded were enrollees who reported at least one episode of binge drinking, but a maximum number of drinks below the gender-specific binge drinking threshold ( $n=1,184$ ), or who reported zero episodes of binge drinking, but a maximum number of drinks above the threshold ( $n=503$ ), for a study population of 28,592.

## Measures

The primary outcome for this study was intensity of binge drinking in the 30 days prior to W3. An episode of binge drinking was defined as having  $\geq 5$  (for men) or  $\geq 4$  (for women) drinks on a single occasion in the last 30 days. Intensity of binge drinking is the maximum number of drinks consumed on a single occasion in the last 30 days, which has been shown to correlate with drinks per binge, an established measure of binge drinking intensity.<sup>6,26</sup> Enrollees reporting zero episodes of binge drinking (including non-drinkers) were considered non-binge drinkers. Based on national data<sup>3</sup> and a previous study,<sup>6</sup> enrollees reporting one or more episodes of binge drinking were placed into one of two categories: low-intensity (5–7 or 4–6 drinks for men or women, respectively) or high-intensity ( $\geq 8$  or  $\geq 7$  drinks for men or women, respectively) binge drinking.

Frequency of binge drinking was defined as the number of binge drinking episodes in the last 30 days. As in a previous Registry study,<sup>23</sup> enrollees were categorized based on the number of occasions on which they reported binge drinking: none, low frequency (1–4), or high frequency ( $\geq 5$ ).<sup>27</sup>

Sociodemographic variables previously associated with excess alcohol use—gender, age, race/ethnicity, and household income (for 2010)—were included as covariates.<sup>3</sup> Information on these variables was collected at either W1 or W3.

Exposure to the events of 9/11 was defined with a summary measure similar to one previously shown to be associated with frequent binge drinking<sup>23</sup> and mental health status and unmet mental healthcare need<sup>28</sup> among Registry enrollees. This measure was defined as the number of positive responses to the following 11 events: being in the North or South WTC towers or another collapsed building at the time of the attack; witnessing  $\geq 3$  events (seeing planes hit the buildings, buildings collapsing, people falling or jumping from buildings, people injured, or people running); fear of being injured or killed; having a relative killed on 9/11; having a friend killed on 9/11; having a coworker killed on 9/11; experiencing intense dust cloud; having lost or damaged possessions; sustaining an injury other than eye irritation/injury; having

evacuated one's home for at least 24 hours after 9/11; and having lost one's job because of 9/11. Exposure was categorized as low (0–2) or high ( $\geq 3$ ) based on the mean (2.4) and median (2.0) number of exposures. Rescue/recovery work was performed by both traditional (e.g., police officers, firefighters) and non-traditional (e.g., construction and utility workers, volunteers) responders and was examined as a separate exposure.

Probable 9/11-related PTSD in the last 30 days was assessed at W3 using the PTSD Checklist-Stressor Specific Version (PCL-17), in which questions in the re-experiencing and avoidance/numbing domains were queried specific to 9/11. The PCL-17 is a self-reported, 17-item scale corresponding to the DSM-IV criteria that are commonly used in epidemiologic research.<sup>29</sup> Cases of probable 9/11-related PTSD were defined using a score of  $\geq 44$  on the PCL-17, which is recommended for use among civilians (sensitivity ranging from 0.94 to 0.97, specificity from 0.86 to 0.99, diagnostic efficiency from 0.83 to 0.96),<sup>29</sup> hereafter referred to as PTSD. As in a previous Registry study,<sup>30</sup> enrollees with missing PCL-17 items and a score from the remaining items that could only be compatible with a total score of  $\leq 43$  or  $\geq 44$  were categorized accordingly; otherwise, PTSD was considered missing.

## Statistical Analysis

Chi-square tests were used to test for significant bivariate associations between binge drinking and demographic and social characteristics, and 9/11-related PTSD and exposures. Multinomial logistic regression was used to examine the association between binge drinking and characteristics that were significant at the bivariate level, additionally adjusting for mode of enrollment. Three models were tested: (1) exposure only; (2) PTSD only; and (3) exposure and PTSD. Interaction terms between exposure level and selected characteristics were tested in Model 3. Data analyses were conducted from 2015 to 2016 using SAS, version 9.4.

