Published in final edited form as:

J Dual Diagn. 2020 October ; 16(4): 373–381. doi:10.1080/15504263.2020.1808749.

Correlates of Concurrent Morbid Obesity and Tobacco Use Disorder Nationally in the Veterans Health Administration

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Abstract

Objective: To examine health, demographic, and service utilization characteristics of veterans with multimorbid TUD and morbid obesity compared to those with either condition alone.

Methods: Health record data were extracted from the Computerized Patient Record System of the Veteran Health Administration (VHA; October 1, 2011 to September 30, 2012). Bivariate and multivariate logistic regression models were used to compare veterans with both TUD and morbid obesity (body mass index [BMI] ≥ 40) to veterans with each condition alone on a range of demographic, health, and service utilization outcome variables that also were extracted from the VHA administrative record.

Results: Veterans with both morbid obesity and TUD showed higher rates of medical and psychiatric comorbidity than did veterans with either condition alone. However, while veterans with tobacco use disorder (TUD) and morbid obesity showed higher rates of comorbid substance use disorders (SUD) than veterans with morbid obesity alone, veterans with both conditions showed substantially lower rates of SUD than those with TUD alone.

Conclusions: Veterans with co-occurring morbid obesity and TUD appear to be at greater risk for medical disease and psychiatric conditions. The unexpected finding that veterans with TUD alone had more concurrent SUDs than veterans with both TUD and morbid obesity suggest the possibility that overeating may be a substitute for substance use in the context of TUD. The multimorbidity profile described here may suggest unique treatment needs for individuals with both TUD and morbid obesity.

Keywords

multimorbidity; obesity; tobacco use disorder; veterans; Veterans Health Association

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Contributors: WR and RR designed the study and conducted the analyses. WR conducted the literature review and wrote a first draft of the manuscript. RR provided critical feedback. Both authors contributed to and have approved the final manuscript.

Conflict of Interest Declaration: No author declares any conflict of interest.

Additional Information: The data set used in this study was created and is managed by the Veterans Affairs Healthcare System

1. Introduction

Obesity and tobacco use are highly prevalent health conditions that are among the leading causes of death and disability in the United States (Mokdad, Marks, Stroup, & Gerberding, 2004). Studies in the growing field of behavioral multimorbidity find that individuals with such multimorbid conditions (e.g., a psychiatric disorder with comorbid substance use disorder) show poorer health outcomes compared to individuals with each condition alone (Bhalla, Stefanovics, & Rosenheck, 2017; MacLean, Sofuoglu, & Rosenheck, 2018; Plana-Ripoll et al., 2019). Further, people with multimorbid conditions show higher rates of health services utilization and account for a disproportionate share of healthcare expenditure (Wolff, Starfield, & Anderson, 2002; Yoon, Zulman, Scott, & Maciejewski, 2014). As such, it is important to document the clinical correlates of individuals experiencing common multimorbidity profiles, because such individuals may experience unique risk profiles compared to patients with single conditions. One common multimorbidity profile is the joint occurrence of tobacco use disorder (TUD) and morbid obesity. Both conditions are associated with poor health outcomes. Tobacco use is a documented risk factor for physical and psychiatric disease, as well as substance use problems (Grant, Hasin, Chou, Stinson, & Dawson, 2004; Department of Health and Human Services, 2014). It is also well established that adults with morbid obesity are at increased risk for both medical and psychiatric conditions (Mather, Cox, Enns, & Sareen, 2009) as compared to their peers who are not obese. While research on health outcomes associated with these two conditions, considered by themselves, is extensive, the health consequences of both disorders occurring within the same individual has received limited study.

Overlapping neurobiological underpinnings of obesity and substance use suggest that the two conditions may arise from a common diathesis, one that could be expected to be especially severe when both conditions occur together. In a recent review, Sinha (2018) argued for common neurobiological underpinnings of obesity and substance use disorders reflecting similar sensitization of reward and stress pathways. Indeed, consumption of highly palatable foods activates brain systems such as the mesolimbic dopamine pathway that are also implicated in the reinforcement of tobacco and other drug use and appear to be altered in individuals with obesity (Volkow, Wang, & Baler, 2011). The combination of these two conditions may thus signal a heightened vulnerability to appetitive psychopathology leading to higher rates of medical problems, substance use, and psychiatric co-morbidity than either condition alone.

White and Grilo (2006) compared rates of psychiatric multimorbidity in women with obesity who also met criteria for binge eating disorder as a function of their history of tobacco use. Results of this study found that participants with obesity and a history of tobacco use showed higher rates of psychiatric disorders, including both anxiety disorders (odds ratio [OR] = 3.49) and major depressive disorder (OR = 2.49). Importantly, those with a history of both obesity and tobacco use were approximately 10 times more likely to meet lifetime criteria for substance abuse/dependence than those with obesity alone. These findings are consistent with the hypothesis that this behavioral multimorbidity is associated with a more severe profile of concurrent behavioral conditions, especially additional addictive disorders. However, the study involved a relatively small sample of women (n = 103) and only

compared the multimorbid group of smokers with obesity to a group with obesity alone, but not to a comparison group characterized by smoking alone.

