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ORIGINAL CONTRIBUTION

Association between mental health and comorbid obesity and hypertension among children and adolescents in the US

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Abstract This paper examines the association between mental health and comorbid obesity and hypertension among US children and adolescents using data from the National Health and Nutritional Examination Survey (NHANES). Questionnaires from NHANES were used to assess mental health during the previous 30 days. Respondents were then categorized into two groups namely "poor mental health" and "good mental health" based on their responses to these survey questions. Three multiple logistic regression models, based on these categories, are estimated to compute the odds ratios and 95 % confidence intervals in the association of obesity and hypertension and mental health. As a select example, the results of Model 2 reveal that compared with respondents who are not obese, obese respondents have increased odds (OR = 1.24; $P < 0.0001$) of poor mental health. Furthermore compared with non-hypertensive respondents, hypertensive respondents have higher odds (OR = 2.96; $P < 0.0001$) of poor mental health. These findings have important implications for mental health management in younger populations. It brings into focus the maintenance of a healthy body mass index and hypertension control in mitigating poor mental health.

Keywords Mental health · Hypertension · Obesity · Comorbidities

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Introduction

The relationship between mental and physical health is a complex one. The presence of a physical condition and a concomitant mental condition complicates this relationship and is usually associated with poorer health outcomes than just when one condition is present. Doherty and Gaughran [1] argued that individuals with mental health conditions have a higher risk of developing physical illnesses. Mental health problems are not uncommon; about 25 % of all individuals experience a mental health illness during their lifetime [1].

The interaction between mental and physical health has been the subject of several studies. Stein et al. [2] found an association between mental disorders and hypertension in a general population. Ul-Haq et al. [3] found that underweight women and young women who are obese also have poorer mental health. A few studies have been devoted to uncovering this linkage in younger populations. Halfon et al. [4] found that obese children had significantly higher odds of having poorer mental health than children who are not obese. Davidson et al. [5] found a significant association between mental health (depression) and hypertension in young black kids, while Grimsrud et al. [6] found evidence to suggest an association between hypertension and mental disorders among younger populations in sub-Saharan Africa. Notwithstanding the plethora of studies investigating the link between mental health on one hand, and obesity and hypertension on the other, there is a general lack of literature in younger populations.

As a motivating example, we examine the association between mental health and comorbid obesity and hypertension among younger populations in the United States (US) using a nationally representative sample. Poor mental health is a general term used in this paper to include

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symptoms of depression and anxiety. The National Health and Nutrition Examination Survey (NHANES) is a valuable data source for investigating the association between mental health on one hand, and obesity and hypertension on the other. This paper contributes to the literature in two ways. First, it uses the NHANES questionnaire to dichotomize between "poor mental health" and "good mental health". NHANES does not provide guidelines for using the questionnaire to classify respondents into the aforementioned groups, and this is the motivation for undertaking this research. Second, a multiple logistic regression based on this dichotomy, is estimated to evaluate the association between mental health and comorbid obesity and hypertension.

The public health consequences of deteriorating mental health in younger populations cannot be ignored. When both mental illness and comorbid physical conditions are present, there is generally a higher overall rate of utilization of medical services. Second, depression has a high case fatality rate when compared to other diseases [7], and has been linked to teenage suicide [8]. Third, depression is often associated with unfavorable health and behavioral outcomes such as substance abuse, risky sexual behaviors, greater likelihood of fighting [7] and high truancy rates and poor academic performance [9].

In reviewing the literature several risk factors were identified as having an association with mental health, in addition to obesity and hypertension. Females are at risk of developing anxiety and depressive disorders. Research suggests that females are twice as likely as males to develop anxiety disorders [10] and more likely to be depressed [7]. Gender differences in the prevalence of mental disorders, if they do exist, are insignificant in childhood years, but may accelerate with age [11]. Household income has been associated with anxiety disorders [12]. Some studies found that low family income was significantly associated with depression [13]. Studies by [13, 14] found that Hispanics are more likely to suffer from depression compared to Non-Hispanic Whites. Research [14] indicates that Non-Hispanic Black males have a higher rate of anxiety disorders relative to Non-Hispanic Whites, although there were no significant differences across races/ethnicities. Reeves et al. [15] argued that obesity could be a potential risk factor for the development of depression because of the interaction and common pathways between them. Thus, it is plausible that these comorbidities could be connected. The relationship between hypertension and depression or anxiety is plausible because of pathophysiological reasons. Jones-Webb et al. [16] and Towsend et al. [17] contend that the mechanism underlying this relationship relates to the sympathetic nervous system and Scalco et al. [18] reported evidence indicating abnormal activity in depressed individual. A study by Scalco et al. [18] suggests that that