## RESULTS

About one fourth of enrollees (24.6%) reported one or more episodes of binge drinking in the 30 days prior to W3. Binge drinking was reported by larger proportions of enrollees who were male, aged 18–44 years, non-Hispanic white, had income  $> \$75,000$ , were rescue/recovery workers, had high WTC exposure, or had 9/11-related PTSD (Table 1). Among all enrollees, 9.1% reported high-intensity binge drinking and 15.6% reported low-intensity binge drinking.

Among those who reported one or more episodes of binge drinking, 36.9% reported high-intensity binge drinking and 33.8% reported high-frequency binge drinking. Almost two thirds (63.7%) of high-frequency binge drinkers were also high-intensity binge drinkers. Among high-intensity binge drinkers, the mean intensity was 10.9 drinks (95% CI=10.8, 11.1; data not shown) and the mean frequency was 8.0 episodes (95% CI=7.7, 8.3; data not shown). Among low-intensity binge drinkers, the mean intensity was 5.3 drinks (95% CI=5.29, 5.34;

data not shown) and the mean frequency was 3.4 episodes (95% CI=3.2, 3.5; data not shown).

When tested in separate models, the effects of exposure and PTSD were similar to what was observed in Model 3, which included both factors (Appendix Table 1, available online). As such, Model 3 (exposure and PTSD) was selected as the final model. Interactions between exposure and selected characteristics (demographic variables and PTSD) were significant only for age group and PTSD among high-intensity binge drinkers ( $p < 0.05$ ) and marginally significant for low-intensity binge drinkers aged 18–34 years ( $p = 0.05$ ; Appendix Table 2, available online). Because exposure interacted significantly with these two covariates, Model 3 was stratified by exposure level. The magnitude of the effects of both age group and PTSD on high-intensity binge drinking were greater among those with low exposure and reduced among those with high exposure compared with the unstratified model (Appendix Table 3, available online).

Compared with non-binge drinkers, the adjusted odds of both low- and high-intensity binge drinking were elevated for men, non-Hispanic whites, and enrollees with income  $> \$75,000$  (Table 2). As age increased, the likelihood of low- and high-intensity binge drinking decreased, with adults aged 18–34 years having the greatest likelihood (AOR=7.20, 95% CI=6.02, 8.62 and AOR=22.13, 95% CI=16.69, 29.35, respectively). Rescue/recovery workers had greater odds of low- and high-intensity binge drinking (AOR=1.07, 95% CI=1.00, 1.15 and AOR=1.61, 95% CI=1.46, 1.77, respectively), as were enrollees with three or more WTC exposures (AOR=1.27, 95% CI=1.18, 1.36 and AOR=1.42, 95% CI=1.29, 1.55, respectively). Enrollees with 9/11-related PTSD also had greater odds of engaging in low-intensity binge drinking (AOR=1.22, 95% CI=1.18, 1.36) and had twice the odds of being high-intensity binge drinkers (AOR=2.07, 95% CI=1.86, 2.30) compared with those without PTSD.

## DISCUSSION

These findings suggest that, a decade after the September 11th attacks, the prevalence and intensity of binge drinking among those directly exposed are higher than national and local estimates (any binge drinking, 24.6% vs 17.1% in the U.S.<sup>3</sup> and 17.9% in NYC<sup>4</sup>; high-intensity binge drinking, 9.1% vs 5.2% in NYC [Division of Epidemiology, New York City Department of Health and Mental Hygiene, unpublished observations, 2011]). Consistent with national data, the prevalence and intensity of binge drinking were higher among enrollees who were men, younger, and reported a household income greater than \$75,000.<sup>3</sup> When compared to NYC adults,