Understanding the multimorbidity burden associated with co-occurring tobacco use and obesity is particularly important for veteran healthcare. United States veterans use tobacco at a significantly higher rate compared to non-veterans (Brown, 2010; Odani, Agaku, Graffunder, Tynan, & Armour, 2018), and tobacco use appears to be a risk factor for substance use and other negative health outcomes in this group (Cooper, Yaqub, Hinds, & Perry, 2019). Veterans also have higher rates of overweight and obesity compared to non-veterans (Nelson, 2006). More recent data from the Veterans Health Administration (VHA) finds that the veteran population continues to show high rates of overweight and obesity, which contributes to poorer health outcomes in this group (Breland et al., 2017).

The current study used national administrative data from the VHA to compare veterans with both diagnoses of TUD (ICD 9 code, 305.1) and morbid obesity (body mass index [BMI] > 40) to veterans with TUD but no obesity (BMI < 30) and morbid obesity with no TUD. Our first goal was to compare these groups on their rates of co-occurring substance use and psychiatric disorders. We hypothesized that individuals with morbid obesity and TUD (i.e., multimorbid group), compared to those with either condition alone, would show higher rates of psychiatric and substance use disorders. Our second goal was to compare these groups on their rates of medical disease and service utilization. Based on previous findings that multimorbidity is associated with higher rates of healthcare utilization (Wolff et al., 2002), we hypothesized that patients in the multimorbid group would show higher rates of co-occurring medical disease and utilize services at a higher rate compared to those with either condition alone.

2. Method

2.1. Data source and classification strategy

Data were extracted from the Computerized Personal Record System of the Veterans Health Administration from FY 2012, October 1, 2011 to September 30, 2012. Veterans carrying a diagnosis of nicotine dependence (ICD code 305.1), met BMI criteria for morbid obesity (i.e., BMI ≥ 40), or met criteria for both conditions were the primary focus of this analysis. Dependent variables (i.e., sociodemographic characteristics; psychiatric, substance use, and medical comorbidities, health service utilization) were also extracted from the VHA electronic record system. All patient information was extracted from both inpatient and outpatient encounters that occurred during the 2012 FY. Access to and use of these data for research purposes has been approved by the facilities' institutional review board.

2.2. Sociodemographics

Sociodemographic variables included age, income, sex, urbanicity of residence, receipt of VA disability compensation or pension, and homelessness and were coded consistent with previous investigations using this dataset (Kelly, Reilly, Quinones, Desai, & Rosenheck, 2018). Geographic location was categorized as either urban or rural based on zip code data and the Rural Urban Commuting Area (RUCA) codes (Rural Health Research Center, 2014).

Data provided by the Department of Defense was used to determine Operation Enduring Freedom/Operation Iraqi Freedom status (i.e., service in recent Middle East conflicts). VA service connection > 50% or less than/equal to 50% was also identified, as was receipt of a non-service-connected pension. Service connection describes compensation that veterans receive due to psychiatric or medical conditions that are related to or aggravated by their military services (Murdoch et al., 2011). Homelessness was determined based on utilization of specialized VA homelessness program services in FY 2012 and/or a V60.0 ICD-10 diagnostic code that reflected a lack of housing during FY 2012. Sociodemographic information was drawn from the most recently collected data available within veterans' health records.

2.3. Psychiatric, substance use, and medical comorbidities

Psychiatric disorders identified according to ICD-9 diagnostic codes included dementia, schizophrenia, bipolar disorder, major depression, other depression, post-traumatic stress disorder, anxiety disorder, adjustment disorder, personality disorder, and other psychiatric diagnosis. Substance use disorders were based on ICD-9 diagnostic codes for dependence or abuse of individual substances including alcohol, cocaine, opioids, sedatives, amphetamine, barbiturates, and cannabis. Count variables were calculated based on the total number of diagnoses reported during encounters in each psychiatric and substance use category. Medical problems were operationalized as total scores on the Charlson Comorbidity Index (CCI; Charlson, Szatrowski, Peterson, & Gold, 1994). The CCI is a standardized measure of physical multimorbidity burden used to summarize physical health status. Scores were calculated based on the presence or absence of key diagnoses present within veterans' clinical records (see Supplemental Table for coding details and ICD-9 codes included in each category). Patients who received a diagnosis or attended a clinical encounter under the context of a previously held diagnosis during FY2012 were coded as meeting criteria for that respective diagnosis. One or more clinical encounters characterized by the respective diagnosis code was treated as evidence of the presence of that diagnosis. All diagnostic ICD-9 codes used to satisfy each psychiatric, substance use, and medical disease category are reported in the supplemental material.

2.4. Service utilization

Health service utilization was examined using inpatient bed section codes and outpatient clinic "stop codes" that identify use of services from specific clinics. These codes included the number emergency room visits (for both psychiatric and other reasons), medical surgical visits, and psychiatric or substance use outpatient visits. A separate residential program use variable was created for residential rehabilitation and treatment program use. Psychotropic medication fills were measured based on VA pharmacy records and included antidepressants, antipsychotics, sedative/anxiolytics, stimulants, anticonvulsants/mood stabilizers, and lithium.

2.5. Data analyses

A series of bivariate analyses compared veterans with both TUD and morbid obesity to those with each condition alone on all dichotomous and continuous outcomes. The sample of participants in this study is so large that traditional hypothesis testing risks rejecting null

hypotheses due to trivial differences that are not clinically meaningful (Cohen, 1990). To address this issue, effect sizes thresholds were used to identify substantial differences between diagnostic groups (risk ratios [RR] < 0.67 or > 1.5; Cohen's d > 0.2 or < 0.2; Cohen, 1988). This approach also reduced the number of comparisons being conducted, effectively controlling the familywise error rates for the subsequent multivariate models.

