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The Impact of Obesity on Mortality and Clinical Outcomes in Patients with Acute Diverticulitis in the United States

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ABSTRACT

Background & Aims: Diverticular disease represents a leading cause of gastrointestinal-related hospitalizations. We sought to identify the adverse consequences of obesity on acute diverticulitis (AD) hospital admissions. By age 85, approximately two-thirds of individuals will develop diverticular disease and up to 25% will develop AD. Generally, obesity confers an increased risk of morbidity and mortality; however, its impact on hospitalized patients with AD are lacking.

Methods: Utilizing ICD-9-CM codes from the National Inpatient Sample (January 2012 – October 2015) we identified patients with a primary discharge diagnosis of AD including 660,820 hospitalizations and 115,785 with obesity. Primary outcomes were mortality, length of stay, and hospitalization cost. Secondary outcomes were AD complications and the need for surgical interventions.

Results: On multivariate analysis, obesity was not associated with an increased risk of mortality (OR=1.1, 95%CI: 0.87-1.41; p= 0.43). However, morbid obesity (BMI > 40 kg/m^2) showed a significant increased risk of mortality (OR=1.69, 95%CI: 1.23-2.31; p<0.001). Obesity was associated with prolonged hospitalizations length of stay by 0.61 days (0.55-0.68; p $<10^{-6}$), higher hospital charges $6,320 ($ 5,500-7,140; p$<10^{-6}$), increased complicated diverticulitis 1.05 (1.01-1.1; p < 0.010) and required more surgical interventions for diverticulitis (OR=1.19, 95%CI: 1.15-1.23; p$<10^{-6}$).

Conclusion: Morbid obesity increases risk for mortality while obesity leads to longer hospitalization stays and greater healthcare cost as well as adverse clinical outcomes and more surgical interventions. Further interventions are required to address obesity and weight loss for patients with diverticulitis to improve clinical outcomes.

Key words: acute diverticulitis – obesity – morbid obesity – mortality – clinical outcome.

Abbreviations: AD: acute diverticulitis; BMI: body mass index; CI: confidence interval; CCI: Charlson- Deyo Comorbidity Index; DD: diverticular disease; ICD-9-CM: International Classification of Diseases, 9th edition, clinical modification; NIS: national inpatient sample.

INTRODUCTION

Diverticular disease (DD) represents a significant cause of morbidity and is a leading cause of gastrointestinal-related hospitalizations [1, 2]. By the age of 85, acute diverticulitis will occur in 25% of patients suffering from [3, 4]. Further, up to one-third of patients may develop complicated diverticulitis with obstruction, perforation, or abscess that may require emergent surgical intervention [5]. Acute diverticulitis (AD) has been increasing in the United States and accounts for over 200,000 annual admissions [6, 7]. In 2013, an estimated $1.6 billion was spent on AD-related emergency department visits [8].

Obesity confers an increased risk of morbidity and mortality leading to cardiovascular disease, cancer, hypertension and type 2 diabetes mellitus [9]. The growing prevalence of childhood and adolescent obesity puts patients at risk for obesity-related comorbidities [10]. The obesity prevalence in the United States increased from 30.5% to 42.4% from 2000 through 2018 [11]. In 2008, obese individuals had medical costs $1,429 more than normal weight individuals [12]. Obesity increases the health-care associated resource utilization, including increasing costs for gastrointestinal surgeries, sepsis-related hospitalizations and inflammatory bowel diseases [13-16].

Physical activity, diet, and obesity have been shown to be modifiable risk factors for DD [1, 17, 18]. The increasing incidence of diverticulitis has been related to age, body mass index (BMI) and increased abdominal visceral and subcutaneous fat [19, 20]. Prospective cohort studies have found that high BMI increased the risk for developing diverticulitis and hospital admission rates [21-23]. Obesity has been shown to be a risk factor for recurrent diverticulitis and complicated diverticulitis [24, 25]. Morbid obesity is both associated with worse outcomes and hospital readmissions in AD [26].