**Table 1.** Sociodemographic Characteristics, WTC Exposure, and PTSD by Binge Drinking at Wave 3 (2011–2012)

Characteristics	Total	Non-binge drinkers, n (%) <sup>d,e</sup>	Binge drinkers <sup>a</sup>			p-value <sup>c</sup>
			Low intensity, n (%) <sup>e,f</sup>	High intensity, n (%) <sup>e,g</sup>	Mean intensity <sup>b</sup> , M (95% CI)	
Total	28,592	21,551 (75.4)	4,445 (15.6)	2,596 (9.1)	7.4 (7.3, 7.5)	
Gender						< 0.0001
Male	17,465 (61.1)	12,366 (70.8)	2,851 (16.3)	2,248 (12.9)	8.1 (8.0, 8.2)	
Female	11,127 (38.9)	9,185 (82.6)	1,594 (14.3)	348 (3.1)	5.5 (5.4, 5.6)	
Age at Wave 3						< 0.0001
18–34	1,577 (5.5)	895 (56.8)	420 (26.6)	262 (16.6)	7.2 (6.9, 7.4)	
35–44	5,410 (18.9)	3,502 (64.7)	1,182 (21.9)	726 (13.4)	7.5 (7.3, 7.6)	
45–64	17,418 (60.9)	13,302 (76.4)	2,586 (14.9)	1,530 (8.8)	7.4 (7.3, 7.5)	
65+	4,187 (14.6)	3,852 (92.0)	257 (6.1)	78 (1.9)	6.6 (6.2, 6.9)	
Race/Ethnicity						< 0.0001
White, non-Hispanic	20,927 (73.2)	15,162 (72.5)	3,579 (17.1)	2,186 (10.5)	7.4 (7.4, 7.5)	
Other race/ethnicity	7,665 (26.8)	6,389 (83.4)	866 (11.3)	410 (5.4)	7.1 (6.9, 7.3)	
Income (2010)						< 0.0001
> \$75,000	16,548 (60.5)	11,729 (70.9)	3,054 (18.5)	1,765 (10.7)	7.4 (7.3, 7.5)	
≤ \$75,000	10,826 (39.6)	8,799 (81.3)	1,272 (11.8)	755 (7.0)	7.4 (7.2, 7.6)	
Rescue/Recovery worker						< 0.0001
Yes	13,343 (46.7)	9,560 (71.7)	2,127 (15.9)	1,656 (12.4)	7.9 (7.8, 8.0)	
No	15,249 (53.3)	11,991 (78.6)	2,318 (15.2)	940 (6.2)	6.7 (6.6, 6.8)	
WTC exposure						< 0.0001
High (≥ 3)	12,670 (44.3)	9132 (72.1)	2,179 (17.2)	1,359 (10.7)	7.5 (7.4, 7.6)	
Low (0–2)	15,922 (55.7)	12,419 (78.0)	2,266 (14.2)	1,237 (7.8)	7.2 (7.1, 7.4)	
Current 9/11-related PTSD <sup>h</sup>						< 0.0001
Yes	4,824 (17.1)	3,352 (69.5)	781 (16.2)	691 (14.3)	8.5 (8.2, 8.7)	
No	23,476 (83.0)	17,953 (76.5)	3,634 (15.5)	1,889 (8.1)	7.1 (7.0, 7.2)	
Frequency of binge drinking <sup>b</sup>						< 0.0001
High frequency	2,377 (33.8)	—	863 (36.3)	1,514 (63.7)	9.4 (9.2, 9.6)	
Low frequency	4,664 (66.2)	—	3,582 (76.8)	1,082 (23.2)	6.3 (6.3, 6.4)	

Note: Boldface indicates statistical significance ( $p < 0.05$ ).

<sup>a</sup>Reported ≥ 1 episode of binge drinking in the last 30 days.

<sup>b</sup>Among enrollees reporting ≥ 1 episode of binge drinking in the last 30 days.

<sup>c</sup>p-value comparing high-intensity binge drinkers, low-intensity binge drinkers, and non-binge drinkers.

<sup>d</sup>Reported no episodes of binge drinking in the last 30 days.

<sup>e</sup>Expressed as row percent.

<sup>f</sup>Reported a maximum number of drinks on a single occasion of 5–7 (males) or 4–6 (females).