All demographic and health outcome variables that met our effect size threshold in the bivariate analyses were included in a subsequent multivariate multinomial logistic regression model. These multivariate models compared the group with concurrent morbid obesity and TUD to the group with TUD alone and the group with morbid obesity alone. In these analyses, the group with TUD and morbid obesity was treated as the reference condition. The independent variable set included all demographic and clinical variables meeting clinical significance threshold in the bivariate models. The significance threshold for these models was $p < .01$.

Separate nested multinomial logistic regression models were estimated for these analyses. The first model (Model 1) only included sociodemographic and diagnostic variables. The second model (Model 2) included all variables Model 1 and a block of the service use variables that met inclusion criteria. The hierarchical ordering of these variables was guided by the assumption that sociodemographic characteristics and diagnoses have a causal effect on rates of service use but not *vice versa*. Thus, any examination of service utilization should control for variance in diagnostic status.

Both adjusted odds ratios and standardized regression coefficients (β) are provided to facilitate comparisons of magnitude of effects between dichotomous and continuous variables. All analyses were conducted using SAS (version 9.2; SAS Institute, Inc., Cary, NC).

3. Results

3.1. Sample characteristics

The analytic sample included 551,143 veterans: 20,368 (3.7%) diagnosed with TUD and meeting morbid obesity criteria; 144,450 (26.2%) who met morbid obesity criteria but carried no diagnosis of TUD (obesity only); and 386,325 (70.1%) a diagnosis of TUD and a BMI < 30 (TUD only).

3.2. Bivariate associations

Table 1 presents bivariate analysis of group differences in dichotomous demographic and health-related outcomes as risk ratios, and Table 2 presents group differences in continuous demographic and health-related outcomes with Cohen's d indicators of effect sizes. Demographic and outcome variables that met our threshold for inclusion in the multivariate models are bolded.

In the bivariate comparison of sociodemographic characteristics between veterans with multimorbid obesity and TUD to those with morbid obesity only, the multimorbid group was more likely to have received a VA pension and have experienced homelessness. The

multimorbid group was also more likely than the morbid obesity only group to be diagnosed with schizophrenia, bipolar disorder, or a personality disorder. Those in the multimorbid group showed substantially higher risk than those with morbid obesity only of being diagnosed with SUD across all substance categories (RR ranging from 3.46 to 6.55). They were more likely to have used inpatient mental health treatment, opioid medications, and residential treatment and to have received antipsychotic medications or lithium. On the continuous outcome variables (Table 2) the multimorbid group was younger than those with morbid obesity only and had more numerous psychiatric diagnoses, substance use diagnoses, psychotropic prescription fills, and outpatient psychiatric and substance use visits.

In the bivariate comparison of veterans with morbid obesity plus TUD to those with TUD only, no substantial differences were noted in sociodemographic characteristics or presence of individual psychiatric diagnoses. Across substance use categories, the multimorbid group was, unexpectedly, substantially *less* likely to be diagnosed with SUDs compared to those with TUD only. The multimorbid group was less likely than the TUD only group to have received inpatient mental health treatment, opioid medications, or residential treatment. On continuous measures, (Table 2) the multimorbid group had significantly fewer substance use diagnoses, but they had a higher score on the Charlson Comorbidity Index and more numerous medical outpatient visits.

3.3. Multivariate associations

Results of the multinomial logistic regression models were largely consistent with the bivariate analyses (Table 3). Compared to the group with morbid obesity only, those with morbid obesity and TUD were younger, more likely to have experienced homelessness, and had more numerous substance use diagnoses. Multimorbid group membership was also associated with higher scores on the Charlson Comorbidity Index and higher total number of psychiatric diagnoses. Compared to the group with morbid obesity only, the group with both conditions showed higher rates of psychotropic and pain-related prescription fills.

In contrast, those with morbid obesity and TUD, when compared to the group with TUD only, were younger, less likely to have experienced homelessness, and had *fewer* substance use diagnoses. The multimorbid group had higher scores on the Charlson Comorbidity Index and higher total number of psychiatric diagnoses. Model 2 included all variables from Model 1 and additionally included a block of service utilization variables. Compared to group with TUD only, those with morbid obesity and TUD showed higher rates of both medical and mental health outpatient service use and higher rates of psychotropic and pain-related prescription fills, but less residential and inpatient psychiatric treatment.

4. Discussion

This study examined rates of diagnostic and service use measures among veterans with both TUD and morbid obesity to those of veterans with each condition alone. Results of the study offered partial support for our initial multimorbidity hypotheses. TUD and morbid obesity was associated with higher rates of additional multimorbidities, including medical and psychiatric disorders, and veterans with both conditions had higher levels of service use than veterans with either condition alone. As such, it appears that multimorbid tobacco use and

morbid obesity may confer additional risk for poor health outcomes in veterans. These results are consistent with the larger multimorbidity literature that has highlighted, in both VA and non-VA contexts, that multimorbidity is associated with more extensive psychopathology (including SUDs), reduced quality of life (Bhalla, Stefanovics, & Rosenheck, 2018; Fortin et al., 2004) and higher rates of health service use (Bhalla & Rosenheck, 2018; Salisbury, Johnson, Purdy, Valderas, & Montgomery, 2011). There was, however, one notable finding that ran counter to our hypothesis: the co-occurrence of TUD with morbid obesity was associated with *lower* rates of substance use co-occurrence than TUD alone.