This analysis utilizes a national cohort to comprehensively study the impact of obesity on hospitalized patients with AD. The aim of this study is to understand the impact of obesity in patients with AD on (i) mortality, (ii) healthcare resource utilization and cost, (iii) diverticular complications and (iv) surgical interventions.

METHODS

Our study utilized data from the National Inpatient Sample (NIS) for the time period January 1st, 2012 – October 31st, 2015. The NIS is the largest, publicly available all-payer inpatient care database in the United States including over 1,000 hospitals from 44 states [27]. The NIS is part of a set of databases developed for the Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality (AHRQ). Each year, the NIS contains data on more than seven million hospital stays each year and weighted estimates to more than 35 million hospitalizations nationally. Because of the de-identified nature of the data, the analysis was exempt from the Institutional Review Board approval.

Our primary patient population consisted of all patients with a primary discharge diagnosis for AD. These patients were identified through the presence of the International Classification of Diseases, 9th edition, clinical modification (ICD-9-CM) codes for AD (ICD-9-CM 562.11, 562.13) (Supplementary Table 1). In addition, the primary comparison of obesity was identified with ICD-9-CM codes (278.0, V85.30 to V85.39) and morbid obesity (278.01, V85.40 to V85.45). The ICD-9-CM codes in this study have reliably been used in other studies using the NIS [28].

Demographic variables in this study were age, gender, race and primary healthcare insurance. Co-morbidity was measured using the Charlson-Deyo index, a validated and widely used measure of co-morbidity among hospitalized patients [29]. The Charlson-Deyo score was categorized into four strata based on the presence of 0, 1, 2 and 3 or more co-morbidities. Hospital characteristics included bed size of the hospital, national region of the hospital (Northeast, Midwest, South, West) and teaching status of the hospital. Our three primary outcomes were in-hospital mortality, length of stay and total hospitalization charges. Secondary outcomes included risk factors for complications of including perforation, abscess, hemorrhage or obstruction and the need for surgical intervention including colectomy, colostomy, anterior resection and abscess drainage.

Patients were first stratified based on the presence of a concomitant obesity. The patient demographics, additional clinical characteristics, and primary and secondary outcome measures were then summarized using mean and standard deviation for normally-distributed continuous variables, median with interquartile range for non-normally distributed continuous variables, or frequencies with percentages for categorical variables. Quantile-Quantile plots were used to test the assumption of normality for continuous measures. To compare these measures between the two groups (Group 1: Diverticulitis Only; Group 2: Diverticulitis + obesity) independent t-tests or Wilcoxon Rank Sum tests (based on normality) were used for continuous measures, and Chi-Square tests were used for categorical variables. Due to the desire to have population-level interpretations, survey weights were applied to all patient-level observations as provided in the NIS database.

Multivariable weighted logistic regression models and resulting odds ratios [with 95% confidence intervals (CIs)] were then used to test for an association between the two diagnosis groups and the outcomes of in-hospital mortality, any surgical interventions (colectomy, colostomy, abscess drainage, anterior resection) and any complications (obstruction, perforation, abscess, fistula, hemorrhage), further adjusting for demographics and additional clinical characteristics. Multivariable weighted linear regression models and resulting odds ratios (with 95%CIs) were used to test for association between the two diagnosis groups and the outcomes of total charges and length of stay, further adjusting for demographics and additional clinical characteristics.