<sup>g</sup>Reported a maximum number of drinks on a single occasion of ≥ 8 (males) or ≥ 7 (females) drinkers.

<sup>h</sup>Defined as a score of ≥ 44 on the PTSD Checklist.

PTSD, posttraumatic stress disorder; WTC, World Trade Center.

the mean intensity among Registry enrollees is comparable; however, a larger proportion of Registry adults who binge drink are doing so with high intensity (36.9% vs 26.3% in NYC [Division of Epidemiology, New York City Department of Health and Mental Hygiene, unpublished observations, 2011]). Among binge drinkers, one in five (21.5%) reported both high-intensity and high-frequency binge drinking, which increase the risk of alcohol poisoning<sup>5</sup> and can result in myriad health and social problems. Although both low- and high-intensity binge drinking present significant risks, the large proportion of high-intensity binge drinkers in this study is particularly troubling and is indicative of the significant association

among traumatic exposure, PTSD, and alcohol use. Moreover, the reduction in the effects of age and PTSD on high-intensity binge drinking among those with higher 9/11 exposure demonstrates that the impact of exposure to the event itself persists more than a decade later.

Similar to a previous Registry study, higher 9/11 exposure was associated with reporting greater intensity of binge drinking.<sup>23</sup> Additionally, rescue/recovery workers were more likely than non-rescue/recovery workers to be high-intensity binge drinkers, which is consistent with previous post-disaster studies reporting elevated levels of alcohol use among rescue/recovery workers.<sup>17,21,23</sup> In this cohort, rescue/recovery workers tend to have experienced

**Table 2.** Multinomial Logistic Regression Results for the Association Between Selected Characteristics and the Intensity of Binge Drinking at Wave 3 (2011–2012; Model 3)

Characteristics	Low-intensity <sup>a</sup> vs Non-binge drinker, AOR (95% CI) <sup>c</sup>	High-intensity <sup>b</sup> vs Non-binge drinker, AOR (95% CI) <sup>c</sup>
Gender		
Male	1.26 (1.17, 1.36)	4.28 (3.77, 4.86)
Female	Ref	Ref
Age at Wave 3		
18–34	7.20 (6.02, 8.62)	22.13 (16.69, 29.35)
35–44	4.43 (3.81, 5.15)	9.50 (7.36, 12.26)
45–64	2.54 (2.21, 2.93)	4.67 (3.65, 5.98)
65+	Ref	Ref
Race/Ethnicity		
White, non-Hispanic	1.61 (1.48, 1.75)	1.94 (1.72, 2.19)
Other race/ethnicity	Ref	Ref
Income (2010)		
> \$75,000	1.43 (1.32, 1.54)	1.2 (1.09, 1.33)
≤ \$75,000	Ref	Ref
Rescue/Recovery worker		
Yes	1.07 (1.00, 1.15)	1.61 (1.46, 1.77)
No	Ref	Ref
WTC exposure		
High (≥ 3)	1.27 (1.18, 1.36)	1.42 (1.29, 1.55)
Low (0 to 2)	Ref	Ref
Current 9/11-related PTSD <sup>d</sup>		
Yes	1.22 (1.12, 1.34)	2.07 (1.86, 2.30)
No	Ref	Ref

<sup>a</sup>Reported a maximum number of drinks on a single occasion of 5–7 (males) or 4–6 (females).

<sup>b</sup>Reported a maximum number of drinks on a single occasion of ≥ 8 (males) or ≥ 7 (females).

<sup>c</sup>AOR and 95% CI; model additionally adjusted for enrollment source.

<sup>d</sup>Defined as a score of ≥ 44 on the PTSD Checklist.

PTSD, posttraumatic stress disorder; WTC, World Trade Center.