These results thus offer an important addition and modification of the results reported by White and Grilo (2006). First, and consistent with White and Grilo, we found that individuals with obesity and TUD were more likely to meet criteria for specific psychiatric disorders (i.e., anxiety disorder, personality disorders) compared to those with obesity alone, as well as with increased numbers of multimorbid substance use disorders. This association appears to be driven primarily by the additional presence of TUD (or, alternatively, the presence of SUD in veterans with obesity increases their risk of tobacco use). However, in this study we were able to add a comparison group of patients with both obesity and TUD to a group with TUD alone. While this analysis showed higher levels of psychiatric disorders within the multimorbid group, the combined group also was characterized by lower levels of SUD. Thus, the multimorbidity effect, found by White and Grilo in the comparison of those with TUD and obesity to those with obesity alone was *not* found in the additional comparison of individuals with TUD and obesity to those with TUD alone.

What does the seemingly counterintuitive finding that co-occurring obesity is associated with reduced risk of co-occurring SUD in tobacco users indicate about the role of addiction vulnerability in obesity? One interpretation is that the presence of obesity does not signal an underlying propensity towards addiction. This interpretation challenges a body of research identifying overlap in the neurobiological pathophysiology of SUD and obesity vulnerability (Volkow & Wise, 2005; Wang et al., 2001). Another interpretation is consistent with the food/drug substitution hypothesis (Kalarchian et al., 2007; Petry, Barry, Pietrzak, & Wagner, 2008). According to this hypothesis, overconsumption of food may satisfy the underlying appetitive drive as substance use, reducing the likelihood that the individual will use substances to excess. Applying this framework to our findings, for individuals with TUD, who show a general vulnerability to addictions, overeating may fulfill similar physiological or psychological needs as substance use, such that individuals with TUD and morbid obesity are less likely to engage in other dysregulated substance use. This interpretation rests on the assumption that morbid obesity represents a pattern of dysregulated food consumption, which is likely to be the case for many but not all people with morbid obesity, since there are other causes of obesity not explained using a food addiction framework (Ziauddeen & Fletcher, 2013).

This finding is novel in that it describes a less well-recognized multimorbidity process. The most commonly described multimorbidity process (complementarity) is that multiple diseases exert an additive negative effect on health, quality of life, functional outcomes, and mortality risk (Marengoni et al., 2011). We observed this additive pattern of risk in the

current study in that the multimorbid group showed higher rates of medical and psychiatric disease compared to the single condition groups. This pattern suggests that multiple disease states signal likely signal underlying health vulnerabilities and may place additive stress on affected organ systems, resulting in poorer general health outcomes. Alternatively, the presence of one disease state might mitigate some of the processes and problems associated with a co-occurring condition. This relationship between disease states has been described for non-CNS diseases (Stiehm, 2006), but far fewer examples of this multimorbidity pattern have been described for behavioral conditions. Given the potentially ameliorative effect of overeating/obesity in this context, it is possible that treating this condition may have the unintended effect of potentiating SUD risk in tobacco users.

Our findings have several clinical implications. Clinicians and clinical guidelines should continue to consider potential substitutive interactions between disease states when treating patients (Guthrie, Payne, Alderson, McMurdo, & Mercer, 2012). Within VHA, comprehensive efforts to reduce rates of obesity among Veterans (e.g., MOVE! Weight Management Program; Littman, Boyko, McDonell, & Fihn, 2012), may benefit from tracking substance use outcomes among their participants, particularly among those with risk factors such as tobacco use. Nonetheless, combined morbid obesity and TUD was associated with higher rates of psychiatric and medical multimorbidity, so there are clearly benefits to treating these conditions that need to be considered. Given the elevated health risk in the multimorbid group, it may also be informative to conduct tobacco use screenings among veterans entering weight management programs. Results also highlight an opportunity to provide additional mental health services to veterans with combined morbid obesity and TUD. Specifically, these patients showed higher rates of psychiatric conditions but were less likely to have received inpatient mental health treatment.

Several methodological limitations deserve comment. First, data were extracted from unstandardized diagnoses in administrative records. While such data have the advantage of reflecting the 201Cclinical reality” as perceived by numerous healthcare providers, some records may have been incomplete. Future studies may employ additional safeguards to improve record accuracy (e.g., requiring two or more clinical encounters characterized by a diagnostic code for a patient to be coded as meeting criteria for that diagnosis). Second, due to the cross-sectional nature of the data, we were not able to confirm temporal associations between the onset of these different disorders. Nevertheless, administrative record datasets play an important role in multimorbidity research because of their large sample sizes (Maciejewski & Bayliss, 2014). Finally, our service utilization outcomes collapsed across different encounter types (e.g., outpatient psychiatric and substance use encounters). It may be beneficial for future research to closely examine service use patterns (e.g., different clinic types) in these clinical groups to better characterize treatment needs.

While results of the current study suggest that combined morbid obesity and TUD is associated with higher rates of medical and psychiatric disease, a common feature of multimorbidity, a notable exception to this general pattern was that veterans with combined morbid obesity and TUD experienced less SUD than those with TUD alone. TUD and obesity together may have a previously unappreciated protective effect with respect to SUD.

These findings deserve further replication and may have implications for treatment in the future.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding/Support:

This manuscript is based on work supported by the VA New England Mental Illness Research, Education, and Clinical Center. The views expressed in the article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs. The sponsor had no role in the design, analysis, interpretation, or publication of this study.