All reported p-values are 2-sided, and the significance cut-off was set at a value of 0.05, which was adjusted using a Bonferroni correction as needed in the case of multiple comparisons. Data analyses were completed in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and R studio (R version 3.6.0, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

There were 660,820 hospitalizations during the study time period (January 1st, 2012 to October 31st, 2015) and 115,785 had obesity. Table I compares the characteristics of patients with AD to those with AD and obesity. Patients with obesity were younger than controls (mean age 55.47 vs 61.2 years, respectively), more likely to be female, black, Hispanic, and had greater co-morbidities. 10.8% of patients in the infection group had a score of 3 or more on the Charlson-Deyo Comorbidity Index compared to 8.8% of controls. Patients with obesity were more likely to be Medicaid patients, self-pay, and from the Midwest or South. Length of stay was greater for obese patients (4 days vs 3 days). Hospitalizations charges were higher for patients with obesity at \$25,969 vs \$23,072 ($p<0.001$). Patients with obesity were more likely to undergo open colectomy (14.4 vs 12.4, $p<0.001$), colostomy (6.4 vs 5.4, $p<0.001$) and abscess drainage (4.9 vs 4.3, $p<0.001$). Patients with obesity had increased complications of diverticulitis including obstruction (8.2% vs 7.8%) and abscess (3.5 vs 3.0, $p<0.001$) but less likely to have hemorrhage (5.2% vs 6.2%).

A multivariate logistic regression analysis adjusting for covariates including patient demographics, hospital characteristics, patient comorbidities demonstrated that overall, obesity was not associated with an increased risk of

Table I. Patient demographics and hospital characteristics, interventions, complications and outcomes of acute diverticulitis with and without obesity

Variables		Diverticulitis	Diverticulitis + Obesity	p value
n		660,820	115,785	
Age in years at admission (mean (SD))		61.20 (15.46)	55.47 (14.28)	<0.001
Female (%)		377,805 (57.2)	72,875 (62.9)	<0.001
Race (%)				<0.001
White		517,010 (78.2)	81,985 (70.8)	
Black		51,560 (7.8)	15,125 (13.1)	
Hispanic		67,290 (10.2)	14,875 (12.8)	
Asian or Pacific Islander		6,805 (1.0)	675 (0.6)	
Native American		2,480 (0.4)	695 (0.6)	
Other		15,675 (2.4)	2,430 (2.1)	
Deyo-Charlson Comorbidity Index (%)				<0.001
0		387,335 (58.6)	53,505 (46.2)	
1		152,085 (23.0)	34,625 (29.9)	
2		63,360 (9.6)	15,205 (13.1)	
≥ 3		58,040 (8.8)	12,450 (10.8)	
Primary expected payer (%)				<0.001
Medicare		283,170 (42.9)	38,460 (33.2)	
Medicaid		48,445 (7.3)	13,980 (12.1)	
Private including HMO		270,970 (41.0)	51,340 (44.3)	
Self-pay		37,235 (5.6)	8,010 (6.9)	
No charge		4,465 (0.7)	990 (0.9)	
Other		16,535 (2.5)	3,005 (2.6)	
Calendar year (%)				<0.001
2012		183,825 (27.8)	28,575 (24.7)	
2013		175,279.9 (26.5)	29,865 (25.8)	
2014		172,895.1 (26.2)	32,025 (27.7)	
2015		128,820 (19.5)	25,320 (21.9)	
Bed size of hospital (%)				<0.001
Small		126,964 (19.2)	20,595 (17.8)	
Medium		198,615(30.1)	36,050 (31.1)	
Large		335,240 (50.7)	59,140 (51.1)	
Region of hospital (%)				<0.001
Northeast		157,019.9 (23.8)	22,890 (19.8)	
Midwest		137,764.9 (20.8)	26,030 (22.5)	
South		265,645.1 (40.2)	48,065 (41.5)	
West		1003,90.1 (15.2)	18,800 (16.2)	
Location teaching status of hospital (%)				<0.001
Rural		87,454.9 (13.2)	13,870 (12.0)	
Urban non-teaching		260,089.9 (39.4)	46,410 (40.1)	
Urban teaching		313,275.1 (47.4)	55,505 (47.9)	
Outcomes	n	660,820	115,785	
	Length of stay (median (IQR))	3 (3)	4 (3)	<0.001
	Total charges (median (IQR))	23,072 (29851.8)	25,969 (34786)	<0.001
	Disposition of patient (%)			<0.001
	Routine	544,505 (82.4)	95,655 (82.6)	
	Transfer to short-term hospital	5,435 (0.8)	890 (0.8)	