obesity and hypertension are risk factors in the development of depression. It is sometimes assumed that regression coefficients are the same in subsets of the data. This assumption is occasionally violated because these subsets of the data are structurally different. Events that occur in each year may not have the same impact. Because of the pooled structure of the data, time effects are controlled for. The time effects are captured by the data release date, which entered as a continuous variables as done in previous studies [19].

Methods

Data

Data used for this study were obtained from [20] which samples individuals from the US population. The survey is conducted by the National Center for Health Statistics of the Center for Health Statistics of the Centers for Disease Control and Prevention (CDC). NHANES data have been collected since 1999 and are released in 2-year cycles; the analysis in this study was conducted with data from four cycles: 2005–2006, 2007–2008, 2009–2010 and 2011–2012. The survey oversamples Non-Hispanic Blacks and Mexican-Americans. Data on race and ethnicity were self-reported with open-ended questions during the home interviews. All participants in NHANES completed a standardized household interview and a comprehensive physical examination.

Assessment of mental health

Mental health was assessed using the current health status questionnaire (HSQ). Respondents were asked two questions from the questionnaire related to their mental health. These were "how many days during the past 30 days was your mental health not good" and "during the past 30 days, for about how many days have you felt worried, tense, or anxious". They reported values ranging from 0 to 30. Because NHANES does not specify cut-off values for assigning respondents to "poor" and "good" mental health groups, we chose cut-off values of <4, <7, and <14 days to be used in our analysis. Finally, we generated a dummy variable that equals one if the number of days is above the cut-off point for any of these questions to represent "poor mental health" and zero if the number of days is below the cut-off point to represent "good mental health".

Measurement of risk factors

The poverty-income ratio is measured as the ratio of a family's income to the US poverty threshold. Obesity was

measured using a dummy variable that equals 1 if the body mass index (BMI) was greater than 30 and 0 otherwise. The BMI was calculated by measuring the height and weight of participants during the interview. Hypertension was assessed using the blood pressure and cholesterol questionnaire (BPQ). Respondents were asked "have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" A "yes" response constitutes a positive screening for hypertension. A dummy variable was then generated to equal one if the response was a "yes" and zero if the response was a "no". Gender and race were assessed using a self-reported response to gender and race/ethnicity questions. The racial categories were Mexican-American, other Hispanic, Non-Hispanic White, Non-Hispanic Black, and other race (including multi-racial). Time effects were represented by the data release number. Because data from NHANES are released in 2-year cycles, this release number captures the time effects.

Statistical analysis

The study sample included 17,352 participants aged 0–18 years from 2005 through 2012. The aggregate sample and the samples for each individual cycle were weighted to account for the complex survey design, which includes oversampling. Respondents were categorized into two groups namely "poor mental health" and "good mental health". A multiple logistic regression, which was weighted and the variance adjusted to account for the complex survey design, was then used to test the hypotheses that obesity and hypertension were associated with mental health. SAS Version 9.3 software was used for all analyses (SAS Institute, Cary, NC, USA). Frequencies and percentages were also generated. Statistical models were adjusted for gender, race, data cycle and the poverty-income ratio. Three models were estimated which corresponds to the number of cut-off days used to dichotomize mental health. In Model 1, the response variable is based on a cut-off value of 4 days. The response variable in Model 2 is based on a cut-off value of 7 days, while the response variable in Model 3 is based on a cut-off value of 14 days.