References

- Bhalla IP, & Rosenheck RA (2018). A change in perspective: From dual diagnosis to multimorbidity. *Psychiatric Services*, 69(1), 112–116. doi: 10.1176/appi.ps.201700194 [PubMed: 29032702]
- Bhalla IP, Stefanovics EA, & Rosenheck RA (2017). Clinical epidemiology of single versus multiple substance use disorders: Polysubstance use disorder. *Medical Care*, 55, S24–S32. doi: 10.1097/MLR.0000000000000731 [PubMed: 28806363]
- Bhalla IP, Stefanovics EA, & Rosenheck RA (2018). Mental health multimorbidity and poor quality of life in patients with schizophrenia. *Schizophrenia Research*, 201, 39–45. doi: 10.1016/j.schres.2018.04.035 [PubMed: 29709490]
- Breland JY, Phibbs CS, Hoggatt KJ, Washington DL, Lee J, Haskell S, ... Frayne SM (2017). The obesity epidemic in the Veterans Health Administration: Prevalence among key populations of women and men Veterans. *Journal of General Internal Medicine*, 32, 11–17. doi: 10.1007/s11606-016-3962-1
- Brown DW (2010). Smoking prevalence among US veterans. *Journal of General Internal Medicine*, 25, 147–149. doi: 10.1007/s11606-009-1160-0 [PubMed: 19894079]
- Charlson M, Szatrowski TP, Peterson J, & Gold J (1994). Validation of a combined comorbidity index. *Journal of Clinical Epidemiology*, 47(11), 1245–1251. [PubMed: 7722560]
- Cohen J (1988). *Statistical power analysis for the behaviors science* (2nd ed). Hillsdale, NJ: Erlbaum.
- Cohen J (1990). Things I have learned (so far). *American Psychologist*, 45(12), 1304–1312. doi: 10.1037/0003-066x.45.12.1304
- Cooper M, Yaqub M, Hinds JT, & Perry CL (2019). A longitudinal analysis of tobacco use in younger and older US veterans. *Preventive Medicine Reports*, 16, 100–990.
- Department of Health and Human Services (2014). *The health consequences of smoking—50 years of progress A report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, National Center for Chronic Disease Prevention and Health Promotion Office on Smoking and Health.
- Fortin M, Lapointe L, Hudon C, Vanasse A, Ntetu AL, & Maltais D (2004). Multimorbidity and quality of life in primary care: A systematic review. *Health and Quality of Life Outcomes*, 2, 51. doi: 10.1186/1477-7525-2-51 [PubMed: 15380021]
- Grant BF, Hasin DS, Chou SP, Stinson FS, & Dawson DA (2004). Nicotine dependence and psychiatric disorders in the United States: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Archives of General Psychiatry*, 61(11), 1107–1115. doi: 10.1001/archpsyc.61.11.1107 [PubMed: 15520358]
- Guthrie B, Payne K, Alderson P, McMurdo ME, & Mercer SW (2012). Adapting clinical guidelines to take account of multimorbidity. *BMJ*, 345, e6341. doi: 10.1136/bmj.e6341 [PubMed: 23036829]
- Kalarchian MA, Marcus MD, Levine MD, Courcoulas AP, Pilkonis PA, Ringham RM, ... Rofey DL (2007). Psychiatric disorders among bariatric surgery candidates: Relationship to obesity and functional health status. *American Journal of Psychiatry*, 164(2), 328–334. doi: 10.1176/ajp.2007.164.2.328 [PubMed: 17267797]