Table I (continued)

	Other transfers, including skilled nursing facility, intermediate care, and another type of facility	41,055 (6.2)	6,040 (5.2)	
	Home health care	62,160 (9.4)	12,215 (10.5)	
	Against medical advice	4,505 (0.7)	565 (0.5)	
	Died in hospital	3,120 (0.5)	410 (0.4)	
	Discharged alive, destination unknown	40 (0)	10 (0)	
Surgical procedures	Colectomy	148,040 (22.4)	28,120 (24.3)	<0.001
	Open colectomy	81,615 (12.4)	16,720 (14.4)	<0.001
	Laparoscopic colectomy	65,325 (9.9)	11,215 (9.7)	0.348
	Colostomy	35,960 (5.4)	7,380 (6.4)	<0.001
	Abscess drainage	28,195 (4.3)	5,620.0 (4.9)	<0.001
	Anterior resection	12,745 (1.9)	2,385.0 (2.1)	0.183
Complications	Obstruction	51,495 (7.8)	9,480 (8.2)	0.039
	Perforation)	2,365 (0.4)	460 (0.4)	0.358
	Abscess	19,610 (3.0)	3,850 (3.3)	0.003
	Fistula	120 (0)	25 (0)	0.724
	Hemorrhage	40,655 (6.2)	6,060 (5.2)	<0.001

HMO: health maintenance organization; SD: standard deviation

mortality (OR=1.1, 95%CI: 0.87-1.41) (Table II). However, when stratified for morbid obesity defined as a BMI>40kg/m^2, morbid obesity was independently associated with a significant risk of mortality (OR=1.69, 95%CI: 1.23-2.31). Obesity was associated with increased need for surgery (OR=1.19, 95%CI: 1.19-1.23), complicated diverticulitis (OR=1.05, 95%CI: 1.01-1.1), length of stay by 0.61 days (95%CI: 0.55,-0.68) and total charges by $6,300 (95%CI: 5,500-7,140).

Multivariate analysis for factors associated with increased surgery include private insurance (OR=1.35, 95%CI: 1.29-1.4), admission to large hospitals (OR=1.47, 95%CI: 1.42-1.52), teaching hospitals (OR=2.14, 95%CI: 2.05-2.22) and hospitals in the West (OR=1.28, 95%CI: 1.23-1.33) (Table III). Factors associated with decreased surgery include age >65 years (OR=0.95, 95%CI: 0.91-0.99), female (OR=0.86, 95%CI: 0.84-0.88), black (OR=0.59, 95%CI: 0.56-0.62), Hispanic (OR=0.62, 95%CI: 0.59-0.64), Medicaid (OR=0.9, 95%CI: 0.85-0.96), Self-pay (OR=0.75, 95%CI: 0.7-0.8) and >3 medical comorbidities on (OR=0.52, 95% CI: 0.5-0.55).

Multivariate analysis for factors associated with complicated diverticulitis include age >65 years (OR=1.76, 95%CI: 1.68,-1.84), black (OR=1.2, 95%CI: 1.14-1.26), >3 medical comorbidities on Charlson-Deyo Comorbidity Index (OR=1.22, 95%CI: 1.16-1.28), large hospitals (OR=1.16, 95%CI: 1.12-1.21), West (OR=1.56, 95%CI: 1.49-1.64) and teaching hospitals (OR=1.08, 95%CI: 1.03-1.13) (Table IV).