Results

After excluding participants with missing values for response and other explanatory variables, 1,502, 1,567 and 1,605 participants were included in the final analytic samples for Models 1, 2 and 3, respectively. With cut-off values of 4, 7 and 14 days, the number of respondents who had poor mental health were 174, 239 and 277,

Table 1 Weighted sample demographic characteristics, NHANES 2005–2012 ($N = 17,352$) for adolescents from 0 to 18 years of age

Characteristics	n	%
Gender		
Male	8,520	50.85
Female	8,197	49.15
Current age, years		
0–5	1,765	5.72
6–10	5,727	34.90
11–15	3,996	28.55
16–18	3,769	30.81
Race/ethnicity		
Mexican-American	4,667	14.55
Other Hispanic	1,585	6.47
Non-Hispanic White	4,815	56.86
Non-Hispanic Black	4,228	14.30
Other race	1,422	7.80

respectively. Table 1 shows the weighted demographic sample statistics of the data. It reveals that among the 17,532 children and adolescents in the study, there were slightly more males than females. The age groups are evenly distributed, with the exception of the 0–5 group which had a substantially lower number of respondents. The majority of the people surveyed were non-Hispanic white (56.86 %). The corresponding demographics for those specifically included in the analytic samples are presented in Table 2. There were slightly more males than females and the age group 16–18 contained all observations because of missing data on the other age groups. Also the majority of respondents included in the analyses were either Non-Hispanic White or Non-Hispanic Black. At least 16 % of respondents were obese and between 1.96 and 2.49 % reported being hypertensive.

The results of the multiple logistic regressions for mental health are presented in Table 3. In Model 1, respondents who are obese are about 1.1 times (OR = 1.11; $P < 0.0001$) more likely to suffer from poor mental health compared with participants who are not obese. Compared to Non-Hispanic Whites, Mexican-Americans and Non-Hispanic Blacks have lower odds of having poor mental health. Finally, being a male reduces your odds of suffering from poor mental health. Regarding Model 2, obese participants have higher odds (OR = 1.24; $P < 0.0001$) of suffering from poor mental health compared with participants who are not obese. Also individuals who are hypertensive have higher odds (OR = 2.96; $P < 0.0001$) of suffering from poor mental health compared with individuals who are not hypertensive. Other interesting results are that male respondents have lower odds (OR = 0.44; $P < 0.0001$) of having poor mental

Table 2 Weighted sample demographic characteristics for respondents included in the final analytic samples

Characteristics	Model 1 (<4 days)		Model 2 (<7 days)		Model 3 (<14 days)	
	n = 1,502	%	n = 1,567	%	n = 1,605	%
Gender						
Male	791	52.69	817	51.86	832	51
Female	711	47.31	750	48.14	773	49
Current age, years						
0–5	–	–	–	–	–	–
6–10	–	–	–	–	–	–
11–15	–	–	–	–	–	–
16–18	540	100	559	100	572	100
Race/ethnicity						
Mexican-American	408	11.32	420	11.09	426	10.96
Other Hispanic	108	5.31	114	5.23	119	5.25
Non-Hispanic White	450	62.38	481	63.16	498	63.43
Non-Hispanic Black	465	15.31	479	15.01	485	14.79
Other race	71	5.65	73	5.49	77	5.54
Comorbidities						
Obesity	287	16.38	304	16.99	306	16.52
Hypertension	49	1.96	54	2.49	54	2.40
Poor mental health	174	16.4	239	21.8	277	24.5

Table 3 Multiple logistic regression analysis of mental health characteristics among US children and adolescents

Variable	Model 1[a] N = 1502		Model 2[b] N = 1567		Model 3[c] N = 1605	
	Odds ratio (95 % CI)	P value	Odds ratio (95 % CI)	P value	Odds ratio (95 % CI)	P value
Obesity	1.11 (1.06–1.16)	<.0001[d]	1.24 (1.16–1.31)	<.0001[d]	1.07 (0.96–1.19)	0.18
Hypertension	1.16 (0.16–8.35)	0.88	2.96 (1.53–5.72)	<.0001[d]	2.73 (1.46–5.10)	0.001[d]
Male	0.46 (0.43–0.49)	<.0001[d]	0.43 (0.41–0.45)	<.0001[d]	0.40 (0.38–0.42)	<.0001[d]
Race						
Non-Hispanic White		Reference		Reference	Reference	Reference
Mexican-American	0.52 (0.38–0.72)	<.0001[d]	0.45 (0.39–0.53)	<.0001[d]	0.46 (0.37–0.59)	<.0001[d]
Other Hispanic	0.90 (0.55–1.47)	0.69	0.77 (0.60–0.99)	0.04[e]	0.78 (0.75–0.81)	<.0001[d]
Non-Hispanic Black	0.59 (0.47–0.74)	<.0001[d]	0.51 (0.30–0.85)	0.01[d]	0.51 (0.33–0.76)	0.001[d]
Other race	0.39 (0.12–1.19)	0.10[f]	0.32 (0.24–0.43)	<.0001[d]	0.37 (0.27–0.49)	<.0001[d]
Poverty-income ratio	0.99 (0.86–1.14)	0.93	0.98 (0.86–1.12)	0.83	0.99 (0.84–1.17)	0.98
Data cycle number	3.45 (2.21–5.41)	<.0001[d]	3.79 (2.28–6.28)	<.0001	3.83 (2.39–6.13)	<.0001[d]