- Kelly MM, Reilly E, Quinones T, Desai N, & Rosenheck R (2018). Long-acting intramuscular naltrexone for opioid use disorder: Utilization and association with multi-morbidity nationally in the Veterans Health Administration. *Drug and Alcohol Dependence*, 183, 111–117. doi: 10.1016/j.drugalcdep.2017.10.017 [PubMed: 29245103]
- Littman AJ, Boyko EJ, McDonnell MB, & Fihn SD (2012). Evaluation of a weight management program for veterans. *Preventing Chronic Disease*, 9, E99. [PubMed: 22595323]
- Maciejewski ML, & Bayliss EA (2014). Approaches to comparative effectiveness research in multimorbid populations. *Medical Care*, 52 Suppl 3, S23–30. doi: 10.1097/MLR.0000000000000060
- MacLean RR, Sofuoglu M, & Rosenheck R (2018). Tobacco and alcohol use disorders: Evaluating multimorbidity. *Addictive Behaviors*, 78, 59–66. doi: 10.1016/j.addbeh.2017.11.006 [PubMed: 29127785]
- Marengoni A, Angleman S, Melis R, Mangialasche F, Karp A, Garmen A,... Fratiglioni L (2011). Aging with multimorbidity: A systematic review of the literature. *Ageing Research Reviews*, 10(4), 430–439. doi: 10.1016/j.arr.2011.03.003 [PubMed: 21402176]
- Mather AA, Cox BJ, Enns MW, & Sareen J (2009). Associations of obesity with psychiatric disorders and suicidal behaviors in a nationally representative sample. *Journal of Psychosomatic Research*, 66(4), 277–285. doi: 10.1016/j.jpsychores.2008.09.008 [PubMed: 19302884]
- Mokdad AH, Marks JS, Stroup DF, & Gerberding JL (2004). Actual causes of death in the United States, 2000. *The Journal of the American Medical Association*, 291(10), 1238–1245. doi: 10.1001/jama.291.10.1238 [PubMed: 15010446]
- Murdoch M, Sayer NA, Spoont MR, Rosenheck R, Noorbaloochi S, Griffin JM,... Hagel EM (2011). Long-term outcomes of disability benefits in US veterans with posttraumatic stress disorder. *Archives of General Psychiatry*, 68(10), 1072–1080. [PubMed: 21969464]
- Nelson KM (2006). The burden of obesity among a national probability sample of veterans. *Journal of General Internal Medicine*, 21(9), 915–919. doi: 10.1111/j.1525-1497.2006.00526.x [PubMed: 16918734]
- Odani S, Agaku IT, Graffunder CM, Tynan MA, & Armour BS (2018). Tobacco product use among military veterans—United States, 2010–2015. *Morbidity and Mortality Weekly Report*, 67(1), 7. [PubMed: 29324732]
- Petry NM, Barry D, Pietrzak RH, & Wagner JA (2008). Overweight and obesity are associated with psychiatric disorders: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Psychosomatic Medicine*, 70(3), 288–297. doi: 10.1097/PSY.0b013e3181651651 [PubMed: 18378873]
- Plana-Ripoll O, Pedersen CB, Holtz Y, Benros ME, Dalsgaard S, de Jonge P,... McGrath JJ (2019). Exploring comorbidity within mental disorders among a Danish national population. *JAMA Psychiatry*. doi: 10.1001/jamapsychiatry.2018.3658
- Salisbury C, Johnson L, Purdy S, Valderas JM, & Montgomery AA (2011). Epidemiology and impact of multimorbidity in primary care: A retrospective cohort study. *British Journal of General Practice*, 61(582), e12–21. doi: 10.3399/bjgp11X548929 [PubMed: 21401985]
- Sinha R (2018). Role of addiction and stress neurobiology on food intake and obesity. *Biological Psychology*, 131, 5–13. doi: 10.1016/j.biopsycho.2017.05.001 [PubMed: 28479142]
- Stiehm ER (2006). Disease versus disease: How one disease may ameliorate another. *Pediatrics*, 117(1), 184–191. doi: 10.1542/peds.2004-2773 [PubMed: 16396876]
- Volkow ND, Wang GJ, & Baler RD (2011). Reward, dopamine and the control of food intake: Implications for obesity. *Trends in Cognitive Science*, 15(1), 37–46. doi: 10.1016/j.tics.2010.11.001
- Volkow ND, & Wise RA (2005). How can drug addiction help us understand obesity? *Nature Neuroscience*, 8(5), 555–560. doi: 10.1038/nn1452 [PubMed: 15856062]
- Wang GJ, Volkow ND, Logan J, Pappas NR, Wong CT, Zhu W,... Fowler JS (2001). Brain dopamine and obesity. *Lancet*, 357(9253), 354–357. [PubMed: 11210998]
- White MA, & Grilo CM (2006). Psychiatric comorbidity in binge-eating disorder as a function of smoking history. *Journal of Clinical Psychiatry*, 67(4), 594–599.

- Wolff JL, Starfield B, & Anderson G (2002). Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. *Archives of Internal Medicine*, 162(20), 2269–2276. [PubMed: 12418941]
- Yoon J, Zulman D, Scott JY, & Maciejewski ML (2014). Costs associated with multimorbidity among VA patients. *Medical Care*, 52, S31–S36. [PubMed: 24561756]
- Ziauddeen H, & Fletcher PC (2013). Is food addiction a valid and useful concept? *Obesity Reviews*, 14, 19–28. doi: 10.1111/j.1467-789X.2012.01046.x [PubMed: 23057499]

Highlights

- Medical multimorbidities predict additional health conditions and poorer outcomes
- Obesity and tobacco use may share common underlying vulnerabilities
- Veterans with both conditions showed higher rates of certain multimorbidities
- Obesity may protect against substance use in tobacco users

Table 1.
Bivariate associations among group affiliation and binomial clinical/sociodemographic variables