DISCUSSION

This is the first national and most comprehensive analysis that reports the effects of obesity on AD in the United States. We found that although patients with obesity did not have an increased risk for mortality, morbid obesity (BMI > 40 kg/m^2) had a statistically significant increased risk of mortality when compared to controls. Obesity was associated with greater healthcare utilization including longer length of stay and hospitalization cost. These patients were also more likely to develop complications of diverticulitis and require more surgical interventions.

Table II. Multivariable analysis of mortality and clinical outcomes in obese patients with acute diverticulitis

Outcome	Multivariable OR*	95% CI	*p* value
Mortality – Obese patients	1.1	(0.87-1.41)	0.43
Mortality in patients with morbid obesity	1.69	(1.23,-2.31)	0.001
Surgery[a]	1.19	(1.15-1.23)	$<10^{-6}$
Complicated diverticulitis[b]	1.05	(1.01-1.1)	0.01
	Multivariable estimated ratio*	95% CI	*p* value
Length of stay	0.61	(0.55-0.68)	$<10^{-6}$
Total charges	6,300	(5,500-7,140)	$<10^{-6}$

CI: confidence interval, OR: Odds ratio; *Multivariable logistic regression model adjusted for: age, gender, race, Charlson- Deyo Comorbidity Index: primary payer, hospital type, hospital bed size; [a] Surgery for diverticulitis including colectomy, colostomy, abscess drainage and anterior resection; [b] Complications of diverticulitis including obstruction, perforation, abscess, hemorrhage or fistula.

Table III. Risk factors associated with surgery in patients with acute diverticulitis

Variables	OR	95% CI	p value
Obesity Type			
Non-Obesity	Ref		
Obesity	1.19	(1.15-1.23)	$<10^{-6}$
Morbid Obesity			
Age in years at admission			
21-64	Ref		
65/65+	0.95	(0.91-0.99)	0.0076
Gender			
Male	Ref		
Female	0.86	(0.84-0.88)	$<10^{-6}$
Race			
White	Ref		
Black	0.59	(0.56-0.62)	$<10^{-6}$
Hispanic	0.62	(0.59-0.64)	$<10^{-6}$
Asian or Pacific Islander	0.6	(0.53-0.68)	$<10^{-6}$
Native American	0.91	(0.76-1.09)	0.32
Other	0.85	(0.79-0.92)	$<10^{-4}$
Primary expected payer			
Medicare	Ref		
Medicaid	0.9	(0.85-0.96)	0.0005
Private including HMO	1.35	(1.29-1.4)	$<10^{-6}$
Self-pay	0.75	(0.7-0.8)	$<10^{-6}$
No charge	0.77	(0.66-0.89)	0.0005
Other	1.21	(1.12-1.3)	$<10^{-5}$
Deyo-Charlson Comorbidity Index			
0	Ref		
1	0.85	(0.82-0.87)	$<10^{-6}$
2	0.68	(0.65-0.71)	$<10^{-6}$
≥3	0.52	(0.5-0.55)	$<10^{-6}$
Bed size of hospital			
Small	Ref		
Medium	1.24	(1.2-1.28)	$<10^{-6}$
Large	1.47	(1.42-1.52)	$<10^{-6}$
Region of hospital			
Northeast	Ref		
Midwest	1.09	(1.05-1.13)	$<10^{-5}$
South	1.14	(1.1-1.17)	$<10^{-6}$
West	1.28	(1.23-1.33)	$<10^{-6}$
Hospital location teaching status			
Rural	Ref		
Urban non-teaching	1.59	(1.52-1.65)	$<10^{-6}$
Urban teaching	2.14	(2.05-2.22)	$<10^{-6}$