[a] Model 1 uses a cut-off of 4 days

[b] Model 2 uses a cut-off of 7 days

[c] Model 3 uses a cut-off of 14 days

[d] Statistically significant at P = 0.01

[e] Statistically significant at P = 0.05

[f] Statistically significant at P = 0.10

health compared with females. An interesting result is that the odds of poor mental health are higher as we move from one data cycle to another. Also relative to non-Hispanic whites, respondents who are Mexican-American, other Hispanic, Non-Hispanic Black and other race have lower odds of suffering from poor mental health. Finally in Model 3, hypertensive respondents are about 2.7 times (OR = 2.73; P = 0.001) more likely to suffer from poor mental health compared with individuals who are not hypertensive. The results also reveal that males are less

likely (OR = 0.40; $P < 0.0001$) to suffer from poor mental health compared to females. Mexican-American, Other Hispanic, Non-Hispanic Black and other race are less likely to suffer from poor mental health compared with Non-Hispanic Whites. Finally, the odds of poor mental health increase from the preceding cycle to the next. These findings indicate that obesity and hypertension are significant risk factors associated with poor mental health.

Discussion

The analysis produced some very informative results. The results demonstrate that obesity and hypertension are associated with increased odds of poor mental health in a representative US population of children and adolescents. A multiple logistic regression was estimated to compute odds ratios in the association of mental health and comorbid obesity and hypertension after controlling for certain demographic variables. Several studies find evidence to support the findings of this research. Reeves et al. [15] indicated that obesity and depression are closely linked. They argued that this link is not coincidental because obesity and depression share a common pathophysiological mechanism. They further contended that obesity and depression share common symptoms such as sleep problems, sedentary behavior and dysregulated food intake which makes this link even more concrete. Studies by Rutledge and Hogan [21] and Kaplan and Nunes [22] provided evidence to suggest an association between hypertension and psychological symptoms such as depression and anxiety. Evans et al. [23] argued that changes in peripheral and central neuroendocrine systems normally accompany these symptoms thereby leading to a decline in physical health. Contrary to research by [13, 14], the evidence from this study suggests that Non-Hispanic Whites have higher odds of having poor mental health. The findings of this study are fully not consistent with the stated hypotheses that mental health is significantly impacted by obesity and hypertension. The results of Model 1 do not lend support to the hypothesis that obesity significantly impacts mental health, while those of Model 3 do not support the hypothesis that hypertension significantly impacts mental health.

A strength of this study is that it uses data from NHANES which is a nationally representative cross-sectional sample. Several limitations of this study are worth mentioning. First, there is no universally agreed upon cut-off point for dichotomizing mental health into "poor" and "good". In this regard, several cut-off points were adopted to ascertain the sensitivity of our findings. Second, mental health was specified as a function of obesity and hypertension, but it is also reasonable to think that

obesity and hypertension could depend on mental health and this issue needs further investigation. Third, respondents who reported having a positive number of days when mental health was not good or when they felt anxious, where not asked follow-up questions to further assess the symptoms of depression or anxiety. Fourth, this study did not take into account the temporal aspect of the association found between mental health and comorbid obesity and hypertension. Fifth, it is also possible that there is under-reporting and this may explain the low number of cases. Finally, there is a large number of missing observations for either the response or other explanatory variables.

Poor mental health can be disruptive and affect basically all spheres of life of children [13]. For example, depression onset before the age of 21, have been known to increase hospitalization rates, overall rates of comorbid disorders and substance abuse disorders [24]. In addition, symptoms of depression are associated with behavioral outcomes including lower achievement on tests, lower teacher-rated grades and poorer peer relationship [9]. These findings are important because there is evidence to suggest that that children who experience depression at an early age often experience more severe episodes later on in life [25, 26].The results of this study have important implications for mental health management in children and adolescents. It brings into focus the maintenance of a healthy body mass index and control of hypertension in improving the mental health of younger populations in the US.

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