	1. Morbid obesity + TUD (n = 20,368) n (%)	2. Morbid obesity (n = 144,450) n (%)	3. TUD (n = 386,325) n (%)	1 v. 2 (ref) RR [95% CI]	1 v. 3 (ref) RR [95% CI]
SOCIO-ENVIRONMENTAL					
Male	18,640 (91.5%)	131,610 (91.1%)	362,899 (93.9%)	1.00 [1.00, 1.01]	0.97 [0.97, 0.98]
Race/Ethnicity					
Hispanic	2,012 (9.9%)	18,683 (12.9%)	37,476 (9.7%)	0.76 [0.73, 0.80]	1.02 [0.98, 1.06]
White	16,091 (79.0%)	11,1601 (77.3%)	297,273 (76.9%)	1.02 [1.01, 1.03]	1.03 [1.02, 1.03]
Black	3,550 (17.4%)	27,639 (19.1%)	76,050 (19.7%)	0.91 [0.86, 0.94]	0.89 [0.86, 0.91]
Mixed Race	393 (1.9%)	2,760 (1.9%)	7,270 (1.9%)	1.01 [0.91, 1.12]	1.02 [0.93, 1.13]
Other Race	185 (0.9%)	1,585 (1.1%)	3,634 (0.9%)	0.83 [0.71, 0.97]	0.97 [0.84, 1.12]
Urbanicity					
Urban area	13,642 (67.0%)	101,031 (70.0%)	268,080 (69.4%)	0.96 [0.95, 0.97]	0.97 [0.96, 0.97]
Large rural area	2,626 (12.9%)	17,771 (12.3%)	48,501 (12.6%)	1.05 [1.01, 1.09]	1.03 [0.99, 1.07]
Small rural area	2,314 (11.3%)	14,321 (9.9%)	39,047 (10.1%)	1.15 [1.10, 1.19]	1.12 [1.08, 1.17]
Isolated rural area	1,786 (8.8%)	11,326 (7.8%)	30,696 (7.9%)	1.12 [1.07, 1.17]	1.10 [1.05, 1.16]
VA pension	917 (4.5%)	3,457 (2.4%)	20,889 (5.4%)	1.88 * [1.75, 2.02]	0.83 [0.78, 0.89]
Service-connected disability					
SC > 50%	5,888 (29%)	41,690 (28.9%)	78,203 (20.2%)	1.00 [0.98, 1.02]	1.43 [1.40, 1.46]
SC < 50%	3,815 (18.7%)	30,050 (20.8%)	65,317 (17.9%)	0.90 [0.87, 0.93]	1.11 [1.08, 1.14]
Homelessness	1,559 (7.7%)	4283 (3.0%)	40,094 (10.4%)	2.58 * [2.44, 2.73]	0.74 [0.70, 0.77]
PSYCHIATRIC DIAGNOSES					
Schizophrenia	1,067 (5.2%)	2,626 (1.8%)	14,331 (3.7%)	2.88 * [2.69, 3.09]	1.41 [1.33, 1.50]
Bipolar disorder	1,225 (6.0%)	3,998 (2.8%)	17,500 (4.5%)	2.17 * [2.04, 2.31]	1.33 [1.26, 1.40]
Major depression	2,645 (13.0%)	12,621 (8.7%)	37,256 (9.6%)	1.49 [1.43, 1.55]	1.35 [1.30, 1.40]
Other depression	6,067 (30.0%)	30,169 (20.9%)	10,1060 (26.2%)	1.43 [1.39, 1.46]	1.14 [1.11, 1.16]
PTSD	4,092 (20.0%)	21,607 (15.0%)	70,428 (18.2%)	1.34 [1.30, 1.38]	1.10 [1.07, 1.13]
Anxiety disorder	2,912 (14.3%)	13,779 (9.5%)	56,667 (14.7%)	1.50 * [1.44, 1.56]	0.98 [0.94, 1.01]
Adjustment disorder	1,139 (5.6%)	5,437 (3.8%)	22,523 (5.8%)	1.49 [1.40, 1.58]	0.96 [0.91, 1.02]

	1. Morbid obesity + TUD (<i>n</i> = 20,368) <i>n</i> (%)	2. Morbid obesity (<i>n</i> = 144,450) <i>n</i> (%)	3. TUD (<i>n</i> = 386,325) <i>n</i> (%)	1 v. 2 (ref) RR [95% CI]	1 v. 3 (ref) RR [95% CI]
Personality disorder	630 (3.1%)	1,772 (1.2%)	9,119 (2.4%)	2.52* [2.31, 2.76]	1.31 [1.21, 1.42]
Other psychiatric diagnosis	2,597 (12.8%)	13,036 (9.0%)	54,955 (14.2%)	1.41 [1.36, 1.47]	0.90 [0.86, 0.93]
PSYCHOTROPIC MEDICATION					
Antidepressant	9,980 (49.0%)	49,615 (34.3%)	159,646 (41.3%)	1.43 [1.40, 1.45]	1.19 [1.17, 1.20]
Antipsychotic	3,053 (15.0%)	10,021 (6.9%)	46,487 (12.0%)	2.16* [2.08, 2.24]	1.25 [1.20, 1.29]
Anxiolytic/sedative	5,131 (25.2%)	25,395 (17.6%)	82,770 (21.4%)	1.43 [1.40, 1.47]	1.18 [1.15, 1.20]
Stimulant	168 (0.8%)	936 (0.6%)	3,103 (0.8%)	1.27 [1.08, 1.50]	1.03 [0.88, 1.20]
Anticonvulsant/mood stabilizer	5038 (24.7%)	26,249 (18.2%)	70,155 (18.2%)	1.36 [1.33, 1.40]	1.36 [1.33, 1.40]
Lithium	288 (1.4%)	877 (0.6%)	4251 (1.1%)	2.33* [2.04, 2.66]	1.29 [1.14, 1.45]
Any psychotropic	12,918 (63.4%)	70,953 (49.1%)	217,941 (56.4%)	1.29 [1.28, 1.31]	1.12 [1.11, 1.14]
SUBSTANCE USE DISORDER DIAGNOSES					
Alcohol	2,866 (14.1%)	5,868 (4.1%)	93,601 (24.2%)	3.46* [3.32, 3.61]	0.58* [0.56, 0.60]
Cocaine	882 (4.3%)	1,082 (0.8%)	23,581 (6.10%)	5.78* [5.30, 6.31]	0.71 [0.66, 0.76]
Cannabis	802 (3.9%)	1,092 (0.7%)	24,105 (6.2%)	5.21* [4.76, 5.70]	0.63* [0.59, 0.68]
Opioids	1,007 (4.9%)	1,470 (1.0%)	28,845 (7.5%)	4.86* [4.49, 5.26]	0.66* [0.62, 0.70]
Sedatives/Hypnotics	90 (<0.1%)	135 (<0.1%)	2,700 (0.1%)	4.73* [3.62, 6.17]	0.63* [0.51, 0.78]
Amphetamines	139 (0.1%)	189 (<0.1%)	3,760 (0.1%)	5.22* [4.19, 6.49]	0.70 [0.59, 0.83]
Hallucinogen	12 (<0.1%)	13 (<0.1%)	3,02 (<0.1%)	6.55* [2.99, 14.35]	0.75 [0.42, 1.34]
SERVICE USE					
Any mental health inpatient treatment	627 (3.1%)	1,442 (1.0%)	17,731 (4.6%)	3.08* [2.81, 3.38]	0.67* [0.62, 0.73]
Opioid medication	1,007 (4.9%)	1,470 (1.0%)	28,845 (7.5%)	4.86* [4.49, 5.26]	0.66* [0.62, 0.70]
Residential Program Use	358 (1.8%)	446 (0.3%)	11,546 (3.0%)	5.69* [4.96, 6.54]	0.59* [0.53, 0.65]