HMO: health maintenance organization

Table IV. Risk factors associated with development of complicated diverticulitis

Variables	OR	95% CI	p value
Obesity Type			
Non-Obesity	Ref		
Obesity	1.05	(1.01-1.1)	0.010
Morbid Obesity			
Age in years at admission			
21-64	Ref		
65/65+	1.76	(1.68-1.84)	$<10^{-6}$
Gender			
Male	Ref		
Female	0.76	(0.74-0.78)	$<10^{-6}$
Race			
White	Ref		
Black	1.2	(1.14-1.26)	$<10^{-6}$
Hispanic	0.75	(0.72-0.79)	$<10^{-6}$
Asian or Pacific Islander	0.94	(0.82-1.08)	0.41
Native American	1.08	(0.88-1.32)	0.48
Other	0.92	(0.83-1.01)	0.078
Primary expected payer			
Medicare	Ref		
Medicaid	0.94	(0.87-1)	0.066
Private including HMO	0.94	(0.9-0.99)	0.019
Self-pay	0.94	(0.87-1.01)	0.092
No charge	0.86	(0.71-1.05)	0.13
Other	1.03	(0.93-1.13)	0.58
Deyo-Charlson Comorbidity Index			
0	Ref		
1	1.17	(1.14-1.21)	$<10^{-6}$
2	1.25	(1.2-1.31)	$<10^{-6}$
≥ 3	1.22	(1.16-1.28)	$<10^{-6}$
Bed size of hospital			
Small	Ref		
Medium	1.09	(1.05-1.14)	$<10^{-4}$
Large	1.16	(1.12-1.21)	$<10^{-6}$
Region of hospital			
Northeast	Ref		
Midwest	1.2	(1.15-1.25)	$<10^{-6}$
South	1.3	(1.26-1.35)	$<10^{-6}$
West	1.56	(1.49-1.64)	$<10^{-6}$
Hospital location teaching status			
Rural	Ref		
Urban non-teaching	0.99	(0.95-1.03)	0.58
Urban teaching	1.08	(1.03-1.13)	0.0006

The relationship between obesity and DD has been well established. Case control studies and prospective studies have found positive correlations of increasing BMI with DD [30-32]. Tursi et al. [33] has shown that patients with BMI over 30 have an increased risk for developing DD. Strate et al. [21] has shown that obesity was independently associated with an increased risk of diverticulitis and diverticular bleeding. In addition, obesity is known to influence the composition and function of intestinal microbiota which will differ from other patients and increase the risk of diverticulitis [34]. Disease risk is reported to be linearly related to the amount of additional body fat [35]. The location of fat appears significant with central abdominal fat conferring the strongest risk factor in both men and women, suggesting a possible metabolic contribution in DD [32, 35-38]. Fat distribution has important clinical implications and its effect has been established on other metabolic diseases such as type 2 diabetes [39]. Pro-inflammatory cytokines are linked to visceral adipose tissue and fat and may account for the harmful effects of obesity [40]. Obesity is associated with a chronic low-grade inflammatory state and may contribute to inflammation in the large intestine. Further, recent theories and evolving pathophysiologic mechanisms of diverticular disease include low-grade inflammation similar to obesity and chronic bowel disorders such as inflammatory bowel disease. The inflammation in obesity has been hypothesized to predispose patients to developing diverticulitis and increases the risk of complicated diverticulitis [35].

Obesity is associated with an increased risk of morbidity and mortality and continues to be an increasing burden on the United States healthcare system [9, 41, 42]. The impact of obesity and morbid obesity on diverticulitis has been associated with adverse clinical outcomes [43-45]. Patel et al. [26] showed that morbid obesity was associated with increased mortality, intensive care admissions, emergent surgery and readmissions within 30 days. We found similar results in that morbidly obese patients (BMI >40 kg/m^2) had a greater and significant risk of mortality. These findings are likely due to greater comorbidities, complicated diverticulitis and a need for surgery in this patient population. Further, obesity has been shown to be an independent risk factor of mortality in AD patients who have to undergo surgery [46]. Therefore, it can be hypothesized that weight loss in obese patients could be beneficial prior to surgery to improve outcomes in these patients. This analysis may help physicians better predict complications and prognoses during AD-hospitalizations.