WTC exposures that were of greater intensity and duration than non-rescue/recovery workers, which may, in part, explain the greater odds of high-intensity binge drinking observed in this group. As mentioned earlier, WTC rescue/recovery workers include both traditional and non-traditional workers, such as firefighters and utility workers. Studies of firefighters in the U.S. have demonstrated that binge drinking is substantially higher among firefighters than the general population.<sup>31,32</sup> A national study of substance use by industry found that construction and utility workers were among the occupations most likely to report high-frequency binge drinking in the last 30 days (16.5% and 10.3%, respectively).<sup>33</sup>

In addition to continued excessive drinking,<sup>23</sup> a large proportion of enrollees suffer from 9/11-related PTSD that has persisted over an 8 to 9-year period.<sup>34,35</sup> In this sample, one in four (26.6%) high-intensity binge drinkers had current 9/11-related PTSD compared with one in six low-intensity binge drinkers (17.5%) or non-binge-drinkers (15.6%). This high burden of PTSD among high-intensity binge drinkers, as demonstrated by the twofold increase in the probability of

high-intensity binge drinking among enrollees with PTSD, suggests that these individuals may be in need of mental health treatment that addresses both PTSD and binge drinking.

Although the majority of binge drinkers do not meet the diagnostic criteria for alcohol dependence,<sup>36</sup> excessive drinking can cause social and health problems<sup>1–3</sup> and exacerbate existing mental health symptoms, but may often be overlooked by providers. Individuals with PTSD and co-occurring substance use disorders are typically excluded from studies of trauma-focused therapies,<sup>14</sup> the recommended first-line treatment for PTSD,<sup>37</sup> despite studies showing reductions in substance use following improvements in PTSD symptom severity.<sup>38,39</sup> Several reasons for this exist, including possible reduced treatment effectiveness and an inability to cope with the intense emotions common to trauma-focused therapy, which may exacerbate the substance use disorder.<sup>40</sup> As such, individ-

uals are often required to maintain a period of abstinence from alcohol or drug use prior to treatment, which for some is not possible. Recent reviews of the literature on prolonged exposure therapy and co-occurring mental health conditions<sup>14,40</sup> showed that although substance use disorders complicate PTSD treatment, they do not preclude it and may, in fact, result in improvements in both conditions. Novel and improved therapies that are structured to address co-occurring substance use disorders, including excessive alcohol/drug use, may yield improvements in both PTSD symptoms and the substance use disorder itself. Unfortunately, it is difficult for patients to find a provider that can treat co-occurring substance use disorders, as not all providers are trained in the use of trauma-focused therapies and others are not comfortable with using these treatments in patients with comorbidities.<sup>40</sup> This indicates not only a need for new therapies, but for increased provider training in trauma-focused therapy, with an emphasis on the treatment of co-occurring substance use disorders.

In addition, the introduction of evidence-based interventions aimed at reducing alcohol consumption could be

instrumental in preparing communities to address increased alcohol consumption post-disaster.<sup>36,41–43</sup> For example, although underused, an important prevention strategy recommended by the U.S. Preventive Services Task Force is screening and brief counseling for excessive alcohol use among adults in primary care settings.<sup>43</sup> Providers in communities in which screening is part of the standard of care will be better equipped to assess and, if necessary, treat excessive alcohol use if and when a disaster or other traumatic event occurs. There are also several population-level policy strategies that have been demonstrated to reduce excessive alcohol use that could be effective in communities impacted by disasters, including dram shop liability, increased alcohol taxes, and regulations of alcohol outlet density.<sup>42</sup>

### Limitations

This study has several limitations, including loss to follow-up between survey waves and self-reported data. Self-reported alcohol consumption may under-represent actual intake, resulting in under-estimates of the frequency and intensity of binge drinking. The assessment of PTSD was based on a self-administered questionnaire, rather than clinical interview; however, the PCL is widely used in epidemiologic studies and considered to have good diagnostic efficiency.<sup>29</sup> Changes in intensity over time could not be examined because of a lack of data on pre-9/11 drinking behaviors and intensity at W2. Data on 9/11 exposures were collected 3–4 and 5–6 years after 9/11 and might be subject to recall bias.

Among the strengths of this analysis are its large sample size and extended period of observation. Registry enrollees represent a population with varied, direct 9/11 exposures and include both rescue/recovery workers and community members. Data in this study were collected 10–11 years after 9/11, representing the longest observation period on post-9/11 alcohol use to date and allowing the authors to examine intensity of binge drinking in addition to frequency.