Note: TUD = tobacco use disorder; RR = risk ratio; VA = Veterans Affairs; SC = service connected; PTSD = post-traumatic stress disorder. For pairwise comparisons, 1 = Morbid obesity + TUD group, 2 = Morbid obesity only group, and 3 = TUD only group. Variables with at least one pairwise comparison meeting our clinical significance criteria and therefore included in the multivariate model are indicated in bold.

* Individual comparisons that meet criteria are noted with an asterisk.

Table 2.

Bivariate associations among group affiliation and continuous clinical/socio-environmental variables

	1. Morbid obesity + TUD (<i>n</i> = 20,368) <i>M</i> (<i>SD</i>)	2. Morbid obesity (<i>n</i> = 144,450) <i>M</i> (<i>SD</i>)	3. TUD (<i>n</i> = 386,325) <i>M</i> (<i>SD</i>)	1 v. 2 (ref) Cohen's <i>d</i>	1 v. 3 (ref) Cohen's <i>d</i>
Age (years)	54.90 (11.09)	58.89 (12.07)	57.18 (13.21)	-0.31	-0.18
Income (USD)	23,866.43 (38,112.99)	30,315.95 (54,951.37)	24,011.03 (45,582.85)	-0.13	-0.01
Psychiatric Diagnosis Count	1.12 (1.30)	0.74 (1.09)	1.01 (1.27)	0.31*	0.08
Psychiatric Medication Count	11.76 (30.20)	6.83 (18.67)	9.31 (25.35)	0.21*	0.10
Substance Use Disorder Count	0.28 (0.70)	0.07 (0.32)	0.46 (0.85)	0.29*	-0.23*
Charlson Comorbidity Index	2.12 (1.95)	1.99 (1.88)	1.71 (1.93)	0.07	0.21*
Emergency Room Visits	0.86 (2.09)	0.56 (1.48)	0.77 (2.06)	0.16	0.05
Medical surgical visits	13.14 (13.73)	11.39 (12.60)	9.56 (10.84)	0.15	0.31*
Psychiatric or substance abuse outpatient visits	7.95 (26.45)	3.14 (13.09)	8.31 (27.36)	0.20*	-0.02

Note. TUD = tobacco use disorder. USD = United States dollars. For pairwise comparisons, 1 = Morbid obesity + TUD group, 2 = Morbid obesity only group, and 3 = TUD only group. Variables with at least one pairwise comparison meeting our clinical significance criteria and therefore included in the multivariate model are indicated in bold.

* Individual comparisons that meet our effect size criteria are noted with an asterisk.

Table 3.

Multinomial logistic regression models evaluating unique clinical predictors of tobacco use/morbid obesity group affiliation

	Morbid obesity + TUD versus morbid obesity only (ref)			Morbid obesity + TUD versus TUD only (ref)		
	AOR	95% CI	β	p	AOR	95% CI
Model 1: Multimorbidity summary model						
Age	0.98	[0.98, 0.98]	-0.15	<.001	0.98	[0.98, 0.98]
VA Pension	1.77	[1.65, 1.90]	0.07	<.001	0.92	[0.86, 0.98]
Homelessness	1.37	[1.29, 1.46]	0.05	<.001	0.88	[0.83, 0.92]
Charlson Comorbidity Index	1.07	[1.07, 1.08]	0.08	<.001	1.16	[1.15, 1.16]
Substance use disorders count	2.65	[2.58, 2.73]	0.41	<.001	0.66	[0.65, 0.68]
Psychiatric disorder count	1.13	[1.12, 1.14]	0.08	<.001	1.12	[1.10, 1.13]
Model 2: Service use variables included						
Residential Treatment	0.95	[0.81, 1.11]	-0.00	.486	0.81	[0.72, 0.92]
Medical/Surgical Visits	1.00	[1.00, 1.00]	0.00	.429	1.02	[1.02, 1.02]
Psychiatric/Substance abuse visits	1.00	[1.00, 1.00]	-0.01	.039	1.00	[1.00, 1.00]
Mental health inpatient visits	0.93	[0.84, 1.03]	-0.01	.180	0.79	[0.65, 0.79]
Psychiatric medication prescriptions	1.00	[1.00, 1.00]	0.03	<.001	1.00	[1.00, 1.00]
Opioid prescriptions	1.03	[1.03, 1.03]	0.09	<.001	1.01	[1.01, 1.01]

Note. TUD = tobacco use disorder; VA = veterans affairs. All variables included in Model 1 are listed. Model 2 also includes the following covariates: age, VA Pension, homelessness, Charlson Comorbidity Index score, substance use disorder count, and psychiatric disorder count. AOR = adjusted odds ratio.