Patients with obesity had more complications and were more likely to undergo surgical interventions including open colectomy, colostomy and abscess drainage. Morbid obesity in AD has been associated with more-intensive surgical interventions including emergent surgery, ostomy creation and open surgery [47]. Additional studies have found a positive relationship with obesity and complicated diverticulitis [25, 37]. Rodríguez-Wong et al. [48] found obese individuals to have a 3.5 odds ratio for developing complicated DD. Risk of recurrent diverticulitis is associated with age, gender, smoking and obesity [49]. Surgery and diverticular complications in AD are associated with increased mortality and identifying interventions to decrease the need for surgery and prevent complications can help improve outcomes in these patients. We report similar findings in previously published literature [47]. Weight reduction is a modifiable risk factor that may reduce admissions for recurrent diverticulitis, prevent complications and decrease the need for surgery.

The relationship between obesity, socioeconomic factors and disparities in care are linked to overall health care and health behavior. The effects of socioeconomic status and social background have significant effects on health care for patients with obesity. We found that patients with obesity were more likely to be black, Hispanic and have Medicaid or self-pay as their primary insurance. Prior studies have shown that black and Hispanic patients were more likely to be admitted for AD compared to whites [50]. African-Americans and obese patients were also more likely to develop recurrent diverticulitis [24]. Further, prior studies have shown that insurance status, including Medicaid or no insurance were predictors of mortality in AD [50]. Prior studies have shown that uninsured patients undergoing surgery have an increased risk of major adverse events and increased mortality [51]. While DD incidence increases with age, patients with obesity are more likely to present at younger ages [47]. We found that patients with obesity were likely to present with earlier onset of disease by 6 years. Identifying disparities in care in AD is important for improving care for these patients.

Few studies have been performed in elucidating the relationship between obesity and race/ethnicity in AD. Black, and Hispanic were less likely to undergo surgery for AD. However, black patients were more likely to develop complications of diverticulitis. Bose et al. [24] did not find a significant difference between race and complicated diverticulitis. We believe the large sample size and national representation of this study is able to better elucidate findings that were not previously significant. Racial disparities in complications and outcomes have been linked to inequality of access to high-quality health care. Previously published literature has shown similar findings in that black or Hispanic patients were less likely to receive surgical treatment or colostomy for AD [50]. Further studies are required on addressing these disparities in AD.

Our study has several limitations. First, it is a retrospective case-control study where data was obtained from a national database using ICD-9-CM codes for diagnoses related to AD and obesity. There is a possibility of misclassification or diagnosis and the codes are based on the quality of documentation. However, there is a high sensitivity and specificity for these codes when used with gastrointestinal diseases. Additional information on medical management and treatment is not captured in the NIS. BMI is a surrogate for visceral fat and is an imperfect measure for obesity that does not account for the location or composition of fat. Abdominal obesity is not a variable in this data set and may account for some variability. However, BMI has been reliably used in many studies with the NIS. There may have been additional complications and comorbidities that may have affected the hospital course that we could not account for. Further studies assessing obesity and outcomes in diverticulitis are required.

CONCLUSIONS

Patients with morbid obesity have an increased risk for mortality. Obesity is associated with longer hospitalization stays, greater healthcare utilization, complications of diverticulitis and a need for surgery. Given the increasing prevalence and health-care burden of diverticulitis, these findings have important clinical implications for preventing adverse outcomes in these patients. These findings provide further evidence for addressing obesity in the general population, and for patients to maintain a healthy weight and adhere to proper lifestyle and diet habits.

Conflicts of interest: None to declare.

Authors' contribution: M.M., T.P., A.P. conceived and designed the study, drafted and wrote the manuscript and approved the final version of the manuscript. W.X., P.G. designed the study, statistical analysis, interpreted the data, contributed to writing of the manuscript.

Supplementary material: To access the supplementary material visit the online version of the *J Gastrointestin Liver Dis* at http://dx.doi.org/10.15403/jgld-2988

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