### CONCLUSIONS

In a population with known exposure to a large-scale traumatic event, beyond traditional risk factors such as age, gender, and income, both low- and high-intensity binge drinking were associated with 9/11-related PTSD and higher levels of 9/11 exposure more than a decade post-disaster. These findings of excessive alcohol use and PTSD underscore the need for therapies that address alcohol/drug use and PTSD symptoms concurrently among those impacted, as well as the inclusion of repeated screening for excessive alcohol/drug use as part of post-event mental health care, and highlight the importance of population-level policy strategies aimed at reducing access to and consumption of alcohol.

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AEW designed the study. AEW, KCZ, and JMM performed the analyses and prepared the first draft of the manuscript. AEW, KCZ, JMM, and RMB participated in interpretation of the data, revised the manuscript for important intellectual content, and approved the final version for submission.

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### SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.amepre.2016.10.034>.

### REFERENCES

1. Sacks JJ, Gonzales KR, Bouchery EE, et al. 2010 national and state costs of excessive alcohol consumption. *Am J Prev Med*. 2015;49(5):e73–e79. <http://dx.doi.org/10.1016/j.amepre.2015.05.031>.
2. Glasheen C, Pemberton MR, Lipari R, et al. Binge drinking and the risk of suicidal thoughts, plans, and attempts. *Addict Behav*. 2015;43:42–49. <http://dx.doi.org/10.1016/j.addbeh.2014.12.005>.
3. Kanny D, Liu Y, Brewer RD, et al. Vital Signs: binge drinking prevalence, frequency, and intensity among adults — United States, 2010. *MMWR Morb Mortal Wkly Rep*. 2012;67(1):14–19.
4. New York City Department of Health and Mental Hygiene. Epiquery: NYC interactive health data system - Community Health Survey 2011. <http://nyc.gov/health/epiquery>. Accessed December 2, 2015.
5. Kanny D, Brewer RD, Mesnick JB, et al. Vital Signs: alcohol poisoning deaths — United States, 2010–2012. *MMWR Morb Mortal Wkly Rep*. 2015;63:1238–1242.
6. Naimi TS, Nelson DE, Brewer RD. The intensity of binge alcohol consumption among U.S. adults. *Am J Prev Med*. 2010;38(2):201–207. <http://dx.doi.org/10.1016/j.amepre.2009.09.039>.
7. Brackbill RM, Hadler JL, DiGrande L, et al. Asthma and posttraumatic stress symptoms 5 to 6 years following exposure to the World Trade Center terrorist attack. *JAMA*. 2009;302(5):502–516. <http://dx.doi.org/10.1001/jama.2009.1121>.
8. Caramanica K, Brackbill RM, Liao T, Stellman SD. Comorbidity of 9/11-related PTSD and depression in the World Trade Center Health Registry 10–11 years postdisaster. *J Trauma Stress*. 2014;27(6):680–688. <http://dx.doi.org/10.1002/jts.21972>.
9. Galea S, Ahern J, Resnick H, et al. Psychological sequelae of the September 11 terrorist attacks in New York City. *N Engl J Med*. 2002;346(13):982–987. <http://dx.doi.org/10.1056/NEJMsa013404>.
10. Keyes KM, Hatzenbuehler ML, Hasin DS. Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic

- evidence for four main types of stressors. *Psychopharmacology (Berl)*. 2011;218(1):1–17. <http://dx.doi.org/10.1007/s00213-011-2236-1>.
11. Zahran S, Peek L, Snodgrass JG, et al. Economics of disaster risk, social vulnerability, and mental health resilience. *Risk Anal*. 2011;31(7):1107–1119. <http://dx.doi.org/10.1111/j.1539-6924.2010.01580.x>.
  12. Pesko MF. Stress and smoking: associations with terrorism and causal impact. *Contemp Econ Policy*. 2013;32(2):351–371. <http://dx.doi.org/10.1111/coep.12021>.
  13. Stewart SH, Conrod PJ. Psychosocial models of functional associations between posttraumatic stress disorder and substance use disorder. In: Quimette P, Brown PJ, eds. *Trauma and Substance Abuse: Causes, Consequences, and Treatment of Comorbid Disorders*, eds., Washington: American Psychological Association, 2003:29–55. <http://dx.doi.org/10.1037/10460-002>.
  14. van Minnen A, Zoellner LA, Harned MS, Mills K. Changes in comorbid conditions after prolonged exposure for PTSD: a literature review. *Curr Psychiatry Rep*. 2015;17(3):549. <http://dx.doi.org/10.1007/s11920-015-0549-1>.
  15. Chapman C, Mills K, Slade T, et al. Remission from post-traumatic stress disorder in the general population. *Psychol Med*. 2012;42(8):1695–1703. <http://dx.doi.org/10.1017/S0033291711002856>.
  16. Kessler RC, Sonnega A, Bromet E, et al. Posttraumatic stress disorder in the National Comorbidity Survey. *Arch Gen Psychiatry*. 1995;52(12):1048–1060. <http://dx.doi.org/10.1001/archpsyc.1995.03950240066012>.
  17. North CS, Oliver J, Pandya A. Examining a comprehensive model of disaster-related posttraumatic stress disorder in systematically studied survivors of 10 disasters. *Am J Public Health*. 2012;102(10):e40–e48. <http://dx.doi.org/10.2105/AJPH.2012.300689>.
  18. Nordlokken A, Pape H, Wentzel-Larsen T, Heir T. Changes in alcohol consumption after a natural disaster: a study of Norwegian survivors after the 2004 Southeast Asia tsunami. *BMC Public Health*. 2013;13:58. <http://dx.doi.org/10.1186/1471-2458-13-58>.
  19. Cerda M, Tracy M, Galea S. A prospective population based study of changes in alcohol use and binge drinking after a mass traumatic event. *Drug Alcohol Depend*. 2011;115(1-2):1–8. <http://dx.doi.org/10.1016/j.drugalcdep.2010.09.011>.
  20. Flory K, Hankin BL, Kloos B, et al. Alcohol and cigarette use and misuse among Hurricane Katrina survivors: psychosocial risk and protective factors. *Subst Use Misuse*. 2009;44(12):1711–1724. <http://dx.doi.org/10.3109/10826080902962128>.
  21. Berninger A, Webber MP, Cohen HW, et al. Trends of elevated PTSD risk in firefighters exposed to the World Trade Center disaster: 2001–2005. *Public Health Rep*. 2010;125(4):556–566.
  22. Vlahov D, Galea S, Resnick H, et al. Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol*. 2002;155(11):988–996. <http://dx.doi.org/10.1093/aje/155.11.988>.
  23. Welch AE, Caramanica K, Maslow CB, et al. Frequent binge drinking five to six years after exposure to 9/11: findings from the World Trade Center Health Registry. *Drug Alcohol Depend*. 2014;140:1–7. <http://dx.doi.org/10.1016/j.drugalcdep.2014.04.013>.
  24. Farfel M, DiGrande L, Brackbill R, et al. An overview of 9/11 experiences and respiratory and mental health conditions among World Trade Center Health Registry enrollees. *J Urban Health*. 2008;85(6):880–909. <http://dx.doi.org/10.1007/s11524-008-9317-4>.
  25. Murphy J, Brackbill R, Thalji L, et al. Measuring and maximizing coverage in the World Trade Center Health Registry. *Stat Med*. 2007;26(8):1688–1701. <http://dx.doi.org/10.1002/sim.2806>.
  26. Esser MB, Kanny D, Brewer RD, Naimi TS. Binge drinking intensity: a comparison of two measures. *Am J Prev Med*. 2012;42(6):625–629. <http://dx.doi.org/10.1016/j.amepre.2012.03.001>.
  27. Substance Abuse and Mental Health Services Administration. *Results from the 2013 National Survey on Drug Use and Health: summary of national findings*. NSDUH Series H-48, HHS Publication No. (SMA) 14-4863. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2014.
  28. Brackbill RM, Stellman SD, Perlman SE, et al. 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*. 2013;81:110–114. <http://dx.doi.org/10.1016/j.socscimed.2012.12.016>.
  29. Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD Checklist (PCL). *Behav Res Ther*. 1996;34(8):669–673. [http://dx.doi.org/10.1016/0005-7967\(96\)00033-2](http://dx.doi.org/10.1016/0005-7967(96)00033-2).
  30. Welch AE, Jasek JP, Caramanica K, et al. Cigarette smoking and 9/11-related posttraumatic stress disorder among World Trade Center Health Registry enrollees, 2003–12. *Prev Med*. 2015;73:94–99. <http://dx.doi.org/10.1016/j.ypmed.2015.01.023>.
  31. Carey MG, Al-Zaiti SS, Dean GE, et al. Sleep problems, depression, substance use, social bonding, and quality of life in professional firefighters. *J Occup Environ Med*. 2011;53(8):928–933. <http://dx.doi.org/10.1097/JOM.0b013e318225898f>.
  32. Haddock CK, Jahnke SA, Poston WS, et al. Alcohol use among firefighters in the Central United States. *Occup Med (Lond)*. 2012;62(8):661–664. <http://dx.doi.org/10.1093/occmed/kqs162>.
  33. Bush DM, Lipari RN. *The CBHSQ Report: substance use and substance use disorder, by industry*. Rockville, MD: Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality; 2015.
  34. Welch AE, Caramanica K, Maslow CB, et al. Trajectories of PTSD among lower Manhattan residents and area workers following the 2001 World Trade Center disaster, 2003–2012. *J Trauma Stress*. 2016;29(2):158–166. <http://dx.doi.org/10.1002/jts.22090>.
  35. Maslow CB, Caramanica K, Welch AE, et al. Trajectories of scores on a screening instrument for PTSD among World Trade Center rescue, recovery, and clean-up workers. *J Trauma Stress*. 2015;28(3):198–205. <http://dx.doi.org/10.1002/jts.22011>.
  36. Esser MB, Hedden SL, Kanny D, et al. Prevalence of alcohol dependence among U.S. adult drinkers, 2009–2011. *Prev Chronic Dis*. 2014;11:E206. <http://dx.doi.org/10.5888/pcd11.140329>.
  37. Foa E, Keane TM, Friedman MJ. *Effective Treatments for PTSD: Practice Guidelines from the International Society for Traumatic Stress Studies*. New York: Guilford Press; 2000.
  38. Back SE, Brady KT, Sonne SC, Verduin ML. Symptom improvement in co-occurring PTSD and alcohol dependence. *J Nerv Ment Dis*. 2006;194(9):690–696. <http://dx.doi.org/10.1097/01.nmd.0000235794.12794.8a>.
  39. Hien DA, Jiang H, Campbell AN, et al. Do treatment improvements in PTSD severity affect substance use outcomes? A secondary analysis from a randomized clinical trial in NIDA's Clinical Trials Network. *Am J Psychiatry*. 2010;167(1):95–101. <http://dx.doi.org/10.1176/appi.ajp.2009.09091261>.
  40. van Minnen A, Harned MS, Zoellner L, Mills K. Examining potential contraindications for prolonged exposure therapy for PTSD. *Eur J Psychotraumatol*. 2012. <http://dx.doi.org/10.3402/ejpt.v3i0.18805>.
  41. Nelson TF, Xuan Z, Babor TF, et al. Efficacy and the strength of evidence of U.S. alcohol control policies. *Am J Prev Med*. 2013;45(1):19–28. <http://dx.doi.org/10.1016/j.amepre.2013.03.008>.
  42. Preventing excessive alcohol consumption. Atlanta (GA): Guide to Community Preventive Services; 2016. [www.thecommunityguide.org/alcohol/index.html](http://www.thecommunityguide.org/alcohol/index.html). Accessed May 9, 2016.
  43. Moyer VA. Screening and behavioral counseling interventions in primary care to reduce alcohol misuse: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med*. 2013;159(3):210–218. <http://dx.doi.org/10.7326/0003-4819-159-3-201308060-00652>.